SECTION 1 - INTRODUCTION **2**

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Section 1 - Introduction

1.1. Background to the Specification

1.1.2. The Particular Specification consists of 32 Sections, 11 Appendices and the Drawings listed in Appendix A.

1.2. Use of the Specification

1.2.1. The Particular Specification shall be read in conjunction with the General Conditions of Contract, the Drawings and all other documents which comprise the Contract.

1.2.2. To the extent that any provision of the Particular Specification is inconsistent with any provision of the General Conditions of Contract, the provisions of the General Conditions of Contract shall prevail.

1.2.1. To the extent that any provision of the Drawings is inconsistent with any provision of the General Conditions of Contract, the provisions of the Conditions of Contract shall prevail.

1.2.2. To the extent that any provision of the Particular Specification is inconsistent with any provision of the Drawings, the provisions of the Particular Specification shall prevail.

1.2.3. The Contractor shall ensure that none of the above documents are read in isolation. They are complementary documents and shall be read in conjunction with one another.

1.2.4. The Particular Specification is hereinafter referred as PS. The reference to the clauses in the PS is prefixed by the letters "PS" (for example, Clause 21.3.4 of the Particular Specification is written as PS 21.3.4).

1.2.5. In the event of any conflict between the requirements of particular parts of this Particular Specification, the order of precedence shall be Sections and Appendices.

1.3 Standards

1.3.1. The Contractor shall comply with the AUTHORITY's Standards as specified.

1.3.2. Where international or national standards are quoted, the Contractor may propose to work to equivalent internationally or nationally recognised standards. Their use shall be subject to approval. Submission for approval are to be supported by a copy of the proposed standards, a detailed comparison of the quoted and proposed standards and, where applicable, an English translation of the proposed standard.

1.3.3. Wherever quoted standards duplicate requirements for a particular criterion, the more stringent standard shall apply. Any conflict in requirements shall be brought to the attention of the Engineer.

SECTION 2 DEFINITIONS AND ABBREVIATIONS 2

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Section 2 Definitions And Abbreviations

Shis Section includes a list of all definitions and abbreviations applicable to the PS in addition to those provided in the Conditions of Contract and the General Specification.

2.1 Definitions

The following definitions are applicable to the PS:

2.1.1 ***"Commercial Speed"*** means the average running speed of train over a given length of track, in mathematical form,

$$Commercial\ Speed = \frac{Distance\ between\ Terminal\ Stations}{Travelling\ Time}$$

where the travelling time includes the 120 second terminus turnaround time. The dwell time is taken as 15 seconds.

2.1.2 ***"Duty Cycle"*** means the total running time of the compressor on load with respect to the total time for the vehicle in service with all compressors running normally on a train, i.e.

$$Duty\ Cycle = \frac{Total\ Compressor\ Running\ Time\ On\ Load}{Total\ Vehicle\ Service\ Time} \times 100\%$$

2.1.3 ***"Main Reservoir Pipe"*** means a main pipeline connecting all cars of the train consist to distribute compressed air to trainborne pneumatic equipment.

2.1.4 ***"T1 Train"*** or ***"T1 Car"*** means the existing trains or cars of T1 class.

2.1.5 ***"Pump-down"*** means transferring all refrigerant to the condenser side before stopping the compressor of the air conditioning unit.

2.1.6 ***"Service Condition"*** means the condition in which a train is ready for passenger service with all trainborne equipment including the emergency and standby systems available and functioning to the required performance as specified in the PS, without any preventive maintenance or cleaning work overdue beyond the tolerance.

2.1.7 ***"Round Trip"*** means the satisfactorily operation of the trains to provide passenger service according to the normal train service headway on the following round journeys:

(a) stations A to B for the C-D-E Line

(b) stations G to H for the I-J Line

(c) stations NN to N for the N Line

(d) stations A to P Avenue for the New E Extension (extended from C-D-E Line)

2.1.8 ***"Existing Subway Lines"*** means the operating lines on the Employer's existing railway network comprising the C-D-E Line, I-J Line and N Line.

2.1.9 ***"Train Operator"*** or ***"Operator"*** means both the Driver (a.k.a. Motorman) who is mainly responsible for train movement control and the Guard who is mainly responsible for train door and Passenger Information System controls.

2.1.10 ***"Railway"*** means the Commission's Subway System operating in CITY as defined for this purpose in the Specification.

2.1.11 ***"Provision"*** means the special requirements as defined for design purpose in the Specification.

2.1.12 ***"Trailer Car"*** means the driving cab car which is equipped with a trailer truck.

2.1.13 ***"Works"*** means all the Plant and things to be executed, undertaken or provided by the Contractor under the Contract.

2.1.14 ***"Plant"*** means machinery, apparatus, materials, goods, including spare parts, articles and things of all kinds to be provided under the Contract other than Contractor's Equipment, services, Design Data, documentation and drawings.

2.1.15 The ***"train"*** means the New Subway Train (a.k.a. NST) to be provided by the Contractor under the Contract.

2.1.16 The ***"Defects Liability Period"*** means the whole period of Warranty (refer to

GC 29) from the date of the Final Acceptance Certificate for the last Six Car Subway Train Set of the first Group (refer to GC 58) to the date of the Final Acceptance Certificate for the last Six Car Subway Train Set of the last Group (refer to GC 58).

2.2 Abbreviations

The following abbreviations shall apply to the PS:

AC	Alternating Current
ACP	Auxiliary Control Panel
ATC	Automatic Train Control
ATP	Automatic Train Protection
CABSIM	Driving Cab Simulator
CPU	Central Processing Unit

DC	Direct Current
DCU	Door Control Unit
DiCU	Display Control Unit
DDSP	Design Data Submission Programme
DI	Design Information
DLP	Defect Liability Period
DMS	Drawing Management System
DSD	Deadman Safety Device
DVAS	Digital Voice Announcement System
DVAU	Digital Voice Announcement Unit
EBR	Emergency Brake Relays
EIDS	Electronic Information Display System
EDD	Electronic Destination Display
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ETND	Electronic Train Number Display
FEA	Finite Element Analysis
FMECA	Failure Modes, Effects and Criticality Analysis
FRC	Fault Report Centre
FRACAS	Failure Reporting And Corrective Action System
FSM	Flashing System Map
FTA	Fault Tree Analysis
GC	General Conditions of Contract
HAZOP	Hazard and Operability Study
H H H H H	eating, Ventilation and Air Conditioning

I I I I I ntermediate Voltage Power Supply

LAN	Local Area Network
LIDS	Liquid Crystal Display (LCD) Information Display System
LPU	Local Processing Unit
LRU	Line Replaceable Unit
LVPS	Low Voltage Power Supply
MCB	Miniature Circuit Breaker
MCP	Master Control Panel
MIS	Multi-media Information System
MMI	Man-Machine Interface
MTBF	Mean Time Between Failure
MDBF	Mean Distance Between Failure
MTTR	Mean Time To Repair

PA	Public Address
PAA	Passenger Assistance Alarm
PAEH	Passenger Alarm Emergency Handle
PAIS	Passenger Assistance Intercom System
PIS	Passenger Information System
PS	Particular Specification
PTT	Press-To-Talk
PWM	Pulse Width Modulation
RAM	Reliability, Availability and Maintainability
R R R R	adio Frequency Interference
S S S S	ystem Assurance Plan
SC	Supplementary Conditions
SDD	System Design Document
SEMP	System Engineering Management Plan
SEMS	System Engineering Management System
SPR	Safety Proving Relay
SRD	System Requirement Document
S S S S	ystem Specification Document
T T T T	raction Brake Controller
TCC	Transit Control Centre
TIN	Train Information Network
TIMS	Train Information Management System
TO	Train Operator
VSS	Video Surveillance Systems
YMSS	Yard Maintenance Support System

WRU Workshop Replaceable Unit

ZVR Zero Velocity Relay

2.3 Abbreviations for Locations

The following abbreviations for running lines and locations shall apply to the PS:

M C-D-E Line

BD I-J Line

SHE N Line

SECTION 3 SCOPE OF THE WORKS 2

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Section 3 Scope Of The Works

3.1 General

3.1.1 The scope of the Works shall comprise, unless specifically excluded, the

design, manufacture, supply, delivery, installation, testing, commissioning and rectification of defects during the Defects Liability Period for the 39 trains, in consists of 6 cars, Cab Simulator (CABSIM), and associated equipment necessary to facilitate operation and maintenance of the trains and CABSIM which include special tools and testing equipment, spare parts, Operation and Maintenance Manuals and training, and all options executed between the Commission and Contractor under the Contract.

3.1.2 It is the Contractor's responsibility to familiarize himself with the AUTHORITY's

operating environment. The Contractor shall satisfy with himself on the condition of all interfacing systems and infrastructures as specified in PS 31 by providing the best interface design that the performance of the Works will not be affected.

3.2 Named Suppliers

The Contractor shall include in the scope of the Works for the supply of the following equipment procured from the Named Suppliers:

(a) Train borne SCS equipment

(b) Train borne radio equipment

(c) Driver's Seat

(d) Collector Shoe

(e) Fire Extinguisher

(f) Maintenance Key

(g) Trip Switch

The details of the Named Suppliers and the equipment are stipulated in Appendix D.

3.3 Engineering Design

3.3.1 The Contractor shall set up a system engineering management system to carry out the conceptual engineering design and detailed engineering design in accordance with the requirements in PS 21.

3.3.2 The design shall ensure the trains meet the requirements of the PS for safe and efficient operation, ease of maintenance and correct functioning and interfaces between the trains and the equipment on the Existing Subway Lines and the equipment provided by other contractors for the new Extension.

3.3.3 The Contractor shall provide a full-scale foamcore mock-up of the cab, driving console and controls (refer to PS 8), and a full-scale engineering

mock-up of the cab (refer to PS 8) and the saloon (refer to PS 7), and a full scale underframe mock up (refer to PS 6) to facilitate the design approval. The mock-ups shall be approved prior to commencement of the manufacture of the first train.

3.3.4 The Contractor shall carry out simulation calculations to verify and validate the specific energy consumption of the trains (refer to Appendix C).

3.3.5 The Contractor shall build and deliver 2 engineering driving cab mock ups with all associated control equipment (refer to PS 19.1.12) and provide the train characteristics, operation and control information (refer to PS 19.1.13) for the construction of the cab simulator.

3.3.6 The Contractor shall provide AUTHORITY the ownership of a complete set of soft copies, in an approved format such as acrobat or MS word, of all national / international codes and standards which have been adopted for the design and build of the trains.

3.4 Testing and Commissioning

3.4.1 The Contractor shall carry out the Works Tests including first article inspections and routine inspections, combined test, EMC and TIMS integration tests, type and routine testings of the cars and equipment, at the Contractor's premises in accordance with the requirements in PS 22 and Clause 2 of Appendix B.

3.4.2 The first train manufactured shall undergo the adjustment tests and the reliability proving test at a Contactor's test track (refer to Clause 2.27 of Appendix B) prior to its delivery to CITY.

3.4.3 The type and routine commissioning testing in CITY shall be carried out in K Carhouse and on the M Line (refer to PS 22.10 and Clause 3 of Appendix B).

3.4.4 The Tests on Completion, Integrated Test and Test Running shall be

undertaken (refer to PS 22.11, PS 22.12 and Clauses 4 and 5 of Appendix B) which shall include the testing with the equipment on the Existing Lines and demonstrate to the satisfaction of the Commission that the trains are suitable for passenger service on the Existing Lines.

3.5 Handing Over of Trains

3.5.1 The Contractor shall hand over the trains to the Commission in accordance

with the Schedule of Delivery in Appendix G upon the completion of the Tests on Completion, Integrated Test and Test Running of the equipment on the Existing Subway Lines to the satisfaction of the Commission.

3.6 Provision OF Subway Profiles Measurement Service

The Contractor shall provide the subway profiles measurement service according to the requirements of Appendix E.

3.7 Provision of IT Support Service

The Contractor shall provide the IT support service (refer to Appendix F) for all IT equipments from the date of issue of the Handing Over Certificate of the first train / CABSIM to the date of issue of the Certificate of Completion of the Works.

3.8 Spare Parts, Special Tools and Testing Equipment

3.8.1 The Contractor shall provide spares for one year of routine maintenance or equivalent to the approved maintenance schedule of the first year for the whole fleet of the trains (refer to PS 24.2.1).

3.8.2 The Contractor shall provide special tools and testing equipment as stipulated in PS 24.3.

3.9 Designated Contractors

The Contractor shall carry out design, interfacing, installation, testing and commissioning activities with other systems interfacing with the trains as detailed in the PS 31 and Appendix I.

3.10 Options

In addition to the basic offer, the following are the options to the scope of the Works:

3.10.1 Option 1 - Additional trains

The scope of this option shall comprise the design, manufacture, supply, delivery, installation, testing, commissioning and rectification of defects during the Defects Liability Period for the following batches of additional trains in accordance with all the requirements as stipulated in this Specification:

a) 8 (eight) additional trains (for E line extension)

b) 21 (twenty one) additional trains (for H6 replacement)

3.10.2 Option 2 - Delivery of trains via U Carhouse

The scope of this option shall comprise the delivery of the trains to K Carhouse via the U Carhouse.

3.10.3 Option 3 - Testing of 18 additional trains at Contractor's test track

The scope of this option shall comprise the testing of 18 trains, in addition to the first manufactured train, at the Contractor's test track prior to the delivery to CITY. The following tests shall be carried out on the 18 additional trains:

a) Adjustment Tests (refer to Clause 2.27.2 of Appendix B)

b) Reliability Proving Test (refer to Clause 2.27.4 of Appendix B)

The accumulative mileage of the train runs (refer to Clause 2.27.4(a)(iii) of Appendix B) and the fault free runs (refer to Clause 2.27.4(c) to (e) of Appendix B) for this option shall be 2 000 km.

3.10.4 Option 4 - Testing of 38 additional trains at Contractor's test track

The scope of this option shall comprise the testing of 38 trains, in addition to the first manufactured train, at the Contractor's test track prior to the delivery to CITY. The following tests shall be carried out on the 38 additional trains:

a) Adjustment Tests (refer to Clause 2.27.2 of Appendix B)

b) Reliability Proving Test (refer to Clause 2.27.4 of Appendix B)

The accumulative mileage of the train runs (refer to Clause 2.27.4(a)(iii) Appendix B) and the fault free runs (refer to Clause 2.27.4(c) to (e) Appendix B) for this option shall be 2 000 km.

3.10.5 Option 5 - Other Spares

The scope of this option shall comprise the supply and delivery of the following spares items:

a) Other Maintenance Spares (refer to PS 24.2.2)

b) Special Spares (refer to PS 24.2.4)

c) Strategic Spares (refer to PS 24.2.5)

3.10.6 Option 6 – Provision of Stationary Battery Charger

The scope of this option shall comprise, unless specifically excluded, the design, manufacture, supply, delivery, installation, testing, commissioning and rectification of defects during the 2 Years Warranty Period for the Stationary Battery Charger and the associated equipment necessary to facilitate operation and maintenance of the battery which include special tools and testing equipment, spare parts and Operation and Maintenance Manuals and training, as specified in Appendix K.

3.10.7 Option 7 - Extended IT Support Service

The scope of this option shall be an extension of the IT support service as specified in PS 3.7 to the following periods:

a) another two (2) years as measured from the date of issue of the Certificate of Completion of the Works

b) another five (5) years as measured from the date of issue of the Certificate of Completion of the Works

c) another ten (10) years as measured from the date of issue of the Certificate of Completion of the Works

3.10.8 Option 8 - Statistic Scale Model Trainset

The scope of this option shall comprise, the design, manufacture, supply and delivery of the statistic scale model trainset. All models shall be thoroughly crafted from an approved material. The scale model train shall be designed and built to exacting standards from the measurements of the real train. Every effort shall be made to assure quality of each part visually close to the real assembly. Special consideration shall be given to provide details of the cab and saloon interiors, vehicle exterior as well as the gangway features. Pricing shall be provided for the following:

a) One trainset which shall be comprised of one cab car and one non-cab car in G Scale i.e. 3/8"=1' with G GAUGE (1:22) train tracks;

b) Up to 15 trainsets of which each trainset shall be comprised of complete six cars train i.e. two cab car and four non-cab cars in HO Scale i.e. 1/8"=1' with HO GAUGE (1:87) train tracks;

c) 15 to 30 trainsets of which each trainset shall be comprised of complete six cars train i.e. two cab car and four non-cab cars in HO Scale i.e. 1/8"=1' with HO GAUGE (1:87) train tracks;

d) 30 to 100 trainsets of which each trainset shall be comprised of complete six cars train i.e. two cab car and four non-cab cars in HO Scale i.e. 1/8"=1' with HO GAUGE (1:87) train tracks.

3.10.9 Option 9 – Provision of Flashing System Map

The scope of this option shall comprise, unless specifically excluded, the design, manufacture, supply, delivery, installation, testing, commissioning and rectification of defects during the Defect Liability Period for the Flashing System Map (FSM) and the associated equipment necessary to facilitate

operation and maintenance of the FSM which include special tools and testing equipment, spare parts and Operation and Maintenance Manuals and training. The FSM shall be complied with the requirements as specified in PS 7.9.1(f), 10.2.8(a)(iii) and 10.2.8(c)(iv). Pricing shall be provided for the following:

a) Four FSM which shall be located at the alternate doorway of the passenger bodyside door of each Subway Car

b) Eight FSM which shall be located at all doorway of the passenger bodyside door of each Subway Car

3.10.10 Option 10 – Provision of Additional Saloon Camera

The scope of this option shall comprise, unless specifically excluded, the design, manufacture, supply, delivery, installation, testing, commissioning and rectification of defects during the Defect Liability Period for the additional Saloon Cameras and the associated equipment necessary to facilitate operation and maintenance of the saloon Camera which include special tools and testing equipment, spare parts and Operation and Maintenance Manuals and training. The additional saloon camera shall be complied with the requirements as specified in PS 7.12.1 and 10.2.7(c)(ii)(2).

3.10.11 Option 11 – Provision of White LED Backlight for the Advertisement Cards

The scope of this option shall comprise, unless specifically excluded, the design, manufacture, supply, delivery, installation, testing, commissioning and rectification of defects during the Defect Liability Period for the white LED backlight and the associated equipment necessary to facilitate operation and maintenance of the white LED backlight which include special tools and testing equipment, spare parts and Operation and Maintenance Manuals and training. The white LED backlight shall be complied with the requirements as specified in PS 7.9.1(b) and 7.9.3(d).

SECTION 4 SYSTEM DESCRIPTION AND PERFORMANCE REQUIREMENTS 2

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Section 4 System Description And Performance Requirements

4.1. Introduction

4.1.1. This Section defines the principal business, customer service, operational and particular performance requirements of the train.

4.1.2. The train shall provide commuter and leisure journeys for the widest possible range of demographic types of the CITY population including the disabled in line with the AUTHORITY's Policy.

4.1.3. The train shall be interchangeable train to train with the existing T1 Trains.

4.1.4. The train must be capable of being operated to provide the specified passenger service in conjunction with the presence of the T1 Trains in accordance with the existing Time Tables.

4.2. Business Requirements

4.2.1. The exterior livery and interior of the train shall deliver an image of high quality and promote the status of the AUTHORITY as the premium transport service in CITY. Whilst the overall design requirements are defined herein the Contractor shall meet the design requirements to achieve the visual design as specified in PS 6 and 7.

4.2.2. The train shall produce a modern, comfortable, cheerful interior conveying an impression of speed, efficiency, and safety while maintaining a strong AUTHORITY’s image of care for passengers.

4.2.3. The train shall be designed and constructed for operational safety both under normal operating and maintenance conditions and in the event of equipment failure.

4.2.4. The features of the trains including the train consist arrangement shall be optimised to maximise the performance and minimise the energy consumption cost, train operation and maintenance cost.

4.3. Customer Service Requirements

4.3.1. Speed

A commercial speed of not less than 33 km/h (20.6 MPH) shall be achieved in a condition of a minimum of 5% coasting including 15 seconds of station dwell time and fully laden load (refer to PS 4.5.3) on all Existing Subway Lines and new extension.

4.3.2. Saloon Environment

(a) The train environment shall be comfortable with air-conditioning and adequate ventilation (refer to PS 15).

(b) An adequate lighting level shall be provided (refer to PS 7).

(c) The train interior space shall be optimised and the free floor area in the saloon shall be maximised.

(d) The capacity requirements are specified in PS 7.4.

(e) A wide gangway shall be provided to connect the saloons of adjacent cars, providing a maximum clear view through the train and capacity for standing passengers and for effective evacuation during an emergency. Detailed requirements are specified in PS 14.

4.3.3. Train Reliability

(a) The train shall achieve the reliability requirement as specified in PS 25.7.

(b) The train shall achieve the availability requirement as specified in PS 25.8.

4.3.4. Passenger Information

Signage shall be easily understood by passengers with effective and coordinated use of graphic and text. All signs shall be in English. Detailed requirements are specified in PS 7.15.

4.3.5. A public address system shall be provided using high quality recording and digitisation in English for routine announcements. Detailed requirements are specified in PS 18.

4.3.6. Passenger assistance alarm facilities with clear instructions shall be provided in the compartments for passengers to gain the attention of the train operator and establish a two-way voice communication in emergency situations. Detailed requirements are specified in PS 18.

4.3.7. On-board passenger information displays shall be provided. Detailed requirements are specified in PS 10.

4.3.8. Disabled Passengers

Appropriate provisions shall be provided for the use of disabled passenger. Detailed requirements are specified in PS 7.

4.3.9. Commercial Supports

(a) Simple advertising panels shall be installed inside trains.

(b) Electronic information displays (including both LED and LCD types) for advertising with "animated graphics" and “movie clips”, shall be provided.

Detailed requirements are specified in PS 7.

4.4. Operational Requirements

4.4.1. Compatibility

(a) The new trains shall be compatible with the interfacing systems of Signaling, Communication equipment, Third Rail Power Supply and Trackwork for the Railway. Detailed Interface requirements for the above systems are specified in Appendix I.

(b) The trains shall comply with the following technical constraints of the Railway:

(i) Nominal gauge of running track 1495 mm (4' 10 7/8") as measured at right angles to the alignment of the track, 16mm (5/8”) below the top of the rail.

(ii) On M Line, running rail type is of 115 lbs/yard American Railway Engineering Association (A.R.E.A.) standard carbon steel. On BD Line, BD

Line, running rail type is of 100 lbs/yard American Railway Association (A.R.A.) type standard carbon steel.

(iii) Minimum horizontal track curvature of radius 116 m (380') in running tracks and 70.1 m (230') in yards. Minimum vertical track curvature of radius 610 m (2000').

(i v) Maximum gradient 3.5 %

(v) Maximum static axle load shall not exceed 14 tonnes.

(v i) Kinematic Envelope shall be as defined in PS 5.

(vii) Nominal power supply system voltage 600 VDC. from third rail traction power supply equipment.

(viii) Main vehicle dimensions such as the train door pitch, shall be as defined on Contract Drawing No. NST 072.

4.4.2. Performance

The traction and braking control shall optimise the available adhesion in achieving the following target values:

(a) Max speed for design purpose: 88 km/h (55 MPH)

(b) Max speed in service: 80 km/h (50 MPH)

(c) Max Acceleration rate: 1.1 m/s

(d) Max jerk rate: 0.8 m/s

(e) Nominal service brake rate: 0.8 m/s

(f) Max service brake rate: 1.35 m/s

(g) Emergency brake rate: 1.4 m/s

(h) Level of coasting: 5 % at a commercial speed of 33 km/h and fully laden load
Level of coasting: 5 % at a commercial speed of 33 km/h and W4 load"

4.4.3. Acceleration Performance

(a) The traction equipment shall provide standard rates of acceleration of the T1 train, and described below, with a third rail voltage of 580 VDC and new wheels (711 mm, 28”):

Time (seconds)	KPH	MPH	Time (seconds)	KPH	MPH
0	0.0	0.0	24	50.4	31.3
2	5.3	3.3	28	52.8	32.8
4	12.2	7.6	32	54.4	33.8
6	18.6	11.6	36	56.0	34.8
8	24.9	15.5	40	57.3	35.6
10	31.1	19.3	44	58.9	36.6
12	36.6	22.7	48	59.3	36.8

14	40.6	25.2	52	61.3	38.1
16	43.0	26.7	56	62.4	38.8
18	45.6	28.3	60	63.4	39.4
20	47.2	29.3	64	64.5	40.1

Standard Rate Performance

(b) The traction equipment shall have the design capability to provide high rate of acceleration of the T1 train, and described below, with a third rail voltage of 580 VDC and new wheels (711 mm, 28”):

Time (seconds)	KPH	MPH	Time (seconds)	KPH	MPH
0	0.0	0.0	24	63.4	39.4
2	6.1	3.8	28	66.9	41.6
4	14.3	8.9	32	69.8	43.4
6	22.4	13.9	36	72.6	45.1
8	30.3	18.8	40	75.0	46.6
10	37.8	23.5	44	77.0	47.8
12	43.7	27.2	48	78.7	48.9
14	48.3	30.0	52	80.3	49.9
16	52.1	32.4	56	81.9	50.9
18	55.5	34.5	60	83.4	51.8
20	58.8	36.5			

High Rate Performance

(c) Full acceleration performances shall be achieved from 720 volts down to 580 volts DC (Same as T1 train).

(d) Below 580 volts the base speed shall be reduced by the voltage ratio to limit the line current.

4.4.4. ~~Recovery Operation - Emergency Push Out~~

(a) ~~Automatic mechanical c~~ouplings shall be provided at train ends to facilitate the emergency push out operation (refer to PS 9.11.1).

(b) In emergency push-out operation, the train shall be able to assist a T1 Train and vice versa.

(c) On a level track, a fully laden train shall be capable of starting and accelerating a defective train which is:
On a level track, a W4 train shall be capable of starting and accelerating a defective train which is:

(i) either a train or a T1 Train; and

(i i) fully laden.

This would then be followed by a 3.5 % gradient for 1.5 km (0.93 miles) and on level track for 2 km (1.24 miles) where the passengers would be detrained. The complete consist shall then be capable of returning from any point on the system to the nearest yard.

4.4.5. Emergency Evacuation

Emergency evacuation shall be possible by the following routes:

(a) through the train front and / or rear to track level;

(b) via saloon side-doors with the assistance of the train operator to a track side

walk-way.

4.4.6. Loss of Power Supply

(a) Emergency systems (refer to PS 17) shall continue to function for 1 hour after a power failure due to loss of the traction or auxiliary power supplies.

(b) Hopper windows (refer to PS 7) shall be provided for additional ventilation in the event of a power failure.

4.4.7. The train operating principles shall be consistent with those of the T1 Trains in order that human errors due to inadvertent use of train operating procedures applicable to only the T1 Trains will be precluded, and in order that the training for experienced train operators of the T1 Trains will be minimised. Control or operating logic conflicting with the existing practices shall be avoided. Copies of the AUTHORITY's train operation procedure are available for the Contractor's reference. Detailed requirements are specified in PS 9.

4.4.8. The saloon layout shall be optimised to facilitate boarding and alighting and to minimise the dwell time at stations.

4.4.9. The cab design shall incorporate ergonomic and human factors to optimise design, comfort, operability and defect and recovery handling. Standardising of equipment and configurations shall be considered to minimise differences with the T1 Trains. Detailed requirements are specified in PS 8.

4.4.10. Facilities shall be provided to assist the train operator to undertake his duty at station stops to minimise station dwell time.

4.4.11. The control equipment and its operation shall be safe, reliable and user-friendly. Equipment status monitoring and fault diagnosis facilities shall be provided and designed to give recovery advice to the train operator so as to minimise the recovery time.

4.4.12. Other Emergency Requirements

(a) A train with traction equipment inoperative on two motored trucks shall be able to continue passenger service for one complete round trip at W4 load.

(b) A W4 laden train shall be able to work one round trip at a maximum speed of 25 km/h (15 MPH).

(c) With two inoperative motored trucks, it must be possible to motor at W4 laden load from any point on the running line to the next station, or refuge, detrain all passengers, and then proceed either to refuge or yard. The above would be performed at a maximum speed of 25 km/h (15 MPH).

(d) Emergency jacking points shall be provided to lift the car body together with the trucks (refer to PS 6).

(e) Due to the geographical reasons, there may be flooding problems posed to the Railway and there are mainly two types of flooding including water and mud flooding. If the level of the water/mud does reach above the rail foot but below the rail top, it is a requirement that the train shall be able to operate to a maximum speed of 25 km/h (15 MPH) in order to maintain a minimum degree of train service under a flooding condition.

4.5. Particular Requirements

4.5.1. Train Consist (refer to Contract Drawing No. NST 072).

(a) The train shall consist of 6 cars which comprises of 10 power trucks and 2 trailer trucks.

(b) The configuration of train units shall be optimised (refer to PS 4.2.4) in order to meet the overall performance requirements and the emergency duties (refer to PS 4.4.3).

(c) In order to avoid the speed / distance measurement errors associated with slip/slide on motored axles which would adversely affect the performance of the future Automatic Train Control (ATC) system, the leading truck of the cab car shall be trailer truck.

4.5.2. Ride Quality

The train shall provide a high quality of ride comfort which is smooth and free from jerks (refer to PS 12).

4.5.3. Load Cases

The following load cases referred to as W1 to W5 shall be used for design purposes:

W1	Train in tare condition
W2	Train in light load condition with 66 passengers per car
W3	Train in average laden condition with 143 passengers per car
W4	Train in service laden condition with 250 passengers per car
W5	Train in crush laden condition with 319 passengers per car

The load cases shall be based on a passenger weight of 70 kg (155 lbs).

4.5.4. Life

The train shall be designed to meet the requirements of the PS for a minimum operational life of 35 years.

4.5.5. Security

The train shall be designed to meet the following security requirements:

(a) Limit the ability to place or hide explosives on or under vehicle;

(b) Improve the ability to see into and out of vehicle;

(c) Reduce the damage that would result from an explosion;

(d) Reduce the damage that would result from a fire;

(e) Reduce the damage that would result from contaminants;

(f) Enhance emergency egress through doors;

(g) Protect the train operator from physical threat;

(h) Network the vehicle with the TCC;

(i) Enable communications between the train operator and passengers; and

(j) Secure the vehicle from theft/unauthorized operations.

Guidelines according to the “Transit Security Design Considerations” issued by the U.S. Department of Transportation (document ref: FTA-TRI-MA-26 7085-05, issue date: November 2004) shall be followed where applicable.

SECTION 5 INFRASTRUCTURE CONSTRAINTS 2

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Section 5 Infrastructure Constraints

5.1 Kinematic Envelope

The Contractor shall submit for approval, by using well accepted computer modelling techniques, such as VAMPIRE®, to provide a calculated Kinematic Envelope (also known as the Maximum Moving Dimension) of the vehicle in order to demonstrate the vehicle compatibility with the infrastructure and ensure that the maximum dynamic displacement of a vehicle outline from track centre-line and from rail level shall not exceed the gauge lines as detailed on the Contract Drawings No. NST 003 to 005 under the conditions specified in PS 5.2. Unless otherwise specified, a minimum clearance of 100mm (3.94”) shall be provided between the kinematic envelope and the undercar equipment gauge line (refer to Contract Drawing No. NST 004).

5.2 Conditions

5.2.1. Kinematic Envelope

The following conditions shall apply under any combinations:

(a) Speeds up to and including 88 km/h (55 MPH).

(b) All conditions of wheel wear and suspension creep.

(c) 0.1g lateral acceleration applied to the body centre of gravity to account for the combined effects of cant deficiency curving (up to 65 mm) and vehicle lateral accelerations due to track irregularities.

(d) Installed cant of up to 100 mm (nominal).

(e) Air suspension normally inflated, deflated or over inflated.

(f) All conditions of car loading.

(g) Maximum car build tolerance.

(h) Forces due to a side wind of the parameters quoted in PS 5.4.

(i) Suspension parameters at the most disadvantageous limits of tolerance and maintenance limit.

(j) Track parameters and tolerances are defined as follows (refer also to Appendix I Annex 1):

Track Gauge (Tangent Track)	1.495
Minimum Track Space (Centre to Centre)	4.270
Minimum Tangent Lengths	
Curved Section	150
Special Track Work	46
Beyond Platform End	30
To a Crossover from a Station Platform	20
Super-elevation	
Total Super-elevation	V2/85R
Maximum Actual Super-elevation	0.100
Maximum Unbalanced Super-elevation	0.065
Maximum Rate of Change of Super-elevation	0.03175
Circular Curves	
Minimum Radius (Main Line)	600
Absolute Minimum Radius (Main Line)	300
Minimum Radius (Yard)	76
Minimum length of Circular Curves	23
Minimum Spiral Length	8.7486EV ≥ 19
Gradients	
Maximum (Main Line)	3.5%
Minimum (Main Line)	0.3%
Station	0.3%
Storage and Lay-Over Tracks	0.3%
Yard Tracks	Level
Minimum Length of Constant Vertical Profile	150

Note: Units are in Meters

5.2.2. Kinematic Envelope in Stations

The car shall not exceed the Kinematic Envelope under the conditions specified in PS 5.2.1 except as modified as follows:

(a) Zero cant deficiency

(b) Zero installed cant

(c) Zero wind loading

(d) Stationary, with the body side doors opening, with the body side doors open and passengers entering or leaving the train.

(e) Moving at a maximum speed of 65 km/h (40 mph) with doors closed and with dynamic movements caused by the specified track irregularities.

(f) Track parameters and tolerances for track within stations are defined in AUTHORITY's document titled, "Engineering Design Standards" which is available for Contractor's use upon request.

5.3. Verification

5.3.1. The method for calculating the Kinematic Envelope shall be submitted for approval.

5.3.2. The Kinematic Envelope calculations for all appropriate conditions listed in PS 5.2, including those for local reduction in Kinematic Envelope through stations, shall be submitted for approval.

5.3.3. The Contractor shall carry out vehicle sway test as specified in PS 22 and Appendix B to verify the method specified in PS 5.3.1.

5.4. Wind Loading

5.4.1. For abnormal conditions such as severe thunderstorm, hurricane or tornado warnings being issued, the speed of side wind shall be taken as 130 km/h in surface section.

5.4.2. Lee side suction shall be allowed for as an additional factor of 20%.

5.5. Axle Load

5.5.1. The maximum permitted axle load of 14 tonnes shall not be exceeded.

5.6. Train Weights

5.6.1. The maximum permitted tare train weight shall not exceed 205 tonnes for the 6 car train consist as specified in PS 4.5.3.

5.6.2. The load cases due to passenger capacity shall refer to PS 4.5.3.

5.6.3. The Contractor shall submit a procedure for controlling the car weight to meet the weight management requirements as specified in PS 21.6.

5.6.4. The Contractor shall carry out weighing tests in accordance with PS 22 and Appendix B.

SECTION 6 - CAR BODY STRUCTURE AND EXTERIOR 2

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Section 6 - Car Body Structure And Exterior

6.1 General

6.1.1. This Section shall be read in conjunction with the referenced Drawings. The dimensions shown on these Drawings are mandatory.

6.1.2. Any proposed change from the specified dimensions shall be submitted for approval.

6.1.3. The Contractor shall propose a car body profile which meets the specified requirements for kinematic envelope, ride quality, structural strength, styling considerations and maintainability.

6.1.4. The Contractor shall construct a full scale underframe mock-up to demonstrate that adequate consideration has been given to the layout of the major equipment, piping, cable ducting and conduits in respect of weight distribution (refer to PS 21.6) and maintenance access (refer to PS 26) during design and manufacturing phases in accordance with SEMS (refer to PS 21).

6.1.5. By SEMP 2, a cab front model, in the scale of 1:20 to the extent of the first passenger door including the first truck, shall be produced by the Contractor to indicate the design aspiration of the exterior styling.

6.2 Styling Considerations

6.2.1. The objectives to be incorporated into the design of the exterior of the train are:

(a) to give the impression of a reliable, efficient and modern train;

(b) to be aesthetically pleasing;

(c) to maintain the family styling with the T1 Trains;

(d) to create a strong corporate image of AUTHORITY.

6.3 Car Body Structure

6.3.1. The car body shall be designed and constructed from stainless steel for a life as defined in PS 4.5.4 under the loading conditions defined in PS 4.5.3 and the requirements of PS 6.

6.3.2. The Contractor shall demonstrate, by a programme of finite element analysis and/or testing (refer to Appendix B), that the requirements of PS 6.4 shall be achieved.

6.3.3. Results of finite element calculations shall be submitted for approval before the commencement of manufacture.

6.3.4. Exterior Finish

(a) The exterior of the cars shall be unpainted and shall have a durable finish designed to minimize the visual effects of deterioration due to ageing.

(b) No corrugation plate on the side structure is allowed and beardless flat plate on side structure shall be provided for anti-strain and aesthetic purposes.

(c) All exterior flat surfaces shall be free of ripples and buckling. Dents, gashes, deep spot weld dimples or other surface imperfections shall not be permitted.

(d) Maximum acceptable variation from a straight line for carbody exterior side shall not exceed 3.2 mm (1/8“) peak-to-valley in 914 mm (36“) over the area. Areas within 203 mm (8”) of the side doors may have a gradual slope towards the door mask with a maximum deviation of 4.76 mm (3/16“) from the side sheet contour.

(e) The Contractor shall provide details of all maintenance operations necessary to maintain the exterior finish of the cars in a serviceable condition, such as the removal of stains and repair of minor damage and scratching.

6.4 Strength Requirement

6.4.1. Proof Loads

The body structure shall withstand the following loading conditions without permanent deformation or any form of damage or deterioration:

(a) A longitudinal compressive force of 1000 kN (220,000 lbs) distributed over the coupler mounting faces combined with the most adverse vertical passenger loading condition.

(b) A longitudinal tensile force of 512 kN (115,000 lbs) distributed over the coupler mounting faces combined with the most adverse vertical passenger loading condition.

(c) A longitudinal compressive force of 600 kN (134,885 lbs) at 762mm (30”) height in all car types reacted at end sill at the other end of the car. This load shall be distributed on the corner posts for the non-cab ends of cars and on the collision and corner posts for the cab end of cab car, in combination with the most adverse passenger loading distribution. The side wall structure can be considered as supporting structure reacting the applied loads to the collision and corner posts. Very localized yielding or plastic deformation that does not

compromise the integrity of the carbody structure is considered acceptable.

(d) A longitudinal compressive force of 300 kN at cant rail height, distributed on the anti-telescoping (A/T) plate above the windscreen of the cab reacted at end sill at the other end of the car, combined with the most adverse passenger loading condition. The side wall structure can be considered as supporting structure reacting the applied loads to the collision and corner posts. Very localized yielding or plastic deformation that does not compromise the integrity of the carbody structure is considered acceptable.

(e) A vertical load of 1.5 times the crush laden (W5) car condition with the car body supported at the secondary suspension positions and with loads distributed to represent actual loading conditions.

(f) A vertical load of 1.1 times the tare (W1) car condition with the car supported at the lifting points.

(g) A twist load corresponding to a car having one truck derailed with the other remaining on level tangent track. The derailed truck will generate a twist load in the following condition. One wheel with flange contact point centered over running rail with a truck / carbody rotation of 12° (3° above over-rotation sensor) relative to this contact point. Both wheels on other axle are no longer in contact with the running rails. The other wheel of the same axle remains in line with the running rail. The wheel opposite to the wheel resting on the flange remains in line with the running rail with a vertical gap of 1.310". The Contractor shall identify all localized yielding or plastic deformation areas that may be subjected under the above twist loading condition by means of finite element analysis and testing (refer to PS 6.3.2). Very localized yielding or plastic deformation that does not compromise the integrity of the carbody structure is considered acceptable.

(h) A longitudinal force equivalent to 5g times the mass of the heaviest truck, applied to the body centre pivot at the traction centre position. This load shall be applied with the most adverse passenger loading condition.

(i) A vertical load equivalent to 2g times the mass of the heaviest truck suspended from its normal body to truck connection points, with the car body being lifted from the car end jacking points (refer to PS 6.6.3) on the adjacent headstock. The other end of the car shall be supported at the secondary

suspension position.

6.4.2. Fatigue Loads

(a) Assessment of fatigue shall be in accordance with Eurocode 3 Part 1-1 Chapter 9 for steel cars, and in accordance with BS 8118: 1991 for aluminium components. Allowable stresses shall be to the mean minus 2 standard deviation level.

(b) The car structure shall withstand the following loads such that the sum of the individual partial damages for all load cases does not exceed unity. The damages shall be summated using Miner's Rule as defined in the standards referenced in PS 6.4.2 (a).

(i) Vertical loading of 10^7 cycles of the stresses caused by the car in the fully laden (W4) condition cycling at ± 0.2g;

(ii) 10^7 cycles of the stress range caused by a car in the fully laden (W4) condition subjected to a lateral acceleration of ± 0.1g;

(iii) 10^7 cycles of the stress range caused by passenger loading/unloading from the tare (W1) condition to the fully laden (W4) condition;

(iv) 10^7 cycles of the stress range caused by a car in the fully laden (W4) condition accelerating under maximum traction conditions followed by braking at maximum service braking rate.

6.4.3. Collision and Energy Absorption

(a) The car structure shall be designed such that, in the event of a collision of a force greater than that which can be absorbed by the couplers and anti-climbers, energy shall be absorbed by plastic deformation in the action of the car between headstocks and bolster before plastic deformation occurs elsewhere in the structure.

(b) The arrangement of energy absorption devices within the couplers and anti-climbers shall maximize the energy absorption capacity of the cars. As a minimum, the arrangement shall withstand the following two train collision scenarios without causing damage to the car structure other than localized yielding:

(i) A 6-car train in a tare (W1) condition to impact a 6-car T1 train loaded at the same condition with parking brakes applied at speeds up to 6.4 km/h (4.0 mph);

(i i) A 6-car train in the tare (W1) condition to impact with a similar train with

parking brakes applied at speeds of up to 10.0 km/h (6.2 mph).

(iii) A 6-car train in the tare (W1) condition impacts with the AUTHORITY Subway

existing buffer stop at speeds of up to 5.0 km/h (3.1 mph).

(c) The cab shall prevent penetration of the following objects:

(i) For panels, framework, detrainment door, but excluding glazing (refer to PS 6.11), a common railway ballast of 50mm size, traveling at twice the maximum operating speed of the train.

(ii) For the cab windscreen (refer to PS 6.11.2), ballistic and large object impacts per FRA Type 1 level certification.

(d) An anti-climbing device shall be provided at the ends of all cars which shall prevent overriding of the vehicle ends in the event of a collision. Due consideration shall be given to the design of the anti-climbing device of the cab car in order to ensure compatibility with the anti-climbing device of the T1 train, of which the dynamic buffing strength is 892 kN (200,000 lbs) as a minimum, and 1,115 kN (250,000 lbs) as a maximum. Typical arrangement of anti-climber of the T1 train shall refer to Contract Drawing No. NST 012. The anti-climbers of the existing T1 trains are located in line with the sill at each end of the vehicle. They are designed to integrate with each other's fins and transfer force through the frame of the vehicle. The T1 vehicles are also equipped with collision posts which are located at the ends of the vehicles, within the body and attached to the frame, with a designed ultimate shear strength of 892 kN (200,000 lbs). These posts add rigidity to the structure and assist in protecting the passenger compartment in the event of a collision.

6.4.4. Body Mounted Equipment

The equipment and mountings shall withstand the loads resulting from the following accelerations:-
7

(a) Proof Loads

Vertical	± 2.0g
Transverse	± 1.0g
Longitudinal	± 5.0g

(b) Fatigue Loads

10 cycles of:-

Vertical	± 0.15g
Transverse	± 0.15g
Longitudinal	± 0.20g

6.4.5. Blast Resistance

The car structure shall be analyzed to demonstrate the general structural behavior caused by the explosion of a bomb where the blast loading is applied at the floor level at the center of a car.

6.5 Repair and Maintenance

The headstocks, drag box and bolsters shall preferably be attached by a method which shall facilitate replacement of complete assemblies if damaged in service.

6.6 Jacking Lifting and Towing

6.6.1. There shall be provision for jacking, lifting and towing points on the cars and trucks to conform with the train maintenance philosophy given in PS 26.

6.6.2. The Contractor shall propose the type and positions of lifting and jacking points to meet the requirements of Appendix I Annex 1 and Appendix I Annex 5. The final arrangement shall be submitted for approval.

6.6.3. Jacking points shall also be provided at ends of the cars for re-railing the car in the event of derailment. The Contractor shall consider the layout of the track and infrastructure as detailed in Appendix I Annex 1 to ensure that the jacking points are suitably positioned.

6.6.4. Towing points shall be provided at all 4 corners of each car to meet the requirements of Appendix I Annex 5 Clause 3.6.1.

6.6.5. Jacking and lifting points shall be clearly marked for ease of identification from the trackside. The detailed interface and method of identification shall be submitted for approval.

6.7 Car Body Insulation

6.7.1. The car body shall be insulated to minimise noise and heat transmission through the structure and reduce air conditioning energy requirements.

6.7.2. ~~Any insulation shall be protected against degradation, shall~~ not allow migration of particles into the car interior and shall be retained even when access panels are opened.

6.8 Aerodynamic Considerations

6.8.1. The Contractor shall consider the following in the design of the train:-

(a) Tunnel portals.

(b) Ambient conditions, in particular the wind speeds.

(c) Protrusions and recesses which disturb airflow or form dirt traps which are difficult to clean shall be avoided.

6.8.2. Exterior light assemblies shall be flush-mounted. Exterior light assemblies shall be flushmounted or surface mounted.

6.8.3. All external cab controls shall be flush-mounted.

6.8.4. Wipers shall not be "parked" perpendicular to high velocity airflow.

6.8.5. Glazing and any associated framing shall be flush or surface fitted in accordance with PS 6.11.

6.8.6. An external rain gutter which shall be continued in the full length of a car, shall be provided to prevent rain from dripping onto passengers at the door positions. Drainage shall be provided to avoid water accumulation. The Contractor may make use of the car gutter to avoid drainage running down the doorway. Another external rain gutter which shall be an integral part with the side plate extrusion, shall be provided above the operator's and guard's sliding windows.

6.9 External Features and Fittings

6.9.1. Wipers

(a) Wipers shall be fitted to clean the windscreens in front of the Train Operator Console and the Auxiliary Console.

(b) Wipers shall sweep the largest possible arc to maximise the cleansed area to meet all the external vision requirements of the train operator, including the viewing of signal sight lines, from both the seated and standing positions. The same swept area shall be provided on the Auxiliary windscreen.

(c) The wipers shall resist the local air speeds at the edges of the windscreen. The force with which the wiper is held against the windscreen shall be limited to avoid the danger of scratching the surface of the glass. Wipers shall not lift off the wiper area at maximum train speed.

6.9.2. Windscreen Washers

(a) A windscreen washer system shall be fitted to wash the windscreens in front

of the Train Operator Console and the Auxiliary Console.

(b) The washer reservoir shall have a minimum capacity of 7 litres.

(c) The washer reservoir shall be refillable from the exterior of the car.

6.9.3. Horn

(a) A horn shall be fitted at each cab end position.

(b) The horn shall meet the requirements of PS 13.14.

(c) The mounting arrangement for the horn shall protect it from damage by flying objects such as ballast, and shall not allow accumulation of leaves, rubbish, water or debris which could affect the performance.

(d) The mounting arrangement shall ensure the uninterrupted operation of the horn even under adverse weather conditions.

6.9.4. Electronic Run Number Display and Electronic Destination Display

(a) A run number display (refer to PS 10.2.8) shall be provided in the upper part of the windscreen on the Auxiliary side of the cab as shown on Contract Drawing. No. NST 072 and shall be clearly visible as the train enters a platform.

(b) A destination display (refer to PS 10.2.8) shall be provided in the centre upper part of the detrainment door of the cab as shown on Contract Drawing. No. NST 072 and shall be clearly visible as the train enters a platform.

6.9.5. Detrainment Door

The requirements for the detrainment door (as part of the Emergency Detrainment Device) are detailed in PS 8.16. The door shall meet the performance requirements with minimum effect on the car's front end design.

6.9.6. ~~Roof~~

~~The train roof shall be smooth with all fittings flush mounted into the roof profile. Any resulting recesses shall be adequately drained.~~

6.9.7. ~~Passenger Bodyside Doors~~

(a) ~~Passenger bodyside doors (refer to PS 16.2) shall be~~ positioned as shown on Contract Drawing. No. NST 072.

(b) A switch which shall only be operated by the AUTHORITY's staff key, shall be provided outside the Subway Car as shown on the Contract Drawing No. NST 065 to allow power operation of either pair of cab end side doors. The key operated switch shall be suitably weatherproofed to prevent the entry of water (including car washing) or other foreign material. The switch assemblies shall be easily removable for maintenance. A switch which shall only be operated by the AUTHORITY's Square SRT Key, shall be provided outside the Subway Car as shown on the Contract Drawing No. NST 065 to allow power operation of either pair of cab end side doors. The key operated switch shall be suitably weatherproofed to prevent the entry of water (including car washing) or other foreign material. The switch assemblies shall be easily removable for maintenance.

(c) The external door pillar shall interface with the carbody side panel giving a contour edge to the carbody side panel. Consideration shall be given to the door pillar interface design such that snow built-up can be restrained in the winter.

(d) Drainage shall be provided at the bottom of the door threshold outside the treadplate (refer to PS 7.8.5). Consideration shall be given to the drainage design in such a way that any small foreign object (e.g. coin or small battery which would be dropped by the passenger on the doorway) will be captured and drained within the above drainage area without obstructing the door operation.

6.9.8. Fairing

(a) An aerodynamic fairing shall be installed around the coupler opening.

(b) The cab fairing shall not interfere with the operation of the coupler and shall not affect the performance of the detrainment ramp or other equipment.

(c) Detrainment door arms shall be positioned such that impact on the appearance of the fairing is minimized. Any slotting shall have the minimum height and width possible. There shall be no detriment to the smooth appearance of the transition from body to fairing.

6.10 Exterior Lighting

6.10.1. General

(a) Exterior lights shall be mounted as defined in Contract Drawing. No. NST 006. Lighting controls shall refer to PS 9.9.

(b) The design shall enable the replacement of lighting units or bulbs to be completed within 15 minutes from the exterior of the train.

(c) Lighting units shall be sealed to IEC 60529 IP65.

(d) Moisture, condensation and dirt shall not collect behind any glazing covers, either in operation or following maintenance.

(e) All exterior lights, except the headlight, shall be maintenance free LED type with minimum operating life of 50,000hrs.

6.10.2. Headlights

(a) The headlight shall be housed within a formed recessed panel.

(b) The headlight shall be a LED type, an incandenscent type or halogen type with double filament provided it meets all other specification requirements.

(c) If it is necessary to step down the supply DC voltage for the halogen lights, an electronic transformer having an efficiency of greater than 80% shall be used.

(d) The headlights shall be angled to avoid dazzling the train operators of oncoming trains. An easy mean and access by maintainer to adjust the aim of the headlights shall be provided.

(e) The headlights shall be visible in daylight, under normal weather conditions, at a distance of 300 m (984') in front of the train.

6.10.3. Exterior Marker Lights

(a) Four exterior marker lights shall be provided at the cab end as shown on the Contract Drawing No. NST 006.

(b) The marker lights shall be visible in daylight, under normal weather conditions, at a distance of 100 m (328'), over a total arc of 160 degrees measured from the centre line of the train.

(c) The marker lights shall be arranged horizontally in groups of two lights in the upper part of the windscreen on each side of the cab. The outer light shall be red and the inner light shall be white in colour.

(d) The marker lights shall be automatically switched on, as detailed in PS 9.9.11 and 9.9.12.

6.10.4. Bodyside Indicator Lights

(a) Bodyside Indicator Lights shall be provided similar to the Contract Drawing No. NST 006.

(b) All the lights on one side shall be visible down the length of the train, on straight track, when viewed from either of the cab side doors on that side of the train.

(c) The bodyside Indicator Lights shall be equipped with 3 different colours of LED lamp which shall be arranged vertically with the following functions:

Vertical Position	**Colour**	**Function**
Top	Red	Doors Open Indicator (Refer to PS 16.2.11.(a)).
Middle	White	Guard's Position Indicator (Refer to PS 16.2.11.(b)).
Bottom	Amber	Any Passenger Assistance Alarm has been operated (Refer to PS 16.2.11.(c))

(d) The protective lenses of the bodyside Indicator Lights shall be neatly flush with the fixture body to ensure they are cleaned when passing through the subway car washing machine.

(e) At each multipurpose area, a Blue LED indicator light, which is ON all the time, shall be mounted adjacent to the door closest to the multipurpose area such that it is visible from the platform.

6.11 Exterior Glazing

6.11.1. General

(a) All exterior glazing shall be made from laminated glass to FRA type I or II and ANSI Z26.1. Alternative design with proven service record shall be submitted for approval.

(b) Cab windscreens and the bodyside windows (including those in the cab and passenger doors) shall not cause visual distortion or reflection under any ambient lighting conditions.
Cab windscreens and the bodyside windows (including those in the cab and passenger doors) shall not cause undue visual distortion or reflection under any ambient lighting conditions that affects train performance..

(c) There shall be no visible defects exceeding the quality requirements as specified by the Contractor and approved by the Engineer, within the viewing ~~area of the glazing.~~

(d) ~~The train operator's external vision shall not be affected by any interior~~ lighting conditions (refer to PS 8.5).

(e) All glass, except the cab windscreens, shall be tinted. The color may be achieved by using a tinted interlayer or by tinting the body of the glass. The color of tint shall be proposed by the Contractor and approved by the Engineer. All external glazing, except the cab windscreens, shall be tinted. The color may be achieved by using a tinted interlayer or by tinting the body of the glass. The color of tint shall be proposed by the Contractor and approved by the Engineer. The tint color and level shall be harmonious throughout the train.

(f) The tint shall not affect the train operator's perception of signals, signal colors, platform mirrors, or any other information displays.

(g) The tint shall not fade throughout the service life of the car.

(h) Where possible, all windows shall be bonded directly into the body structure.

(i) Where possible, all windows shall be flush with the car profile in order to

provide minimum aerodynamic resistance.

(j) The window design shall allow for ease of removal and replacement of glass from outside the train. If bonding is used, after bonding, the train shall be suitable for return to service within 8 hours.

(k) The bonding system shall not degrade over the service life of the car.

(l) The bonding system shall maintain the integrity of the glazing in the event of a trainborne fire or an external fire in a tunnel to permit passenger evacuation of the train.

(m) All windows shall be sealed and water tight for the life of the train and shall meet the testing requirements of Appendix B.

(n) Edges of all cab and bodyside glazing shall be screen printed black to conceal any structure or trim detail and to protect the bond from UV light.

(o) Cab and bodyside glazing shall meet the light and solar heat transmittances given below:

	Light Transmission	**Solar Heat**
Cab Windows	76 % 84.8 %	72 % 61.1 %
Bodyside Windows	47 % 42.8 %	49 % 45.6 %

(Table Values modified)

6.11.2. Cab Windows

(a) Visibility through all cab windows shall not be impaired, with all auxiliary equipment operating normally, under any of the ambient conditions as specified.

(b) Cab windscreens shall be high impact resistant glass compliant to FRA type I

and ANSI Z26.1. Integral windscreen heating is not required.

(c) The cab side window shall be a sliding design which can be freely opened and shut to enable the guard to lean out and view the station platform in both directions with ease. All metal parts of the windows shall be of anodized aluminum to eliminate soiling of clothes and hands of the guard. A positive mean shall be included to hold the window in the closed position, be effectively weather-stripped to prevent water entry when passing through the car washing machines, be reinforced for hard usage, and designed to eliminate rattling. A drip guard trough shall be provided over the sliding windows. The window design shall allow manual operation with one hand and it shall be

able to slide freely with no binding and wear of sliding components. The force to open or close the window shall be less than 35N (8 lbs). The cab side window together with the associated operating mechanism shall be designed for frequent usage of 80 cycles (i.e. window down and up once on each cycle) per day, 7 days a weeks and no maintenance shall be required for at least 5 year. An endurance test shall be conducted to demonstrate that the above requirements of life expectancy have been satisfied. A fully functional production type installation shall be provided in the cab mock-up to review and prove the design of the cab side window.

(d) On the cab to saloon partition door, a surveillance glass window shall be provided. The window shall be tinted and have a mirrored finish, such that the window shall allow the operator to view the surveillance mirror outside the cab.

(e) The cab windscreen shall be either vandal-proof or equipped with an appropriate anti-graffiti film on the interior and exterior faces to facilitate ease repair of any scratch due to vandalism.

6.11.3. Car Bodyside Windows

(a) Bodyside windows and bodyside door windows shall be provided as defined in Contract Drawing No. NST 072.

(b) Passenger bodyside and bodyside door windows shall be single glazed and comply with FRA Type II, ANSI Z26.1.

(c) Not used.

(d) Not used.

(e) The window panel shall be either vandal-proof or equipped with an appropriate anti-graffiti film on the interior and exterior faces to facilitate ease repair of any scratch due to vandalism.

(f) Due consideration shall be given to the windows material, such that in the event of explosion, they are more resilient and shatter into fewer pieces in order to minimise the injury to the nearby passenger by the shards.

(g) Hopper windows shall be fitted to all passenger windows as detailed in PS 7.5.9 for emergency ventilation only, and shall be designed to allow easy opening by passengers, even after prolonged periods of closure.

(h) The hopper windows shall not rattle under any conditions or inadvertently open when subjected to the external pressure pulses experienced on the railway.

6.12 Materials Fit and Finish

6.12.1. All exterior panels, glazing and components shall be flush or surface fitting and neatly finished.

6.12.2. Bodyside rippling shall be kept to a minimum. The exterior of the car body shall be smooth and generally free of protuberances, sharp edges and weld spatter.

6.12.3. Not used.

6.13 Schedule of Colour and Finishes

6.13.1. For those exterior parts that require painting, such as, the cab front and fairing, they shall match the colour of the unpainted car body. The Contractor shall submit samples of the proposed colour match and finish of the cab front and of the carbody material for Approval. NCS colour system or an equivalent colour system, as submitted by the Contractor and accepted by the Engineer, shall be used (refer to PS 7.3.2).

6.13.2. The recess in which the head and tail lights are mounted shall be coloured red NCS 4020 Y90R or equivalent.

6.13.3. The colour and finish of all painted items shall not fade or deteriorate due to mechanical washing, UV radiation, or any condition usually encountered in a service or maintenance environment for a minimum period to be mutually established between the Contactor and the AUTHORITY.

6.13.4. Where decals are used, they shall meet the following requirements:-

(a) The decals shall be made of reflective film.

(b) The decals shall not require replacement for any reason for minimum period to be mutually established between the Contractor and the AUTHORITY.

(c) The decals shall meet the following requirements for the service life specified in (b):-

(i) The decals shall not stretch, shrink, or blister.

(i i) The decals shall not stain.

(i i i) Decal colours shall not fade or suffer any colour disfigurement.

(i v) Replacement decals shall match in terms of size and colour of the existing decals.

(v) Decals shall be easily removable at the end of their service life.

(vi) Decals shall have a high abrasion resistance and be resistant to all chemicals and contaminants likely to be encountered in service.

(d) Car numbers shall be coloured Black NCS 9500N or equivalent with a matt finish.

(e) The anti-climbers, couplers, trucks and all other equipment below the floor line that may easily be seen by observers on the opposite station platform shall be painted black with the exception of the wheels which shall be unpainted.

6.14 Stepping Distance

6.14.1. The door system shall be designed to minimise the stepping distance i.e. the gap between the platform edge and the passenger doors in the opened position, in order to avoid passenger trappage.

6.14.2. A nominal stepping distance of not greater than 70 mm (2.8”) shall be achieved between the outer edge of the passenger doorway threshold and the platform edge on straight platform.

6.14.3. For calculation purposes

(a) the platform edge shall be taken as 1645 mm (64.8”) from the centre-line of the track;

(b) the train shall be assumed to be on straight track.

6.14.4. The Contractor shall submit calculations to demonstrate that the required nominal stepping distance will be achieved.

6.15 Intercar Barrier

6.15.1. Intercar barriers shall be installed on both sides of each intercar gangway to

prevent access from passenger.

6.15.2. The intercar barrier and all associated connections shall perform to the loading under the operational requirements PS 4.4.1.

6.15.3. The disconnection and installation of intercar barriers shall not require removal of any component or structure from the car body.

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Section 7 - Interior Of Carbody

7.1 General

7.1.1. The objective of the interior design shall be to create a quality environment for commuter and leisure journeys for the widest possible range of demographic types of CITY population including the disabled.

7.1.2. To enable the Commission to render a quality service, the design shall be user-friendly, clean, safe and modern. The structures, furnishings and other components located in the saloon interior shall be free of any sharp projections, corners or rough finishes detrimental to the safety of persons within the interior of the car.

7.1.3. The basic configuration shall be similar to the existing T1 cars. The Contractor is encouraged to view the interior of the T1 cars in order to maximize his understanding of the requirements. In all instances, the requirements of this PS shall apply.

7.1.4. This Section shall be read in conjunction with the referenced Contract Drawings.

7.2 Evaluation Requirements

7.2.1 Industrial and Ergonomics Specialist

(a) Apart from meeting the functional requirements laid down in this PS, the saloon interior shall be designed with due ergonomic and aesthetic considerations.

(b) The Contractor shall submit for approval the Curriculum Vitae of the industrial and ergonomics specialists.

7.2.2 Programme

(a) The Contractor shall submit for approval a staged programme detailing the process for achieving the requirements of this Section. The process shall demonstrate that the requirements are successfully integrated with the engineering requirements of this PS. The programme shall be submitted during SEMP Stage 1.

(b) The programme shall identify, but not be limited to, the following activities:

(i) Perspective drawings and artist's impressions to demonstrate the Contractor's understanding of the required style, image and aesthetics.

(i i) Dimensional drawings indicating all key dimensions.

(i i i) Reference samples of components such as seats (refer to PS 7.6).

(i v) A full-scale, half-car-length engineering mock-up of the saloon interior.

(v) Design review meetings amongst the Engineer, the Contractor and his industrial design specialists.

(v i) Ergonomic trials on the full-scale half-car-length engineering mock-up, including but not be limited to the following:

(1) The Electronic and LCD Information Displays sight line trials.

(2) Trials on the passenger seat profile, operation of the flip-up seat, PAIS and the PAA strip.

(vii) Retrofitting of major equipment on the full-scale half-car-length engineering mock-up, including at least one set of the Electronic and LCD Information Displays and two sets of the saloon door drive mechanism.

7.2.3 Full-Scale Half-Car-Length Engineering Saloon Mock-up

The full-scale half-car-length engineering saloon mock-up shall represent the required image, style and aesthetics and shall include the following:

(a) Gangway

(b) Multi-purpose area.

(c) Production standard surface finishes, materials, tolerances, panel fits and colours.

(d) Access required for maintenance purposes to all equipment such as light fittings, door gears, Electronic and LCD Information Displays and saloon air conditioning control access panels.

(e) All engineering features such as fasteners, panel locks, exhaust and return air grilles, and wherever possible proposed production items shall be used.

(f) All saloon features such as Stanchions, hand rails, draughtscreens, signages, advertisement cards and fire extinguisher shall be included.

All saloon features such as Stanchions, hand rails, draughtscreens, signage's, and advertisement cards shall be included.

(g) Fully representative production light fittings which shall be used to measure lighting levels and demonstrating the desired lighting balance and ambience.

(h) Fully representative production seats for evaluation.

(i) Electronic and LCD Information Displays shall be functional for evaluation such as sight lines.

(j) At least two sets of saloon doors shall be functional for evaluation.

7.2.4 Erection, Transportation and Retrofitting

(a) The full-scale half-car-length engineering mock-up shall be erected at the Contractor's premises for evaluation.

The Contractor shall submit a list of equipment from those specified in PS 7.2.3 that will not be available during the mock-up development stage for approval during SEMP Stage 1.

~~(b) The Contractor shall be required to modify the full scale half car length engineering mock-up in accordance with the Engineer's comments.~~ All design changes and modifications shall follow the Configuration Control Programme requirements (refer to P 21.13).

(a) The full-scale half-car-length engineering mock-up shall be errected at the Contractor's premises for evaluation and user trials. Upon completion of all evaluations, the mock-up shall be shipped to and erected at AUTHORITY facilities.

(b) The Contractor shall submit a list of equipment from those specified in PS 7.2.3 that will not be available during the mock-up development stage for

approval during SEMP Stage 1. For items not available, efforts shall be made to have "placeholder" items installed to support as much of the evaluation activity criteria as possible.

(c) (No replacement specifications text, original text is deleted.)

(d) (No replacement specifications text, original text is deleted.)

7.2.5 Passenger Flow Study

The Contractor shall carry out a limited passenger flow study in order to understand the passenger flow through the cab end detrainment devices. As part of the study, a dynamic simulation of passengers as they flow through the cab end detrainment device, shall be provided. The simulation shall

incorporate a wide range of parameters, freely adjustable during a simulation run, that tune the generic model to real life situations. This flexibility, shall include but not limited to, passenger type (including the wheel-chaired passenger), the Time of day, exit constraints, or Passenger density distribution, which shall allow many scenarios to be explored.

7.3 Overall Concept

7.3.1 Styling

(a) The overall requirement for the train interior is to retain the general layout of the T1 trains while improving in seating, ceiling, lighting, colours, surface textures, methods of fixing/attaching internal fittings and equipment, and general aesthetics.

(b) The overall image of the train shall be open and friendly, reassuring the passenger of the safety and reliability of the train service.

(c) Large glazed areas and body side windows, shall be used to enhance illuminosity and facilitate the viewing of station names.

(d) The interior design shall ensure compliance with the maintenance and reliability requirements as detailed in PS 26.

(e) Simple controls shall be used for any passenger-operated features.

7.3.2 Colours

(a) The Contractor shall base the colour scheme and styling proposals on the T1 train and any divergence from its directions shall be clearly identified and justified. It should be noted that the overall design responsibility shall vest on the Contractor. The Contractor shall satisfy himself that the interior design proposal does not compromise or contradict any other requirements of the Specification. Colours as specified have been taken from the Natural Colour System (NCS) 1986 defined by Standardiserungskommissionen I Sverige (SIS)

and the Scandinavian Colour Institute (SCI). The Contractor shall use this system as a guideline to specify colours. Final colours selected shall be as per samples provided by the Contractor and approved by the Engineer.

(b) Where the same colour is specified for different types of finishes or materials, the maximum effort shall be made to ensure matching of colours. The Contractor shall use the most difficult material as a datum for matching the colours of other materials.

(c) The Engineer shall confirm the colour scheme for the train interior prior to commencement of the full-scale half-car-length engineering mock-up.

7.3.3 Finishes

(a) Finishes used shall be free from visible marks or defects as defined by the Contractor and approved by the Engineer.

(b) Finishes used shall satisfy the cleaning requirements detailed in PS 7.17.2.

(c) The gloss levels quoted are stated as percentage gloss. Unless otherwise stated, all finishes shall be smooth and in solid colour.

(d) The floor level through the inter-car gangway shall be flat and unobstructed ~~(except for the bridge plate).~~

7.3.4 ~~Samples~~

(a) To ascertain durability and colour consistency, the Contractor shall supply samples of selected materials and finishes used on the train as defined by the ~~Engineer.~~

(b) ~~Upon approval of the range of materials and decorative panels, the Contractor shall submit 4 numbered samples with size of 150 mm x 150 mm (6" x 6") of each finished panel with different colour, material and finishes, and flooring material. These samples will be retained by the Commission as a basis for assessing colour consistency, surface finishes, deterioration and quality. Any deviation above acceptable levels, defined by the Contractor and approved by the Engineer, from these samples during production shall not be accepted.~~

(b) Upon approval of the range of materials and decorative panels, the Contractor shall submit a minimum of 4 numbered samples with size of 150 mm x 150 mm (6" x 6") of each finished panel with different colour, material and finishes, and flooring material. These samples will be retained by the Commission as a basis for assessing colour consistency, surface finishes, deterioration and quality. Any deviation above acceptable levels, defined by the Contractor and approved by the Engineer, from these samples during production shall not be accepted.

(c) The Contractor shall submit samples of the grades of all metallic carbody finish with size of 150 mm x 150 mm (6" x 6") within six months following the Notification of Award in order for the Engineer to approve the finish to be incorporated on the mock-up.

7.4 Passenger Capacity

7.4.1 Passenger Accommodation

(a) Provision shall be made for 68 seats per non-cab car and 60 seats (plus 4 perch seats) per cab car in accordance with the layout in Contract Drawing No. NST 072.

~~(i)~~

(b) Multi-purpose Area

Provision shall be made for two multi-purpose area per non-cab car and one multi-purpose area per cab car.

(i) Provision shall be made for two multi-purpose areas per non-cab car and per cab car.

(i i) The multi-purpose area shall be available adjacent to the gangway end in accordance with Contract Drawing No. NST 072.

(i i i) The design of the multi-purpose area shall ensure that a clear path from the nearest door to the wheelchair restraint unit (refer to PS 7.6.4(d)) is provided and safe access for other passengers shall still be maintained.

(iv) Space requirements for wheeled mobility according to Americans with Disabilities Act (ADA): ADA Accessibility Guidelines for Buildings and Facilities (ADAAG), September 2002, shall be met, where applicable, and the space shall not be interfered with by any part of the vehicle.

(v) The draughtscreen (refer to PS 7.7.8) of the multi-purpose area shall be designed to work as a bulkhead for the prevention of forward/backward movement of a wheelchaired passenger.

7.4.2 Passenger Anthropometry

The passenger anthropometry shall be based on the 5th percentile female to 95th percentile male of the Canadian population.

7.5 Interior Panels

7.5.1 General

(a) A systematic approach shall be adopted for the sizes and proportions of all interior panels. Access panels shall be considered as part of the interior design concept.

(b) All panels shall be installed to avoid creaking, rattling or drumming during service.

(c) Panels shall be modular and fully interchangeable, i.e. not coach-built.

(d) Large, one-piece mouldings which restrict access to other fittings and inhibit removal for repair or replacement shall be avoided.

(e) Horizontal ledges that may allow dust settlement shall be avoided.

(f) The panels shall be of sufficient structural integrity to avoid distortion or damage.

(g) The Contractor shall ensure the absence of hazards to passengers or staff such as sharp edges either in the finished cars or on or behind panels when removed to provide access for maintenance.

(h) Any hinged or removable access panel shall be secured from falling whilst being opened or removed, and free of sharp edges and corners.

7.5.2 Fixings and Catches

(a) All fixings and catches shall be concealed unless the method of fastening is visually harmonious with the overall styling.

(b) All panels shall be easily removable and replaceable incurring the minimum of disturbance to adjacent areas and flooring. All panels shall not require the use of any sealants or other compounds for replacement. Lining panels shall not restrict access to equipment.

7.5.3 Joints

(a) The number of joints within the train interior shall be minimised.

(b) All exposed edges shall be pre-finished with a uniform and radiused edge.

(c) All panel joints throughout the ceiling and body side panels shall be consistently treated and shall be visually compatible and harmonious with the overall scheme. All tolerance gaps shall be uniform and minimized.

(d) All panels and adjacent elements of the interior trim shall resist dirt and foreign bodies.

(e) Tolerance gaps shall not unveil or provide access to equipment or the space behind panels. The gaps shall either be masked from behind or fitted with an appropriately finished item.

7.5.4 Panels and Door Locks

(a) The key and the lock mechanism shall be designed in compliance with the following requirements (refer also PS 32):

(i) A co-ordinated keys and locks system shall be used for the trains.

(i i) The system shall ensure that AUTHORITY's staff are only allowed to operate or have

access to equipment as required in the course of their duties.

(iii) The system shall be designed to allow different levels of access for the staff,

for example, the train operator and the maintenance personnel. The levels of access shall be submitted for approval.

(i v) It shall not be possible for unauthorised staff or passengers to open cubicles or cabinets, or operate equipment, using commonly available tools or implements.

(v) The keys and locks design shall be as per AUTHORITY's existing vehicles.

The keys and locks design shall be as per AUTHORITY's new Square SRT Key (Refer to AUTHORITY drawing 20099)

(v i) The Contractor shall submit a schedule of keys and locks in accordance with the Configuration Management (refer to PS 21.13), specifying the quantity of each type to be supplied and functions of the various types with listing for each type of all cubicles, cabinets and equipment which they will operate.

(v i i) The number of different types of keys and locks shall be kept to a minimum. (viii) Indications shall be provided on locks to show the closed position.

(i x) Keys and locks shall not be able to be broken by normal manual forces.

(x) Keys and locks shall be designed not to subject to excessive wear such that their ability to continue to function satisfactorily for the life of the train (refer to PS 4.5.4) will be impaired.

(b) The key shall be required to access the following:

(i) all interior maintenance panels, such as the door coving panel and the ceiling coving panel.

(i i) operate the Tapeswitch of the PAA strip (refer to PS 7.11.4)

(i i i) operate the door isolation device (refer to PS 16.2.8)

(i v) operate the door internal manual release device (refer to PS 16.2.10(a)

Item (iv): (No replacement specifications text, original text is deleted.)

(c) The key escutcheon shall be of minimal size with the minimum visual impact on the appearance of the interior.

7.5.5 Service Life of Panels

(a) Panels used shall have the same service life as the train as detailed in PS 4.5.4.

(b) Panels used shall maintain their original shape without distortion under changes of temperature, or corrode throughout their service life.

(c) Panel coatings shall have an agreed durability, during which the panel finish shall:

(i) Not blister

(i i) Not crack

(i i i) Discolour or lose its gloss level

(i v) Remain colour fast

(v) Show no signs of colour deterioration

(d) All panels shall withstand the cleaning of graffiti, rub marks and scuffing by cleaning agents without causing any damage or colour degradation.

7.5.6 ~~Saloon Ceiling Panels~~

(a) ~~The ceiling shall house lighting, PA loudspe~~akers and their associated components.

(b) Maintenance access shall be provided for all ceiling mounted components such as the return air grills, return air temperature sensor and air filters.

(c) Access to test, maintain and replace these components shall be achieved from within the saloon by one competent maintenance staff using hand tools within

20 minutes. The Contractor shall demonstrate achievement of this requirement.

(d) The ceiling shall incorporate an insulation between the warm saloon and the chilled air in the air conditioning plenum in order to prevent condensation.

(e) Tactile finish shall be provided under the low ceiling area for the visually challenged passengers to distinguish features including the continuous path leading to doorway and the longitudinal center of the car and gangway. The tactile finish shall be resistant to vandalism.

7.5.7 Ceiling Coving Panels

(a) The ceiling coving shall be used for carrying signages, advertisements and graphical display boards.

(b) The system of coving shall be modular in design, providing a consistent linear band along the car.

(c) Advertisement card holders shall be designed for maximum simplicity of use, are to be provided over the seat bay at the coving.

(d) Any advertisement card shall be removed or replaced within a maximum of 20 seconds, though the method of retention shall inhibit unauthorised removal. Size of the advertisement card shall refer to Contract Drawings No. NST 024 and NST 073.

(e) The length of the coving panels for those mounted with advertisement cards or the LCD Information Display shall be the same and shall be symmetrical with the centreline of the seat bay.

(f) Those coving panels mounted with LCD Information Display shall be able to hinge down and get over the hand rail over the seat. When hinged down the ceiling coving panel shall be positively retained to prevent unintentional movement.

7.5.8 Door Coving Panels

~~(a)~~

(a) ~~Door coving panels shall be fitted at each d~~oorway to cover the door ~~(b)~~ equipment.

(b) When hinged down the door coving panel shall be positively retained to prevent unintentional movement.

7.5.9 Saloon Window Panels

The window panel shall be a single-piece bodyside panel, installed horizontally between the door pocket panels on either side, and vertically between the ceiling coving and bench seat.

It shall be possible to replace the sealed window units without removal of the window panel and the flexible trim.

(a) The window panel shall be a single-piece bodyside panel, installed horizontally between the door pocket panels on either side, and vertically between the ceiling coving and the heater rail.

(b) It shall be possible to replace the sealed window units without removal of the window panel."

(c) Advertisement card holders shall be designed for maximum simplicity of use, are to be provided over the seat bay at the coving, except at the multi-purpose area.

(d) Any advertisement card shall be removed or replaced within a maximum of 20 seconds, though the method of retention shall inhibit unauthorised removal. Size of the advertisement card shall refer to Contract Drawings No. NST 024 and NST 073, or approved equal.

(e) Hooks for AUTHORITY's Advertising Publications shall be provided adjacent to doors #4,#10 and #15. Design shall be similar to the existing T1 train.

7.5.10 Door Pocket Panels

(a) The door pocket panel shall be a single-piece bodyside panel, and shall interface with the door pillar coving panel and the window panel.

7.5.11 Door Pillar Coving Panel

(a) The door pillar coving panel shall interface with the door pocket panel at the draughtscreen and be fitted vertically between the ceiling coving and floor coving.

The door pillar coving panel shall interface with the door pocket panel at the draughtscreen and be fitted between the ceiling coving and the floor.

(b) Passenger alarm microphones shall form part of the Passenger Assistance Intercom System (PAIS) which shall be incorporated into the door pillars and flush or surface mounted onto the door pillar coving panels. Minimum width of the door pillar shall be 3".

(c) The design of the door pillar shall ensure that the door prevents hand trapping whilst the doors are in operation.

(d) Three "D" ring and clip according to Contract Drawing No. NST-016 shall be provided on each side of the door pillar for the door barrier.

7.5.12 Door Pillar Floor Coving

(a) The door pillar floor coving shall cover the lower bodyside around the base of the door pillars. It interfaces with the floorboards, treadplates, draughtscreen, and the door pillar coving panel.

(b) The coving to floor interface shall align with the treadplate to floor visual interface giving a continuous straight edge to the floor covering.

(c) The coving shall align in height with the bodyside door kickplate.

(d) The profile, finish and edge of the coving shall match and align with the bodyside floor coving in the multi-purpose area.

7.5.13 Bodyside Door

(a) The bodyside door cladding panel shall provide an inner surface to the door leaf and a robust, decorative finish and shall shroud window fixings.

(b) A bodyside door kickplate shall be fitted to provide a robust surface at foot level. This shall be surface mounted on the surface of the cladding panel and align in height with the door pillar floor coving panel.

Item (b): (No specifications text modifications required.)

7.5.14 Car End Bulkhead

(a) A recess shall be provided at each car end bulkhead or low ceiling for the Electronic Information Display (please refer to PS 10.2.8(a)(i)(1)).

(b) For the car end bulkhead of the driving cab, a kickplate shall be fitted to provide a robust surface at foot level. It shall align in height with the door pillar floor coving.

(c) A card holder shall be fitted on the cab side of car end # 1 and non-cab side of car end # 2 (refer to Contract Drawing No. NST-075 for the naming convention) of the bulkhead for putting the AUTHORITY's By-Law. It shall be designed to prevent removal of the AUTHORITY's By-Law card without the requisite hand tool such as allen key or screwdriver. The frame shall be strong enough to prevent tampering. Size of the By-Law notice card shall refer to Contract Drawing No. NST 025.

(d) Design of the AUTHORITY's By-Law card holder frames shall enable replacement of the AUTHORITY's By-Law card by one man within 5 minutes with the requisite hand tool.

(e) Advertisement card holders shall be designed for maximum simplicity of use, are to be provided on the saloon side surface of the left hand side of the bulkhead.

(f) Any advertisement card which is specified in Section 7.5.9.(e) shall be removed or replaced within a maximum of 20 seconds, though the method of retention shall inhibit unauthorised removal.

7.5.15 Cab Saloon Partition Door

(a) The cab saloon partition door cladding panel shall provide an inner surface to the door leaf and a robust, decorative finish.

(b) A kickplate shall be fitted to provide a robust surface at foot level. This shall be surface mounted on the surface of the cladding panel and align in height with the cab end bulkhead kickplate.

7.5.16 Gangway Swing Panels and Gangway End Bulkheads

(a) A recess shall be provided at the gangway end bulkhead or low ceiling for the Electronic Information Display (please refer to PS 10.2.8(a)(i)(1)).

(b) A fixed grabhandle shall be provided on both sides of the gangway, such that it does not protrude into the gangway opening.

7.5.17 Materials

(a) Transportation grade material which shall be of attractive, easy to clean, and graffiti resistant, shall be provided for the vehicle interior panels.

(b) All interior panels shall comply with the fire performance requirements and the durability requirements in PS 7.5.5.

(c) The compliance of (b) above shall be demonstrated by suitable testing.

7.6 Seating

7.6.1 (b) Spatial Arrangement

(a) According to the Contract Drawing No. NST 072, the saloon shall be fitted with the following types of seat:

(i) ~~At the bulkhead area of each cab back wall, one 2-place perch seat assembly which shall be covered with the~~ same cloth surface as the other seats, shall be provided on both side;

(i i) In the middle of each car, six numbers of 9-place seat assembly which shall be

a combination of both perimeter and transverse seating arrangement according

to the design of T1 train, shall be provided; and

(iii) At the gangway ends, one perimeter seat assembly of either 3-place or 4-place, longitudinally disposed along each side of the car, shall be provided.

There shall be two multi-purpose area provided at each car. For those locations that are designated as the multi-purpose area, two assemblies of flip-up seats i.e. one 2-place and one 3-place according to the design of T1 train, shall be provided.

There shall be two multi-purpose area provided at each car. For those locations that are designated as the multi-purpose area, 1 assembly of 3 x 1P flip-up seats shall be provided.

(c) All seats shells as shown on the Contract Drawing No. NST 006, shall be stainless steel or aluminum, clothed non-slip surface for the seat cushion and satin finish for all exposed metallic surface. The seat shells shall be supported ~~by aluminum seat frames. The overall seat shall be resistant to vandalism, scrapes, scratches, stains and graffiti.~~

All seats shells shall be stainless steel or aluminum, clothed non-slip surface for the seat cushion and satin or #4 finish for all exposed metallic surface. The seats shall be supported by aluminum seat frames. The overall seat shall ~~be resistant to vandalism, scrapes, scratches, stains and graffiti.~~

7.6.2 Seat Profile

(a) ~~Clothed finish seats shall be installed which prev~~ent sliding due to normal accelerations/decelerations. Except the perch seats, all seat cushions and seat backs shall be interchangeable with T1 train.

Clothed finish seats shall be installed which prevent sliding due to normal accelerations/decelerations. Except for perch and flip-up seats, all seat cushions and seat backs shall be interchangeable.

~~(d)~~

(b) The design of the seat cushion and seat backs shall be based on the T1 train concept as shown on Contract Drawing No. NST 006.

(c) Ergonomic trials shall be conducted to review the seat design (refer to PS 7.2.2(b)(vi)). Approval on the seat design will be given upon satisfactory results from the ergonomic trials.

A seat sample shall be provided by the Contractor for approval within two months after the award of Contract to demonstrate the required finish of the passenger seat. The Contractor shall fabricate the passenger seat in accordance with the above Approved sample finish and the Approved seating profile.
Item (d): (No replacement specifications text, original text is deleted.)

7.6.3 Construction Requirements

(a) All similar seat cushion and seat backs shall be interchangeable. Similarly, all seat frames and pedestals of corresponding design shall be interchangeable.

(b) The seat surface shall have no sharp edges or projecting corners to snag passengers' clothing.

(c) The seat surface shall be easily cleanable and the edges shall integrate with the seat supportive structure smoothly to ensure no dirt traps are present.

(d) There shall be no manufacturing marks of any kind on the exposed seat surface.

(e) The seat shall be mounted on totally enclosed aluminum supportive structure, such as, a cantilever arrangement as attached on the carbody sidewall, in order to provide a barrier-free vision of the car from a viewing perspective of underneath the seat and to maximize the free area beneath the cantilever seats for easy cleaning. Each seat placement shall be capable of carrying an evenly distributed load of 252 kg (555 lbs) without damage or failure of seat attachments.

The seat shall be mounted on an aluminum supportive structure, such as, a cantilever arrangement as attached on the carbody sidewall, in order to provide a barrier-free vision of the car from a viewing perspective of underneath the seat and to maximize the free area beneath the cantilever seats for easy cleaning. Each seat placement shall be capable of carrying an evenly distributed load of 252 kg (555 lbs) without damage or failure of seat attachments.

(f) The seat supportive structure shall form a closed base underneath the seat.

(g) The front face of the baseboard heater air grille shall be blended visually with the floor by the continuation of the floor covering material up the front of the air grille.

(h) The ends of seat assembly shall be closed.

(i) All joints between the baseboard heater air grille and the floor covering and the bodyside coving shall be sealed to IEC 60529 IP54, and designed to avoid the creation of dirt traps or the use of visible fasteners.

All joints between the baseboard heater grill and the floor covering shall be sealed to IEC 60529 IP 54, and designed to avoid the creation of dirt traps or the use of visible fasteners

(j) For those perimeter seats that are located at the gangway ends, seat plinth which shall be complied with the above construction requirements, can be allowed. The space enclosed by the plinth may be employed to house equipment or devices that do not normally require access during service checks (refer to PS 26.3.2).

(k) Simple and quick maintenance access to the enclosed equipment in the seat plinth shall be provided. The design shall permit access to the enclosed equipment within 10 minutes by two competent maintenance staff.

(l) If a hinged design is adopted, then the seat pan shall be positively retained to

(m)

(n) The seats shall have the full service life of the train without any performance degradation in normal operation, excluding acts of vandalism. Normal wearing of the raised textured surface over time is permitted and will not considered to be performance degradation provided that the wear amount is not so great as to permit sliding during normal accelerations/decelerations.

The seats shall have the full service life of the train without any performance degradation in normal operation, excluding acts of vandalism. Normal wearing of the insert fabric surface over time is permitted and will not considered to be performance degradation provided that the wear amount is not so great as to permit sliding during normal accelerations/decelerations.

(o) The seat shells shall be manufactured from stainless steel or aluminum. Samples of proposed materials shall be submitted for approval.

Adequate length and proper shape of the location pin of the seat shells shall be provided to aid installation of the seat shell onto the seat frame. Design shall be similar to the existing T1 train.

7.6.4 Flip-Up Seats

(a) The seat shall be easily flip-up with a vertical force of no more than 4.5 kg (10 lb.). Once the seat is in the flip-up position, the seat shall be firmly latched. Design of the flip-up seat shall be based on and interchangeable with the existing T1 train.

The seat return to up position. The seat shall initiate going to the down

position with a vertical force of no more than 4.5 kg (10 lb.). Once the seat is in the flip-up position, the seat shall be firmly latched. Design of the flip-up seat shall be based on and interchangeable with the existing T1 train.

(b) A manual release device shall be provided to put back the seat onto the original position. Once the seat is lowered, it shall be able to stay in the lowered position when it is used as normal passenger seat.

~~Item (b): (No replacement specifications text, original text is deleted.)~~

(c) ~~At the underside of the 3-Person flip-up seat, a PAA strip (refer to PS~~ 7.11.1(c)) shall be provided. The PAA tapeswitch shall only be operational ~~when the seat is in the flip up position.~~

~~Item (c): (No replacemen~~t specifications text, original text is deleted.)

~~(e)~~
~~(i)~~
~~(ii)~~
(d) A Wheelchair Restraint Unit shall be provided to allow a wheelchaired passenger locking the wheelchair in place during travelling. The arrangement
~~(iii)~~ of the existing T1 train shall be adopted as a design baseline (refer to Contract Drawing No. NST 085).

The Wheelchair Restraint Unit shall be operated as follows:

Lift the Flip-Up Seat.

Insert the wheelchair far enough into the Wheelchair Locking Mechanism until it locks.

To release the wheelchair pull the Manual Release Handle.

Items (d, e, e-i, e-ii, e-iii): (No replacement specifications text, original text is deleted.)

(f) No electrical power shall be required to operate the flip-up seat and the wheelchair restraint unit.

No electrical power shall be required to operate the flip-up seat.

7.7 Passenger Retention

7.7.1 General

(a) Stanchions, hand rails and grabhandles shall be supplied and installed in accordance with the design of T1 train at the following locations:

(i) each side of each seat bay

(i i) seat bays

(i i i) multi-purpose area

(i v) along the longitudinal centreline of the car

(v) gangway areas

(v i) a vertical stanchion located at the meeting points of the longitudinal centreline of the car and the centreline of those doorways that have no multi-purpose area

(b) All stanchions, hand rails and grabhandles shall be fabricated from stainless steel tube and shall have a common finish.

(c) All stanchions, hand rails and gangway grabhandles shall be of 32 mm (1 1/4 inches) diameter.

(e) All stanchions, hand rails and grabhandles shall be capable of carrying the following loading requirements with minimal permanent deformation of the stanchions, grabhandles, hand rails or their attachments to the car, and no detachment of fittings or attachments:

(i) Horizontal load of 900 N (202 lb) applied as a point load at any point of any stanchion or grabhandle span, superimposed by an uniformly distributed load of 1300 N/m (89 lb/ft).

(ii) Vertical load of 900 N (202 lb) applied as a point load at any point of any hand rail span, superimposed by an uniformly distributed load of 1300 N/m (89 lb/ft)

(f)

(g) A minimum clearance of 50 mm shall be maintained around any stanchion, grabhandle and hand rail.

(h) Colour Section

(i) In order to support visually challenged passengers, all stanchions and grabhandles shall be fitted with a colour section of high contrast color design with smooth texture. It shall be Satin stainless steel with non-directional finish and complied with 50% gloss level for the colour section. The colour section shall be either red or yellow. As part of the the operability design (refer to PS 21.5, the Contractor shall submit the colour scheme for approval.

In order to support visually challenged passengers, all stanchions and grabhandles shall be fitted with a color section of high contrast color design with smooth texture. Stanchions shall be stainless steel 180-grit finish with a minimum 50% gloss level for the color section. Handholds shall also be

stainless steel with a minimum 50% gloss level for the color section. The color section shall be red.

(ii) For the vertical stanchions of the seat bench, the height and position of the colour contrasted section shall be 170 mm measured from the centre of the horizontal grab rail and 950 mm measured from the floor level

(iii) The height and position of the colour contrasted section of the central stanchion, the doorway and the gangway grabhandle shall be vertically aligned with that on the seat mounted stanchions.

(i) All stanchions, handles, and seat structures shall be capable of withstanding all loads due to normal operation and loading as specified in PS 7.6.3(e), PS 7.7.1(e)(i) and PS 7.7.1(e)(ii).

7.7.2 Centre Stanchion and Hand rail Assembly

(a) The stanchion shall be fitted on both sides along the seat bays. In the centre of each doorway, a straight stanchion shall be fitted on the ceiling, in order to assist passengers passing through the doorway. Spring loaded handholds of which the form, fit and function shall be identical with those that are used on the T1 trains, shall be provided. Refer to Contract Drawing No. NST 074 for preferred location and minimum quantity of the spring loaded handholds.

(b) Stanchions shall not contribute to the structural strength of the car body. Stanchion fittings visible to passengers shall be minimal and integrate into the design of the interior. Fittings at floor level shall not produce a hazard to passengers and shall not trap dirt.

(c) Joints between stanchions and hand rails shall have no sharp edges or sharp fixings.

(d) The complete pole assembly shall be easily assembled and disassembled for maintenance access to the ceiling by one competent maintenance staff in 5

minutes.

(e) It shall be possible to remove individual horizontal rails if required without disturbing other areas of the assembly.

7.7.3 Seat Mounted Stanchion and Hand rail

(a) Inclined stanchion shall be positioned at every draughtscreen to assist passengers passing through the train.

(b) Hand rails shall be provided horizontally between draughtscreen stanchions over the seating bays.

(c) All visible joints in the pole assemblies shall be minimised with recessed or concealed fasteners.

(d) Any fastenings used to interface the poles to the draughtscreen support shall be recessed or concealed.

(e) The layout of the stanchions and hand rails shall ensure adequate maintenance access to the ceiling coving equipment.

7.7.4 Gangway Stanchion and Grabhandle

(a) The gangway stanchion and grabhandles shall be provided.

(b) The stanchion shall be fitted on both side of the gangway.

(c) ~~The fixed grabhandles shall not protrude into the gangway opening.~~

7.7.8 ~~Draughtscreens~~

(a) The glazed portion of the draughtscreens and its surround shall have sufficient strength to resist the loads defined in PS 7.18.

Item (a): (No replacement specifications text, original text is deleted.)

(b) The draughtscreen shall be of laminated toughened safety glass to BS 857:1967.

The draughtscreen shall be of laminated toughened safety glass to BS 857:1967, or equivalent.

(c) Replacement of the glass shall not require the use of any adhesive or sealant.

(d) The exposed edges of the glass shall be chamfered or rounded to ensure passenger safety.

(e) Glazing shall be resiliently mounted in fittings designed to allow easy replacement.

(f) Recessed or concealed fasteners shall be used on the sides or bottom face of the draughtscreen support.

(g) The glazing shall run parallel to the inclined stanchion at its front edge and to the bodyside at its back edge.

7.8 Flooring

7.8.1 General

(a) The car floor shall be continuous over the complete area of the saloon and shall be free from traps, gaps and holes.

(b) The quality of the flooring shall reflect the design philosophy in PS 7.1.

(c) Not used.

(d) Floor covering in combination with the sub-floor shall meet the specified fire performance requirements.

(e) Flooring shall remain non-slip and not present a hazard to passengers when wet.

(f) The transition between saloon floor and gangway vestibule between cars shall be smooth and free from steps and unduly steep gradients which would impede the flow of passengers between cars.

(g) The Contractor shall submit for approval, a programme of testing to satisfactorily demonstrate the requirements of PS 7.8.3 and 7.8.4 are met.

(h) Tactile finish shall be provided for the visually challenged passengers to distinguish features including the continuous path leading to doorway and the longitudinal center of the car. Due consideration shall be given to the design of the tactile finish in order to ensure that no tripping hazard will be caused.

Tactile finish shall be provided for the visually challenged passengers to distinguish features including the continuous path leading to doorway and longitudinal center of the car. The tactile finish shall be modeled along the lines of the BS7997:2003 standard, but realistically sized for this transit application. The height of projection of the tactile finish shall be 2.5mm max to minimize the potential for a tripping hazard. Additionally, the tactile finish shall be easily cleaned.

7.8.2 Joint

(a) Floor covering material shall be laid with the minimum number of joints.

(b) Floor covering shall be so arranged to ensure that the bend radius required at the plinth/baseboard heater base does not coincide with a joint in the covering that will affect the visual continuity between the plinth/baseboard heater and floor.

(c) Not Used.

(d) Joints shall be sealed against the ingress of dirt, moisture and water.

(e) Any sealant used shall be coloured to match the background colour of the floor covering.

7.8.3 Flooring Life

(a) ~~The floor covering shall have a service life for a minimum period to be mutually~~ established between the Contactor and the AUTHORITY.

(b) Floor covering and coving shall be securely fixed to the car floor for the specified life of the train.

~~Floor covering shall be securely fixed~~ to the car floor for the specified life of the train.

(c) Floor covering shall show no signs of wear and the colour shall not fade for the specified service life. A full abrasion test programme shall be submitted for approval.

(d) It shall be feasible to replace all, or sections of the floor covering and coving during the life of the train if necessary.

It shall be feasible to replace all, or sections of the floor covering during the life of the train if necessary.

(e) The flooring shall not be damaged or discoloured by any materials usually encountered in depot or service use.

7.8.4 Cleaning Requirements

(a) Flooring shall remain colour fast under the following BS 1006:1990 conditions:-

(i) light

(i i) shampoo

(i i i) dry cleaning

(i v) water spotting

(v) acid spotting

(v i) alkali spotting

(v i i) rubbing

(b) Flooring shall be easily cleaned with the minimum of effort using readily available cleaning agents meeting the requirements as specified in PS 7.17.2.

(c) Flooring shall not require glazing, polishing or any other post-production re-finishing to maintain its finish.

(d) Flooring shall suit the cleaning schedules as detailed in PS 26 and during service and shall not appear dirty between scheduled cleaning.

7.8.5 Treadplates

(a) Treadplates at all saloon side doorways shall be metallic and slip resistant. Due consideration shall be given on the surface design of the treadplates in such a way that any foreign liquid (e.g. detergent or water which would be leaked through the bodyside doors during pressurized car wash) will be trapped and drained within the treadplates area without flowing into the saloon floor.

(b) Material of the treadplates shall not deteriorate upon acid washing.

(c) There shall be no logo, name or other trademark engraved or stamped on the treadplate.

7.9 Lighting

7.9.1 General

2

(a) The car lighting consists of two longitudinal rows of fluorescent tubes in accordance with the general arrangement as depicted in Contract Drawing No. NST 074. All interior fluorescent lighting shall be supplied from the low voltage DC system. The Contractor may offer alternative solid state lighting solution including white light LED technology which are equivalent to or better than those herein, and which the Contractor shall justify to the satisfaction of the Engineer.

(b) [Option] White LED backlight shall be provided for the advertisement cards and existing AUTHORITY Subway route maps (refer to PS 7.10.1(b). The entire surface of the lighting panel shall be evenly illuminated. The minimum

luminous intensity provided by the LED backlight shall be 140 cd/m . The quantities of LED backlight is subject to Option 9 (refer to PS 3.10.9) whereas the existing AUTHORITY Subway route map will be replaced by the Flashing System Map.

(c) The fixtures shall be complete with lamps, ballasts, controls and accessories sufficient to make a complete lighting system.

(d) All light fixtures shall be protected and diffused. No exposed light sources will be accepted. Light sources shall be chosen to minimise the generation of

heat. Diffusers shall not be hot to touch. All light fittings shall be sealed to IP 54, IEC 60529 to prevent the ingress of dirt and foreign objects.

(e) Two prismatic portions shall be provided by the diffusers: lower horizontal portion to direct high intensity glare-free light to the reading plane of seated passengers, and a second clear prismatic upper vertical portion to direct light to the ceiling.

(f) [Option] Above the doorway, a LED Flashing System Map (i.e. dynamic route map) should be provided on the light fixtures of the door coving panel as an Active Line Diagrams in order to give visual information:

(i) on the location and direction of the train;

(i i) line flashing at inter-change station;

(i i i) door opening side.

The Contractor shall design the artwork of the LED Flashing System map according to the Commission's Subway Route Map in an agreed upon arrangement to prevent tampering. The route map shall be mounted on the inside of a transparent lens.

(g) The fluorescent lamps shall be of the instant-start cool white type with emphasis on the maximum length requirement.

(h) Exterior emergency lighting shall consist of incandescent or LED lamps designed for railway service, and located over each end door of a six car unit, outside the Subway Car. Interior emergency lighting shall be provided by powering four of the fluorescent lamps from the battery. These four lamps shall be located symmetrically two on each side of the Subway Car and arranged at doors 1-2, 5-6, 9-10, 13-14 so that these doorway areas are illuminated.

(i) Electronic ballasts which shall effectively eliminate all visual flicker and audio hum, shall be provided. The frequency of an inverter-ballast output shall be no less than 20 kHz and each such ballast shall be protected against application of reverse polarity.

(j) Ballasts, regardless of supply voltage, shall be of such a design that they are not damaged if left connected to a defective or a non-existent fluorescent tube

and this feature shall be achieved without switching at the tube socket.

(k) The fluorescent lamp system shall meet the specified noise requirements.

(l) All lamps and fixtures used throughout the Subway Car shall be of a type commercially available in Canada.

(m) Once closed the diffuser shall withstand loads in accordance with PS 7.18.

(n) Under the threshold at the door header of each doorway, a flashing yellow LED light fixtures shall be provided to indicate that the door is about to close.

(o) The lighting requirements of this Section shall be fully demonstrated on the Contractor's interior mock-up, in particular the overall lighting effect, lighting levels and consistency of colour and temperature.

7.9.2 Visual Effect

(a) Lighting shall not reduce the view through windows by seated passengers as a result of reflections.

(b) Seated or standing passengers shall not be dazzled by any interior lighting.

(c) Consistency of colour and temperature shall be maintained throughout the interior.

(d) Lights shall not be perceived to flicker.

(e) The light fittings shall be arranged such that no shadows will be cast on seated passengers, signage or advertising panels.

7.9.3 Lighting levels

(a) Illumination levels quoted below are maintained illuminance which is the average illuminance over the reference surface at the end of the complete maintenance cycle i.e. it is the minimum value to which the illuminance is allowed to fall.

(b) A maintenance factor of 0.8 shall be applied to the lighting design to take into account the various depreciation factors such as dirt on luminaries and diffuser and lamp lumen depreciation. The maintenance factor shall be defined as the ratio of the illuminance producing by the lighting system at the end of the maintenance period to the illuminance produced by the system

when new.

(c) The lighting shall achieve a level of uniformity of 0.8 throughout the interior for all specified illumination levels. The illuminance uniformity shall be defined as the ratio of minimum to the average illuminance measured over the reference surface.

(d) The illumination intensity on the upper surfaces of a horizontal plane, at the mid point of the Subway Car, 84 cm (33 inches) above the floor, with nominal regulated voltage available at the fluorescent lamps and with no advertising material in place, shall be not less than 485 lux (45 foot candles) at a distance of 38 cm (15 inches) from the longitudinal centre line of the Subway Car. As the sides of the Subway Car are approached, the lighting intensity readings at

the same height from the floor shall diminish to not less than 377 lux (35 foot candles). The lighting shall be as uniform throughout the Subway Car as practicable and shall provide adequate illumination of ceiling, advertising cards, gangway areas and doorways.

[Option]

Or as an option of the Option 11 (refer to PS 3.10.11), the illumination intensity on the upper surfaces of a horizontal plane, at the mid point of the Subway Car, 84 cm (33 inches) above the floor, with nominal regulated voltage available at the fluorescent lamps and without LED back lighting, shall be not less than 485 lux (45 foot candles) at a distance of 38 cm (15 inches) from the longitudinal centre line of the Subway Car. As the sides of the Subway Car are approached, the lighting intensity readings at the same height from the floor shall diminish to not less than 377 lux (35 foot candles). The lighting shall be as uniform throughout the Subway Car as practicable and shall provide adequate illumination of ceiling, advertising cards, gangway areas and doorways.

(e) There shall be no shallowing or light cut-off, and reflection from the hand rail, on the ceiling coving panels and the associated electronic and LCD information displays.

(f) Light measurements, with a measuring grid of not greater than 1m

(longitudinal) x 0.5m (transverse), shall be carried out to confirm compliance with the lighting requirements.

7.9.4 Emergency Lighting

The DC lights shall be arranged so that all the door bays shall be sufficiently illuminated to achieve a minimum illumination level of 100 lux, measured at a level of 1 metre above the floor, under emergency situation.

7.9.5 Diffuser

(a) All diffusers shall be positively secured to the ceiling panel. The inboard side of the diffuser shall be hinged to the ceiling panel. Quick release, tamper

resistant fastenings shall be used to retain the diffuser closed.

(b) Design of diffusers shall be based on T1.

(c) The diffuser shall run the full length of the ceiling panel assembly. The glazed length of the diffusers shall match with the tube length to avoid dark areas of lens.

7.9.6 Reliability and Maintainability

(a) The minimum life of the fluorescent tubes (defined as 20% luminance degradation) shall be at least 7 500 hours under normal operating conditions. Normal operating conditions shall be deemed to be two switching cycles per day with the lamp energised 19 hours per day.

(b) All diffusers shall have a smooth finish to facilitate ease of cleaning.

(c) Suitable access shall be provided to enable all faces of the diffuser to be cleaned in-situ.

(d) The diffusers shall be easily opened to permit each tube to be replaced by one competent maintenance staff in one minute.

(e) All light fittings shall be easily replaceable using only simple tools.

7.10 Commercial Aids

7.10.1 Advertisements

(a) The advertisement cards and the LCD Information Display System (LIDS)

(refer to PS 10.2.8.(a)(i)(1)) shall be installed on the ceiling coving panel in the following manner:

(i) Each seat bay shall either install advertisement cards or LIDS.

(i i) They shall be installed on alternative seat bay.

(i i i) Each pair of opposite seat bays shall have both advertisement cards and LIDS.

(b) Based on T1 design, the posters, advertisement cards and existing AUTHORITY Subway route maps shall be mounted on the window panel and ceiling coving of the relevant seat bay, making each car shall be able to

put minimum of 15 nos. of 20"x28" poster, 32 nos. of 11"x35" advertisement cards and 4 nos. of existing AUTHORITY Subway route maps. The quantities of existing AUTHORITY Subway route maps is subject to Option 9 (refer to PS 3.10.9) whereas the existing AUTHORITY Subway route map will be replaced by the Flashing System Map.

(c) The advertisement cards shall not sag or otherwise display an untidy appearance. All edges shall be covered once in place.

(d) Each advertisement card shall be located such that it cannot migrate out of position.

7.10.2 Electronic Information Display System (EIDS)

(a) A total of 2 Electronic Information Display System (EIDS) per car shall be provided at the bulkhead wall or low ceiling as specified in PS 7.10.1(a) (refer also to PS 10.2.8(a)(i)(1)).

(b) The Contractor shall conduct ergonomic trials to maximise the visibility of the Electronic Information Displays to the passengers.

The EIDS shroud shall be aesthetically finished and blended seamlessly with the low ceiling finish. The EIDS shall be mounted by tamperproof fasteners.

7.10.3 LCD Information Display System (LIDS)

(a) A total of three (3) LIDS per car shall be provided on the seat bay panels (refer to PS 7.10.1(a)(ii)) of the alternate seat bay.

(b) The Contractor shall conduct ergonomic trials to maximize the visibility of the LIDS to the passengers.

7.11 Communications

7.11.1 Passenger Alarm Device

(a) Passenger alarm device shall be provided to enable passengers to gain the attention of the train operator and initiate a two-way communication by using the Passenger Assistance Intercom System (PAIS) in accordance with PS 18.4.14.

(b) The passenger alarm device shall include PAA strip and PAIS.

(c) PAA strip

(i) PAA strip shall be provided to enable passengers to gain the attention of the train operator in accordance with PS 18.

(ii) The PAA strip shall be a PAA Tapeswitch according to the design of the existing T1 train.

(iii) There shall be eight sets of PAA tapeswitches per car to be distributed on those seat bays and each car ends that are shown in Contract Drawing No. NST 072.

(d) Passenger Assistance Intercom System (PAIS)

(i) PAIS which shall be flush or surface mounted on the door pillar and side panel of the multi-purpose area.

(ii) PAIS shall be provided to enable passengers to gain the attention of the train operator and initiate a two-way communication in accordance with PS 18.

(iii) The PAIS shall include Passenger Alarm Emergency Handles (refer to PS 7.11.5), PAA Microphone and PA Loudspeaker.

(i v) There shall be six sets of PAIS per car i.e. four PAIS shall be distributed on the door pillar of an alternated doorway as shown in Contract Drawing No. NST 072 for a standing passenger, and two PAIS shall be located in each multi-purpose area of the two car ends and to be within the reach of a wheel-chaired passenger.

(v) Passenger alarm microphones which shall be flush mounted and vandal-proof.

(v i) Subject to the result of the design review on the engineering saloon mock-up (refer to PS 7.2.3), the centre of the microphone unit shall be 1 470 mm from finished floor level for the standing passenger and 1 330 mm from finished floor level for the wheel-chaired passenger.

7.11.2 Public Address Loudspeakers

(a) The train shall be fitted with a public address system audible from any position in the train. Performance requirements are detailed in PS 18.

(b) The PA loudspeakers shall be located and equally spaced on the ceiling.

(c) The number, size, location and spacing of the PA loudspeakers shall be carefully designed to:

(i) meet the performance requirements in PS 18.4.

(i i) meet the air flow requirements in PS 15.6.

(i i i) meet the airborne noise requirements in PS 21.8.

(i v) integrate with the ceiling profile, stanchions layout and the saloon interior styling.

(d) The PA loudspeakers shall be surface and resiliently mounted on the ceiling panel.

(e) The PA loudspeakers shall be readily accessible for maintenance purposes.

(f) PA loudspeaker grilles shall be so designed to prevent malicious damage to the speakers.

7.11.3 PAIS Microphones

(a) For those microphones that are located in the door way, they shall be aesthetically integrated with the door pillar. For those microphones that are located in the multi-purpose area, they shall be aesthetically integrated with the side panel.

(b) The microphone shall be readily accessible for maintenance purposes.

(c) The microphone grilles shall be so designed to prevent malicious damage to the unit.

7.11.4 PAA Strip

(a) A PAA strip in a form of Tapeswitch shall be provided to advise the operator and guard that a passenger requires assistance.

(b) The following Tapeswitches shall be provided to activate the alarm:

(i) Horizontal alarm Tapeswitches shall be provided at high level to service each of the 9-passenger seat bays on each side of the Subway Car

(ii) At the cab end of the Subway Car, two 61 cm (24") long alarm Tapeswitch shall be provided at high level, horizontal, adjacent to and on both side of the cab to saloon partition door.

(iii) At the non-cab end of the Subway Car, one 61 cm (24") long alarm tape-switch shall be provided at high level, horizontal, adjacent to the EIDS.

(iv) On the underside of the three-passenger flip-up seat, one 61 cm (24") long alarm Tapeswitch which shall be activated only when the seat is in the flip-up position, shall be provided.

(c) When any Tapeswitch is depressed the following shall occur:

(i) An alarm message shall be issued to the train operator by the TIMS to identify the location of the activated Tapeswitch. The two exterior amber warning lights shall be illuminated on the Subway Car on which the alarm has been activated.

(ii) Whilst the Tapeswitch shall be a designed for ease of actuation i.e. the Tapeswitch can be actuated by pressing at any point, the Tapeswitch shall also be designed to eliminate the possibility of accidental activation.

(iv) The status of the Tapeswitch shall be monitored by the TIMS (refer to PS 18.4.14) and recorded in the Event Recorder.

(d) The TIMS alarm message and the exterior amber warning lights shall be remained in the condition as specified above until the PAA reset pushbutton located on the Guard Control Panel (refer to PS 7.13) is depressed.

(e) To facilitate the trouble shooting of this circuit, quick disconnects shall be provided in central locations to permit isolation of individual tapeswitches.

(f) Tapeswitches shall be sealed at both ends to prevent water entry.

7.11.5 Passenger Alarm Emergency Handle (PAEH)

(a) The operation of the PAEH shall enable a passenger to speak to the train operator via the adjacent PA microphone.

(b) The handle of the PAEH shall be a pull down type switch.

(c) The handle of the PAEH shall be designed to eliminate the possibility of accidental activation.

(d) When the pull down handle is operated, it shall be spring biased in the operated position. The original position can be resumed by AUTHORITY Staff Key (refer to PS 32).

When the pull down handle is operated, it shall be spring biased in the operated position. The original position can be resumed by AUTHORITY Square SRT Key (refer to PS 32).

(e) The handle of the PAEH shall resist a downward pull load of 900 N at its installed location with no permanent deformation to any part of the handle assembly. This shall be demonstrated by a type test.

(f) Operation of the PAEH shall:

(i) Illuminate a red LED indicator integrated with the PAEH assembly to enable the train operator to identify, in a crowded train, which Handle has been activated.

(ii) Issue an alarm message to the train operator by the TIMS to identify the location of the activated PAIS. The two exterior amber warning lights shall be illuminated on the Subway Car on which the alarm has been activated.

(g) The status of the PAEH shall be monitored by the TIMS (refer to PS 18.4.14).

7.12 Video surveillance systems

7.12.1 A video surveillance systems shall be provided inside each car (refer to PS 10.2.7). And a surveillance camera shall be provided at the following locations:

(a) For each cab end, adjacent to the tapeswitch near the cab to saloon partition door;

(b) For each gangway end; and

(c) For each multi-purpose area.

[Option]

Or as an Option 10 (refer to PS 3.10.10), the video surveillance systems shall be provided inside each car (refer to PS 10.2.7). And a hidden full-color surveillance camera shall be provided at each doorway.

7.12.2 The surveillance camera shall be surface and resiliently mounted on the interior panel.

7.12.3 The surveillance camera shall be readily accessible for maintenance purposes.

7.12.4 The protective cover of the surveillance camera shall be so designed to prevent malicious damage.

7.13 Guard Control Panel

7.13.1 A Guard Control Panel shall be provided and positioned on the top of right hand side corner of each car end.

7.13.2 Inside the Guard Control Panel shall consist of :

(a) PAA Reset Pushbutton (refer to PS 7.11.4(d)).

(b) Brake Isolation Valve (refer to PS 13.12.1)

Item (b): (No specifications text modifications required.)

(c) Power supply socket according to the requirements of PS 8.10.4.

7.13.3 No live electrical terminals shall be exposed to the operator inside the Guard Control Panel.

7.13.4 The door cover of the Guard Control Panel shall only be opened by the AUTHORITY's

staff key (refer to PS 32).

The door cover of the Guard Control Panel shall only be opened by the AUTHORITY's Square SRT Key (refer to PS 32).

7.14 Environmental Control

7.14.1 Air Conditioning

(a) Air conditioning outlet vents shall be located between the coving panel edges and the ceiling panels.

(b) The air outlets ducts shall be so arranged to achieve the air conditioning performance specified in PS 15.

(c) All grilles, covers and meshes shall be designed to prevent the deliberate insertion of objects or trapping of limbs and be highly resistant to accidental or deliberate damage. They shall be readily removable for cleaning but shall be of a design that inhibits settlement of dust or dirt on visible surfaces.

7.14.2 ~~Hopper Windows~~

(a) ~~Hopper windows shall be incorp~~orated at each bodyside window.

(b) The hopper window frame shall be discrete and as flush as possible. It shall be made of the same assembly as the passenger window.

(c) The hopper window shall incorporate a positive locking mechanism and with appropriate signage. The locks shall be highly robust to withstand passenger abuse and easy to operate. The hopper window shall be remained in a lock position unless automatically disengaged in an emergency situation, as determined by the operator. In normal operation, the passenger shall not be able to open the hopper window.

Hopper window lock nolonger exists.

7.15 Signage

7.15.1 Types of Signage

The following 3 categories of signage will be displayed in the interior:-

(a) Static signage appropriate to operating and maintenance staff (such as safety and procedural) and name plates (such as door number plates, car number plates and gangway end identification plate)

(b) Static signage shall include:

(i) General regulations such as "No Smoking".

(ii) Customer behaviour encouragement such as "Please offer your seat to the disabled".

(iii) Operation instructions such as the PAA strip, hopper window and the cab to saloon door.

(i v) Warning labels such as "Keep clear of doors".

(v) Emergency signs such as the emergency exit signage and directions to emergency exits.

(c) Dynamic information in the form of the Electronic and LCD Information Displays detailed in PS 7.10.2.

7.15.2 Design and Supply of Signage

(a) The design and supply of the signage described in PS 7.15.1(a) above, shall be the responsibility of the Contractor.

(b) The design of the signage described in PS 7.15.1(b) and (c) above, in terms of the artwork, nomenclature, content and colour, will be provided by the Engineer during the design stage. The Contractor shall supply the signage to the Engineer's design. The artwork and layout of the signages shall be based on the existing T1 Trains.

(c) All signs within the passenger areas shall be in English.

(d) The labels for the emergency signage/instructions shall be reflective type for exterior signs and HPPL (high performance photoluminescent) for interior signs.

7.15.3 Positioning of Signage

(a) The Engineer shall determine the position of those signage in PS 7.15.1(b).

(b) The Contractor shall be responsible for the integration of all of the signage into the interior design such that it shall complement the interior styling.

(c) Individual signs shall be fixed so as to enable easy replacement by authorised personnel but discourage unauthorised removal.

(d) The positional location of individual signs shall be suitably defined to enable them to be installed or replaced accurately and neatly by unskilled staff.

(e) The door number identification plate/decal shall be provided adjacent to each doorway.

(f) The car numbering information shall be integrated within the PAA signage to be designed by the Engineer.

(g) Information and warning signs shall be located in the ceiling and door coving panels.

7.16 Fire Fighting Equipment

7.16.1 The, 1.14 kg (2 1/2 pound) Flag Model ABC-025, multi-purpose type fire extinguisher with a rating of 1A10B:C equipped with a ring pin seal shall be purchased from the Named Supplier, installed, interfaced, tested and commissioned. One fire extinguisher shall be provided in each operator's cab. It shall be mounted on an agreed bracket and located as shown on the NST-006 Contract Drawing. Each extinguisher shall be stamped "AUTHORITY" in 10 mm (3/8 inch) letters.

Two fire extinguishers shall be provided in each operator's cab. It shall be mounted on an agreed bracket and located as shown on the NST-006 Contract Drawing. Each extinguisher shall be stamped "AUTHORITY" in 10 mm (3/8 inch) letters.

7.16.2 Each extinguisher shall be securely mounted in the stowage position of the driving cab. The extinguisher shall be secured by a means which shall prevent rattle and accidental dislodgement but which shall allow the extinguisher to be easily released in an emergency.

7.16.3 The colour of the fire extinguisher shall be agreed with the Engineer.

7.17 Maintainability

7.17.1 Maintenance Requirements

(a) The interior design shall minimize maintenance and meet the requirements detailed in PS 26.

(b) Maintenance requirements specific to interior panels and flooring are detailed in PS 7.5 and 7.8 respectively.

(c) Equipment located behind interior trim panels shall be provided with adequate provision for access. Such provision for access shall be integrated into the design of the interior and have minimum visual impact.

(d) An anti-graffiti film which has a capability for installation, removal and replacement in situ, shall be provided on all windows at both sides of exterior and interior of the subway car. The anti-graffiti film shall be designed for fast and easy cleaning and removal, with no ghosting and no adhesive residue, low-glare performance and two-dimensional conformability. The anti-graffiti

film shall be tested to and conformed with the BS6853.

This does not apply to front facing windows and windshield.

7.17.2 Cleaning Requirements

(a) The interior layout, materials, and detail design of the car interior shall be such that one person can clean one car interior of all litter, clean up spillage of solids and liquids.

(b) The design shall facilitate ease of cleaning and avoid trapping dirt.

(c) Cleaning requirements specific to interior panels and flooring are detailed in PS 7.5 and 7.8 respectively.

7.17.3 Cleaning Philosophy

(a) The Contractor shall submit for approval the cleaning materials proposed for the cleaning of the interior, including graffiti remover.

(b) All materials selected by the Contractor shall facilitate easy cleaning. Materials shall all be capable of being cleaned by the methods specified in PS 26 without any deterioration in the material's appearance, shape or property.

(c) The interior design shall facilitate maintenance of a clean appearance.

(d) The interior design must provide a rewarding environment to clean and maintain.

(e) Cleaning performance must not decline with time.

(f) The Contractor shall ensure that there are no dirt traps or areas in the interior which cannot be reached or accessed by the cleaning equipment.

(g) To aid cleaning, forms shall employ smooth lines with minimal projections.

7.18 Safety Requirements

7.18.1 Strength of Fixtures and Fittings

(a) All fixtures and fittings, such as stanchions, hand rails, draughtscreens and seat structures, shall be capable of withstanding, without permanent deformation, all loads due to normal service.

(b) The Contractor shall submit calculations to verify the strength of all fixtures and fittings as specified by the Contractor and approved by the Engineer.

7.18.2 Safety and Security

(a) Safety shall be paramount and shall be reflected in all aspects of the design.

(b) The following shall be carefully considered:

(i) All projecting elements shall be rounded

(i i) All external corners shall be rounded

(i i i) Gaps between elements shall not create hazardous traps

(i v) All components shall remain secure if impacted and any broken elements should not leave projections

(v) Easy access to replace items if damaged shall be provided

(v i) Ensure consistency of location and operation logic for all key safety elements, such as alarms, information and fire extinguishers. All notices shall be adjacent to the referred item and clearly displayed, whilst being co-ordinated with one another

(v i i) In the event of an accident, the integrity, shape and location of all elements shall contribute to the safety and well-being of passengers, both from injury and ease of evacuation

(c) Access to safety equipment, such as fire fighting equipment and passenger communication, positions shall be clearly indicated and unobstructed.

(d) The materials (such as surface coating, metals, insulants, adhesives and fluids) used in the construction of the interiors shall not give rise to health hazards for passengers and staff. The materials shall also be suitable for normal repair operations (such as welding and cutting) without the need for staff to be protected by other than normal means.

(e) No material used in the construction of the train shall be capable of supporting

fungus, mildew, rotting or infestation.

(f) The interior of the train shall be designed to avoid pockets where illegal substances (such as drugs and explosives) can be stowed.

(g) Antimicrobial Coating

(i) To ensure health and safety of the passengers by controlling the spread and growth of many unwanted organisms, such as bacteria, mold, mildew and yeast, it is a requirement that all spring loaded handholds, stanchions, hand rails and grabhandles shall be coated with an AgION™ antimicrobial compound, which shall be able to effectively stop the growth and kills

bacteria over a short period of time through the continuous controlled release of silver (Ag) ions.

(ii) The life expectancy of the antimicrobial coating, under normal operating conditions, shall be determined by the Contractor and submitted for approval.

(iii) The coating performance shall not be affected by cleaning with a harsh detergent such as bleach.

(i v) For those stanchions and grabhandles that are fitted with colour section, the antimicrobial compound shall be blended into the surface coating.

(v) Coating containing the antimicrobial compound shall have a hardness of 2H minimum when tested per ASTM D3363.

SECTION 8 - CAB FACILITIES AND LAYOUT 2

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Section 8 - Cab Facilities and Layout

8.1 General

8.1.1. The interior of the cab shall be designed to meet the following objectives:

(a) An aesthetically attractive, pleasing interior which enhances the working environment of the train operator (which includes both the Operator and the Guard as defined in the AUTHORITY's "Subway/SRT Rule Book")

(b) Be comfortable for the train operator

(c) Be able to meet functional requirements

(d) Allow efficient, safe and stress-free execution of operating tasks

(e) Efficient and safe detrainment procedures

(f) Be easy to clean and maintain

(g) Be able to withstand daily wear and tear over the life of the train

(h) Smooth integration with the cab front design

(i) Comply with the specified operability and ergonomic requirements.

8.1.2. The general arrangement of the cab controls, indications and seat shall enable all normal driving functions to be achieved while the train operator is seated.

8.1.3. Windows shall provide good all-round visibility and prevent the ingress of

any rain.

8.1.4. All the cab facilities, with the exception of signages, shall be properly marked with labels or markings in English only (refer to PS 8.7.3). The signages shall be in English (refer to PS 8.20). The position, colour, pictograms and characters shall be submitted for approval.

8.1.5. All materials used shall satisfy the specified fire performance requirements.

8.1.6. Noise levels within the cab shall meet the specified requirements.

8.1.7. All components unless otherwise specified shall meet the reliability requirements.

8.1.8. Details of the cab arrangement, layout of the control consoles and

maintenance requirements shall be submitted for approval.

8.2 Ergonomic Design

8.2.1. Industrial & Ergonomics Specialist

(a) Apart from meeting the functional requirements laid down in this PS, the cab shall be designed with due ergonomic and aesthetic considerations.

(b) The Contractor shall submit for approval the Curriculum Vitae of the industrial and ergonomics specialists.

8.2.2. Cab Design Programme

(a) The Contractor shall submit for approval a staged programme detailing the processes for achieving the aesthetic and performance requirements of this section and thereby demonstrate their integration with the engineering requirements of this Specification. The programme shall be submitted during SEMP Stage 1.

(b) The Contractor shall be required to construct two full-scale mock-ups:

(i) Foamcore mock-up of the cab interior

(i i) Engineering mock-up of the cab interior and exterior

(c) The cab ergonomic design process shall include the following activities:-

(i) Ergonomic survey of the driving cabs of the existing T1 Train and the operating procedures.

(ii) Perspective drawings and artists impressions to demonstrate the Contractors understanding of the required style, image and aesthetics.

(iii) Dimensional drawings indicating key dimensions such as the overall length, door positions and clear openings, and sight lines.

(iv) General layout drawings showing the arrangement of equipment within the cab, taking full account of access, maintenance, cooling, cabling and fixing requirements.

(v) Review and development of pictograms on pushbuttons, switches and indicators.

(vi) A full-scale foamcore mock-up of the cab interior to demonstrate the concept

design.

(vii) Reference samples of components such as seats, lights, pushbuttons and indicators.

(viii) A full-scale engineering mock-up of the cab interior and exterior.

(ix) Design review meetings/presentations amongst the Engineer, the Contractor and his industrial design specialist.

(x) Ergonomic trials on the foamcore mock-up and the full-scale engineering mock-up, including but not be limited to the following:

1) Interior and exterior sight line trials.

2) Train operator trials on the use of cab equipment and facilities such as the detrainment device operation, driver's seat and auxiliary seat, operability of cab controls and the correct interpretation of pictograms.

(xi) Retrofitting of major equipment on the full-scale engineering mock-up such as the cab to saloon door drive mechanism, TIMS and VSS trainborne video display screens (refer to PS 10).

(xii) Transportation of the full-scale engineering mock-up from the Contractor's premises back to CITY.

8.2.3. Full-Scale Engineering Cab Mock-up

The full-scale engineering cab mock-up shall represent the required image, style and aesthetics and shall include the following:

(a) Interior

(i) Surface finishes, materials, tolerances, panel fits and colours shall comply with production standard wherever possible.

(i i) Access required for the purpose of maintenance to all equipment such as light

fittings and door gear access panels should be functional.

(iii) All engineering features such as fasteners and panel locks, wherever possible actual production items shall be used.

(i v) Representative production interior and exterior light fittings for measuring lighting levels and demonstrate the desired lighting balance.

(v) Representative production cab air conditioning control panel and vents.

(vi) All information displays such as the VSS and TIMS shall be functional for evaluation.

(vii) All control pushbuttons and indicators shall be represented by actual production items. Where illuminating controls are required then this feature shall be represented on the mock-up.

(viii) Exterior glazing such that sight lines and the elimination of internal reflections can be verified.

(ix) Fully representative production seats complete with all adjustments such as the train operator's seat sliding mechanism (refer to PS 8.13).

(x) Fully representative detrainment door and the associated mechanism (refer to PS 8.16).

(b) Exterior

(i) Representative production standard exterior profile.

(ii) Exterior maintenance access such as light fittings and windscreen washer bottle.

(iii) Representative production standard external features and fittings such as destination display, train number display, lightings and wipers. Actual production items shall be used wherever possible.

(iv) Representative production standard detrainment door. It shall be fully functional for evaluation (refer to PS 16.3).

(v) The cab mock-up shall include an exterior carbody section of which the material used shall be identical with the approved type and of sufficient length to demonstrate the jointing arrangement and the matching of panels between

the cab superstructure and carbody.

8.2.4. Construction

The structural integrity of the full-scale engineering mock-up, in particular for the detrainment door, shall be strong enough for repeated use for ongoing training purpose.

8.2.5. Erection, Transportation and Retrofitting

(a) The foamcore mock-up shall be erected at the Commission's premises in CITY whereas the full-scale engineering mock-up shall be erected at the Contractor's premises for evaluation.

(b) The Contractor shall submit a list of equipment from those specified in PS 8.2.3 that will not be available during the mock-up development stage for approval during SEMP Stage 1.

(c) The Contractor shall retrofit the equipment in PS 8.2.5(b) to the full-scale engineering mock-up once the equipment become available.

(d) The Contractor shall be required to modify the full-scale engineering mock-ups in accordance with the Engineer's comments. All design changes and modifications shall follow the specified Configuration Control Programme requirements.

(e) The Contractor shall be responsible for the transportation of the full-scale engineering mock-up from the Contractor's premises back to the Commission's premises to a specified location to be advised by the Engineer. The delivery of the full-scale engineering mock-up shall be concurrent with the delivery of the second train to CITY. All the modifications shall be completed before transportation back to CITY.

8.3 Ergonomic Considerations

8.3.1. The Train Operator

The cab shall be designed in accordance with current anthropometric data sources representative of the Canadian or American Population. Refer to the following examples of anthropometric data sources:

(a) CSA Standard (CSA-Z412) Guideline on Office Ergonomics. Dec. 2000. CSA International. Ontario. Canada.

(b) NASA. Anthropometric Sourcebook (1978). NASA Reference Publication No. 1024, Houston TX: NASA (NTIS, Springfield, VA 22161, Order No. 79 11 734).

(c) Henry Dreyfuss Associates. The Measure of Man and Woman: Human Factors In Design. 1993. Whitney Library of Design, an imprint of Watson - Guptill Publications, New York.

8.3.2. Sit/Stand Work Station

(a) The seating and control arrangements shall permit the train operator to carry out all the tasks detailed in PS 8.4 from either the seated or standing position. This shall allow the train operator to change or adjust posture to avoid tiredness and increase vigilance.

(b) The design shall allow clear external sight lines such that the full range of train operators can meet the vision requirements detailed in PS 8.5.

(c) Access and egress through the cab side doors and the emergency exits shall not be impeded by cab seats or control equipment.

(d) The train operator's seat design shall be comfortable, supportive, flexible and adjustable to maintain comfort for all train operators over a 4 hour period.

(e) An adjustable footrest shall be provided to allow a comfortable posture to be achieved by all train operators.

(f) Adequate legroom shall be allowed for all train operators.

(g) The work station shall allow comfortable reach to all regularly used controls.

(h) The train operator's head swing envelope, whilst in the seated or standing operation position, shall remain clear of the cab structure.

8.3.3. Control Layout

(a) The design shall conform to the best practices and good ergonomic principles, in particular with regard to the following:-

(i) The grouping of controls into different zones to satisfy ergonomic and operating needs

(i i) The size of controls, switches, displays and indicators

(i i i) The separation of controls and switches

(i v) The viewing distance (relaxed) to displays and indicators

(v) The comfortable and easy reach of controls

(v i) The determination of colours for displays and indicators

(b) Specific requirements for a particular control are detailed in the relevant Section.

8.4 Train Operator Duties

8.4.1. Job Purpose

The train operator is responsible for passenger train safety and the efficient operation of the trains (both on running lines and in Yards and sidings) in accordance with the working timetables or special schedule. The train

operator executes the duties in compliance with the relevant Commission's manuals or documents.

8.4.2. Main Train Operator Tasks

(a) Train preparation - As detailed in PS 9.2.

(b) Manual operation - As detailed in PS 9.6

(c) Saloon door opening and closing at platforms using controls provided on the Train Operator Console. The guard shall also be required to operate these door opening and closing controls, whilst standing at the corresponding cab side.

(d) Communication with the passengers, Traffic Controller in the Transit Control Centre, Yard Controller and train operator.

(e) Safety monitoring, defects and incidents handling, and co-ordination of safety procedures and actions.

(f) Observation of track signals as described in PS 8.5.

(g) Observation of Platform Mirror allowing the train operator a full view of the platform and train doors from the seated position.

(h) Vision and shunting within the Yard environment.

(i) Observation and control during train coupling and uncoupling.

8.4.3 Functional Responsibilities

(a) Equipment Operating Skills

The train operator is required to operate the Controller Handle, switches and equipment (such as TIMS, Radio, DVAS and PA) installed in the driving cab. The required operating skills and the associated training requirements shall be kept to a minimum.

(b) Decision Making

Based on job knowledge, the train operator must make quick and logical decisions to handle train defects or to deal with emergency incidents, without referring to supervisor.

(c) Fault Detection and Reporting

With the aid of the TIMS, the train operator shall be able to diagnose fault symptoms, identify train defect(s) and initiate appropriate actions to recover

train service, independently or with the assistance from other staff, if necessary but the design shall minimise the operating tasks.

(d) Supervision/Management

Through the communication system of the train (refer to PS 18), the train operator shall be able to obtain direct supervision from the train staff supervisor. During the handling of train defect or dealing with an incident, the train operator communicates or consults when required with Traffic Controller in the Transit Control Centre or the Station Local In-charge.

8.5 Vision Requirements

8.5.1. General

(a) The cab design shall maximise the train operator's vision through the cab windscreens and the cab side windows.

(b) The vision requirements shall be met by both seated and standing train operators.

(c) Sight lines shall not be distorted by glass as required by PS 6.11.

(d) Reflections from indicators, displays and console wash lighting shall not adversely affect the train operator's vision by day or by night.

(e) The colour of the glass on the cab side windows shall not affect the perception of signals, platform mirrors or any other exterior displays, as required by PS 6.11.

8.5.2. Signal Sight Lines

(a) Signals will be positioned to the side of the track within a height range of

track level to a maximum height of 3.5 m (12’).

(b) Signals will be positioned predominantly to the right hand side of the track, at a distance of no more than 750 mm (30”) outside the structure gauge.

(c) The train operator, without head or body movement, shall have full sight of all signals down to a distance of 4 m (13’) or less, measured between the front of the train and the signal.

(d) Under the permission of TCC, the train operator can manually key-by an automatic signal that has a red aspect lit. Typically, the key-by levers are located approximately ten feet ahead of the signal. To ensure the compatibility

with this key-by operation, it is a requirement that the distance between the centre lines of the cab window and the first leading truck shall be similar to the T1 train distance. The Contractor shall demonstrate that the manual key-by operation can be done by a train operator in the NST design.

(e) When the above key-by operation is completed, it is a requirement that the train operator shall be able to visually check the wayside train stop arm has cleared.

8.5.3. Vision of the Train Operator Console

The train operator shall have a full view of all displays and controls in the cab in both the seated and the standing positions.

8.6 Interior Styling Considerations

8.6.1. All shapes shall have rounded edges and corners, and to minimise the number of protrusions, in order to reduce injury on impact and to ease cleaning.

8.6.2. Styling aspirations require that the design shall possess:

(a) A neat layout
(b) Be ease to use
(c) Colours as defined in PS 8.19
(d) Matt finishes
(e) Flush fitting surfaces
(f) Flush controls whenever possible

8.6.3. The controls shall integrate with the styling but be commensurate with durability, cleaning and safety.

8.7 Basic Layout

8.7.1. General

The cab general layout shall be in accordance with the existing T1 Car (refer to Contract Drawing No. NST 069) and shall take account of the structural requirements detailed in PS 6.4.

8.7.2. Equipment Grouping

(a) Equipment shall be grouped in the cab to support the main train operator tasks defined in PS 8.4 and located for ease of use, operating sequence, frequency of use, functional relationship between controls and displays and for the safety critical nature of the information or control task.

(b) Whilst the detailed design of the equipment layout shall be done by the Contractor in accordance with the Specification requirements, the Commission has developed a preferred grouping arrangement of the cab controls, and they are located into the following major equipment zones as described below:

(i) Train Operator Console and Window

(i i) Auxiliary Console and Window

(i i i) "Right Hand Side" Cab Side Wall

(i v) "Left Hand Side" Cab Side Wall

(v) Ceiling

Each of the major equipment zones shall be divided into sub-zones to indicate the preferred controls grouping.

(a) The Contractor may propose alternative equipment grouping arrangement, together with ergonomic and operability justifications, for approval.

(b) The cab controls shall be classified into the following functions in view of their type of usage:

(i) Normal

(i i) Backup

(i i i) Emergency

8.7.3. Control Panels

(a) Spatial Arrangement

(i) Controls shall be located on the Train Operator Console, Auxiliary Console, Cab Side Wall Panels (Right Hand Side and Left Hand Side) and the ceiling.

(i i) The function and performance requirements of the controls are detailed in PS

9.

(b) Construction

(i) All panels, controls and instrument fixings on the Train Operator Console and the Auxiliary Console shall be invisible to the train operator where practicable.

(ii) Access to any control or instrument for maintenance purposes shall not be possible without an approved key.

(iii) Panels shall be strong, not dent and not corrode under normal in-service operating conditions during the life of the train.

(iv) Panels and controls shall be sealed to IEC 60529 IP65. Panels shall be sealed

to IEC 60529 IP34.
Item (iv): (No specifications text modifications required.)

(v) Simple access shall be provided for replacement of illuminated light sources on all illuminated equipment by one maintenance staff within 30 minutes.

(c) Pushbuttons and Indicators

(i) Unless otherwise stated, all pushbuttons shall be non-illuminating, momentary pushbuttons, flush mounted and approximate dimensions 25 mm (square or circular).

(i i) Unless otherwise stated, all indicators shall be flush or surface mounted and approximate dimensions 25 mm (1”) (square or circular).

(i i i) All illuminated pushbuttons or indicators shall be illuminated with multiple LED lights which shall be supplied from a single power source. Each light source shall be supplied by separate supply circuits to minimise the risk of failure.

(i v) Non-illuminated pushbuttons shall match illuminated pushbuttons in their physical appearance and method of operation.

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(v) Illuminated pushbuttons or indicators shall be of a type that shows the difference between the "on" and "off" state.

(v i) Control illumination and instrument panels shall not reflect in the cab windscreens.

(v i i) The indications shall be illuminated only when the associated circuits are operative.

(viii) Unless otherwise specified, high intensity LEDs of minimum intensity of 20

mcd 45 viewing angle shall be provided for the indications in the driving cabs and the Guard Control Panel (refer to PS 7.13).

(d) Legends

(i) The Contractors shall submit a list of the legends for the controls for approval.

(i i) The legends for the controls shall be clearly marked in English on the panels.

(i i i) The type font shall be Helvetica Medium with a minimum character height of 4 mm (0.16”). All legends shall be in mixed case.

(i v) The legends on the panels shall be durable for the service life of the train.

(e) Miniature Circuit Breaker (MCB) Labels

(i) The MCB panel shall incorporate grey colour coded labels for the MCB supply in the categories of DC and AC.

(i i) The grey colour coded label shall be easily distinguishable between the three

sources of MCB supply as well as the legends on the label.

(iii) The colour of the legends on the MCB labels shall be identical for the above two sources of MCB supply.

8.7.4. Train Operator Position

(a) A Train Operator Console and seat shall be arranged as far as practicable according to the existing T1 cars.

(b) It shall be located to meet the sighting, reach and comfort requirements of this Section.

8.7.5. Auxiliary Position

(a) An Auxiliary Console shall be provided on the other side (i.e. Left Hand Side) of the Train Operator Console.

(b) It shall be located to meet the sighting, reach and comfort requirements of this Section.

(c) The Auxiliary position shall include a perch seat as detailed in PS 8.13.3.

8.7.6. Detrainment Walkway

(a) A clear, unobstructed walkway shall be provided between the cab to saloon

partition door and the detrainment door. The walkway shall be centrally located to allow train-to-train detrainment.

(b) The clear opening width of the detrainment doorway shall be 762±20 mm (30” ± 0.8”).

(c) The minimum width of the detrainment walkway down the detrainment ramp shall be 711 mm (28”).

8.7.7. Emergency Detrainment Device

An emergency detrainment device shall be centrally located at the front of the cab. It shall allow detrainment as defined in PS 8.16 to track.

8.7.8. Cab to Saloon Partition Door

A two-way door shall be located at the rear of the cab to provide the facilities as detailed in PS 16.4.

8.7.9. Cab Side Wall Panel

Cab Side Wall Panels for both Left and Right Hand Sides shall be provided for the passenger doors control as detailed in PS 16.

8.7.10. Ceiling Panel

(a) The ceiling panel shall be used for location of lighting and air conditioning outlets as defined in PS 8.12.

(b) The ceiling panel shall allow sufficient headroom for all train operators.

(c) The ceiling panel shall be extended at the sides to conceal cab side door operating and control gear, but incorporate access for maintenance.

8.8 Train Operator Console and Window Area

8.8.1. General Console Layout

(a) Three separate console mouldings on the Train Operator Console shall be provided:

(i) Main Train Operator Console moulding

(i i) Train Radio and control console moulding

(i i i) DVAS and PA control console moulding

The arrangement of an existing Train Operator Console which is shown in the Contract Drawings No. NST 008 and NST 069, shall be adopted as the design baseline, where applicable.

(b) The Train Radio Control Unit (refer to PS 8.8.3(a)) and the DVAS and PA Master Control Panel (refer to PS 8.8.5(a)) shall be mounted on a separate and removable moulding or equipment housing from the main Train Operator Console so that the communication equipment can be upgraded in the future without any interruption to the Train Operator Console.

(c) The pushbuttons (with the exception of Horn and Emergency Stop) and indicators as specified in PS 8.8.4 and 8.8.7 below shall be matched functionally.

(d) Windscreen Wiper/ Washer Switch (refer to PS 6.9)

(i) The Windscreen Wiper/Washer Switch shall control the windscreen wiper and washer of both windscreens.

(i i) The following control functions shall be integrated within the controller:

(1) Park or OFF function

(2) Slow speed operation (25±1 cycles per minute)

(3) High speed operation (50±1 cycles per minute)

(4) Wash function

The switch shall be ergonomically designed and the physical appearance of the switch shall be matched with the rest of the controls on the consoles.

(e) “Right Hand Side” Reading Light Pushbutton (refer to PS 8.14.2)

(f) It shall operate the reading light above the Train Operator Console.

(g) Radio Handset (refer to PS 18.2)

(i) Handset shall be a telephone style handset with a press-to-talk facility.

(i i) A coiled cable shall be provided which shall neatly stow in a recess on the

console and not be prone to being caught or tangled.

(i i i) It shall be connected to the Console via a suitable plug or socket.

(i v) The telephone recess shall be easily cleaned and adequately drained.

(h) Integrated Controls and Indicators Panel

(i) Door Closed Indicator (green in colour) – indicator illuminated when the door proving loop circuit (refer to PS 9.9.7) is completed.

(i i) SCS Bypass Switch Indicator (red in colour) – indicator illuminated when the associated by-pass switch is operated.

(iii) Wheel Spin/Slide Indicator (amber in colour) – indicator illuminated when the associated by-pass switch is operated.

(i v) Control Test O.K. Indicator (amber in colour) – indicator illuminated when the associated by-pass switch is operated.

(v) Door Interlock By-Pass Indicator (red in colour) – indicator illuminated when the associated by-pass switch is operated.

(v i) Zero Velocity By-Pass Indicator (amber in colour) – indicator illuminated when the associated by-pass switch is operated.

(v i i) Auxiliary Power Fault Indicator (amber in colour) – indicator illuminated

when the associated by-pass switch is operated.

(viii) Traction Fault Indicator (amber in colour) – indicator illuminated when the associated by-pass switch is operated.

~~associated~~ by-pass

(ix) Trip Switch / Emergency Brake Loop By-Pass Indicator (amber in colour) – indicator illuminated when the associated by-pass switch is operated.

(x) ~~Emergency Brake Indicator (red in colour) – indicator illuminated when the switch is operated~~.

Emergency Brake Indicator (red in color) – indicator illuminated when the train is in emergency braking.

(xi) ~~Parking Brake Applied Indicator (red in colour) – indicator illuminated when~~ the associated by-pass ~~switch is operated~~.

Parking Brake Applied Indicator (red in color) – indicator illuminated when parking brake is applied.

(xii) EP. Brake Indicator (amber in colour) – indicator illuminated when the associated by-pass switch is operated.

(xiii) Ventilation fault indicator (amber in colour) – indicator illuminated when the associated by-pass switch is operated.

(xiv) Couple Pushbutton (red in colour with flip-open cover)
Item (xiv): (No specifications text modifications required.)

(xv) Uncouple Pushbutton (green in colour)

(xvi) Control Test Pushbutton (built-in red colour LED – ON when operate pushbutton, with flip-open cover)

(x v i i) Dimmer Pushbutton (amber in colour)

(x v i i i) General Fault Reset Pushbutton (amber in colour)

(x i x) Bell Pushbutton (amber in colour with flip-open cover) (refer to PS 9.12.8).

(x x) Indicator Test Pushbutton (amber in colour) – all indicators shall be illuminated when the pushbutton is depressed.

Unless otherwise specified, LED shall be used for all indicators. Control functions shall refer to PS 9.12.2. The arrangement of the existing Console

Indicator Panel which is shown in the Contract Drawing No. NST 068, shall be adopted as the design baseline, where applicable.

8.8.2. Windscreen Area

(a) Destination Display and Controls

A destination display shall be provided on the upper part of the windscreen as specified in PS 6.9.4. The destination shall be visible inside the cab.

(b) Sun Visor

(i) A sun visor shall be fitted which shall be extendable down to height such that a minimum clear vision will be maintained through the window to enable a safe driving decision to be made by the train operator.

(i i) It shall be freely adjustable stopping at any height and remaining steady at the

position set.

(iii) It shall not rattle or vibrate excessively as to affect the visibility of the train operator under all train operating conditions.

(i v) It shall be possible to secure the sun visor in the stowed position.

(v) It shall be non-reflective.

(v i) It shall permit an acceptable level of visibility through the sun visor.

(v i i) It shall not cause colour distortion of the track signal.

(c) Train Number Display and Controls (refer to PS 6.9.4)

8.8.3. Radio and TIMS Control Area

(a) Train Radio Control Unit and Loudspeaker (refer to PS 18.2)

(i) The equipment housing for the Train Radio Control Unit and the loudspeaker shall be designed to be easily removable from the Train Operator Console (refer to PS 8.8.1(b) & (c)).

(ii) Refer to Appendix I Annex 4 for the dimensional details of the Train Radio Control Unit and the loudspeaker.

(b) TIMS Display and Controls (refer to PS 10.7)

8.8.4. Instrumentation Area

(a) Speedometer

(i) A speedometer which formed part of the TOD of the SCS (refer to Clause 1.2.1 of Appendix I Annex 3) shall be installed.

(ii) Provision shall be made to allow for easy access of inputs to the TOD for test purposes.

(b) Duplex Pressure Gauge

(i) The Duplex Pressure Gauge shall be an analogue pointer device with two separate scales indicating brake cylinder pressure and main reservoir pipe pressure.

(i i) Markings, numerals, pointers and characters shall be white on a black background and shall comply with BS 3693 : 1992.

(i i i) The display should be side or back lit.

(i v) Numerals and text shall be in Helvetica Medium.

(v) The pointer shall have parallel sides, except that the end shall taper such that the tip is the same width as the scale markings.

(v i) The main reservoir pipe pressure scale shall incorporate colour coded bands: green to indicate a safe and satisfactory condition, yellow to indicate a condition requiring caution, checking or delay and red to indicate a potential danger or malfunction requiring immediate action.

(v i i) The gauge shall have a range of 30% greater than the main reservoir pipe safety valve pressure.

(c) Emergency Stop Pushbutton (refer to PS 9.9.5)

(i) Emergency Stop Pushbutton shall be a red "mushroom" type button with protective collar to protect against accidental actuation.

(i i) It shall have a minimum diameter 55 mm and shall protrude approximately 30 mm from the surface to facilitate operation in an emergency.

(i i i) The pushbutton shall be designed such that it will provide an obvious visual indication to the train operator that it has been operated.

(d) General Fault Reset Pushbutton (refer to PS 9.12.2)

(e) Parking Brake Pushbutton (refer to PS 9.12.2)

(f) Overspeed Alarm (refer to PS 9.6.3(b))

8.8.5. DVAS and PA Master Control Panel

(a) The equipment housing for the DVAS and PA Master Control Panel (refer to PS 18.4) and the microphone) shall be designed to be easily removable from the Train Operator Console (refer to PS 8.8.1(b) and (c)).

(b) DVAS and PA Microphone (refer to PS 18.4)

(i) The microphone and the associated coiled cable cord shall be positioned on the DVAS and PA Master Control Panel equipment housing to ensure the safe, neat and convenience operation of the microphone and the surrounding controls.

(ii) It shall be connected to the equipment housing via a suitable plug or socket.

(iii) The microphone recess shall be easily cleaned and adequately drained.

(c) VSS Trainborne Video Display (refer to PS 18.3)

The screen shall be shrouded to prevent sunlight causing reflections or glare. The screen image shall not reflect in the windscreen or other cab windows at night.

8.8.6. Cab Side Wall Control Panels

The Door Control Panel which shall comprise of the following equipment, shall be provided for each Cab Side Wall Control Panels on both side of the cab. The arrangement of the existing “Right Hand Side” Door Control Console which is shown in the Contract Drawing No. NST 067, shall be adopted as the design baseline, where applicable. The “Left Hand Side” Door Control Console shall be an mirror image of the “Right Hand Side” console:

(a) Door Control Master Switch

(i) A single handle Door Control Master Switch which shall only be operated ~~with the AUTHORITY 's staff key (refer to PS 32) to activate the door control circuit.~~ with the AUTHORITY 's Square SRT Key (refer to PS 32) to activate the door control circuit.

(ii) Clockwise rotation of the handle to approximately 90° shall turn the door control master switch to the "ON" position and the door control circuit shall be activated.

(iii) Counter-clockwise rotation of the handle shall turn the door control master

switch to the "OFF" position and the door control circuit shall be deactivated.

(iv) The handle shall be normally locked in the "OFF" position with the staff key removed.

(v) Clockwise rotation of the key shall unlock the handle and when the handle is moved to the "ON" position, the key shall become captured.

(vi) It shall be impossible to move the key to the locked position unless the handle is in its "OFF" position.

(vii) Turning the handle to its "OFF" position shall allow the spring lock to lock the handle in the "OFF" position and release the key.

(viii) The panel and enclosure shall be constructed to prevent the entry of water from an open window and provide for drainage of condensate.

(b) Two door "open" pushbutton switches which shall be red in colour and shall be simultaneously depressed to command the doors on that side of the train to open.

(c) One doors "close" pushbutton switch which shall be green in colour.

(d) ~~Two doors "closed and locked" LED indicator light which shall be green in colour~~.

<u>One door "closed and locked" LED indicator light which shall be green in color.</u>

(e) Buzzer Pushbutton (refer to PS 9.12.8)

A bi-coloured LED Indicator ~~to show the status of: (a) when the LED is not illuminated, the door control is not active; (b) when the LED is illuminated in green colour, the door control is enabled; and (c) red to indicate that another~~

~~Door Control Master Switch (PS 8.8.6(a)) of the train has been moved away from the "OFF " position~~.

An amber indicator to show the status of the Door Supply and a red indicator to indicate that another Door Master Switch of the train has been activated

In addition to the bi-coloured LED indicator as specified in PS 8.8.6 (f), a single LED indicator shall be provided in the Master Door Control Panel to maintain consistency with the existing door operation.

8.8.7. Master Control Area

(a) Traction Brake Controller (TBC) (refer to PS 9.6.2)

(i) The TBC shall have an ergonomically shaped handle.

(i i) The TBC shall incorporate a Dead-person's Safety Device.

(i i i) The TBC shall comply with the detailed operational requirements defined in PS 9.6.2.

(b) Mode Selector (refer to PS 9.5.2)

(i) The switch shall be within easy reach of the train operator with labels indicating mode positions clearly visible.

(ii) Mode positions shall be positively indented to confirm selection and prevent vibration or accidental knocking causing a change in selection.

(c) Emergency Reset Pushbutton (refer to PS 9.9.5(c)(iii))

(d) Horn Pushbutton

(i) Two horn pushbutton shall be provided and located at the top corners of both side of the Master Control Area.

(ii) Horn shall be a yellow "mushroom" button of diameter 40 mm, and shall protrude approximately 25 mm from the surface to facilitate operation in an emergency.

(iii) It shall be clearly discernible from the large, red Emergency Stop Pushbutton.

8.8.8. Adjustable Footrest

A two-position adjustable footrest with a non-slip surface shall be provided

under the Train Operator Console to ensure a relaxed seated position.

8.8.9. Coffee Cup Holder

A coffee cup holder of open bottom type with a 2” deep stopper at the end and able to hold up to 3.5" diameter cup shall be provided to keep the cup in place and for quick coffee access according to the design of the T1 train. The coffee cup holder shall be located at the corner space between the Master Control Area (refer to PS 8.8.7) and Cab Side Wall Control Panels (refer to PS 8.8.6). Design consideration shall be given to the coffee cup holder in such a way that there shall be no spilling hazard of the hot liquid inside the cup when it is placed in the cup holder, and the cup holder itself shall not be an obstacle for access through the cab bodyside door.

8.9 Auxiliary Console and Window Area

8.9.1. An auxiliary console which shall be a two separate console mouldings located on the "Left Hand Side" of the cab, shall be provided:

(i) Auxiliary Train Operator Console moulding

(i i) Auxiliary Cubicle moulding

8.9.2. For the Auxiliary Train Operator Console, it shall be comprised of equipment as specified in PS 8.9.9 to 8.9.15. For the Auxiliary Cubicle, it shall be able to store in an orderly manner the equipment as specified in PS 8.9.4 to 8.9.7 and the method of stowage shall prevent unauthorized access except by the use of the cab door key as detailed in PS 32.

8.9.3. Fire Extinguisher

(a) The Auxiliary Cubicle shall provide a recess for an ease access of the fire extinguisher. The extinguisher shall be securely retained within the recess with a quick release retaining bracket.

(b) The fire extinguisher shall be identical to the one specified in PS 7.16.

8.9.4. Auto coupler Pneumatic Isolation Valve

(a) This isolation valve shall be recessed into the Auxiliary Cubicle.

(b) The isolation valve shall be covered with a transparent panel, which shall be arranged such that it will not close; and hence provide a visual indication; if the isolation valve has been operated.

(c) Provision shall be made for the panel in the open position to be suitably restrained.

8.9.5. Door Barrier

~~Space shall be provided for the AUTHORITY ’s door barrier, measuring (300 x 300 x 150) mm.~~

It is a requirement that Door Barriers according to the following requirements, shall be provided:

(a) The design of door barrier shall be able to fit in the space of doorway which shall be measured as (300 x 300 x 150) mm.

(b) The design of the door barrier shall be similar to T1 (refer to Contract Drawing No. NST-016) and shall be installed on each side of the door pillar by using the "D" ring and clip according to PS 7.5.11(d).

(c) Material of door barrier shall be durable and complied with the specific requirements according to Sections 20.2 and 20.3 of the Specification.

(d) Sample of door barrier shall be submitted or approval prior to mass

production.

(e) Quantity required: 2 per cab for 39 TR trainsets plus 2 for the CABSIM.

8.9.6. Collector Shoe Isolating Sticks

One collector shoe isolating stick as detailed on the Contract Drawings No. NST 028 shall be provided with each cab. Space shall be provided for the collector isolating stick.

8.9.7. Uncoupling Lever

One uncoupling lever according to the Contract Drawing No. NST 035 shall be provided with each cab. Space shall be provided for the uncoupling lever.

8.9.8. Cab Side Wall Control Panels (refer to PS 8.8.6)

8.9.9. DVAS and PA Auxiliary Control Panel (refer to PS 8.8.5 and 18.4)

8.9.10. Sun Visor (refer to PS 8.8.2(b))

8.9.11. Windscreen Wiper/ Washer Switch (refer to PS 8.8.1(d))

8.9.12. Emergency Stop Pushbutton shall be identical to that specified in PS 8.8.4(c).

8.9.13. Horn Pushbutton shall be identical to that specified in PS 8.8.7(d).

8.9.14. “Left Hand Side” Reading Light Pushbutton shall be identical to that specified in 8.8.1(e), except that it control the reading light above the Auxiliary Console.

8.9.15. Coffee Cup Holder (refer to PS 8.8.9)

8.10 "Right Hand Side” Cab Back Wall

The following equipment shall be provided in the "right hand side” cab back wall:

8.10.1. Emergency Control Panel

(a) This control panel shall be recessed to ensure that train operator will not hit his head on the controls during the seat sliding operation.

(b) Each control shall be labelled and comprised a sealed switch. The height of the panel shall be suitable to allow train operator to operate the controls and to read the labels for the controls.

(c) The panel shall be covered with a transparent panel, which shall be arranged such that it will not close; and hence provide a visual indication; if one of the sealed switches has been operated.

(d) Provision shall be made for the panel in the open position to be suitably restrained.

(e) The following sealed switches shall be included:

(i) Trip Switch / Emergency Brake Loop By-Pass Switch (refer to PS 9.9.6)

(i i) Door Interlock By-Pass Switch (refer to PS 9.9.7)

(i i i) Brake Loop Selector Switch (refer to PS 9.12.3 (b))

(i v) Zero Velocity By-Pass Switch (refer to PS 9.8.13)

(v) SCS Bypass Switch (refer to Appendix I Annex 3 Clause 2.1.4),

The design of all by-pass switches shall ensure that no single point failure will produce an undemanded by-pass output signal from the switch. The status of all by-pass switches shall be monitored by the TIMS. Operation of any by-pass switch shall be reported to the train operator and recorded in the Event Recorder.

(f) Emergency Traction Power Off Pushbutton (refer to PS 9.4)

(g) Snow brake switch (refer to PS 9.12.5)

(h) Buzzer with at least 10 different selectable buzzer tones and 80dB (typical) sound output at 0.5m (1.6’) (refer to PS 9.12.8)

(i) Single stroke signal bell with 78dB (typical) sound output (refer to PS 9.12.8)

8.10.2. Auxiliary Control Panel

(a) Auxiliary ON (a.k.a. Battery Connect) Pushbutton (Refer to PS 9.2.1)

(b) Auxiliary OFF (a.k.a. Battery Disconnect) Pushbutton (Refer to PS 9.3.1)

(c) Traction Fault Indicator (Refer to PS 9.12.2)

(d) Emergency Traction Power Off Pushbutton (Refer to PS 9.4.1) – shall be equipped with transparent spring return flip-over protective cover to prevent inadvertent operation. The status of this pushbutton shall be monitored by the TIMS. Operation of this pushbutton shall be reported to the train operator and recorded in the Event Recorder.

(e) Auxiliary Power Fault Indicator (Refer to PS 9.12.2)

(f) Ventilation Fault Indicator (Refer to PS 9.12.2)

8.10.3. Cab Main Light Pushbutton (refer to PS 8.14.1.(e)).

8.10.4. Power Supply Socket

(a) To enable the use of AC portable electrically operated equipment, the driving cab and the Guard Control Panel (refer to PS 7.13) shall be equipped with a polarized receptacle as fed from the battery supply and fused at 15 amperes, plus and another receptacle of U-ground type fed from the 120 V AC supply and fused at 20 amperes. The AC receptacle shall be mounted with the earth pin lowermost and complied with Canadian plug and socket standards as outlined by CSA in publication C22.2, No. 42.

(b) The socket outlet shall be easily accessible.

(c) The supply shall always be available, whenever the corresponding AC supply is available.

(d) The AC supply shall be provided from an isolation transformer. The centre tapping of the transformer output winding shall be earthed to the carbody.

8.10.5. Battery Voltmeter

8.11 "Left hand side" Cab Back Wall

8.11.1. Coat Hook

The Left Hand Side Cab Side Wall shall be fitted with a coat hook for a train operator to hang a jacket without it obstructing any switches or controls and without it being exposed to any particularly dirt areas.

8.11.2. Auxiliary Seat

Auxiliary seat shall satisfy the requirements specified in PS 8.13.

8.11.3. MCB panel

(a) MCB panel shall consist of miniature circuit breakers as detailed in PS 9.

(b) The panel shall be covered by a transparent cover.

8.12 Ceiling

8.12.1. Air Fan and Vents

(a) A low noise and maintenance free type air fan with variable speeds shall be provided to regulate the airflow.

(b) An adjustable air supply vent shall be provided to adjust airflow onto the train operator's head and torso, or to direct the airflow away from the train operator if so desired, to ensure a draught-free environment.

(c) A separate air supply vent shall be provided to direct airflow onto the cab windows for defroster purpose.

(d) The air return vent and the air supply vent shall be located to avoid short circuit of cool air.

8.12.2. Air Fan Control Panel

Air Fan speed control which shall allow adjustment of the speed and quantity of conditioned air into the cab.

8.12.3. A cab main light shall provide general illumination throughout the cab as specified in PS 8.14.1.

8.12.4. Reading lights shall provide illumination as specified in PS 8.14.2.

8.12.5. Detrainment light shall be mounted in the ceiling to provide illumination as detailed in PS 8.14.3, during an emergency detrainment.

8.13 Seating

8.13.1. General

(a) The train operator and auxiliary seats shall be installed in each cab and located in the Right and Left Hand Sides respectively.

(b) ~~The seats shall be designed in accordance with the ergonomic requirements detailed in PS 8.3~~.

The operator seat shall be designed in accordance with the ergonomic requirements detailed in PS 8.3.

(c) The design and location of the seats shall allow train operator to meet the vision requirements detailed in PS 8.5.

(d) ~~The upholstery material shall be designed to avoid causing the train operator to perspire excessively. The colour and finish shall be as defined in PS 8.19~~.

The auxiliary perch seat shall use black fabric of the same type as on the passenger seats.

8.13.2. Train Operator Seat

(a) The Contractor shall purchase from the Named Supplier of the Operator's seat.

(b) Maintainability

The train operator's seat shall be designed such that it can be removed and installed by one competent maintenance staff within 20 minutes.

8.13.3. Auxiliary Seat

(a) A perch seat shall be provided for occasional use by a train operator.

(b) The seat shall be fitted using quick release fastenings to allow simple maintenance access to equipment behind the bulkhead.

8.14 Cab Lighting

8.14.1. Main Light

(a) A main cab light shall be provided in the ceiling.

(b) ~~This light shall provide general illumination throughout the cab to an average level of 200 lux at floor level.~~ This light shall provide general illumination throughout the cab to an average level of 140 lux at floor level.

(c) The light shall have a colour temperature of 3500 - 4500 K.

(d) The light shall not reflect in the windscreen, other cab windows, VSS trainborne video display screens, or other console displays.

(e) The light shall be switched by the control detailed in PS 8.10. It shall also be automatically switched on at full illumination when the cab to saloon partition door is opened, including in the event of an emergency detrainment.

~~8.14.2. Reading Light~~

~~(a)~~ Reading lights shall ~~be provided in the ceiling above the Train Operator Console and Auxiliary Console.~~

(b) ~~These lights shall provide a narrow beam of light sufficient to allow reading at the console without illuminating the complete console.~~

(c) The light level, measured at the ~~console, due to this light alone shall be 300 lux.~~

(d) ~~The light shall not reflect in any cab window, VSS trainborne video display screen or other console displays.~~

(e) ~~Controls shall be provided as specified in PS 8.8 and 8.9.~~

Item 8.14.2 removed (No replacement Specification required)

8.14.3. Detrainment Light

(a) A detrainment light shall be mounted in the cab ceiling.

(b) It shall provide a minimum light level of 200 lux on the detrainment ladder and up to 2 m beyond the ladder when in the deployed position.

(c) The light shall automatically illuminate upon deployment of the Emergency Detrainment Device.

8.15 Cab Doors

8.15.1. General

(a) Cab doors comprising a saloon to cab partition door, an emergency detrainment door and 2 manually-operated siding-plug doors.

(b) All external cab doors shall meet the sealing, locking and performance requirements detailed in PS 16.

(c) All external cab doors shall withstand the aerodynamic pressure pulses and glazing requirements detailed in PS 6.8.

8.15.2. Cab to Saloon Partition Door

A cab to saloon partition door shall be provided as specified in PS 16.4.

8.15.3. Emergency Detrainment Door

The emergency detrainment door shall be provided as part of the Emergency Detrainment Device detailed in PS 8.16.

8.15.4. Cab Bodyside Doors

(a) A manual operate single leaf sliding plug type of cab bodyside door of a similar construction to the passenger bodyside doors, shall be provided, with at least 500 mm clear width and 1 950 mm clear height, for each side of the cab. The cab side window (refer to PS 6.11.2(c)) shall form an integral part of the cab bodyside door.

(b) The sliding door tracks shall be aesthetically hidden within the cab front or car side.

(c) Each door shall incorporate a heavy duty mechanical lock which engages automatically when the door is fully closed. The mechanical lock shall be spring loaded and manually released by using the door opening device.

(d) The lock shall positively engage the door leaf and be able to release automatically when the door opening device are legitimately operated.

(e) On each cab side door, two door opening device shall be provided adjacent to ~~the cab~~ door on both inside and outside of the cab. On the cab exterior, the device shall be located at a position that is accessible from the platform, the track or from the depressed floor in the yard.

(f) This device shall only be operated by using the cab door key, to unlock the door. When the lock is released, it shall be possible to push/slide open the door from inside or outside of the cab.

(g) The door leading ~~edge seals shall be configured in such a way, utilizing interlocking mating arrangements, that the locking devices shall not engage in the presence of small obstruction of maximum thickness 3 mm at any height~~ of application using the measurement gauge as shown ~~in the Contract Drawing No. NST 077~~.

The door leading edge seals shall be configured in such a way, utilizing interlocking mating arrangements, that the locking devices shall not engage in the presence of small obstruction of MINIMUM thickness 3 mm at any height ~~of application using the measurement gauge as shown in the Contract~~ Drawing No. NST 077.

(h) Each mechanical lock shall be fitted with a sensor to prove that the door is locked. The status of the mechanical lock shall be interlocked with the door proving loop circuit (refer to PS 9.9.7) monitored by the TIMS.

(i) The mechanical lock shall not require lubrication between overhauls.

(j) Steps shall be provided on the cab exterior to facilitate entry into the cab through the cab bodyside door from rail level. The step width shall be a

minimum of 400 mm and the step depth a minimum of 180 mm, with a minimum aperture height of 165 mm. The steps shall have an anti-slip surface. The steps shall be aerodynamically shaped.

(k) Grab-handle shall be provided inside the cab, on both sides of each cab side door pillar, to assist entry to the cab from rail level. The minimum width between grabhandles shall be greater than 500 mm so as not to restrict access through the cab side doors. The grabhandle shall be of diameter 30 mm with a clearance of at least 40 mm around the handrail. All grabhandles shall withstand a horizontal load of 900 N applied as a point load at any point of handle span, superimpose by an uniformly distributed load of 1 300 N/m shall not bend and cause any permanent deformation on the grabhandle or their attachments carbody.

8.16 Emergency Detrainment Device

8.16.1. General

(a) The device shall comprise a detrainment door panel and detrainment ramp completed with handrails that operate as shown in Contract Drawing No. NST 072.

(b) The emergency detrainment device shall allow the detrainment of 1500 passengers in a maximum period of 25 minutes, including deployment time.

(c) The minimum headroom height through the detrainment door shall be 1 930 mm for all modes of detrainment.

(d) The design life of the Emergency Detrainment Device shall be equal to the life of the train.

(e) A fully functional production type installation shall be provided in the cab mock-up to review and prove the design of the detrainment door.

(f) Testing shall be conducted to demonstrate that the requirements of PS 8.16 have been satisfied (refer to Appendix B Clause 2.11).

(g) On the detrainment door panel, a glass window shall be provided. Identical requirement of Cab Windows shall be applied to this detrainment door window (refer to PS 6.11.2). The size of the detrainment door window shall be maximised to provide the train operator a good vision, and the upper position of this window shall be aligned with the horizontal line of the Cab windscreens.

(h) Instructions which shall be written in English with the aid of graphical illustration, simple and easy to understand, for operating the emergency

device including both detrainment door and ramp shall be provided and prominently displayed.

8.16.2. Detrainment Modes

(a) The detrainment door shall have one basic modes of operation, namely, the Train-to-Track detrainment mode.

(b) Not used.

(c) After detrainment door panel has been either slide-opened or upward lifted, a detrainment ramp shall be available for Train-to-Track detrainment purpose.

(d) The detrainment ramp shall comprised of the foldable ramp with handrails and it shall be stored behind the detrainment door panel when it is not in use.

(e) In the stored position, the detrainment ramp shall be integrated into the design of the cab interior. The transition between detrainment ramp fittings and the cab floor shall be smooth and free from steps. Fittings at floor level shall not trap dirt.

(f) Once manually activated, the deployment of the ramp and the handrails shall be fully automated and the ramp shall be rendered ready for immediate use.

(g) During the ramp deployment, the walkway floor shall be deployed, and the handrails shall be automatically folded up at the same time.

(h) In the deployed position, the detrainment ramp shall be able to rest firmly on top of the track.

(i) The deployment process of the detrainment ramp shall not be more than 2 steps.

(j) An additional device which shall be accessible from the outside and underneath of the cab, to operate detrainment door and deploy the detrainment ramp, shall be provided.

(k) The ramp shall be equipped with handrails on both side to guide passengers safely down the ramp. The handrails shall be automatically erected when the detrainment ramp is deployed.

(l) A floodlight which shall form part of the emergency system (refer to PS 17.1.4) and be located at the top corner of the cab, shall be provided and automatically lit up when the detrainment door panel is deployed to provide illumination on the exit path. The illumination intensity on the upper surfaces of a horizontal plane, at the mid point of the doorway of the detrainment ramp, 84 cm (33 inches) above the floor, with nominal regulated voltage available,

shall be not less than 485 lx (45 foot candles) at a distance of 38 cm (15 inches) from the longitudinal centre line of the detrainment ramp.

8.16.3. Mechanism

(a) The detrainment door mechanism shall be robust and durable. Its fitness for purpose shall be proven by type test as stipulated in Appendix B Clause 2.11.

(b) The mechanism shall be designed to prevent rattling, chafing or mechanical degradation in any way during its service life in the stowed position.

(c) When operated, the mechanism shall function in a safe and secure manner that inspires confidence in use of the device amongst potentially disoriented users. Loud noises shall be avoided during deployment.

(d) The deployment rate shall be controlled to minimise risk of injury to users or other third parties in front of the train. It shall allow sufficient time for an able bodied person to move out of the way if an unexpected release of the ramp occurs.

(e) For the automatic deployment of the secondary ramp, its rate of deployment shall be carefully designed to reduce the risk of passenger injury in an attempt to rush out into the ramp.

(f) The mechanism shall be designed to be safe for use by untrained users presenting no finger traps or other dangers when deployed.

(g) The walking surface of the deployed detrainment ramp shall be:

(i) stiff

(i i) clear and flat

(i i i) anti-slip, even when wet

(h) The deployed ramp shall make an angle with the track of 20° or less.

(i) The edges of the ramp shall be clearly marked.

(j) Handrails shall be provided along the full length of the detrainment ramp to assist the detrainment of passengers.

(k) An emergency hand held flashlight shall be attached on the panel adjacent to the detrainment door panel.

(l) The status of the detrainment door shall be monitored by the TIMS as part of the Door Closed Proving Loop according to PS 9.9.7.

(m) A detailed safety study shall be conducted on the Emergency Detrainment

Device as stipulated in PS 25. Special consideration shall be given to the situations of :

(i) Failure to deploy

(i i) Accidentally deployed

8.16.4. Deployment

(a) The device shall be easily operated under the following conditions:

(i) all types of straight and curved track as specified in Appendix I Annex I.

(i i) all train loading conditions, including fully deflated suspension.

(i i i) all environmental conditions as specified.

(i v) easy to deploy by one 5th percentile Canadian female.

(b) The method of deployment shall be simple to operate and easy to understand, requiring only limited instructions.

(c) The detrainment door shall be opened and the ramp deployed by an untrained member of the public in less than 1 minute (refer to 8.16.2(c)). The satisfactory achievement of this shall be determined by type test using untrained persons in a simulated emergency situation.

(d) The method of deployment shall be designed to safeguard against the possibility of accidental deployment. Deployment shall require a specific and deliberate act.

8.16.5. Stowage

(a) The deployed emergency ramp door shall be stowed and restored to the normal position in 5 minutes or less by one trained person.

(b) The stowed condition achieved in this time shall be a fully operational state, not an intermediate un-set state. Any specialised tools required for stowage shall be suitable for in-cab storage and provision shall be made to stow them

where they shall not rattle or obstruct other routine cab activities.

(c) When stowed, the door shall in its aperture preventing any draughts, dirt or water entering the cab and it shall not generate any wind related or other noise. The arrangement shall comply to IEC 60529 IP65.

8.16.6. Strength

(a) The device shall withstand a passenger load applied over the complete ramp area of 6 passengers/m2, each of mass 60 kg (132 lbs), under all deployed conditions. An additional safety factor of 1.5 shall also be incorporated.

(b) The device shall not suffer cosmetic, structural or other damage when

operated.

8.16.7. Reliability

(a) The device shall designed for a 99.99% reliability on opening (fully automated or with manual help). The endurance test described in Appendix B Clause 2.11 shall then be used solely to validate the design.

(b) For reliability calculation purpose, the frequency of usage shall assume to be twice per annum across the whole fleet of trains.

8.17 Cab Flooring

The cab floor shall be fitted with the same covering and board as that specified for the saloon flooring in PS 7.8.

8.18 Internal Panels

8.18.1. Internal cladding panels comprising:-

(a) Wall panels

(b) Ceiling panels

(c) Pillar cladding

(d) Console panels

(e) Cab rear panels

8.18.2. The panels shall allow access for maintenance or repair to any components, wiring or ducting. The panels shall cover all wiring, ducting, piping and structure.

8.18.3. The number of fixings shall be minimised. As far as practicable, no fixings

shall be visible or accessible to the train operator. Access into consoles or electrical cabinets shall only be possible by the use of an approved key.

8.18.4. All gaps between panels shall be designed to project a neat, flush and parallel appearance.

8.18.5. All corners and edges in the cab shall have a radius of no less than 5 mm (0.2”). Wall to floor, and wall to ceiling joints shall have contoured covings similar to the passenger interior compartment to facilitate cleaning.

8.18.6. The panels shall be easily cleaned. There shall be no dirt traps.

8.18.7. The panels shall not be prone to breakage or denting, in everyday use. The finish shall not deteriorate significantly over the life of the train.

8.19 Colour

8.19.1. Colours used shall follow the National Colour System (NCS) 1986 as specified in PS 7.3.2(a) and (b) or an equivalent colour systems which shall be submitted for approval.

8.19.2. The Contractor shall follow the colour scheme as specified in the following table:

Item	Description	Colour
1	Instrument and control panels	Black NCS 8502R
2	Console upper surfaces	Grey NCS 5500N
3	Console lower surfaces	Grey NCS 1000N
4	Side and rear wall panels	Grey NCS 6502Y
5	Pillars	Grey NCS 6502Y
6	Ceiling panels	Off White NCS 0502Y
7	Seating upholstery	Red NCS 2080 Y90R Black NCS 9500N
8	Seat mouldings	Grey
9	TBC and Mode Selector	Black NCS 8502R
10	Floor	Same as saloon flooring as specified

Item	Description	Colour
1	Instrument and control panels	Black FLNA 40757
2	Console upper surfaces	Grey FLNA 40794
3	Console lower surfaces	Grey FLNA 40795
4	Side and rear wall panels	Grey P-203-CA
5	Pillars	Grey FLNA 40794
6	Ceiling panels	Off White HPL P-271-CA Fresh Mist
7	Seating upholstery	Black Leather
8	TBC and Mode Selector	FLNA 40757
9	Floor	Same as saloon flooring as specified

8

(e) Tactile finish

8.19.3. The gloss level shall be 50+ 5% unless otherwise specified. Adjacent panels shall be selected to minimise the visual difference between the gloss levels.

8.20 Signage

8.20.1. General

Wherever possible graphic symbols shall be used. Where text is employed it shall be in the English language.

8.20.2. Cab Detrainment doors

(a) Signage according to APTA SS-PS-002-98 Rev 2, “Standard for Emergency Signage for Egress/Access of Passenger Rail Equipment”, shall be provided.

(b) The signage used on the cab to saloon partition door and the emergency detrainment device shall be submitted for approval.

SECTION 9 OPERATION AND CONTROL 1

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Section 9 Operation And Control

9.1 General

9.1.1. The design of train operating and control principles shall be consistent with those of the existing T1 Trains in order to preclude human errors due to inadvertent use of the accustomed train operating procedures and minimise the

training for train operators of the existing T1 Trains. The arrangement of control and indication equipments of the existing T1 cab which is provided in Contract Drawings No. NST 067, NST 068 and NST 069, shall be adopted as the design baseline, where applicable.

9.1.2. For the purpose of this Section, the basic operation and control requirements are specified according to the experience gained from the existing T1 Trains. Operating or control logic conflicting with the existing practices shall be avoided. Copies of the Commission's train operation procedures for operating the existing T1 Trains are available for the Contractor's reference.

9.1.3. This Section shall be read in conjunction with PS 4 - System Description and Performance Requirements, PS 8 - Cab Facilities and Layout, PS 10 - Train Information Management System, PS 18 - Communication and PS 21.5 - Operability Plan to ensure proper integration of human factors into the specific operation and control requirements, along with the train systems

hardware, software, data and other elements.

9.1.4. Unless otherwise specified, all the operation and control circuits shall be 37.5DC supplied. These 37.5VDC supplied systems/equipment shall function satisfactorily at battery supply voltages of 37.5VDC as specified in PS 17.4.1.

9.1.5. The Contractor shall minimize the use of control relays on the train for reliability and maintainability reasons. Unless it is approved by the Engineer, solid state or microprocessor based control equipment shall be used as far as practicable.

9.2 Train Systems Initialisation

The following control arrangement shall be provided for manual preparation of the train when the train is not located in the depot equipped with the YMSS (refer to Appendix I Annex 4):

9.2.1. When the Auxiliary On pushbutton (refer to PS 8.10.2(a)) is pressed and released, the following systems/equipment shall be automatically activated:

(a) Train Information Management System (refer to PS 10);

(b) DC circuit (refer to PS 17.4);

(c) emergency systems (refer to PS 17.1.4);

(d) communication system (refer to PS 18.1.4).

9.2.2. When the 600VDC traction supply (refer to Appendix I Annex 2) is collected, the following system/equipment shall be automatically activated:

(a) auxiliary converter (refer to PS 17.1.1);

(b) air compressor (refer to PS 17.1.1);

(c) AC circuit (refer to PS 17.3);

(d) Saloon air conditioning units (refer to PS 15.10); and

(e) lighting (refer to PS 7.9).

Sequential control arrangements similar to those specified above shall also be provided for the automatic train preparation (refer to PS 10.3.2).

9.3 Train Systems Shut Down

The following control arrangement shall be provided for manual shut down of the train when the train is not located in the depot equipped with the YMSS (refer to Appendix I Annex 4):

9.3.1. When the Auxiliary Off pushbutton (refer to PS 8.10.2(b)) is pressed and released, the shutdown sequence of the systems/equipment shall be automatically initiated in the reversed order of PS 9.2.

9.3.2. The following functions shall be performed in addition to the above shutdown sequence:

(a) After the completion of pumping down the refrigerant of the air conditioning system (refer to PS 15.15.9), the auxiliary converters shall be shut down.

(b) In order to avoid arcing occurred in the high tension circuit breakers, all 600VDC systems/equipment including auxiliary converters and air compressors shall shut down before the associated 600VDC power collection circuit is isolated.

(c) The emergency systems (refer to PS 17.1.4) shall remain energised from the battery supply for a minimum of 120 sec when the Auxiliary Off control is activated (refer to PS 9.3.1). After this 120 sec, the battery power supply shall be switched off completely (refer to PS 17.4.1). The above timing function shall be easily adjustable by maintenance personnel between 60 to 300 sec.

Sequential control arrangements similar to those specified above shall also be provided for the automatic train shut down (refer to PS 10.3.3).

9.4 Traction Power Control

9.4.1. Emergency Traction Power Off Function

(a) Once the Emergency Traction Power Off Pushbutton (refer to PS 8.10.2(d)) is pressed and released, it shall override the normal shutdown sequence (refer to PS 9.3.2(a) and (b)) and immediately isolate all the traction supply on the train and trip the high voltage equipment supplied by the third rail traction supply.

(b) The activation of the Emergency Traction Power Off Pushbutton shall not affect the normal operation of the systems/equipment listed in PS 9.2.1.

9.5 Modes of Operation

9.5.1. The modes of operation and direction of movement of the train shall be determined by the position of the mode selector (refer to PS 8.8.7(b)).

9.5.2. The mode selector shall have the following three valid sequential positions of Reverse, OFF and Forward to facilitate four modes of operation. The OFF position shall be the default position. Also, it shall not be possible to directly

select Forward mode from the Reverse position, or vice versa, without previously having selected each of the OFF modes:

(a) OFF

All controls except the auxiliary functions specified in PS 9.2 to 9.4 shall be inoperative. Emergency brake shall be applied in this mode of operation.

(b) Reverse

When the SCS Bypass Switch has been operated (refer to Appendix I Annex 3 Clause 2.1.4), reverse mode of operation is a manual mode of driving in a reverse direction without any guidance provided by the automatic train control system and the maximum speed shall be limited to 25 km/h (16 MPH) by the Traction and Braking System, and emergency brake shall be applied if the above limit of maximum speed is exceeded. When the SCS Bypass Switch has not been operated, reverse mode of operation is a manual mode of driving in a reverse direction under the protection of SCS. To facilitate the reverse mode of operation, whenever the mode selector is operated at the Reverse mode in regardless of the SCS Bypass Switch status, the trainborne video display of the VSS (refer to PS 10.2.7) shall be automatically switched to the image of the Cab Front Camera of the rear cab. Such that the train operator can view the trackside condition when moving the train in reverse.

(c) Forward

When the SCS Bypass Switch has been operated (refer to Appendix I Annex 3 Clause 2.1.4), forward mode of operation is a manual mode of driving in a forward direction without any supervision provided by the automatic train control system and the maximum speed shall be limited to 80 km/h (50 MPH) by the Traction and Braking System, and emergency brake shall be applied if the above speed limit is exceeded. When the SCS Bypass Switch has not been operated, reverse mode of operation is a manual mode of driving in a forward direction under the protection of SCS.

(d) SCS

When the Speed Control System (SCS) is operative and the SCS Bypass Switch has not been operated (refer to Appendix I Annex 3 Clause 2.1.4), the SCS mode of operation is a manual driving with target speed provided by the SCS (refer to Appendix I Annex 3). ATP protection is also provided in both forward and reverse direction.

9.5.3. Each switch position shall be detented and clearly identifiable.

9.5.4. The mode selector shall prevent any undefined states being achieved when changing mode.

9.5.5. Permitted mode changes shall only be possible when zero velocity is proved (refer to PS 11.5.9). Mode changes attempted at train speeds greater than zero velocity shall cause the emergency brake to be applied.

9.5.6. The mode selector shall include a key switch mechanism, incorporating two positions (Locked and Unlocked) that shall be controlled only by the mode selector key. A mode selector key shall be provided to interface with the above key switch mechanism. The key switch locking control shall not be easily overridden by any general industrial hand tools. The mode selector key

shall be robust in design, vandal-proof and the weight shall not be more than 100g (0.22 lbs).

9.5.7. The key switch shall mechanically inhibit the rotation of the mode selector, unless the mode selector key is inserted and rotated to the unlocked position.

9.5.8. The mode selector key shall be physically retained in the unlocked position, thus removal of the key shall only be possible in the locked position. The selection of the locked position shall only be possible with the mode selector in the OFF position.

9.6 Train Movement Control

9.6.1. The train movement shall be manually controlled by the use of traction brake controller (refer to PS 8.8.7(a)).

9.6.2. Traction Brake Controller (TBC)

(a) The TBC shall provide the manual driving inputs to the traction and braking system and convert the traction and braking demand linearly according to the degree of inclination of the controller handle (refer to Table 9-1).

(b) A T-shape handle shall be provided for the TBC as the controller handle. The operation of the controller handle shall be a horizontal motion along a single axis and there shall be no backlash throughout the whole range of angular ~~movement of the controller handle disregard its direction of motion.~~

(c) The TBC shall provide signals to the safety proving system (refer to PS 9.9.5).

(d) The TBC shall be operative only when the mode selector is moved to either Forward or Reverse position (refer to PS 9.5.2).

(e) There shall be a Dead-Person ~~Safety Device (DSD) feature incorporated into the controller to protect the train in the event of the incapacity of the train operator, when driving in all manual operating modes of SCS, Forward or~~

~~Reverse. Release of the DSD for a preset value of time (which shall be easily adjustable by the maintainer in the workshop for the range of 0.5 to 3 secs at a~~ step of 0.5 sec) shall activate the DSD. Activation of the DSD ~~shall stop the train by applying the emergency brake. The DSD shall not activate when: (1) the TBC handle is rotated 90° in either direction with a rotational force of 0.5 to 1.5Nm, or (2) the TBC handle is placed in the full service braking or emergency~~ positions (refer to Items 8 and 9 of Table 9-1).

There shall be a Dead-Person Safety Device (DSD) feature incorporated into the controller to protect the train in the event of the incapacity of the train operator, when driving in all manual operating modes of SCS, Forward or Reverse. Release of the DSD shall activate the DSD. Activation of the DSD

shall stop the train by applying the emergency brake. The DSD shall not activate when: (1) the TBC handle is rotated 90 in either direction with a rotational force of 0.5 to 1.5Nm, or (2) the TBC handle is placed in the full service braking or emergency positions (refer to Items 8 and 9 of Table 9-1).

(f) The DSD shall be monitored by both the safety proving system and the Event Recorder (refer to PS 10.6).

(g) The design of the TBC shall ensure that it is impossible to override the specified safety features particularly the DSD by using any easily available object.

(h) The controller shall incorporate four distinct positions or operating ranges (refer to Table 9-1):-

(i) Coasting (refer to Item 1 of the Table 9-1)

This position shall inhibit the power contactors control (refer to PS 11.5) and also provide a zero traction/braking effort demand.

(ii) Motoring (refer to Items 2 to 5 of the Table 9-1)

This range shall initiate the power contactor control and provide the tractive effort demand. It is a requirement that no motoring command shall be issued when the door control circuit is activated by the door enable signal (refer to PS 9.8.6) unless the zero velocity by-pass switch is operated (refer to PS 9.8.13).

(iii) Braking (refer to Items 6 to 8 of the Table 9-1)

This range shall initiate the power contactor control and provide the brake effort demand.

(iv) Emergency (refer to Item 9 of the Table 9-1)

This position shall initiate the emergency brake application.

(i) The characteristics of the tractive effort/braking effort output versus the TBC position shall be according to Table 9-1.

(j) All positions shall be visually identified by an engraved position identifications.

(k) The controller handle shall be spring biased towards the full service braking position (refer to Item 8 of Table 9-1) when unattended.

(l) The level of spring force and the operating resistance of the controller handle and the DSD shall not cause any stress or fatigue hazard to the train operator for an average 8 hours of continuous train operation by using the TBC. As a minimum requirement, for the controller handle, a maximum operating resistance by whole hand grip of 120N and angular displacement of 45o for both direction of motion shall be adopted.

(m) The length of the lever of the controller handle shall be determined by the mechanical advantage of the system according to the train operator position and the limitations of the 5th percentile female train operator. Handle shape shall be cylindrical, spherical or shaped to fit the hand grip but with no sharp edges. Anti-slip texturing shall be applied.

9.6.3. Train Movement Control

(a) No train movement shall be allowed unless the following conditions are fulfilled:

(i) The train is operated in the SCS, Forward or Reverse mode;

(i i) The TBC handle is not put at the “Emergency” position;

(i i i) No over speed penalty brake application is made;

(i v) DSD is not activated (refer to PS 9.6.2(e)); and

(v) The safety proving circuits are properly setup (refer to PS 9.9.5).

(b) Overspeed Protection

(i) SCS Mode

The maximum train speed shall be restricted to 5 km/h below the civil speed limit by the SCS. At the maximum speed , an overspeed alarm shall be activated by the SCS to alert the train operator. The emergency brake shall be applied when the speed is 3 km/h exceeded the maximum speed limit. When the train is operated in SCS mode, the above overspeed protection shall be provided by the ATC system.

(ii) Forward and Reverse Modes

When the train is operated in SCS mode, overspeed protection shall be provided by the ATC system. When the SCS Bypass Switch has been operated (refer to Appendix I Annex 3 Clause 2.1.4), overspeed protection shall be provided by the traction and braking system in such a manner that:

(1) Under forward mode of operation, at a speed of 78 km/h (48.5 MPH), the tractive effort shall be removed and an overspeed alarm shall be activated to alert the train operator. The emergency brake shall be applied when the speed exceeded 80 km/h (50 MPH).

(2) Under reverse mode of operation, at a speed of 23 km/h (14 MPH), the

tractive effort shall be removed and an overspeed alarm shall be activated to alert the train operator. The emergency brake shall be applied when the speed exceeded 25 km/h (16 MPH).

(iii) The purpose of the overspeed protection function provided by the traction and braking system, is to apply a penalty of emergency brake as a warning signal to alert the operator, who is operating the train under a degraded mode of operation i.e. when the SCS Bypass Switch has been operated, that the allowable speed has been exceeded. Hence, this overspeed protection shall not be considered as a vital function. The Contractor shall utilize a reliable electrical interlocks, such as, an overspeed alarm output and an overspeed emergency brake request output from the traction and braking system on every car within the consist to contribute to the consist-wide overspeed alarm, to implement the overspeed protection function, in such a way that the overspeed protection function shall be reliably provided even if only one of the consist traction and braking systems detects, or is able to detect, the overspeed condition.

(iv) The integrity of the overspeed protection system shall be continuously monitored. Any abnormality detected, such as, false fed, shall be reported to the train operator via the TIMS and this event shall be logged in the event recorder.

(v) The above overspeed settings of both alarm and application of emergency brake shall be adjustable by maintenance personnel between 10 to 30 km/h.

9.7 Coupling and Uncoupling Operation

9.7.1. The train movement control requirements associated with the coupling and uncoupling operation shall refer to PS 9.6.

9.7.2. When Coupling from the Driving Cab

(a) When two trains are moved close enough that the two coupler faces are mating against each other, the mechanical and pneumatic coupling process shall be performed automatically without any intervention from the train operator.

(b) After the pneumatic valves of the couples are mated together in PS 9.7.2(a) above, the actual passages of pneumatic air connections between the two cars shall be established by a coupling mode selection valve. This coupling mode selection valve shall be provided in the driving cab to enable the train operator to select the pneumatic connection between the two trains after the completion of automatic coupling process. The default position of the coupling mode selection valve shall isolate passages of pneumatic air connections. When the pneumatic coupling mode is selected, the pneumatic connection via the main air pipe of the autocoupler shall be made. Otherwise, the two pneumatic

coupling connections shall be isolated from each other.

9.7.3. When Uncoupling from the Driving Cab

(a) An uncouple pushbutton shall be provided in the driving cab (refer to PS 8.8.1(h)(xv)) to control the position of the coupler pin of the automatic coupler.

(b) When the uncouple pushbutton is kept pressed, the coupler pin of the automatic coupler shall be retracted completely to facilitate the mechanical uncoupling process.

(c) When the automatic couplers are uncoupled, the pneumatic coupling connection shall be automatically retracted and sealed to IP 65 of IEC 60529. Item (c): (No specifications text modifications required.)

9.7.4. - Train Divide Detection

(a) An independent circuit, namely the train divide detection circuit, shall be provided to detect and prove that all inter-car couplers are mechanically coupled and not broke away.

(b) ~~As a minimum requirement, the above detection circuit shall be able to detect the correct positions and conditions of the following areas:~~

(i) ~~The mating faces of the two couplers; and~~

(i i) ~~The draw bars of the two couplers~~. As a minimum requirement, the above detection circuit shall be able to detect the correct position and condition of the mating faces of the semi-permanent bar couplers.

(c) In case any car of a train is accidentally uncoupled or broke away, this circuit shall be able to perform the following functions:

(i) Positively detect the train is physically divided;

(ii) Detect precisely the point of train separation and report this to the train operator; and

(iii) Interrupt the brake loop circuit (refer to PS 9.9.6).

This event shall also be logged in the Event Recorder.

9.7.5. Manual Uncoupling Operations

To facilitate manual uncoupling, the design of the cab end coupler shall be compatible with the uncoupling lever according to the Contract Drawing No. NST 035.

9.8 Passenger Door Control

9.8.1. ~~The normal operation of the saloon doors shall be under the control of the~~ guard from the non-active ~~cab i.e. where the mode selector is stayed in the "OFF" position, by using the Staff Key (refer to PS 32) to unlock the Door Control Master Switch either on Right hand or Left hand side of cab (refer to PS 8.8.6(a)) and place it to the ON position. When the Door Control Master Switch is activated, door controls in the other cab including an active cab i.e. where the mode selector is moved away from the "OFF" position, shall be isolated~~.

The normal operation of the saloon doors shall be under the control of the guard from the non-active cab i.e. where the mode selector is stayed in the "OFF" position, by using the Square SFT Key (refer to PS 32) to unlock the Door Control Master Switch either on Right hand or Left hand side of cab (refer to PS 8.8.6(a)) and place it to the ON position. When the Door Control Master Switch is activated, door controls in the other cab including an active cab i.e. where the mode selector is moved away from the "OFF" position, shall be isolated.

9.8.2. The passenger doors system shall consist of the control functions of doors open, doors close, doors proving and doors isolation.

9.8.3. The driving cab shall be equipped with control circuits that shall operate the doors independently on each side of the train. Each side, i.e. left and right, shall be designed to be totally independent from each other ensuring that any failure of one side shall not affect the other.

9.8.4. Each circuit shall be designed to ensure that under no circumstances, on a moving train, shall it be possible for a train door to be opened due to an incorrect operation by the train operator or due to a single point failure.

9.8.5. Operation of the passenger doors shall only be possible when there is only one Door Control Master Switch has been operated in the ON position.

9.8.6. When the Door Control Master Switch is moved to the “ON” position, a Door

Enable signal shall be provided to activate the door control circuit under the following conditions:

(a) Zero Velocity Relay is energized (refer to PS 11.5.9);

(b) Emergency or service braking command is issued (refer to PS 9.6.2(h)(iii)); and

(c) No motoring (refer to PS 9.6.2(h)(ii)) or coasting (refer to PS 9.6.2(h)(i)) command is issued.

9.8.7. Upon receiving this door enable signal, the bi-coloured LED of the Door Control Panel (refer to PS 8.8.6(f)) ~~shall be illuminated in green colour in order to signify that the door open control circuit is enabled. Then, once the~~

~~two door open pushbuttons (refer to PS 8.8.6(b)) are pressed and released by the train operator, the door open signal shall be transmitted to the individual door control units (refer to PS 16.2.6) through two dedicated pair of hardwired trainlines i.e. one pair dedicated for each door side operation~~. An amber indicator will illuminate in order to signify that the door control circuit is enabled (door supply). Then, once the two door open pushbuttons (refer to PS 8.8.6(b)) are pressed and released by the train operator, the door open signal shall be transmitted to the individual door control units (refer to PS 16.2.6) through two dedicated pair of hardwired trainlines i.e. one pair dedicated for each door side operation.

9.8.8. When the door close pushbutton (refer to PS 8.8.6(c)) is pressed and released, a door close signal shall be sent to the door control units through another independant mean for each door side for door closing operation.

9.8.9. The design of these trainlines shall ensure that no wrong side failure shall be allowed to produce any incorrect door control signal particularly the undemanded passenger door open signal or incorrect passenger door opening side.

9.8.10. The circuit integrity of the door control devices shall be monitored by the TIMS, any abnormality, such as, jammed pushbutton, detected shall be reported to the train operator and logged into the Event Recorder.

9.8.11. For the purpose of door control unit (DCU) interface (refer to PS 16.2.6), the zero velocity signal (refer to PS 11.5.9) shall also be used as an independent signal to enable the DCU for door operation. This zero velocity signal shall be transmitted through another dedicated hardwired trainlines between the traction and braking systems and the DCU. The design of these control wires shall ensure that no wrong side failure shall be allowed to produce an unqualified door enable status.

9.8.12. Door Close Warning

~~A door closing warning chime shall be sounded throughout the train for approximately three seconds: one seconds prior to the door starting to close~~

and two s~~econds after the door started to close.~~

A door closing warning chime shall be sounded throughout the train for approximately three seconds: one second prior to the door starting to close and two seconds after the door started to close. The door closing chime shall be played upon validation of the door close command and a configurable delay (varying between 0 to 5 sec) in the door operator shall hold to door from closing until the chime is partially or fully played.

9.8.13. Door Enable Signals Bypass

In the event that the Door Enable signal or the Zero Velocity signal is not available due to the equipment failure, a bypass switch, namely, the Zero Velocity By-Pass switch (refer to PS 8.10.1(e)(iv)), shall be provided to bypass these two signals. ~~When this Zero Velocity Bypass Switch is operated,~~ the bi-coloured ~~LED shall be illuminated in green colour to signify the above door control interlocks are bypassed from the associated door opening circuit and it is ready for door opening operation.~~

The amber indicator will illuminate to signify the above door control interlocks are bypassed from the associated door opening circuit and it is ready for door opening operation.

9.8.14. An independent hardwired door proving circuit (refer to PS 9.9.7) shall be provided to monitor and report the doors status via the TIMS and the Door Closed Indicator and Outside Door Indicator (refer to PS 9.9.7(e)).

9.8.15. In the event that the train is shutdown, i.e. the Auxiliary Off control has been activated, all passenger doors shall be operated to the default state of the closed position and all passenger doors controls shall be disabled.

9.8.16. Change-end Operation

The following sequential control functions shall be provided for use when the train arrived at the terminal station where changing the controlling cab is required:

(a) when the Door Control Master Switch (refer to PS 8.8.6) is operated to the OFF position, all saloon doors shall stay in the previous condition either opened or closed ;

(b) then the corresponding side of the Door Control Master Switch of the other driving cab is operated to the ON position to take over the controls, all saloon door states shall remain unchanged;

(c) thereafter the door state shall follow the operation of the associated door

control pushbutton of that driving cab.

9.8.17. Special Door Operation

(a) The following sequential control functions shall be provided to open both side of Door:

(i) one side of door is opened;

(i i) when the Door Control Master Switch is operated to the OFF position, all

saloon doors shall stay in the opened state;

(iii) then the other side of the Door Control Master Switch of the same cab is operated to the ON position to open the other side of the door;

(iv) thereafter the door state shall follow the operation of the door control pushbutton of the associated Door Control Master Switch of that driving cab.

(b) Status of the Door Control Master Switch shall be monitored by the TIMS. In the event that more than one Door Control Master Switches of a train have been operated, the train system shall:

(i) the bi-coloured ~~LED of the Door Control Panel (refer to PS 8.8.6(f)) shall be illuminated in red colour;~~ The red indicator of the Door Master Switch Panel shall be illuminated

(ii) report by the TIMS to the train operator with the location of the other activated Door Control Master Switch and record in the Event Recorder as an Operating Event (refer to PS 10.3.5(b)); and

(iii) maintain the door in the previous state until there is only one Door Control Master Switch has been activated.

9.8.18. Other operation requirements of the passenger door system control shall refer to PS 10.5.4 and 16.2.

9.9 Safety Related Controls

9.9.1. DSD

In order to ensure the alertness of the train operator during manual train operation, a DSD shall be provided to monitor the status of the train operator. The detailed requirements of the DSD shall refer to PS 9.6.

9.9.2. Not Used

9.9.3. Not Used

9.9.4. Passenger Alarm Device (PAD)

In the event the passenger(s) needs to communicate with the train operator, the PAD system shall be provided to facilitate an effective and reliable communication between the driving cab and saloon of the above passenger(s). The detailed requirements of the passenger alarm shall refer to PS 7.11.1 and PS 18.4.15.

9.9.5. Safety Proving Circuit

(a) The safety proving circuit shall be a dedicated hardwired circuit which shall control two Safety Proving Relays (SPRs) or a safe alternate arrangement as approved by the Engineer.

(b) When either one of the SPRs is de-energised, the emergency brake of the train shall be applied by interrupting the brake loop circuit (refer to PS 9.9.6).

(c) In order to set up the safety proving circuit, the following conditions shall be fulfilled:

(i) The train shall be at standstill. The required relay interlock shall be provided by the zero velocity relays (ZVRs) (refer to PS 11.5.9);

(i i) Forward or Reverse mode is selected;

(i i i) Place the TBC handle in Full Service Brake position (refer to Item 8 of Table 9-1) and adequate brake pressures achieved (refer to PS 9.9.5(d)(i)). Press and release the Emergency Reset Pushbutton;

(i v) When the train is operated in SCS mode only, the emergency brake relays (EBRs) are energised (refer to Appendix I Annex 3). When the train is not operated in SCS mode i.e. when the SCS Bypass Switch has been operated (refer to Appendix I Annex 3 Clause 2.1.4), the above EBR function shall be overridden; and

(v) None of the emergency stop pushbuttons being activated.

(d) The following safety proving circuit performance requirements shall be fulfilled:

(i) A brake cylinder governor shall be used to positively indicate that adequate brakes are applied i.e. it shall drop out at a brake cylinder air pressure giving sufficient brake force to hold a crush laden train on a 3% grade under the most adverse wind loading.

(i i) The two SPRs shall control separately the positive and negative supply of the

brake loop circuit (refer to PS 9.9.6) via the safety proving circuit in order to meet "2-wire stop and start" requirements.

(iii) The "2-wire stop and start" features of the traction and braking equipment shall be separated for all modes. One contact from each SPR relay shall be connected in series with the associated power contactors control logic circuit in order to meet the requirement as specified in PS 11.5.

(iv) If either SPR drops out, the other shall also drop out subsequently and remain in the dropped out state except in the event of ATC system failures, such as, if the EBRs drop out with the train at standstill (output from the zero speed channels of the ATC unit is presented to energise the ZVRs) and brakes are proved applied, the SPRs shall not drop out thus preventing an unnecessary penalty of emergency brake application.

(v) In the event that the EBR is de-energised by the ATC system when the train is operating in SCS mode and moving (i.e. the ZVRs are dropped out), the SPRs shall drop out thus causing a penalty of emergency brake application.

(v i) In the event that the EBR is de-energised by the ATC system when the train is operating in SCS mode and stationary with the brakes released, the SPRs shall drop out thus causing a penalty of emergency brake application.

(v i i) The SPRs shall also drop out in the event of a DSD operation (refer to PS

9.6.2(e)) or if an emergency stop push button is pressed in the operative cab.

(viii) One contact from each SPR relay shall be connected in series with the brake loop circuit in order to complete the brake loop.

(e) In the event of ATC equipment failure, the SCS Bypass Switch has been operated (refer to Appendix I Annex 3 Clause 2.1.4), to enable the reset, fall back operations or setting up of safety proving circuit.

(f) When the DSD is activated or when any emergency stop pushbutton has been

operated, the SPRs shall be de-energised and the safety proving circuit shall be interrupted. Under such circumstance, the release of emergency brake shall not be possible unless the safety proving circuit is set up again by repeating procedures of PS 9.9.5(c) and the brake loop circuit is completed.

(g) In the event that both source of controlling the ZVRs are failed, the zero velocity by-pass switch (refer to PS 8.10.1(e)(iv)) shall be operated to override the above interlocking functions.

(h) Operation of the zero velocity by-pass switch shall be reported to the train operator and logged into the Event Recorder.

9.9.6. Brake Loop Circuit

(a) The brake loop circuit shall be a dedicated hardwired circuit which directly controls the emergency brake application. The emergency brake shall not be released except when the brake loop is completed.

(b) The brake loop shall include a pair of hardwired trainlines, or an alternate arrangement based on the T1 train concept.

(c) One of the above hardwired trainline shall be fed through the safety proving circuit (refer to PS 9.9.5(e)(viii)) from the leading cab car of the train.

(d) In any car of a train, all trip switches (refer to Appendix I Annex 3 Clause 2.2.2(c)) and all main air governor switches shall be closed i.e. no trip switch has been operated and the main reservoir pressure shall be proved by the

associated main reservoir governor (refer to PS 13.5.1).

(e) No train divide devices (refer to PS 9.7.4) shall be activated and the mode selector of the rear driving cab shall be placed in the "OFF" position. This shall also allow another train wire (refer to PS 9.9.6(f)) to be fed from the rear of the train.

(f) The return path of the above train wire after completing the circuit stipulated in PS 9.9.6(c) to 9.9.6(e) plus PS 9.9.5(d)(ii), shall perform the following control circuit functions so that when it is de-energised:

(i) the emergency brake of each car of a train shall be applied; and

(i i) the traction power of the train shall be cut off.

(g) The integrity of the above two train wires shall be continuously monitored. Any abnormality, such as false feed, shall be detected and reported to the train operator via the TIMS. This event shall be logged in the Event Recorder.

(h) In the event that both brake loop circuit and the redundant circuit (refer to PS 9.12.3) are failed, the Trip Switch / Emergency Brake Loop By-Pass Switch (refer to PS 8.10.1(e)) shall be operated to override the above interlocking functions and control directly the emergency brake and traction circuit.

(i) Operation of the brake loop cut out switch shall be reported to the train ~~operator and logged into the Event Recorder.~~

9.9.7. Door Proving Loop Circuit

(a) The door proving loop circuit shall be a dedicated hardwired circuit which provides monitoring function for each passenger door, cab door and emergency door to prove these doors are closed.

(b) The door proving loop shall monitor that:

(i) all passenger doors are closed and locked;

(i i) both side of cab bodyside doors of the non-active ~~cab (i.e. where the mode~~

~~selector is stayed in the "OFF" position) are closed and locked;~~

~~(iii) both emergency doors are closed and locked;~~

(ii) both side of cab bodyside doors are closed and locked;

(iii) Not used. (Text deleted)

(iv) all passenger alarm assistance alarm are not activated; and

(v) none of the passenger door manual release devices is activated.

(c) An easy means shall be provided to by-pass the monitoring function of the above passenger alarm emergency handles by the maintenance personnel when required.

(d) The power of the door proving loop circuit shall be supplied from the active cab only.

(e) The output of the door proving loop circuit shall only be present when there is continuity through all monitored devices. The state of the door proving shall be:

(i) visually indicated in the active cab (refer to PS 8.8.6(d)).

(i i) interlocked with the driving controls (refer to PS 9.9.7(f)).

(i i i) visually indicated on each car exterior (refer to PS 6.10.4).

(i v) reported to both the TIMS and the Event Recorder. Item (iv): (No specifications text modifications required.)

(f) When the output of the door proving loop circuit is lost, it shall cause the application of full service brake and inhibition of any further train movement once the train has been proven to be stopped at a station, unless the door proving loop circuit is re-established or is cut-out (refer to PS 9.9.7(h)). Loss of the door proving loop circuit output with a train speed greater than zero velocity shall have no effect on the performance of the train, until the train is stationary at a station stop.

(g) The integrity of the above door proving loop circuit shall be continuously monitored. Any abnormality, such as, false fed, shall be detected and reported to the train operator via the TIMS. This event shall be logged in the Event Recorder.

(h) In the event of door proving loop circuit failure, operation of the Door Interlock By-Pass Switch (refer to PS 8.10.1(e)) shall override the above interlocking functions.

(i) Operation of the door loop cut out switch shall be reported to the train operator and logged into the Event Recorder.

9.9.8. Event Recorder

In order to facilitate incident investigation, an Event Recorder shall be provided to record all essential information of the train system in real time. Detailed requirements of the event recorder shall refer to PS 10.6.

9.9.9. Smoke detection device

An automatic smoke detection system which shall be able to detect the presence of smoke in the fresh air inlet duct, shall operate to report to the train operator and Event Recorder, and activate dampers so as to shut off the smoky air intake by operating in a 100% recirculation mode (refer to PS 15.7).

9.9.10. Speedometer

The train speed shall be indicated by speedometers which shall be provided by the ATC system when the train is operating under SCS mode (refer to Appendix I Annex 3).

9.9.11. Head and Tail Lights

(a) When the train system is initialised according to PS 9.2.1, the tail lights of the driving cab shall be automatically turned on.

(b) When the train is operating from a driving cab, the head lights of this active cab car shall be automatically turned on and its tail lights shall be automatically turned off when the mode selector is moved away from the "OFF" position.

9.9.12. Marker Flashing Light

(a) The Marker Flashing Light shall be activated when the trip switch is isolated (refer to Appendix I Annex 3), Emergency Brake Loop is bypassed (refer to PS 9.9.6(h)) or the Door Proving Loop Circuit (refer to PS 9.9.7(h)) is by-passed.

(b) When the Marker Flashing Light is activated, the following functions shall be

provided:

(i) An audible alarm i.e. buzzer (refer to PS 8.10.1(h)) shall sound in the cab for 10 seconds. When de-energized, this audible alarm shall be automatically reset within 30 seconds.

(i i) The two amber warning lights which shall be located on the train operator's windshield wiper housing, shall be flashed at the rate of 60 times per minute with approximately 50% ON time.

(iii) The two white marker lights which shall be located at the front of the cab car, shall flash at the rate of 60 times per minute with approximately 50% ON time.

(c) When the trip switch, Emergency Brake Loop and the Door Proving Loop Circuit are restored to their normal positions, both alarm and flashing lights shall be automatically stopped.

9.9.13. Forward Brake Light (FBL)

(a) In order to enhance visual communication between the wayside working parties and the train operator, it is a requirement that an additional amber color exterior light which shall be lit on when the vehicle is operated in forward direction with brake applied, shall be provided. Due consideration shall be given on the FBL location and form of indication (for example, flashing feature according to vehicle speed or braking command). The Contractor shall provide justification on the design which shall be substantiate by the hazard analysis (refer to PS 25.5.4).

(b) It is a requirement that when the vehicle is operated in reverse direction, the FBL of the rear cab shall be flashed in a frequency of 0.5Hz i.e. 1 sec on and 1 sec off. Also, all horns shall be automatically operated in the same frequency of the FBL with the opposite cycle i.e. short blast of horn shall be provided when the FBL is off. An easy mean to allow turning on/off of the above horn operation or alternation of the operating frequency, shall be provided by the TIMS for the maintainer.

9.10 Train and Passenger Information Management

During passenger service of the train, essential information shall be reliably supplied to the train operator and passengers by the train management and communication system. The detailed requirements of the train and passenger information management shall refer to PS 10 - Train Information Management System and PS 18 - communication.

9.11 Emergency Operations

9.11.1. Push out

(a) As an essential part of the recovery performance requirements (refer to PS 4.4.4), the train shall be able to facilitate emergency push out operation to assist an immobile train of either the existing T1 or the new train in the event

of failure.

(b) The associated coupling and uncoupling operations shall refer to PS 9.7. In order to avoid consequential failure caused by coupling to the faulty pneumatic equipment of the defective train, for example, main air leakage, the coupling selection valve will be used to isolate the faulty pneumatic equipment prior to coupling for push out (refer to PS 9.7.2(b)).

(c) During the pushout operation. An ease mean of communicating link between

the two trains involved shall be provided. The design shall be based on a similar solution according to the T1 trains which is a separate intercom box with an umbilical cord and power connection that plugged into the two adjacent cabs.

9.11.2. Emergency Evacuation

(a) The requirements of the 2 routes of emergency evacuation by using the emergency door and/or the saloon side-door shall be referred to PS 4.4.5 and PS 16.3.

(b) Normally passengers are detrained to the track and this is called "train to track" detrainment. In this case, the emergency device shall be able to operate as an evacuation ramp to facilitate a safe "train to track" detrainment operation.

(c) Not used.

(d) When the emergency evacuation is carried out by using the emergency door, as long as the emergency door is opened, an electrical interlock shall be provided to automatically apply maximum service brake on the whole train disregard the position of the TBC and the modes of operation, so that the train shall be automatically secured to facilitate safe emergency evacuation operation.

(e) Operation of the emergency door shall be logged into the Event Recorder.

9.11.3. Loss of Traction or Auxiliary Power Supply

In the event of loss of traction or auxiliary power supply, the emergency systems shall automatically operate and continue to function for a minimum 1 hour (refer to PS 4.4.6(a)).

9.11.4. Tunnel Fire

In the event of a fire being present in the tunnel, the automatic smoke detection system shall operate to provide a full recirculation ventilation within

the saloon (refer to PS 15.7). The normal functions of the train systems shall not be affected, in particular the train movement control function, so as to facilitate the transfer of passengers to a safe place.

9.11.5. Person Under Train

It shall be able to safely and efficiently jack the train from track level particularly in a tunnel. The design shall:

(a) provide a good identification marking and easy access to jacking points from track level;

(b) provide secure accommodation for the jacks in the jacking points; and

(c) minimise the need of using any special process, tools or equipment in order to complete the jacking process.

Detailed requirements shall comply with Appendix I Annex 5.

9.11.6. Flooding

In the event that there is flooding problems of either water or mud flooding posed to the Railway, if the level of the water/mud does reach above the rail foot but below the rail top, the train shall be able to operate under Forward/Reverse mode to a maximum speed of 25 km/h (15 MPH) in order to maintain a minimum degree of train service under a flooding condition.

9.12 Special Controls

9.12.1. Defect Handling

(a) In order to facilitate an efficient and effective train system fault recovery, the three modes of defect handling functions as specified in PS 10.3.7 shall be provided.

(b) As a back up function to the TIMS (also refer to PS 9.12.2), a general fault reset pushbutton shall be provided (refer to PS 8.8.4(d)) to launch a system-wide reset operation of the whole train, including the door system, traction and braking equipment, auxiliary electrical supply system and air conditioning and ventilation system, to reset those miscellaneous faults of the train system. The above system-wide reset function shall not include the communication system and TIMS in order to avoid unnecessary service delay due to system initialisation process of these systems. The general fault reset pushbutton shall be operative only when zero velocity is proved (refer to PS 11.5.9), with the train in Full Service or Emergency Brake.

9.12.2. TIMS Back Up Operation

In the event that the display terminal (refer to PS 10.8) or the data transmission link (refer to PS 10.1.1) of the TIMS is failed and the train operator cannot interact with the train system through the TIMS, the following back up functions shall be provided to facilitate the train operator to continue normal passenger service of the train for at least one round trip without withdrawal the train from service immediately:

(a) communication controls;

(b) train movement controls;

(c) Train system status indications

The indication lights listed in PS 8.8.1(h) shall be provided in the form of LEDs to inform the train operator about the train system status according to the following requirements:

(i) Emergency brake indicators shall be off and indicators of EP. Brake, door closed and the green Bodyside Indicator Lights (refer to PS 6.10.4) (if all passenger doors are closed) shall be illuminated when the mode selector of that driving cab is moved away from the "OFF" position.

(ii) Voltmeter shall show the battery voltage. Location of the voltmeter shall refer to PS 8.10.5.

(iii) Train divided indicator shall be illuminated when any one of the train divide devices (refer to PS 9.7.4) is activated.

(i v) Traction fault indicator shall be illuminated when there is any fault such as overcurrent or earth faults in the traction and braking equipment.

(v) Auxiliary power fault indicator shall be illuminated when any auxiliary power supply, such as, 3 phase or battery charging supply fails.

(v i) Ventilation fault indicator shall be illuminated when any air conditioning unit loses its ventilation function.

(d) Indication Controls

(i) Move the mode selector to OFF position, door supply and emergency brake indicators shall turn on.

(ii) Move the mode selector to either Forward or Reverse position, the EP brake indicator, door closed and green Bodyside Indicator Lights shall illuminate.

(iii) Operate the Trip Switch / Emergency Brake Loop By-Pass Switch, all associated control interlocks shall be overridden (refer to PS 9.9.6(h)) and the Trip Switch / Emergency Brake Loop By-Pass indicator shall illuminate. Deactivate the above by-pass switch, all associated control interlocks shall be resumed and the corresponding indicator shall extinguish.

(iv) Operate the Door Interlock By-Pass Switch, all associated control interlocks shall be overridden (refer to PS 9.9.7(h)) and the Door Interlock By-Pass indicator shall illuminate. Deactivate the above by-pass switch, all associated control interlocks shall be resumed and the corresponding indicator shall extinguish.

(v) Operate the Zero Velocity By-Pass switch, all associated control interlocks shall be overridden (refer to PS 9.8.13 and 9.9.5(g)) and the Zero Velocity By-Pass indicator shall illuminate. Deactivate the above by-pass switch, all associated control interlocks shall be resumed and the corresponding indicator

shall extinguish.

(v i) Apply parking brake. Parking brake applied indicator shall illuminate.

(v i i) Release parking brake. Parking brake applied indicator shall extinguish.

(v i i i) Activate snow brake. Blue indicator (refer to PS 9.12.5) shall illuminate.

(i x) Deactivate snow brake. Blue indicator shall extinguish.

(x) Control test indicator shall respond to the traction control / power tests according to PS 11.6.12 i.e. the red indication shall illuminate only if the test is failed.

(x i) Move the mode selector to OFF position. EP brake indicator, door closed and green Bodyside Indicator Lights shall extinguish. Also, the red marker light shall illuminate and the white marker light shall extinguish.

(x i i) When any door is opened, the door open light i.e. red Bodyside Indicator Lights shall illuminated.

(x i i i) When any PAA is activated, amber Bodyside Indicator Lights of the affected

car shall illuminate.

(xiv) When the Door Control Master Switch is operated to the ON position, the guard position indicator light i.e. the white Bodyside Indicator Lights shall illuminate.

(e) Although the above requirements are based on a TIMS back up purpose, all specified back up functions shall be available disregard the status of the TIMS.

9.12.3. Brake Loop Circuit Back Up Control

(a) A redundant circuits shall be provided for the brake loop circuit (refer to PS 9.9.6) in the following manners:

(i) The circuit configuration particularly the safety proving parameters provided by the circuit interlocks of the redundant circuit shall be identical to the brake loop circuit.

(i i) There shall be no common mode failure between the redundant circuit and the

brake loop circuit.

(b) A facility, namely, Brake Loop Selector Switch, to enable selection of either of the brake loop circuit and the redundant circuit shall be provided.

(c) Even though the redundant circuit has not been selected, the conditions of this redundant circuit shall be continuously monitored by the TIMS. Any circuit fault occurred in these redundant circuits shall be reported to the train operator and recorded in the Event Recorder.

(d) Operation of the Brake Loop Selector Switch shall be reported to the train operator and Event Recorder.

9.12.4. Supplementary Controls

(a) Train number display and destination indicator

The train number display and destination indicator shall display train numbers and destination according to the information provided either by the ATC system (refer to Appendix I Annex 3) or the TIMS (refer to PS 10.2.8).

(b) Lighting controls

(i) Cab light

The cab light shall illuminate by:

(1) opening of the cab to saloon partition door; or

(2) using the cab main light switch.

(ii) Saloon light

The saloon lights including both emergency lights and AC lights shall turn on automatically when the DC and AC supplies respectively are available.

(iii) Reading light

The reading light shall be turned on by using the reading light control switch.

9.12.5. Snow Brake Control

(a) Snow braking function which is to maintain a continuous light application of all brake shoes to the wheels of the train, in order to keep snow and ice from accumulating, shall be provide.

(b) To activate the snow brake, a "snow brake" switch shall be provided in the driving cab and interlocked with the mode selector i.e. the snow brake switch shall be functional only when the mode selector is moved away from the

"OFF" position. Operation of this switch shall maintain a low brake cylinder pressure to bring the brake shoes in contact with the wheels with sufficient force to provide an effective snow braking function when the TBC is operated in coasting or motoring position.

(c) A blue warning light shall be provided and it shall be illuminated when the snow brake switch is operated. Location of the blue warning light shall refer to Contract Drawing No. NST 006. Due consideration shall be given to the position, light orientation and intensity of the warning light, such that when it is illuminated, it shall be visible from a station platform and also to the operator but shall not dazzle the operator in a darkened tunnel.

(d) Activation of the snow brake switch shall has no effect on the normal operation of the braking system.

(e) Operation of the above snow brake switch shall be reported to the train operator and recorded in the Event Recorder.

9.12.6. Manual parking brake application

With the mode selector is placed in the SCS, forward or reverse position, once the parking brake pushbutton is pressed and released, all parking brakes of the train shall be applied and remained in an applied condition until the mode selector state is changed.

9.12.7. Train Washing Operation

To facilitate an effective train washing operation with a constant slow speed of 5 km/h (5 MPH), when the train is operated in the forward mode only, the traction and braking system shall respond to provide the constant slow speed operation provided that the following conditions are fulfilled:

(a) When the train is operated in the forward mode:

(i) the TBC handle is put at the +10° notched position;

(i i) no overspeed penalty brake application is made;

(i i i) deadman safety device is activated; and

(i v) the safety circuits are setup.

(b) The train operator has selected the corresponding menu of command input on the TIMS display terminal, an icon of constant slow speed push button shall be provided on the screen for the train operator to activate, then the train operator is to command the train to move by putting the TBC handle to the +10° notched position. Once the desired train speed is reached, and the train operator has pressed and released the associated icon of constant slow speed push button which shall be provided on the TIMS display terminal, the train speed shall be regulated automatically to within ± 0.5 km/h of the above desired speed. The constant slow speed operation shall be overridden when:

(i) The position of the TBC is moved away from the +10° position;

(i i) deadman safety device is released; or

(i i i) the safety circuits are interrupted

There shall be no response to the desired speed input via the constant slow speed push button if the train speed is higher than 5 km/h (3 MPH).

9.12.8. Train Operator's Audio Signal System

(a) To facilitate audio signal transmission between the train operators of the two driving cabs of a train, a bell and buzzer signal system shall be provided.

(b) The bell signal system shall comprise of a bell pushbutton (refer to PS

8.8.1(h)(xix)) and a single stroke signal bell (refer to PS 8.10.1(h)(i)). The bells in both cabs shall be activated when the bell pushbutton of the active cab i.e. the mode selector is moved away from the OFF position, is pressed and the bell shall be deactivated when the pushbutton is released.

(c) The buzzer signal system shall comprise of a buzzer pushbutton (refer to PS 8.8.6(e)) and a buzzer (refer to PS 8.10.1(h)). The buzzers in both cabs shall be activated when the buzzer pushbutton of the activated door control panel i.e. the door master switch is moved to the ON position, is pressed and the buzzer shall be deactivated when the pushbutton is released.

Item	Position	Effect
1	Coasting:	No driving/braking command
2	Limited Motoring:	Smooth increase in tractive effort for train starting
3	Motoring: The TBC handle remains at the +10o detented	The tractive effort produced shall be smoothly increased for running to a maximum speed of 25 km/h (15 MPH)
4	Motoring: The TBC handle is moved beyond the +10o detented position i.e. between +10o to +45o	The tractive effort produced shall be smoothly increased for running to a maximum speed of 80 km/h (50 MPH) (the reference value of tractive effort demand shall increase with increasing inclination linearly)
5	Full Motoring:	The reference value of tractive effort demand produced has its maximum value
6	Minimum Braking: The TBC handle is moved to -10o (with	Smooth increase in service braking effort for the commencement of service braking mode
7	Braking: The TBC handle is moved between -10o to -	The reference value of service braking effort demand shall increase with increasing inclination linearly
8	Full Service Braking (default position): The TBC handle is moved to -40o (with	The reference value of service braking effort demand produced has its maximum value
9	Emergency: The TBC handle is stayed at -45o (with	Emergency braking

Note: The convention of the TBC handle position shall be:

Positive angular displacement means moving the TBC handle away from the train operator i.e. motoring mode.

Table 9-1 TBC Handle Position

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Section 10 Train Information Management System

10.1 General

10.1.1. The Train Information Management System (TIMS) shall be a microprocessor based control system using the latest and proven technologies of semi-conductor, software and data communication to control and monitor the major trainborne equipment, such as, the door, brake, propulsion, auxiliary and air conditioning systems, through the Train Information Network (TIN). For Propulsion and Braking, interface requirements shall be based on IEEE Std 1475-1999 "IEEE Standard for the Functioning of and Interfaces among Propulsion, Friction Brake, and Train-borne Master Control on Rail Rapid Transit Vehicles" shall be met.

10.1.2. The design of the TIMS shall consider the train as a total complete system and the TIMS shall provide a centralized function to control and monitor all its subsystems operation and fault status, fault data logging, incident investigation and reporting.

10.1.3. The TIMS shall provide for real-time distributed control and modular processing of subsystems in a redundant manner with high reliability and availability in the adverse operating environment.

10.1.4. The TIMS shall be designed for ease of fault diagnosis and maintenance.

10.1.5. The TIMS shall function as an Event Recorder to record operating status of critical control circuits and components.

10.1.6. The TIMS shall be designed to minimize the needs for individual trainline wires and hardwires across couplers. The type of TIMS transmission link to be used shall preferably be a screened coaxial cable but a fiber optic cable may also be proposed as an alternative. These proposed links shall be proven in a comparable operating environment.

10.1.7. The TIMS system and architecture will be developed in order to meet the

overall RAMS trainset requirement.

10.2 Communication Network Requirements

10.2.1. Train Information Network (TIN)

(a) The TIN shall be based on a two-level hierarchy structure consisting of a Train Consist Network and System Sub-Network(s). System Sub-Network shall be connected to the Train Consist Network via a System Sub-Network Gateway. Communications protocols shall be complied with or derived from the IEEE Std 1473-1999 “IEEE Standard for Communications Protocol

Aboard Trains".

(b) TIN Initialization

(i) The TIN initialization shall be started once the power up initialization of the train has occurred. No train operator intervention is required during the initialization process.

(ii) The TIN shall first check the healthy status of all the TIN equipment including Train Consist Network, System Sub-Networks, ATC / Communications Gateways, Gateways, LPU's with real time clock, TIMS display terminal, Event Recorder and Control Interface Units. All equipment failures shall be logged, displayed on the TIMS display terminal and reported to the YMSS if train is within the coverage of the YMSS.

(iii) The TIN shall then configure itself automatically. Each connected device shall receive a unique address identifying its position and orientation (left/right, front/rear).

(iv) Once the initialization process is completed, data communication service shall be started and data shall be able to be transferred among any connected devices.

(v) Default operating and control parameters / values (including the recording schemes of the Event Recorder) shall be transmitted to each train subsystems. These default operating parameters / values shall be able to be viewed, edited and changed by maintenance staff when the TIMS is in the Maintenance Mode. The default operating and control parameters / values shall set all train subsystems / devices in the safe state (for example brakes to be applied and doors closed). Operating Parameters shall be modifiable using the Portable PC and/or the YMSS computer.

(vi) The train consist shall be uncoupled / coupled on major maintenance activity by maintenance staff. The TIN shall be able to maintain partial operation of both the Train Consist Network and System sub-network(s) on all uncoupled units. This may be achieved by automatic or manual operation of switches, insertion of matching resistors or other methods. Once uncoupling / coupling

is completed, the TIN shall re-configure itself automatically to enable the data communication service unless the cars forming the consist have changed. In this eventuality, the consist shall be reconfigured using a portable PC. The train consist as recognised by the TIMS shall be displayed on the TIMS display terminal.

(vii) From power up initialization of the train, the TIN of TIMS shall complete its initialization and start data transmission within 45 seconds. The Train Systems Initialization shall then be started to perform checking of the healthiness and correct functioning of all trainborne systems which shall be completed within

5 minutes.

(viii) Once power up initialization is completed, operation of the TIN shall not be interrupted by occupation status of either driving cab.

(ix) In case of equipment failure causing malfunction or loss of a local processing unit, the TIMS shall isolate the faulty local processing unit and resume full function or degraded mode operation within 5 seconds.

(x) For the equipment status monitoring function, the total system response time from the change of equipment status to be shown up on the TIMS display terminal shall not be greater than 500ms.

(x i) Not Used

(x i i) For train control purpose, the TIN shall be able to complete the data transmission of the train operator's command from the TIMS display terminal to the output port of the local process unit within 0.5 seconds.

(x i i i) Delays in displaying diagnosed fault message on the TIMS display terminal following a failure of equipment under monitoring shall be less than 2 seconds.

(x i v) TIMS shall be designed to minimize false or incorrect diagnosis.

(x v) Any failure of the TIMS shall not affect the emergency performances specified in PS 4.4.

(c) Train Consist Network

(i) Dedicated shielded twisted pair cables shall be used for the Train ~~Consist Network. Fiber optic cable may be proposed as an alternative~~.

Dedicated shielded twisted wire cables shall be used for the Train Consist Network. Fiber optic cable may be proposed as an alternative

(ii) The Train Consist Network shall be able to transmit data at a minimum baud rate of 1.0 Mbits/sec.

(iii) ~~The Train Consist Network shall transmit signals on the dedicated train line wires through the length of the train and across the electrical contacts of the~~ electrical connection boxes of the automatic couplers and the semi-permanent ~~bar couplers~~.

The Train Consist Network shall transmit signals on the dedicated train line wires through the length of the train.

(iv) The Train Consist Network shall be provided in a dual redundant configuration. The data on the two lines of the Train Consist Network shall be continuously monitored and shall be identical. In case of failure of one line, data shall still be able to be transmitted and received via the operational line. The faulty wire shall be detected and reported to the master LPU.

(d) System Sub-Network

(i) Dedicated shielded twisted pair cables shall be used for the System Sub-Network. Fiber optic cable may be proposed as an alternative.

(i i) The System Sub-Network shall be able to transmit data at a rate sufficient to meet the system function while maintaining loading capacity as stipulated in PS 10.4.4 (b).

(i i i) Not Used

(i v) Not Used

(v) The System Sub-Network shall be provided in a redundant configuration. In case of failure of one line, data shall still be able to be transmitted and received via the operational line. The faulty wire shall be detected and reported to the master LPU. Sub-network redundancy usage will be based on the system criticality and shall be approved by the Engineer.

(e) Sub-Network Gateway

(i) The Sub-Network Gateway shall be provided on a system basis to connect a system (e.g. PIS) to the Train Consist Network thus facilitating data exchange between these two levels of networks.

(i i) Consideration shall be given to reduce the bandwidth requirement of the Train

Consist Network. Only information required throughout the train shall be passed from the System Sub-Networks to the Train Consist Network.

(f) Fault Tolerance

The TIN shall be designed and constructed such that correct operation of it shall be maintained regardless of the health of the equipment connected to it. Failure of a piece of equipment shall not prevent unrelated equipment from normal working. This shall apply to the following scenarios:

(i) occasional corruption or loss of data

(i i) Train Consist Network and System Sub-Networks interruption or short circuit (iii) denied access to Train Consist Network and System Sub-Networks

(i v) configuration error

(v) loss and reintegration of network nodes

10.2.2. Refer to PS 10.2.4

10.2.3. Refer to PS 10.2.4

10.2.4. Local Processing Unit (LPU)

(a) A LPU shall be provided in each car which shall interface with various devices and intelligent train subsystems in order to enable the data communication service.

(b) The location for mounting the LPU shall be carefully selected in order to facilitate easy access for maintenance and minimize the wiring works between the devices and train subsystems and the LPU.

(c) To reduce the complexity of the LPU, the LPU and connected devices / train subsystems shall be designed and constructed such that peer to peer communication between devices / train subsystems on the same car shall not be required to be routed through the LPU as far as practicable.

(d) Failure of any LPU shall not cause any global loss of the TIMS functionality.

(e) The LPU in each cab car shall execute the application program for the overall control and administration of the TIMS.

(f) The local LPU shall interface with its local TIMS display terminal for operation of the MMI (refer to PS 10.7) in providing information display and receipt of operator commands.

(g) The design of the LPU's shall ensure that the performance of memory size, real time processing capability, real time response, reliability and ease of programming are optimized.

(h) Each LPU shall be provided with a real time clock. The real time clock of the master LPU of TIN shall act as the System Master Clock for the TIMS and

synchronize all the TIN equipment and all connected devices / train subsystems.

(i) The System Master Clock shall synchronize all the TIN equipment and connected devices / train subsystems time during the TIMS initialization process and regularly thereafter.

(j) ~~The System Master Clock shall be synchronized with the YMSS on receipt of time synchronization information embedded in the commands during data download of the YMSS~~.

The System Master Clock shall be synchronized with the YMSS on receipt of

time synchronization information embedded in the commands during data download of the YMSS or an alternative specified by the Engineer.

(k) Established reliability figures shall determine if redundant LPU's are required.

10.2.5. Event Recorder

(a) The Event Recorder shall consist of two types of memory module, namely: Main Memory and Extended Memory. As a minimum, the Event Recorder shall record the signals in Table 1 of IEEE Std. 1482.1-1999 "IEEE Standard for Rail Transit Vehicle Event Recorders" in the Main Memory module. All other signals shall be recorded in the Extended Memory module.

(b) The Event Recorder shall be able to be configured to apply different recording schemes for the specified three different types of data as follows:

(i) Fixed text event message

(i i) Variable text event message

(i i i) Stripchart or "Analog" type of data

(c) The Event Recorder Main Memory shall have a minimum capacity of 10 hours and a minimum of 32 channels continuous recording at a sampling rate of 1 sample per second. It shall be provided in each cab car.

(d) This device shall monitor and flag any operation of critical function, such as, emergency brake applied by the train operator via the activation of emergency stop push buttons or deadman's switch, emergency door. In addition, any abnormal operation shall be recorded including wrong side saloon door operation. Detailed monitoring arrangement shall be agreed with the Engineer.

(e) The Event Recorder shall incorporate playback function for signals recorded and shall be supplied completed with a diagnostic software for analyzing the recorded data.

(f) The Main Memory module used for the storage of data shall be removable to allow playback on other common commercially available computer equipment.

(g) The Event Recorder's Main Memory shall be housed in a robust, lockable, crash and fire resistant box according to IEEE Std 1482.1-1999 "IEEE Standard for Rail Transit Vehicle Event Recorders". The Event Recorder shall be stowed such that illegal tampering with the complete unit shall not be possible.

(h) The location of the Main Memory module used for the storage of data shall be carefully selected in order to ensure that all recorded data is protected from loss due to vibration, shock and impact force in the event of train collision. The memory module shall be able to withstand a shock of 30g in the direction

of travel without any loss of the data.

(i) The data recorded on both the memory module shall be well protected and facilities shall be provided to prevent:

(1) Unauthorized access and the accidental erasure of the recorded data.

(2) Removal of the memory module from the train by unauthorized person.

(j) A memory reader shall be provided to enable the extraction of the data from both memory modules when it is removed from the train and transfer to an IBM® compatible PC.

(k) All extracted data shall be compatible with the operating system of Microsoft© Window® XP (or later version, if approved) and software of Oracle DataBase for Window® or an alternative specified by the Engineer.

(l) The Extended memory module shall have sufficient capacity to retain information for a period of 120 minutes on rolling memory (first in first out basis) at a higher data sampling rate. The proposed number of signals monitored and the signal sampling rate shall be submitted for approval.

(m) The recorded data within any period of time shall be retrieved from the recorded data without ambiguity.

(n) Data recorded shall be non-volatile type in the event of loss of train power supply and retained for a minimum of 4 weeks with no external power supply present.

(o) Faults Detected

(1) The condition under which a fault is detected shall be recorded together with the fault to assist the analysis of the failure. The parameters to be recorded shall include:

(1) Fault type

(2) Car number

(3) Date and time the fault is detected

(4) Station name

(5) Line number

(6) Train speed

(7) Date and time the fault is cleared, and

(8) Staff ID and run number (if it has been input by the train operator)

(2) The Event Recorder shall also be able to record in Extended memory module other digital and analogue data which shall assist the fault analysis. The list of data to be recorded shall be optimized for each fault.

(3) Features shall be provided to prevent the repeated recording of a permanent

failure on the train to avoid memory overflow. This shall include overwriting the previous faults recorded based on a first-in-first-out principle, stop recording when memory is full or to record the first and the last few occurrences of the same fault only.

(p) Vital Operational Signals

(1) Vital operational signals shall be continuously monitored by the TIMS and recorded by the Event Recorder. The list of vital operational signals shall be subject to approval.

(2) The recording of vital operational signals shall be triggered by the change of the signals to minimize memory requirement. Digital data shall be recorded when there is a change in status. Analogue data shall be recorded when the change of data is above a pre-defined value.

(q) Equipment Performance Parameters

(1) Equipment performance parameters selected via the portable PC and/or YMSS computer which reflect the condition of the equipment shall be recorded by the Event Recorder.

(2) Only the latest sample of performance parameters shall be recorded and shall cover at least 200 samples or the latest 30 minutes data for each selected parameter.

(3) The sample size shall be adjustable.

(r) Configuration of the Event Recorder shall be able to be performed remotely

via a portable PC and/or YMSS computer when the TIMS is in the Maintenance Mode. The recording schemes for each of the three different types of data as stipulated shall be able to be changed via a portable PC and/or the YMSS computer.

10.2.6. ATC / Communications Gateway

(a) An ATC / Communications Gateway shall be provided in each cab car to interface with the trainborne ATC and Communications equipment.

(b) The ATC / Communications Gateway shall connect the following trainborne equipment to the TIN to enable data communication service:

(i) ATC

(i i) DVAS and PA

(i i i) VSS

(i v) PIS

(v) Wireless LAN for YMSS

(vi) Radio

(c) The design and construction of the ATC / Communications Gateway shall ensure that the interface requirements of the trainborne ATC (refer to Appendix I Annex 3) and Communications equipment (refer to PS 18 and Appendix I Annex 4) are satisfied.

(d) The ATC / Communications Gateway shall interface with the trainborne ATC via a RS 232 serial link interface.

(e) The ATC / Communications Gateway shall interface with the remaining sub-systems via the Train Consist Network.

10.2.7. Video Surveillance Systems (VSS)

(a) A full color video surveillance systems as a safety measure and for detecting and preventing crime in a railway environment, shall be provided inside the train. The VSS shall output the video data for both local monitoring by train operator in realtime and local storage in the digital video recorder. Note that all recorded image of the videos may be used as evidence and presented to the Canadian Courts.

(b) The image quality of the VSS shall be able to facilitate realtime monitoring of video surveillance data collected inside of transit vehicles for both locally by the vehicle operator and remotely after retrieving the video data from the removable hard drives, and identify potential incidents or threats based on received processing parameters.

(c) The VSS shall include the following equipment:

(i) One trainborne video display shall be provided on each cab and the display control shall be subject to the operability engineering design (refer to PS 21.5). The trainborne video display shall be viewed clearly by the train operator at both the sitting and standing positions in front of the train operator console. The trainborne video display shall be aesthetically integrated into the driving console (refer to PS 8).

(ii) Three types of cameras which shall be operational automatically when the train systems are initialized (refer to PS 9.2), shall be provided:

(1) Cab Front Camera. One camera shall be provided at each cab front. The camera shall be strategically located to capture the complete forward looking views of the trackside, preferably in the same perspective angle of a seated train operator, in order to facilitate the train operator of the rear driving cab to monitor the track condition when it is required. Video recording of the cab front camera shall be continuous and the rear view shall be recorded only when the train is reversing.

(2) ~~Saloon Camera. Two cameras shall be provided on each car. The cameras shall be strategically located to capture the complete views all passengers inside a car, in order to facilitate the train operator to monitor all passenger movements inside the complete train. Video recording of the saloon camera shall be event driven i.e. by PAIS or PAA activation, including buffers of 30secs before and after.~~

Saloon Camera. Four cameras shall be provided on each car. The cameras shall be strategically located to capture the complete views all passengers inside a car, in order to facilitate the train operator to monitor all passenger movements inside the complete train. Video recording of the saloon camera shall be event driven i.e. by PAIS or PAA activation, Video event recording shall start 10 minutes prior to PAA or PAIS activation and shall end upon their de-activation

[Option]

Or as an option to the Option 10 (refer to PS 3.10.10), the VSS shall meet the following requirements:

- Eight additional cameras shall be provided on each car i.e. one maintenance

  free hidden camera shall be mounted on each doorway which shall be facing inside the car in order to capture the image of passenger's face when existing the train.

- Video recording of the hidden camera at the doorway shall be event driven i.e. 15 secs before the opening of door, whole duration of door in an opened state and 15 secs after the closing of door.

- Playback function shall be provided. The train operator shall be able to select any camera of the train and play back the video image by using the trainborne video display. Such playback shall not interrupt ongoing video recording, nor the quality of the recording shall be compromised.

- Real-time remote viewing of video data of any one train of the whole AUTHORITY's subway system. A prototype shall be provided on retrofitting the required equipment onto an existing T1 car as if it is a NST, in order to demonstrate the functionalities and performance of the above system.

(3) Multi-purpose Area Camera. One camera which shall be located in such a way that it shall be possible to capture the image of passengers when they are using the multi-purpose area, shall be provided in each multi-purpose area. The camera shall be able to record at a higher speed and capture the view of the passenger who operated the passenger alarm emergency handle and

communicating with the train operator over the PA microphone, in order to facilitate the train operator to monitor the passenger's conditions including discernible facial features, and the entire face should be in focus. Video recording of the multi-purpose area camera shall be event driven i.e. by activation of the PAIS at the same multi-purpose area, including buffers of 30secs before and after. For storage capacity sizing, the system shall be

capable to capture 7 times of PAA/PAIS activation (15 minutes per event) per day of the whole fleet of NST in the M line.

(iii) The cameras shall be linked to a robust non-multiplexed digital video recorders which shall maximize the storage of video data from the individual cameras. The digital video recorders shall be served as the central processor of the cameras, controlling the acquisition of signal, applying the necessary processing functions to optimize the data, and delivering an output video signal for display on the trainborne video display with an image file of minimum 1024 x 780 pixels. A dedicated trainline shall be provided to support the video data/signal transmission from the cameras to the trainborne video displays. Or alternatively, the video data/signal transmission from the cameras to the trainborne video displays shall be transmitted on the TIMS network.

(iv) The video data (which includes the audio data of the PAIS (refer to PS 18.3.7(b)(iii)) shall be stored on a removable hard drives which shall be housed in a robust, lockable box and shall be stowed such that illegal tampering shall not be possible. The removable hard drives shall be sized with a minimum capacity of 45 days continuous recording at a video capturing rate of 12 frames per second.

(v) The video data as stored on the removable hard drives shall be able to be transferred to the Offline Playback Unit (OPU) for review.

(v i) The OPU shall be an IBM© compatible workstation equipped with a software to allow access to still images, video streams, playback and editing of the video data as transferred. Software function of image zooming shall be provided to enlarge image of a passenger who is standing at the far end of the gangway of a car.

(v i i) The OPU video playback and editing software shall be compatible with the operating system of Microsoft© Window® XP (or later version, if approved).

(v i i i) Onboard memory for video data shall meet the following requirements:

(1) Enough memory for 45 days of video data recording. Daily download of video

data of event driven camera shall be performed by using the wireless communication of the YMSS. Download on demand of video data of forward view camera shall be possible using the wireless communication of the YMSS.

(2) Not used.

(ix) The video data shall provide an accurate information of what the train operator sees. Those information that required for identification and configuration purpose, for example, date and time stamps, the corresponding camera and car numbers, and etc, shall be automatically recorded in the video

data and display to the train operator.

(d) The camera shall be weather-proofing, and resistance to tampering, impacts, and hazardous substances. The following special features shall be provided: backlight compensation, dynamic noise reduction and remote and automatic lens control In addition, the cameras shall be able to withstand the specified vibration and shock and resistant to electrical interference. Using a 1/4" CCD or other as approved, the camera shall provide a minimum of 380TV lines of resolution, in color with a minimum illumination level of 0.5Lux.

(e) The trainborne video display shall conform to the following requirements:

(i) ~~An industrial grade 12 ” to 15" full color Liquid Crystal Display (LCD) compact trainborne video display shall be provided. High resolution images shall be generated to allow the train operator viewing the images in a clear, legible form, so as to read the detailed texture, shape, size, color, position, orientation and movement of the passengers in realtime~~.

~~An industrial grade 10" full color Liquid Crystal Display (LCD) compact~~ trainborne video display shall be provided. High resolution images shall be generated to allow the train operator viewing the images in a clear, legible form, so as to read the detailed texture, shape, size, color, position, orientation and movement of the passengers in realtime.

(ii) The display unit shall be protected from fraudulent use by a non-reflective,

~~glareless and vandalproof reinforced glass. The light transmissivity of the protective glass shall not be less than 95%. The design, material specification, fixing method and a sample of the protective glass shall be submitted for approval~~.

The display unit shall be protected from fraudulent use by a non-reflective, glareless and vandalproof reinforced glass or other material as approved by the engineer. The light transmissivity of the protective glass shall not be less than 95%. The design, material specification, fixing method and a sample of the protective glass shall be submitted for approval.

(i i i) The backlight module of the display unit shall be quickly replaceable on bench by an electronic technician.

(iv) No build-up/decay lag or image retention shall be noticeable during the normal operation of the display. The response time of the picture elements shall be less than 50 msec.

(v) Manual picture controls of the display including, power on/off, brightness, contrast, color balance, shall be provided at the front panel of the display.

(v i) Automatic Light Control function shall be provided to allow the brightness and contrast of the display to be automatically adapted to different lighting conditions of the driving cab.

(v i i) The Automatic Light Control function shall be disabled and overridden by the manual control buttons on the front panel of the display.

(v i i i) Not Used

(i x) Configuration of the display shall be able to be performed on site by the built-in On-Screen-Display features or by a portable terminal via a configuration port at the front panel of the display.

(x) All configuration data shall be stored in non-volatile memory in the display and shall be preserved even after power interruption.

(x i) Control Requirements

(1) As long as the DC circuit (refer to PS 17.4) is started up and the mode selector is not put at the “Shutdown” position (refer to PS 9.5), the display control functions of the trainborne video display shall remained operative.

(2) Display control for selection of video images shall be provided as follows:

- Defaulted display mode shall be a split-screen to show a minimum quad view simultaneously showing the images of 4 different cameras, 2 cars at a time, as follows: the front 2 cars cameras, then the 2 middle cars cameras followed by the last 2 cars cameras.
- The train operator shall be able to select a single screen of any camera image or scroll through different images. The selection of the desired camera image shall be accomplished by simple menu selection.
- The camera shall have its own address so that the associated image shall be easily selected based on the address.
- Once the driving mode is being selected at any cab of a train (refer to PS 9.5), the above control functions shall be remained operative at both cabs independently.

- The VSS video data archive shall not exceed maximum durations of 72 hours in a “first-in-first-out ” manner

10.2.8. Passenger Information System (PIS)

(a) General

(i) The PIS shall include the following equipment:

(1) Electronic Information Display System (EIDS) shall be provided inside the saloon. The displays of EIDS shall be viewed clearly by the passengers at both

the sitting and standing positions inside the saloon. The displays shall be aesthetically integrated into the saloon panels;

(2) Electronic Destination Display (EDD) and Electronic Train Number Display (ETND) shall be provided in the cab; and

(3) [Option] Flashing System Map (FSM) shall be provided above the doorway of the passenger bodyside door.

(ii) Requirements according to IEEE Std 1477-1998 "IEEE Standard for Passenger Information System for Rail Transit Vehicles" shall be met.

(iii) ~~The PIS shall achieve a reliability of 3000 car kkm/failure~~. The PIS system and architecture will be developed in order to meet the overall RAMS trainset requirement.

(iv) The PIS shall meet the following interface requirements with the TIMS:

(1) To transmit and receive the required information from TIMS.

(2) To display the real time, train number (provision only for realtime train number display), name of route and names of next and destination stations in the TIMS display terminal.

(3) A separate graphical window shall be provided for the train operator to select for viewing the messages of the EIDS that are broadcasting to the passengers.

(4) During ~~the normal circumstances, the station code shall be updated according to the station information provided by the ATC system. In the event that the data transmission link between the ATC system and the TIMS is failed, this~~ fault shall be reported to the t~~rain operator and the TIMS shall automatically perform the update of the station codes according to the following sequential control logic:~~

~~if~~

~~- the train speed is decreased to 0 km/h; and~~

- the passenger doors of the train has been commanded to open and ~~close once;~~

~~then~~

~~- the station code of the next station shall be updated and displayed in the FSM, LIDS and EIDS according to the specified system routes.~~

(4) During the normal circumstances, the station code shall be updated according to the station information provided by the ATC system. In the event that the data transmission link between the ATC system and the TIMS is failed or that a tag is missed or failed, the TIMS shall automatically perform the update of the station codes according to the following sequential control logic: Each station announcement tag shall have an associated virtual tag defined in the

TIMS PIS database. The propulsion system shall report to the TIMS the traveled distance that the TIMS shall use to trigger specific station announcement upon reaching associated virtual tag. Since both ATC announcement tag and TIMS virtual tag process operate in parallel, a software mechanism shall ensure that a particular station announcement is not repeated unwontedly.

(5) Whenever the operation of the data transmission link between the ATC system and the TIMS is resumed, the above control functions of station code update shall be automatically transferred back to the ATC system via the TIMS. This transferring process shall be continuously reversible until the intervention of the train operator.

(6) The following control functions shall be provided to facilitate the train operator to control the PIS:

- remotely turn on or off the LEDs or LCD backlight of the displays ~~of each~~ sub-systems ~~of the PIS through the TIMS display terminal;~~
- ~~manually change the train number, name of route and names of next and destination stations through the TIMS display terminal; and~~
- ~~manually reset the PIS to the default~~ state for re-initialization ~~purpose through the TIMS display terminal~~.

- remotely turn on or off the LEDs or LCD backlight of the displays of each sub-systems of the PIS and MIS through the TIMS display terminal;
- manually change the train number, names of next station and destination stations through the TIMS display terminal; and
- manually reset the PIS to the default state for re-initialization purpose through the TIMS display terminal."

(v) Automatic Fault Diagnosis and Health Test

(1) The PIS shall be able to detect, at any time when the PIS is in operation, any hardware and software fault. The faults shall be monitored by the TIMS.

(2) ~~The PIS shall be able to carry out a health test when the health test command is received from TIMS. The health test shall be able to be conducted on all FSMs, LIDSs, EIDSs, EDDs and ETNDs separately.~~

The PIS shall be able to carry out a health test when the health test command is received from TIMS.

(b) Refer to PS 10.2.9

(c) EDD, ETND and EIDS Display Panels

The LED display panels shall conform to the following requirements:

(i) ~~For the EDD, the LED display panel, it shall conform with the following requirements:~~

(1) the LED display panel shall be ultra bright, two lines, single ~~color in amber~~ visible in sun-light ~~LEDs, 24 pixel high by 120 pixel wide display matrix, yielding up to 10 characters per line with 113 mm (4.5”) high characters. The display shall be a high resolution. 4.76 mm (1875 ”) pitch / LED center to center pixel spacing. An alternative configuration, such as a combined EDD and ETND, may be considered subject to approval by the Engineer.~~

the LED display panel shall be ultra bright, one line, multiple pages, single color in amber visible in sun-light LEDs, 10 pixel high by 70 pixel wide display matrix, yielding up to 10 characters per line with 88 mm (3.5”) high characters. The display shall have a resolution of 8.9 mm (3500 ”) pitch / LED center to center pixel spacing.

The LED display panel shall be ultra bright, single line, single color in amber visible in sun-light LEDs, 10 pixel high by 18 pixel wide display matrix, yielding up to 3 characters per line with 88 mm (3.5") high characters. The display shall be a high resolution.8.9 mm (3500") pitch / LED center to center pixel spacing.

(2) The color and the character size of the display shall be designed to achieve the required visibility by the train operators and the passengers, and also to match with the overall aesthetic design of the cab front.

(3) The EDD shall be legible from the station platform on either side of the train at a minimum distance of 30 m ahead of the train and at an angle of up to 45 degree, by a person with normal eyesight.

(4) The EDD shall be legible in direct sunlight when the train is running in open section, and in artificial light and darkness in underground section.

(5) There shall be no escape of light from EDD into the cab.

(6) No incorrect information shall be shown by the EDD. The display shall be

switched off if any fault is detected in the EDD.

(7) The train operator shall control the EDD via the TIMS.

(8) Not Used

(9) ~~An amber LED shall be provided on the rear of the EDD to indicate the status of the power supply~~.

No power LED shall be required on the rear of the EDD

(10) ~~The time taken for the display of the correct destination after the initial power up of the train shall not exceed twenty (20) second~~.

The time taken for the display of the correct destination after the initial power up of the train shall not exceed twenty (20) second after initialization of the destination.

(11) Following a change of selection it shall take less than five (5) seconds for the EDD to change to the selected destination, as specified by IEEE 1477-1998.

(12) The EDD shall recover itself and display the correct destination within twenty (20) second when power supply is available.

(13) The EDD completed with the power supply shall be designed in modular form to minimize the cable connections. The EDD shall be installed on each driving cab. Ergonomics and aesthetics shall be taken into account in the mounting and design of the display.

(14) The protective glass or equivalent shall be provided to prevent any damage from heat and sunlight (color fading), and shall not affect the color quality of the display.

(15) The method of mounting the EDD behind the windscreen in the driving cab shall allow easy installation and removal. All the cable connections to EDD shall be of plug and socket type, and the female connector shall be mounted on the car body side. Removal and installation of one EDD shall be completed by two trained maintenance staff within 20 minutes.

(16) The enclosure shall be designed for modular plug-in type PCBs. Access to the electronics shall be achieved within 15 minutes for maintenance and service purposes.

(17) The power supply for the EDD shall be taken from the DC output of the auxiliary converter system (refer to PS 17.4). ~~The supply shall be available~~

~~when either one of the auxiliary converter set is running~~. The power supply for the ETND shall available when either one of the auxiliary converter set is running.

(18) Suitably rated MCB shall be provided.

(19) For communication interface, the data shall be transmitted from the TIMS through a separate RS485 bus or the System Sub-Network at a minimum data

transmission rate of 9,600 baud.

(2 0) Provision for Future Expansion

(2 1) The software of the EDD shall be designed to allow new destinations to be incorporated easily by the Commission. The destination database shall be stored in flash memory within the DiCU thus allowing for centralized update or changes to be easily implemented for new routes. The memory shall be sufficient to store up to 100 destinations and 20 messages.

(2 2) Hardware and software tool shall be provided to carry out the change. The required software change shall be carried out with IBM compatible computer equipment.

(2 3) The Contractor shall provide all the necessary detailed instructions and special equipment to enable the Engineer to reprogram the unit to incorporate the new destinations.

(ii) For the ETND, it shall conform with the following requirements (alternative design of equivalent or better performance, shall be submitted for approval):

(1) The LED display panel shall be ultra bright, single line, single color in amber visible in sun-light LEDs, 12 pixel high by 48 pixel wide display matrix, yielding up to 4 characters per line with 113 mm (4.5”) high characters. The display shall be a high resolution. 4.76 mm (1875”) pitch / LED center to center pixel spacing.

(2) The ETND shall be legible from station platforms on either side of the train at a minimum distance of 25 m and at an angle of up to 45 degree, by a person with normal eyesight.

(3) The ETND shall be legible in direct sunlight when the train is running in open section, and in artificial light and darkness in underground section.

(4) The color and the character size of the display shall be designed to achieve the required visibility, and also to match the overall aesthetic design of the cab

front. The design shall be submitted for approval.

(5) Not Used

(6) The train operator shall control the ETND via the TIMS.

(7) An amber LED shall be provided ~~on the rear of the ETND to show the power on of the ETND~~.

No power LED shall be provided on the rear of the ETND.

(8) ~~The time taken for the display of the train number after the initial power up of~~ the train shall ~~not exceed twenty (20) seconds~~.

The time taken for the display of the train number after the initial power up of the train shall not exceed twenty (20) seconds after initialization of the train ID.

(9) The ETND shall recover itself and display the correct destination within twenty (20) seconds when power supply is available.

(1 0) Following a change of selection it shall take less than five (5) seconds for the ETND to change to the selected train number, as specified by IEEE 1477- 1998.

(1 1) The ETND completed with the power supply shall be designed in modular form to minimize the cable connections.

(1 2) The method of mounting the ETND behind the windscreen in the driving cab shall allow easy installation and removal. All the cable connections to ETDN shall be of plug and socket type, and the female connector shall be mounted on the car body side. Removal and installation of one ETDN shall be completed by two trained maintenance staff within 20 minutes.

(1 3) The enclosure shall be designed for modular plug-in type PCBs. Access to the electronics shall be achieved within 15 minutes for maintenance and ~~service purposes.~~

(1 4) The power supply for the ETND shall be taken from the DC output of the auxiliary converter. The supply shall be available when either one of the auxiliary converter set is running.

(1 5) Suitably rated MCB shall be provided.

(1 6) ~~For communication interface, the data shall be transmitted from the TIMS~~ through a separate RS485 bus or the System Sub-

Network.

For communication interface, the ETND shall be controlled by the EDD via a clocked bi-directional serial interface.

(iii) For the EIDS, the LED display panel, it shall conform with the following requirements:

(1) The display panel shall be three lines tri-color LEDs (i.e. green, red and amber) on a black background (LED off state). The number of the LED pixel shall not

be less than 160 x 32 (i.e. 5120 pixel) per each panel in the displaying area. The pixel diameter shall be 3 mm and the pixel per pitch shall not be greater than 4 mm. An alternative configuration may be considered for better ~~resolution.~~

(2) ~~The EIDS shall be able to display the passenger information of two types of~~ data, namely, operational and commercial. The display panel shall ~~be able to show both text messages and low resolution animated graphics~~.

The EIDS shall be able to display passenger information in both text messages and low resolution pre-programmed animated graphics

(3) Two levels of LED illumination shall be provided to cater for the tunnel and overhead section ambient lighting condition.

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(4) The display panel shall have good display quality on uniformity of luminous intensity. For a same color within an LED matrix, the ratio of maximum to minimum luminous intensity shall not be greater than 2.

(5) The viewing angle to the display panel for a clear and sharp image at a distance of 5m shall not less than ±60 .

(6) The display panel shall be able to display a minimum of five (5) frames per second for text and fifteen (15) frames per second for animated graphics.

(7) The display panel shall be designed to make flushed with the panels of the saloon interior after installation.

(8) The design of the display panel enclosure shall be tamper resistant, and shall not allow passenger to disassemble the unit from the front.

(9) All equipment of the panel shall be sealed to IEC60529 IP54 once installed in the car.

(1 0) The exterior design of the display panel shall blend in with the aesthetics

of the vehicle interior finishing and the final product shall be seamlessly integrated into the vehicle's interior design.

(1 1) The exact locations for the panels inside the saloon shall be determined by the Engineer during the detail design stage.

(1 2) The LED matrix shall be protected by a replaceable tamper-proof front shield which shall be a protective toughened glass comply with BS 857:1990 or equivalent. It shall also be protected from vandalism by passengers.

(1 3) The front shield shall be non-reflective, glareless and with light transmissivity

of not less than 95%. The front shield shall not affect the color quality of the display.

(14) The front shield shall be field replaceable.

(15) The two (2) EIDS installed in each car of the trains shall be supplied by DC power.

(16) The EIDS shall be operated satisfactorily at battery supply voltages of 37.5 VDC.

(17) The display panel shall be equipped with a highly efficient and reliable internal power supply converter to supply power for control and displaying functions of the LED matrix. The noise power level generated by the converter shall be limited below 30dB in the audible frequency ranged from 20Hz to 20kHz.

(18) When there is a loss of AC power on the train, the EIDS shall operate according to the load shedding rules to be determined during design reviews, in order to save the emergency DC power from the battery.

(19) The display panels shall be of modular design and consist of LED display matrix, power supplies, microprocessor control card with memory storage and interface card.

(20) The interface card shall interface ~~the EIDS with the DiCU, either via the TIN~~ or via a dedicated PIS network. One local serial port (DB-9 ~~RS232 or alternate as approved) shall be provided for local download (for example, firmware and fonts) to the panels~~.

The interface card shall interface the EIDS with the DiCU, via the TIN network. TIN network shall be used for local download (for example, firmware and fonts) to the panels.

(21) The microprocessor control card shall control and drive the display function of the LED matrix so that the panel shall display the message according to the

display sequence as instructed by the DiCU.

(22) The Display Panel shall have its own address so that the physical panel location shall be easily identified based on the address.

(23) The watch-dog function shall be provided for the micro-processor card to monitor the operation of the processor and shall reset the micro-processor in case of processor hang up.

(24) The control card shall have two different types of storage memory as shown

below:

(25) The re-programmable RAM shall be used for buffer memory to store the frequently changed or updated messages received from the DiCU.

(26) The memory size shall be large enough to store at least one 20-minute display cycle of information messages.

(27) ~~The memory shall be sustained by charged capacitor without data lost for at least 2 hours.~~ The SCI memory shall use none volatile flash memory (including pre-programmed graphics database). The display content data is stored in the TIMS LPU that controls what is displayed on each EID.

(28) The non-volatile Flash Memory is used to store rare change data files like microprocessor boots, control firmwares, English fonts.

(29) The memory size shall be enough to store at least 5 types of English fonts and control firmwares.

(30) The data files inside the Flash Memory shall be re-programmable through both ways of DiCU and the serial port.

(31) The Display Panels shall have internal temperature sensor to monitor the temperature of the LED display matrix so that the operating temperature shall not exceed 65°C (149°F).

(32) Under the normal operating temperature range, the Display Panels shall be cooled by natural convection so that the temperature remains below 65°C (149°F). If the temperature exceeds normal temperature range, the panels shall diminish the brightness of the display and shut off the display LED matrix above a critical pre-set temperature level and restore the display to normal operation when temperature drops to acceptable levels.

(33) The Display Panels shall have a built-in photo sensor which shall

automatically adjust the intensity of the LED matrix. At least two levels of LED illumination shall be provided to cater for the tunnel and overhead section ambient lighting condition. The Contractor shall submit the illumination intensity of the LEDs and the intensity variation between LEDs at the two levels for approval.

(34) The brightness of the display panel shall be automatically diminished to the dimmest mode in case of the failure of the either sensor.

(35) All software upgrades of the Display Panels shall be on-line downloadable from the DiCU.

(36) Diagnostic function shall be provided to check the hardware and software status of the Display Panels. The Diagnostic function shall include two levels checking: Self and Polled Diagnostic function.

(37) The Self Diagnostic function shall be performed automatically by the display panels as shown in the following table.

Items	Diagnostic Details	Frequency
1	Test the functionalities of hardware, such as, LED matrix, control module	Only at initial power up.
2	Check the version software such as control firmware, English fonts.	Only at initial power up.
3	Check the versions of information messages received from DiCU.	Every two hours.

The updated result of self diagnostic test shall be sent to the DiCU. DiCU shall send the result to the TIMS as described in 10.3.5.

(38) The Polled Diagnostic Function command shall be issued through the Bulk Data Transmission Facilities via the TIMS. The DiCU shall request all display panels to perform the Self Diagnostic Test following reception of the Polled Diagnostic Function from the TIMS and shall collect the diagnostic result from the TIMS immediately.

If there is fault found in the diagnostic test, fault message including the display panel address and fault type shall be reported to the Bulk Data Transmission Facilities via TIMS.

(39) ~~The LED matrix shall not at any time show blank screen under normal operation condition so that train operators can easily know whether the display panel function normally or not.~~

The LED matrix shall normally display information except when information integrity is compromised or when the train operator order a target sign to blank out using the TIMS display.

(40) Not Used

(iv) [Option] Flashing System Map (FSM)

(1) The FSM display shall be installed in each door coving panel as part of the light fixture. The space of the door coving panel shall be fully utilized to maximize the FSM display area.

(2) The FSM shall display information on a real time basis. The information displayed to the passengers shall include:

- the line that the train is running on,
- the direction to which the train is travelling
- terminal station
- next station the train will arrive
- current station the train stop
- ~~interchange station and the corresponding line for interchange~~
- ~~passenger doors ' opening side~~
- interchange station and the corresponding line for interchange"

(3) The system shall not display incorrect information. A failure in any display units shall not affect the normal operation of other display units in the system.

(4) At least one display shall be clearly legible from any location within the saloon by a person with normal eyesight.

(5) The system shall be designed so that passengers can easily read the information from any seating or standing position within the saloon area under all artificial and natural lighting, including bright sunlight in open sections of the Existing Subway Lines.

(6) ~~The system shall be able to accommodate future extension of the New E by means of a simple modification on the graphics and software.~~ Subject to the final alignment of the New E Extension, four stations, ~~namely, N West, A West, York D and P West will be added to the North of the existing B station. The following requirements on the FSM graphic upgrade process for the future extension shall be met~~:

The system shall be able to accommodate future extension of the New E by means of a simple modification on the graphics and software. Subject to the final alignment of the New E Extension, six stations, namely, N West, A West, York D and P West, Hwy 407 Transitway, Vaughan Corporate Centre will be added to the North of the existing B station. The following requirements on the FSM graphic upgrade process for the future extension shall be met:

- The FSM graphic can be slide out without interference from adjacent panel and the modification of the FSM graphics for each display panel shall be completed within 5 minutes by a trained staff.
- The FSM graphics and the LED layout shall be properly and quickly aligned after the change of the graphic.
- The design shall prevent the ingress of moisture between the FSM graphics and the protective covering sheet.

(7) The Contractor shall demonstrate the legibility of the display mounted in the saloon, under various viewing conditions from all points in the saloon, to the ~~satisfaction~~ of the Engineer, prior to the full production of the equipment.

(8) ~~The display unit shall indicate the train's location in the form of a pictorial~~ map for all Existing Subway ~~Lines on which the train will run. A separate integrated display shall indicate the side on which doors will open.~~

The display unit shall indicate the train's location in the form of a pictorial map for all Existing Subway Lines on which the train will run.

(9) The display of the information in PS 10.2.8(c)(iv)(2) shall be achieved by the switching on, off and flashing of correct LEDs, installed in the system route map.

(1 0) The flashing time of the LEDs shall be

- On time : 600ms
- Off time: 400ms

(11) ~~Each station shall be indicated by a discrete extra bright LED as per FSM graphics. Two separate LEDs shall be used for indicating passenger door 's~~ opening side: Green LED shall be used for the designated door opening side and red LED shall be used for the non-designated ~~door opening side or the door has been isolated (refer to PS 16.2.13(c)(ii)).~~

Each station shall be indicated by a discrete extra bright LED as per FSM graphics. Two separate LEDs shall be used for indicating passenger door 's opening side: Green LED shall be used for the designated door opening side and red LED shall be used for the non-designated door opening side or the door has been isolated (refer to PS 16.2.13(c)(ii)).

(1 2) Different colored LEDs shall be used for interchange stations.

(1 3) The FSMs shall make use of the information received from the TIMS to control the LED display.

(1 4) The FSM completed with the power supply shall be designed in modular form to minimize the cable connections. The dimensions of the FSM shall enable it to be fitted into the door coving panel, and the FSM shall be mounted flush with the coving panel.

(1 5) ~~The total weight of the FSM shall not be greater than 10 kg.~~

The total weight of the FSM shall not be greater than12.5 Kg.

(1 6) The design of the FSM enclosure shall be tamper resistant, and it shall not allow passengers to disassemble the unit from the front.

(1 7) The electrical connection to the FSM shall not be accessible to passengers. Cable route shall prevent sharp bend causing damages to the cable.

(1 8) The method of mounting the FSM to the door coving panel shall allow easy installation to and removal from the door coving panel. All the cable connections to FSM shall be of plug and socket type, and the female connector shall be mounted on the car body side. Removal and installation of one FSM shall be completed by two trained maintenance staff within 20 minutes.

(1 9) The FSM shall be designed for modular plug-in type PCBs. Access to the electronics shall be achieved within 15 minutes for maintenance and service purposes.

(2 0) No special cleaning procedure for the FSM protective cover sheet will be required, i.e. the cleaning method shall be identical to those for the coving panels.

(2 1) ~~The power supply for the FSM shall be obtained from the DC output of the auxiliary converter system (refer to PS 17.3). The electrical loads of the FSMs shall be operated according to the load shedding rules~~ to be determined during ~~design reviews~~.

The power supply for the FSM shall be obtained from the EID. The electrical loads of the FSMs shall be operated according to the load shedding rules to be determined during design reviews.

(2 2) Not Used

(2 3) Suitably rated MCBs shall be provided.

(2 4) The FSM function shall be recovered automatically after a transient loss of power supply.

(2 5) ~~Flash EPROM shall be used in the FSMs to allow the software program~~ change t~~hrough the DiCU.~~

FSM will not use EPROM

(d) Initialization of the PIS

~~The PIS shall be initialized by the DiCU when a new route code, destination code and station code are received from the Bulk Data Transmission Facilities~~

~~(refer to PS 18.6.2). The PIS shall automatically display on the FSM, EDD, EIDS and LIDS the destination, this station and the next station according to the route code, destination code and station code as received.~~

The PIS shall be initialized by the DiCU when a new destination is entered in the TIMS display. The run number (or train number) must be entered from the TIMS display or the RCP. The PIS shall automatically display the destination on the EDD and the run number on the ETND. The FSM, EIDS and LIDS PIS window will start displaying the station announcement once reaching the first ATC announcement tag or when the operator will re-synchronize the PIS while stop in any station.

(e) Normal Station Running

A normal running from one station (station X-1) to another station (station X) shall be divided into three different states. The transition from one state to another state shall be triggered by the following:

- station code,
- platform side code, and
- door status code

The PIS shall automatically update and display on the FSM, EDD, EIDS and LIDS this station, platform side, door status and the next station according to the above status codes. The details on the presentation style are stipulated in Table 10-5.

(f) Interchange Station

If the next station (station X) is an interchange station, the details on the presentation style are stipulated in Table 10-6.

(g) Terminal Station

If the next station (station X) is a terminal station, the details on the presentation style are stipulated in Table 10-7.

(h) Terminal and Interchange Station

If the next station (station X) is a terminal station and an interchange station at the same time, the details on the presentation style are stipulated in Table 10-8.

(i) Train Service Regulation Requirement

The design of the PIS shall facilitate the following train service regulation and display the correct information as soon as new data are received from the TIMS.

(1) Change of line during service

The train may change line during the service run. The PIS shall be able to display the correct destination according to the change of the route code.

(2) Turn short at station

The train may be turned short at some stations. The PIS shall be able to display the destination according to the change of the destination code.

(3) Time out protection

~~The time out protection shall be provided such that when no signal is received from the DiCU for 10 minutes, the display panels LEDs shall be switched off~~ in order not to show any incorrect information ~~to the passengers. Upon receipt of valid signal from the DiCU, the display panels LEDs shall be switched on again and response according to the signal command~~.

The time out protection shall be provided such that when no signal is received from the DiCU for three consecutive heartbeat (TIMS Global Data refreshed at +/- 100 msec), the display panels LEDs shall revert to default display in order not to show any incorrect information to the passengers. Upon receipt of valid signal from the DiCU, the display panels LEDs shall be switched on again and response according to the signal command.

(j) Interface with DiCU

The PIS shall obtain the following information from DiCU:

(1) Route Code

Route code contains the information of the line and direction in which the

train is running. The route code shall include the 8 normal service line numbers and the special line numbers due to train service regulation.

(2) Station Code

Station code contains the information of the next station the train shall arrive. A new station code shall be received from the TIMS when the train leave the head-wall of each station.

(3) Door Status Code

Door open / close signal contains the information on the status of the door. Doors shall be opened when the train stops at a platform, and shall be closed when the train is ready for departure.

(4) Destination Code

Destination code contains information of the terminal station the train shall arrive. This code shall be received from TIMS during initialization of the PIS or re initialization at any station of the running line due to train service regulation.

(5) Platform Side Code

This code contains the platform side on which the passenger doors shall be opened at next station. The data structure shall represent the following four different states, namely, left, right, left and right, and undefined.

(6) PIS Power On and Off Commands

The PIS LEDs on and off commands are used to switch on or off the LEDs of the display panels.

(7) Health Test Command

This command shall initiate the health test on PIS equipment.

(k) There shall be four categories of messages to be displayed by the EIDS:

(1) ~~Centralized Special Message~~

- ~~Centralized special message shall be used by TCC to inform passenger the special operational condition.~~
- The message ~~shall be composed of an introductory graphic frames followed by English text frames. The English texts in the text frames shall be sent via the Real Time Transmission Facilities.~~

- When the text is received, the DiCU shall validate the software key embedded ~~in the text to ensure that it is sent from the correct message terminal.~~
- ~~The validated text shall be sent to the MIS and to the EIDS display panels to be displayed for three times consecutively.~~

(1) Free Text BDTF Message

- Free Text BDTF message shall be used by TCC to inform passenger the special operational condition.
- The message shall be composed of an introductory graphic frames followed by English text frames on EID and only text frames on LID PIS window. The English texts in the text frames shall be sent via the Bulk Data Transmission Facilities (BDTF).

- When the text is received, the DiCU shall validate the software key embedded in the text to ensure that it is sent from the correct message terminal.
- The validated text shall be sent to the LID and EIDS display panels to be displayed for three times consecutively

(2) Trainborne Special Message

- ~~Trainborne special message shall be used by the train operator to inform passenger the special operational condition of the train. The message shall be further classified as type I and type II to set different priority.~~
- ~~The message shall be composed of an introductory graphic frames followed by English text frames.~~
- These messages shall be updated via ~~the Bulk Data Transmission Facilities~~ and stored in the DiCU non-volatile ~~flash memory.~~
- ~~The messages shall be sent to the MIS and to the EIDS and be displayed when the corresponding information is received from the DVAS and PA.~~ The display of message shall ~~be synchronized with the audio broadcast by DVAS and PA.~~
- Trainborne special message shall be used by the train operator to inform passenger the special operational condition of the train. The message shall have less priority then Free text BDTF message but higher priority then station/transfer message.
- The message shall be composed of an introductory graphic frames followed by English text frames.
- These messages shall be updated via the YMSS and stored in the DiCU ~~n~~on-volatile flash memory.
- The messages shall be sent to the MIS and to the EIDS and the display of message shall be synchronized with the associated audio broadcast by DVAS on the PA.

(3) EIDS Programmed Message

- ~~Programmed message to be displayed in the EIDS shall be simplified passenger information such as weather report, news headlines, financial information, advertisements or AUTHORITY message, in the form of English text~~ and low-resolution ~~animations.~~
- The EIDS programmed messages shall be generated and dispatched ~~from~~

~~the Media Team Workstation (refer to PS 18.5.6) to all trains via the Bulk Data Transmission Facilities.~~

- ~~The display sequence of the EIDS programmed message shall be controlled by the DCU via a scheduling list. The length of the scheduling~~ list ~~shall be adjustable to store a maximum of 512 messages.~~
- ~~Each message in the scheduling list shall carry a unique identification number, name, version code and scheduling criteria.~~
- ~~Scheduling criteria shall include time of day, day of week, calendar date,~~

~~expiry date and train geographic location.~~

- ~~EIDS programmed messages which meet the scheduling criteria shall be displayed one by one in accordance with the identification number in ascending order defined in the DCU scheduling list. The display sequence shall be repeated automatically after the last message in the list is displayed.~~
- Programmed message to be displayed in the EIDS shall be simplified passenger information such as weather report, news headlines, financial information, advertisements or AUTHORITY message, in the form of English text and introduction low-resolution animations or static bitmap.
- The EIDS programmed messages shall be generated and dispatched from the Media Team Workstation (refer to PS 18.5.6) to all trains via the Bulk Data Transmission Facilities or YMSS depending of the record size.
- The display sequence of the EIDS programmed message shall be controlled by the MICU via a scheduling list and relay to the DCU. The length of the scheduling list shall be adjustable to store a maximum of 512 messages (same records then LIDS programmed messages).
- Each message in the scheduling list shall carry a unique identification number, name, version code and scheduling criteria.
- Scheduling criteria shall include time of day, day of week, calendar date, expiry date and train geographic location.
- EIDS programmed messages which meet the scheduling criteria shall be displayed one by one in accordance with the identification number in ~~ascending order~~ defined in the MICU scheduling list. The display sequence shall be repeated automatically after the last message in the list is displayed.

(4) ~~Trainborne Operational Message~~

- ~~Trainborne operational message shall inform passenger the name and~~ interchange facilities of the coming station.
- ~~The message shall compose of an introductory graphic frames followed by English text frame.~~
- ~~Messages shall be updated via the Bulk Data Transmission Facilities and~~ stored in the non-volatile ~~flash memory of the DiCU.~~
- The message shall be displayed ~~on the EIDS and MIS display panels when the corresponding information is received from the DVAS and PA.~~
- ~~Trainborne operational message shall not interrupt the programmed~~

~~message. The design of the system shall synchronize the display of the~~ station ~~name with the audio broadcast from DVAS and PA which is triggered by the train operator at a random time after the train leave the station.~~

(4) Station and Transfer Message

- Station and transfer message shall inform passenger the name and interchange facilities of the coming station.
- The message shall compose of an introductory graphic frames followed by

English text frame.

- Messages shall be updated via the YMSS and stored in the non-volatile flash memory of the DiCU.
- The message shall be displayed on the EIDS and MIS LID PIS window when the corresponding information is played by the DVAS on the PA.
- The design of the system shall synchronize the display of the station name with the audio broadcast by the DVAS on the PA which is triggered automatically when approaching and leaving station.

(l) Message Priority

(1) ~~The display sequence of all categories of messages to be displayed by the EIDS shall be controlled by the DiCU while the sequence of messages to be displayed on the LIDS shall be controlled by the Multimedia Controller, according to the message priority. Message of higher priority shall interrupt the message being displayed on the EIDS and MIS display panels with lower priority~~.

The display sequence of all categories of messages to be displayed by the EIDS shall be controlled by the DiCU while the sequence of messages to be displayed on the LIDS shall be controlled by the Multimedia Controller with the exception of the LIS PIS window that will be controlled by the DiCU, according to the message priority. Message of higher priority shall interrupt the message being displayed on the EIDS and MIS display panels with lower priority.

Priority	Type of message
1	Trainborne special message - type I
2	Centralized special message
3	Trainborne special message - type II
4	Programmed message
5	Trainborne operational message

where 1 represents the highest priority and 10 is the lowest priority

Priority	**Type of message**
1	Door chime and audio announcement (audio+LID+EID)
2	CTPA (audio)
3	OTPA (audio)
4	Emergency msg (audio+LID+EID)
5	Station and transfer msg including In route

	msg (audio+LID+EID)
6	Special msg (audio+LID+EID)
7	Free text BDTF msg (LID+EID)
8	EID programmed msg (EID)
9	LID programmed msg (LID)
10	

(3) Any message having been interrupted by higher priority message shall be displayed again after the completion of the higher priority message.

(4) Messages shall not interrupt the message being displayed on the EIDS and LIDS display panels with the same or higher priority. The message shall be displayed after the completion of the current message.

(m) Display Capability

The EIDS shall display all categories of messages as stipulated above in accordance with the message priority.

(iv) Train Information Network (TIN)

(1) The DiCU of the various cars shall use the TIN to exchange data and information between themselves. Each DCU shall then communicate the appropriate data to the EIDS display panels installed in its car, either through the Train Information Network or through the PIS Network, as specified in 10.2.8 (c) (iii).

(2) The TIN shall allow transmission of data and information throughout the entire length of train.

(3) The TIN shall be designed to minimize the needs for individual trainline wires and hardwires across couplers. Shielded and twisted pairs cable shall be employed but fiber optic cable may also be proposed as an alternative.

(4) Any failure of the TIN shall automatically be isolated and shall not affect the operation of the DiCU and the interface with the DVAS and PA.

10.2.9 Multi-media Information System (MIS)

(a) General

The MIS shall primarily display commercial / advertisement information to passengers using color LCD displays. Operational information shall also be displayed in a predefined section of the LIDS. The MIS shall be independent of the PIS and have its own controller.

(b) MIS Controler

One MIS Controller shall be installed in each cab car. The MIS Controllers shall interface with the Train Information Network (TIN) to communicate with the DCU, the TIMS and each car's LIDS. The MIS Controller shall receive the programmed messages data via the Bulk Data Transmission Facilities.

(c) LIDS Display Panel

The LIDS display panel shall conform to the following requirements:

(i) An industrial grade 14" full colour LCD monitor shall be provided.

(i i) The display shall be protected from fraudulent use by a non-reflective,

~~glareless and vandalproof reinforced glass. The light transmissivity of the protective glass shall not be less than 95%. The design, material specification, fixing method and a sample of the protective glass shall be submitted for approval.~~

The display shall be protected from fraudulent use by a non-reflective, glareless (10% reflective) and vandalproof (using a removable window film) tempered glass. The light transmissivity of the protective glass shall not be less than 86%. The design, material specification, fixing method and a sample of the protective glass shall be submitted for approval.

(d) DiCU Interface

The MIS Controller shall interface with the DCU to obtain the information required to control the display of special and operational messages on the LIDS. Refer to section 10.2.8 (k) for a description of the Centralized Special Messages, Trainborne Special Messages and Trainborne Operational Messages.

(e) LIDS Programmed Message

(i) Programmed message to be displayed on the LIDS shall be passenger

information such as weather report, news headlines, financial information, advertisements or AUTHORITY message.

(i i) The message shall mainly be composed of graphic frames with a small number of English text frames.

(i i i) These messages shall be generated and dispatched from the Media Team Workstation (refer to PS 18.5.6) to all trains via the Bulk Data Transmission Facilities.

(i v) The display sequence of the LIDS programmed message shall be controlled by a scheduling list. The length of the scheduling list shall be adjustable to store a maximum of 512 messages.

(v) Each message in the scheduling list shall carry a unique identification number, name, version code and scheduling criteria.

(v i) Scheduling criteria shall include time of day, day of week, calendar date, expiry date and geographic location in order to allow the message to be displayed for a specific target group of passengers.

(v i i) LIDS programmed message which meet the scheduling criteria shall be displayed one by one in accordance with the identification number in ascending order defined in the scheduling list. The display sequence shall be repeated automatically after the last message in the list is displayed.

10.3 Train Operation Aids

10.3.1. General

(a) The TIMS shall provide a centralized function to monitor all its subsystems operation, fault status and failure reporting to the train operator.

(b) Real-time information including diagnostic results and fault logs shall be reported to the train operator and the YMSS.

(c) The TIMS shall be equipped with a TIN (TIN) which provides a data communication service for connecting trainborne systems and devices. It shall enable the transfer of information, commands and signals among the trainborne systems and devices.

(d) Not Used

10.3.2. Automatic System Initialization

(a) When the train systems are initialized (refer to PS 9.2), the TIMS shall automatically perform initial checking of all TIMS sub-systems. It shall then initiate static function and sequence testing for all trainborne systems to verify correct functions and healthiness. Should no system malfunction be detected, the TIMS shall transmit a "train healthy" signal back to both the YMSS when the train is located inside the depot, and the train operator. Otherwise, respective fault code and diagnostic messages shall be transmitted to the YMSS.

In addition, an extended concept of "Train Birth Certficate" involving a complete Train Systems Test under TIMS supervision shall be provided. The birth certificate shall comprise two components:

(i) An interactive pre-departure test sequence commanded by the Subway Yard Operator (SYO) to test on-board systems and validate that they meet their respective operability requirements;

(ii) A manual verification performed by the SYO.

The result of the pre-departure tests shall be kept internally in the TIMS and sent to the YMSS. The YMSS shall allow printing of pre-departure test reports, including the manual verification checklist. A successfull pre-departure test shall be valid only for a limited period of time (8 hours), after which it shall fall back to "Required" status. The pre-departure test status shall be reported by the TIMS to the YMSS in the form of specific statuses: Required, In Progress, Passed or Failed.

(b) Initialization shall consist of two parts, firstly the TIN initialization and then the train systems initialization. The TIN initialization shall be completed within the time as stipulated in PS 10.2.1 for start of data communication service. The train systems initialization shall be completed within the time as stipulated in PS 10.2.1 for acquiring the healthy status of all the train subsystems and driving cab controls under TIMS monitoring.

(c) The train systems initialization shall be started when the TIN initialization is completed and data communication service is available. The 600VDC third rail power supply shall be connected to energies the auxiliary system. Static function and sequence testing for all trainborne systems and driving cab controls shall be initiated to verify correct functions.

(d) During TIN and train systems initialization, the TIMS display terminal shall display a message indicating that TIMS initialization is in progress and no user operation / command shall be accepted.

10.3.3. Automatic System Shut-down

When the manual shut down of the train systems are activated (refer to PS 9.3), the TIMS shall down load diagnostic and performance monitoring data recorded by the TIMS to the YMSS when the train is located inside the depot. Upon completion of the data transmission, the TIMS shall then proceed to shut down all trainborne equipment.

10.3.4. Automatic System Monitoring and Information Display

(a) The TIMS shall be used to monitor and display the operation status of all train systems and display the essential information to the train operator through the TIMS display terminal. The Contractor shall submit the list of the proposed system and/or subsystems that are to be monitored and displayed by the TIMS with their interface details for approval.

(b) As a minimum requirement, the following information shall be displayed on the train operator TIMS display terminal:

(i) General operational information

- Station Identity
- Destination
- Train number
- TIMS system real time

(ii) General train information

- line voltage
- line current
- auxiliary equipment
- saloon temperature
- car loading

(iii) Passenger information

(c) The display shall also be integrated with the other screening function to provide specific information of other trainborne systems.

10.3.5. Automatic Fault Reporting and Recording

(a) A diagnosis function shall be provided to ensure that unusual legitimate operations or genuine faults of trainborne equipment are identified, logged, and, if appropriate, reported to the train operator for attention.

(b) Faults detected shall be classified into at least five levels:

(i) Critical Fault

Fault which requires the immediate action/attention of the train operator is classified as critical fault.

(ii) Operating Event

Action performed by the operator or event which is triggered by the train operator and requires the attention of the Transit Control Centre (TCC).

(iii) Maintenance Event

Event which requires the attention of the maintenance staff after the train complete the scheduled service.

(iv) Record

A maintenance record which requires the attention of the maintenance staff during routine maintenance.

(v) Notice

Information or reminder to aid the train operator during normal service under defined conditions.

Based on the failure effect, the criticality level of each diagnosis requirements shall be designed and submitted for approval.

(c) The TIMS shall respond according to the following table:

Criticality Level		Response of TIMS		
		Request Acknowledge[1]	Display of fault[2]	Log in to the memory[3]
1	Critical Fault	✓	✓	✓
2	Operating Event		✓	✓
3	Maintenance Event			
4	Record			
5	Notice			

Note:

[1]: Request the train operator in the active cab to acknowledge the occurrence of the fault through the TIMS display terminal.

[2]: Display the fault message in the current fault screen.

[3]: Record the fault/event in the memory

✓: TIMS shall respond

✗: TIMS shall not respond

(d) In addition to the classification of the fault message criticality level, the fault information shall be prioritized into two groups, namely, primary and secondary. For primary group of fault information, it shall include those safety critical systems, such as, automatic train control, traction and braking, doors, communication, ventilation and emergency lighting, whilst the other auxiliaries systems would be in the secondary group.

(e) For fault information in the primary category, fault message shall be transmitted upon occurrence through the radio via the TIMS to the TCC (refer to Appendix I Annex 4 Clause 2.5.3).

(f) Both fault messages of primary and secondary category shall be transmitted during the designated station stops through the Bulk Data Transmission Facilities.

(g) The information shall also be transmitted through the YMSS (refer to Appendix I Annex 4) so as to allow the relevant replaceable spare to be ready in advanced to the train returning to the depot, thus allowing quick turnaround in maintenance and repair.

(h) In addition, the TIMS shall relay and transmit the fault data according to the following table:

Criticality Level		Transmission from TIMS	
		Bulk Data Transmission Facilities	YMSS
1	Critical Fault		
2	Operating Event		
3	Maintenance Event		
4	Record		
5	Notice		

Note:

: Transmit the fault message to the Transit Control Centre through the air interface.

: Transmit the fault message to the depot through the communication interface.

: TIMS shall respond

: TIMS shall not respond

The final classification and criticality levels shall be approved by the Engineer.

10.3.6. Defect Handling

Based on the capability of the individual train systems and the associated failure effect, faults detected shall be handled by the following three modes:

(a) Automatic defect handling

(i) When a train system is reported faulty, it shall report to the TIMS and automatically attempt to re-start.

(ii) For those system/equipment failure which significantly affect normal passenger service shall be managed automatically through the TIMS and displayed to the train operator. In addition, the TIMS will derive from the correspondance of Events to Register of Train Failure (RTF) criteria, a train healthiness status that will be

provided to the YMSS as specified in 18.6.6 (d) herein.

(b) Semi-automatic defect handling

(i) When a train system is reported faulty, it shall report to the TIMS and advise the train operator to re-start it through the TIMS display terminal.

(ii) For that system/equipment failure which requires operation decision to be made by the train operator shall be managed semi-automatically through the TIMS and displayed to the train operator.

(c) Manual defect handling

(i) When a train system is reported faulty, it shall report to the TIMS and advise the train operator how to re-start it remotely from the driving cab and/or locally in the concerned car.

(ii) For that system/equipment failure which requires operation intervention to be made by the train operator shall be managed manually and displayed to the train operator.

In order to reduce the time for fault recovery, due consideration shall be given to ensure full automatic defect handling functions are provided as far as practicable.

10.3.7. Diagnosis Rules

(a) To facilitate the ~~defect handling process, the Contractor shall provide a complete set of diagnosis rules for TIMS to identify the faults and perform appropriate defect handling activities according to the specified operability requirements.~~

To facilitate the defect handling process, the Contractor shall provide a complete set of diagnosis rules for TIMS to identify the faults and perform

appropriate defect handling activities according to the specified operability requirements. In addition, the TIMS will derive from the correspondance of Events to Register of Train Failure (RTF) criteria, a train healthiness status that will be provided to the YMSS as specified in 18.6.6 (d) herein.

(b) Each diagnosis rule shall have a time delay function to avoid spurious fault detection.

(c) A fault shall be detected only if the detection criteria has been satisfied for a pre-defined period of time.

(d) The pre-defined ~~time delay shall be adjustable from 0 to 10 second with a minimum step of 500ms. The time delay~~ shall be easily adjustable on-site ~~by~~

~~the maintainer~~. The pre-defined time delay shall be adjustable from 0 to 10 second with a minimum step of 500ms. The time delay shall be easily adjustable from the YMSS by the maintainer"

(e) ~~An easy to program with password protected software which shall form part of the special tools and test equipment (refer to PS 24.3), shall be provided for the maintainer to define and modify the above diagnosis rules. The Engineer may need new diagnosis rules in the future. The Contractor shall provide adequate spare hardware and software facilities for building up a minimum sets of 100 new diagnosis rules.~~

An easy to program with password protected software which shall form part of the special tools and test equipment (refer to PS 24.3), shall be provided for the maintainer to configure the above diagnosis rules. The Engineer may need new diagnosis rules in the future. The Contractor shall provide adequate spare hardware and software facilities for building up a minimum sets of 100 new diagnosis rules.

10.4 Particular subsystem requirements

10.4.1. Display Control for EIDS and LIDS

(a) The EIDS and LIDS shall be controlled by the Display Control Unit (DiCU). The LIDS shall be controlled by the MIS Controller, as described in section 10.2.9.

(b) DiCU

(i) The Display Control Unit (DiCU) is the main control part of the whole trainborne EIDS and LIDS. DiCU shall control the traffic of the Train Information Network of the EIDS display sequence of messages, interface with different systems and manage all the EIDS display panels.

(ii) Only one DiCU shall act as the train master DiCU to control all the EIDS

display panels of the train; using the other cars DiCUs to relay the data to their local EIDS display panels.

(iii) DiCU shall decode data received from all interfacing systems using an error detection and correction protocol.

(iv) Diagnostic function shall be provided to check the hardware and software status of the DiCUs. The Diagnostic function shall include two levels checking.

(v) Self Diagnostic Function

The self diagnostic function shall be performed automatically by all DiCUs as shown in the following table.

Items	Diagnostic Details	Frequency
1	Test the functionalities of hard wares, such as, interface modules, control module and	Only at initial power up.
2	Check the version of all control firmware	Only at initial power up.
3	Check the versions of information messages stored in the memory of DiCU.	Every two hours.

The diagnostic result shall be sent to the TIMS and then transmitted through the Bulk Data Transmission Facility for record.

(vi) Polled Diagnostic Function

When Polled Diagnostic Function command is received from the TIMS, each DiCU shall request its local car equipment to perform the Self Diagnostic Test again. Each DiCU shall then consolidate all the diagnostic result of its local car equipment and then send it to the TIMS for transmission to the Bulk Data Transmission Facility.

(vii) If there is fault found in the diagnostic test, fault message including the DiCU address and fault type shall be sent by each DiCU to the TIMS for transmission to the Bulk Data Transmission Facility.

(viii) DiCU shall keep all fault messages in its flash memory.

(ix) EIDS Display Panels

(1) DCU shall communicate with all EIDS display panels through the Train Information Network or the PIS network, as specified in 10.2.8 (c) (iii)..

(2) DCU shall transmit the updated messages stored inside its local memory to every panels at the beginning of operation.

(3) Only those ~~messages scheduled to be displayed within the next 2 hours shall be transmitted by DCU to the display panels~~.

Only the message to be displayed will be transferred in real time by the DiCU to the EID and LID PIS window

(4) ~~DCU shall issue instruction and data to the display panels to invoke the display of the desired message. The messages sequence used by the DCU~~ shall be according to the pre-determined ~~schedule, time of day or location as~~ stated in the scheduling list. ~~Message being displayed on all display panels shall be synchronized~~.

DiCU shall transfer the text to display and the EID graphic trigger to the display panels (EID and LID PIS window) in real time. The EID Programmed messages sequence used by the MIS addressed to the DiCU shall be according to the pre-determined schedule, time of day or location as stated in the scheduling list. Message being displayed on all display panels shall be synchronized.

(5) DCU shall collect the diagnostic results from all display panels of its local car during the initial power up routine and send them to the TIMS.

(x) Digital Voice Announcement System (DVAS and PA)

(1) DiCU shall interface with the DVAS and PA to obtain information of door status, next station, pre-recorded DVAS and PA message codes to display next station name, pre-recorded DVAS and PA text message in parallel with the audible announcement from DVAS and PA.

(2) DiCU shall interpret the DVAS and PA code and transmit the corresponding code to instruct the display of corresponding station name or pre-recorded DVAS and PA messages.

(x i) Not Used

(x i i) Bulk Data Transmission Facilities
- ~~Mes~~sages files

(1) One trainborne transceivers of the Bulk Data Transmission Facilities shall be installed in each A car of a train.

(2) DiCU shall interface with the activated transceiver to communicate with Station Server transceiver, which shall be installed in certain strategic station

platform, when the train is within Station Server's coverage area.

(3) DiCU shall receive from the Station Server

Data files, for example, pre-recorded ~~messages and English font files.~~

~~and then relay them to the relevant memory location of all display panels at right moment.~~

Free text BDTF messages files

Data files, for example, MIS Travel content database (including EID Programmed messages).

and then relay them to the relevant memory location to be displayed at right moment."

(4) DiCU shall send to the Station Server

- Fault messages of EIDS on train

- EIDS Polled Diagnostic and Self Diagnostic results when requested

Station Server shall relay the receive data to the depot through the Commission's IDN.

(c) DiCU Mastership

(i) Each DiCU shall have its own logical hardware address.

(i i) One of the DiCUs shall automatically designate itself the master DiCU and

shall control the entire EIDS when initial power up.

(iii) The master DiCU shall:

(1) verify the available equipment, including checking to verify if there are other DiCUs and the number of EIDS and LIDS Display Panels, on the Train Information Network.

(2) control the data traffic flow between DiCUs along the Train Information Network.

(3) scan for and monitor the existence of other DiCUs equipment along the Train Information Network. When there is added or deleted DiCU equipment from the Train Information Network, the DiCU shall:

- Re-initialize to account for the added or deleted elements.

- Scan the Train Information Network for 3 times in a 2-minute interval if there is deleted elements.

- Record the absent elements in the fault log if the deleted elements still absent.

- If there is added elements, the added elements shall be capable of displaying messages as soon as they are received from the master DiCU. For those other elements that are already in the Train Information Network, it shall continue to function normally during the updating of the added elements.

(4) show the real-time ~~clock onto all display panels when door close signal received from DVAS~~.

show the real-time clock onto all EID when door close signal received from DCRP.

(5) Not Used

(6) resolve the priority of transmitting data from DiCU to Station Server. The priority of transmitting data shall be:

Priority	Data information
1	EIDS fault messages, including address of fault equipment (either DiCU or EDP), time of fault found and fault type.
2	Polled Diagnostic result
3	updated Self Diagnostic result

(d) Not Used

(e) Electrical Requirement of DiCU

(i) DiCU shall be supplied by 37.5VDC.

(i i) When there is a loss of AC power on the train, DiCU shall manage the display of messages to display on the panels according to the load shedding rules to be determined during design reviews.

(f) Internal Architecture of DiCU

~~(i)~~ The DiCU shall include at least the following configuration:

(1) ~~Microprocessor and controller boards for controlling and scheduling of data and messages received.~~

(2) ~~Not used.~~

(3) Re-programmable ~~memory for storage of frequently changed or updated~~

- ~~messages such as: news, weather, advertisements, AUTHORITY messages.~~

- ~~The memory size shall be doubled to the size required to hold all messages~~ files, including all message files of one 20-minute ~~display cycle and those files that are not scheduled to be displayed in the next two hours.~~

- ~~The memory shall be sustained~~ by an internal back-up ~~battery or be re-~~ programmable non-volatile Flash Memory to provide long-term ~~storage of the message data in the absence of DC power.~~

- ~~The memory size shall only be large enough to store control firmwares.~~

(4) Re-programmable non-volatile ~~Flash Memory for storage of rare change files~~ like microprocessor boots, ~~control firmwares.~~

- The files inside the Flash Memory shall be re-programmable ~~through High Speed Data Link.~~

(i) The DiCU shall be implemented as a TIMS function.

(1) The TIMS shall offer the possibility to change or update messages such as: special messages, station and transfer messages.

- The memory size shall be doubled to the size required to hold all messages files.

- The memory shall re-programmable non-volatile Flash Memory to provide long-term storage of the message data in the absence of DC power.

(2) Re-programmable non-volatile Flash Memory for storage of rare change files like microprocessor boots, control firmwares.

- The files inside the Flash Memory shall be re-programmable through High Speed Data Link.

(5) Real-time clock

(6) Interface Module with Bulk Data Transmission Facilities transceiver to send ~~and receive data to/from Station Server.~~

(7) Interface Module with Real Time Transmission Facilities receiver.

(8) Interface Module with DVAS and PA.

(ii) The microprocessor and controller shall have watch-dog function to monitor the operation of the processor and shall reset the microprocessor in case of processor hang up.

(iii) All electronic cards shall be in modular design and shall be easily accessible, maintainable and replaceable.

(iv) Each electronic card shall have sufficient visual indications for system status

to give a clear indications of all on-line activities. This shall include receive signal, power available, power on and fault.

(g) Mechanical Requirement of DiCU

(i) The exact locations for DiCU mounting shall be determined by the Engineer during the detail design stage.

(i i) ~~A metallic case shall be used as enclosure for all components of the DiCU.~~ The ~~enclosure case shall be sealed to IEC60529 IP54~~.

The DiCU function shall be implemented inside the TIMS LPU that shall be sealed to IEC60529 IP20."

(h) Display Control of LIDS

(i) Multimedia System Diagnostics

Diagnostic function shall be provided to check the hardware and software status of the Multimedia Controller and LIDS, both in the form of self-diagnostics and polled diagnostics initiated from TIMS. Rthe results of the diagnostics shall be sent to the TIMS for transmission to the Bulk Data Transmission Facility.

(ii) Electrical Requirements of Multimedia Controller

The Multimedia Controller shall be supplied by 37.5VDC. When there is a loss of AC power on the train, the Multimedia Controller shall manage the display of messages on LIDS according to the load shedding rules to be determined during design reviews.

(iii) Architecture of Multimedia Controller

The Multimedia Controller shall have re-programmable non-volatile Flash Memory for storage of frequently changed or updated messages such as news,

weather, advertisements and AUTHORITY operational and special messages as well as for storage of the software and parameters.

(iv) Mechanical Requirements of Multimedia Controller

The exact locations for Multimedia Controller mounting shall be determined during the detail design stage.

10.4.2. Control Interface

(a) A Control Interface shall be provided in each cab car for interfacing the driving cab controls with the TIMS. Excepting those that are specified, such

as, the directional commands of forward and reverse, motoring and braking commands, tractive effort commands provided by the traction and braking controller.

(b) The Control Interface shall check the validity of all momentary control signals of the driving cab before forwarding them to the TIMS. The momentary control signal shall be checked to ensure that it possess a valid rising and falling edge to ensure that no contact jam close or contact jam open exists in the control button. In case the signal is detected to be invalid, the Control Interface shall ignore the signal and report the status (jam close / jam open) of the associated control button to the TIMS.

(c) The Control Interface shall detect and eliminate the issue of conflicting control signals (for example simultaneous door open and door close signal) to the TIMS from the driving cab. When those conflicting control signals that are safety related (for example simultaneous door enable and motoring signal), have been detected, the train system shall be able to operate in a safe state, then the TIMS shall report to the train operator and record in the Event Recorder as a Critical Event. Determination of safe state shall form part of the Hazard Analysis (refer to PS 25.5).

(d) The Control Interface shall provide parallel input checking such that only a single control signal shall be sent when there is simultaneous operation of parallel control buttons (for example simultaneous activation of the door open button from both sides).

(e) A maintenance port employing RS 232C serial interface shall be provided for connecting an IBM compatible PC operating under MS Windows® XP (or later version, if approved) or an alternative specified by the Engineer, to monitor and check the status of all the controls and indications of the driving cab. PC based software compatible with MS Windows® XP (or later version, if approved) or an alternative specified by the Engineer, shall be provided to perform this function, together with details of the required hardware link connection.

(f) All the parameters ~~and logic for checking momentary control signal validity, conflicting control signals and parallel input signal checking shall be able to be changed via the maintenance port when the TIMS is in the Maintenance Mode~~.

All the parameters for checking momentary control signal validity, conflicting control signals and parallel input signal checking shall be able to be changed via the maintenance port when the TIMS is in the Maintenance Mode.

(g) Display Control of LIDS

(i) One ~~MIS Controller shall be provided and located in each cab car.~~

The MIS Controller shall be implemented in the Communication Control Unit (CCU) present in every car.

(ii) One of the train's MIS Controllers shall communicate with the LIDS located in each car of the train through the Train Information Network.

(iii) The MIS Controller shall receive the messages to display on the LIDS from the Media Team Workstation via the Train Information Network.

10.4.3. Real Time Protocol and Interface

(a) The TIMS shall employ a non-proprietary and industrially proven real time operating system and networking protocol to ensure that the requirements as stipulated in PS 10 are fully satisfied.

(b) The TIN functions shall be layered with reference to the OSI 7-layer model for networks defined in ISO 7498/1. It is accepted that not all layers shall be used or fully implemented but development and enhancement at any one layer shall be accomplished without modification being required to any other layers.

(c) Network protocol employing either deterministic or non-deterministic medium access control method may be adopted for the Train Consist Network and System Sub-Network.

(d) A minimum number of network protocols shall be adopted and shall work cooperatively with each other in the sense that minimum conversion overhead is required.

(e) An error checking mechanism (employing cyclic redundancy check sum for each data package, byte truncation and data field length check) shall be adopted to ensure that errors introduced during transmission shall be detected and shall not affect the result of the application using the data. Erroneous messages shall be automatically filtered out and discarded without propagating in the TIN.

(f) Any erroneous message shall not cause any train subsystems / equipment to be in an unsafe state.

(g) The Contractor shall submit for approval calculations and quantitative analysis of the network traffic and the delay-throughput characteristics to demonstrate full compliance with the requirements.

(h) The Contractor shall provide detailed justification on the choice of network protocols based on the specified requirements.

(i) Interface with LPU

(j) It is preferred that each train sub-system except the ATC / Communications interface to be connected to the TIMS shall possess network intelligence such that they can be directly connected to the System Sub-Network without routing through the LPU.

(k) Multi-drop interface of RS 485 may be used as alternative to connect the train sub-system to the LPU.

10.4.4. Loading

(a) Processor Loading

For all LPU's, ATC / Communications Gateways, Gateways, Sub-systems and Control Interface, the processor loading shall not exceed the following figures:

(1) Processor loading not exceeding mean - 50% of the processor time

(2) Processor loading not exceeding peak - 80% of the processor time

(b) TIN

For the TIN, the loading of the networks shall not exceed the following figures:

(1) Network loading not exceeding mean - 40% of the network time

(2) Network loading not exceeding peak - 60% of the network time

10.4.5. Resource Spare Capability

(a) Memory and Input/Output Facilities

A minimum of 20% spare capacity of processing power and memory storage shall be provided in each LPU, ATC / Communications Gateway, Gateway, Sub-systems and Control Interface.

(b) The minimum spare capacities for input and output shall be as shown in the table below:

Input and Output Facilitie	**Minimum Spare Capacities**
Digital Inputs	10 DC inputs per Car
Analogue Inputs	2 DC inputs per Car
Digital Outputs	2 DC output per Car
Serial Interface	1 RS 232 port with at least 50% spare communication
Network Interface	1 spare System Sub-Network port per sub-network

Input and Output Facilitie	Minimum Spare Capacities
	1 spare Train Consist Network port per each cab car

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10.4.6. Data Management

(a) The TIN shall cater for the following two different types of data:

(i) Process data which consist of frequent, time-critical but short duration data (for example traction control data)

(ii) Message data which consist of less urgent but possibly lengthy data (for example logging)

(b) The TIN shall support the transmission of the two types of data by offering the following data transmission service:

(i) Periodic data transmission which transmits data at a regular interval

(i i) Sporadic data transmission which transmits data on request or when triggered by an event

(c) Periodic Data Transmission

(i) Periodic data transmission service shall occupy a small portion of the basic network activity period. During this period, process data which are critical shall be transmitted.

(i i) The transmission shall be processed without a check back to avoid delay in

receiving acknowledgement from receivers.

(iii) Freshness supervision shall be employed to avoid operating with obsolete data

as a result of equipment failure.

(iv) Error recovery is inherent due to the cyclic transmission of data. A lost sample shall be refreshed in next transmission. The safety of transmission shall be guaranteed by this cyclic transmission and the cyclic redundancy check sum associated with each package of process data.

(d) Sporadic Data Transmission

(i) Sporadic data transmission service shall occupy the remaining portion of the basic network activity period. It shall transmit message data, if there is any, which is less urgent.

(ii) The transmission shall be processed with check back by the receiving unit to ensure a reliable transmission.

(iii) In the event that the sporadic data transmission service is used for transmitting safety related control signals (refer to PS 9.9), a higher priority shall be assigned which ensures that they are transmitted in advance of other lower priority data.

(e) The Contractor shall submit calculations and quantitative analysis for approval to demonstrate that the allocation of periodic and sporadic data transmission is appropriate in delivering the required performance.

(f) Fault / Logging Data Management

(i) Local memory shall be provided for major train subsystems to store all event logging and detected faults. Other systems shall transmit all events on TIN for processing and logging by the TIMS. Systems with and without local memory to be approved by the Engineer.

(i i) Only those faults that are required to be acknowledged by the operator or

displayed on the TIMS display terminal shall be transmitted. Also, data that is required to be stored in the Event Recorder shall also be transmitted.

(iii) Copies of each of the detected faults shall be transmitted from the TIMS to the YMSS or to the TCC.

(g) To cater for different operating scenarios, the TIMS shall operate in the following three modes: Operator Mode, Depot Mode and Maintenance Mode.

(h) Operator Mode

(i) This is the default operating mode of the TIMS.

(i i) The periodic and sporadic data transmission services shall be maintained as per the designed condition for normal passenger service.

(i) Depot Mode

(i) The TIMS shall be automatically switched to this operating mode during the automatic train shut-down operation (refer to PS 10.3.3) and the data download / upload operation by the YMSS.

(i i) During this mode, no information shall be sent.

(i i i) A message indicating that TIMS is in the depot mode shall be displayed on the TIMS display terminal.

(iv) On completion of the data download / upload or automatic train shut-down operation, the TIMS shall automatically revert back to the operator mode.

(j) Maintenance Mode

(i) This mode shall be password or key protected and can only be initiated by authorized maintenance staff.

(ii) The maintenance staff shall be able to view and change some of all the available operating and control parameters of each train subsystems and the recording schemes of the Event Recorder using the Portable PC and/or the YMSS.

(iii) The maintenance staff shall also be able to edit and change the TIN configuration and settings in this mode using the Portable PC and/or the YMSS.

(k) Data Format

(i) Data shall be transmitted and stored in binary format in the TIMS to enhance the storage and transmission efficiency.

(ii) Conversion software shall be provided in both the TIMS and the maintenance terminal to allow the conversion of binary data into commercially available database format of Oracle DataBase for Window® or an alternative specified by the Engineer.

10.5 Equipment Control and Monitoring

10.5.1. General

(a) The Monitoring and Diagnostic functions shall be distributed between the TIMS and the sub-systems. The Monitoring and Diagnostic functions shall be distributed between the TIMS and the sub-systems. The TIMS shall provide

an automatic data transmission function to transfer the required information, commands and signals for control and testing among the train systems.

(b) Safety critical controls such as Emergency Braking Loop, Door Summary, Door side open or Door Side Enable command shall be done through hardwired trainlines. Other controls shall be accomplished either through hardwired trainlines or through TIMS. As approved by the engineer. The primary role of TIMS shall be limited to reliably transmit the required data to and from the train systems.

(c) A testing function for system healthy check of the trainborne equipment shall be provided for the train operator via the TIMS display terminal.

(d) A data management strategy shall be submitted for approval to define the design concepts of what and how the equipment information shall be displayed (refer to PS 10.3.5), fault data shall be reported and recorded (refer to PS 10.3.6) and defect shall be handled (refer to PS 10.3.7).

(e) The TIMS shall provide a control interface to all driving cab controls and indications as specified in 10.4.2.

(f) The data management strategy shall also address the classification and any special management of the safety critical/related signal.

10.5.2. Refer to PS 10.4.2.

10.5.3. Traction and braking system

The TIMS shall provide the following functions of:

(a) ~~Monitoring and recording the traction energy consumption (refer to PS 11.6.12(c)) on a car basis~~. Monitoring and recording the traction energy consumption (refer to PS 11.6.11 on a car basis.

(b) ~~Not Used~~

(c) Facilitating the train operator to initiate the traction test according to the requirements specified in PS 11.6.13(a) and 11.6.13(b). Any fault detected shall be logged and recorded by the TIMS.

(d) Recording ~~and displaying any fault status of the wheel slip/slide protection system (refer to PS 11.7.4)~~. Recording and displaying any fault status of the wheel slip/slide protection system (refer to PS 11.13.3).

(e) Recording and displaying ~~any identified permanently locked axle (refer to PS 11.7.5)~~.

Recording and displaying any identified permanently locked axle (refer to PS 11.13.4).

(f) Allowing to turn off a failed traction and braking system isolation function on a car basis (refer to PS 11.3.17) and failed friction brake on a truck basis (refer to PS 11.16.4).

(g) Recording and displaying any brake rate deviation (refer to PS 11.20.2).

(h) Recording the accumulative mileage run of each cars and traction motors for maintenance scheduling (refer to PS 10.6.2).

(i) Recording and displaying the train speed on the TIMS display terminal (refer to PS 9.12.4(b)(ii)) when the train is operating under Forward or Reverse mode (refer to PS 9.6.3(g) with SCS Bypass switch has been operated.

(j) Conveying all logical commands generated by the associated mode selector (refer to PS 9.5.2) and traction brake controller (refer to PS 9.6.2) which are activated by the train operator into the associated hardwire trainlines and transmit to the required circuits according to the logic tables shown in Table 10-2 to 10-5.

(k) Monitoring the conditions of the above trainline signals and response according to the logic tables shown in Table 10-6. For any conflicting logical commands, such as, both forward and reverse wires are energized, and both motoring and braking wires are energized, the train system shall be responded as follows:

(i) if the fault is occurred during operation, it shall remain as previous state; or

(i i) if the fault is occurred during train startup i.e. no previous state is available, it shall reset to the default state which shall be emergency or full service brake applied depends on the state of the brake loop circuit (refer to PS 9.9.6).

This fault shall be reported to train operator and logged into the Event Recorder.

(l) Monitoring the integrity of the speed detection circuit and report when fault is ~~detected (refer to~~ Appendix ~~I Ann~~ex 3).

~~system failed~~

(m) The train system shall be operated through the TIMS according to the logic table shown in Table 10-7. For any illegal logic state i.e. the faulty state occurred shall be reported to the train operator and logged into the Event

Recorder.

(n) Recording and displaying the modes of operation (refer to PS 9.5.2) and TBC position (refer to PS 9.6.2(h)) on the TIMS display terminal.

10.5.4. Door System

The TIMS shall provide a signal processing function to:

(a) Monitor and record the by-pass command ~~activated by the train operator to control the train door by isolating the ATC safety signals when the ATC (refer to PS 9.8.15)~~.

Monitor and record the by-pass command activated by the train operator to

control the train door by isolating the propulsion safety signals.

(b) Facilitate the remote isolation of a defective door control unit individually, for example, by inhibiting its door opening in addition of a standard manual door isolation switch.

(c) Monitor the healthiness status of each door pair, such as, the operating time, the fully closed signal provided by the door proving device (refer to PS 16.2.9(b).

(d) Monitor any operation of the manual emergency release device (refer to PS 16.2.10).

(e) Facilitate maintenance adjustment of train door operation profile parameters (refer to PS 16.2.12(a)(v)) using the Portable PC and/or the YMSS computer.

(f) The TIMS shall continuously monitor the conditions of the trainline door commands of open and close. For any conflicting logical commands, such as, both open and close wires are energized, the train system shall be responded according to PS 16.2.6. This fault shall be reported to train operator and logged into the Event Recorder.

10.5.5. Air conditioning system

(a) In order to ensure the passenger comfort and optimize the energy consumption of the air conditioning units, an automatic control of the air conditioning systems shall be provided according to the following conditions:

(i) Daily basis

For a preset period of time, such as, the non-traffic hours, all air conditioning units shall be automatically shut down by the TIMS until the starting period of traffic hours is reached, then all air conditioning units shall be re-started again.

For a preset value of the passenger loads which shall be derived by the air

pressure as received from the air bags of each car, the target saloon temperature setting shall be regulated by TIMS linearly from 24oC (75oF) setting in the W4 loading condition to 22oC (72oF) setting in the W1 loading condition.

(ii) Seasonal basis

For a pre-defined period of months, the target saloon temperature setting shall be regulated by TIMS to 24oC (75oF) setting in the summer and 22oC (72oF) setting in the winter.

(b) ~~For backup purpose, an overriding function shall be provided to override the~~ above commands of shutdown/re-start ~~and temperature setting either by means of the individual local control of the air conditioning unit or via the train operator's input device through the TIMS~~.

For backup purpose, an overriding function shall be provided to override the above commands of shutdown/re-start defined in section 10.5.5 (i). Also, the seasonal temperature setting defined in section 10.5.5 (ii) shall be changeable via the train operator's input device through the TIMS.

(c) All the above setting of time/periods shall be easily adjustable by the maintenance personnel via the TIMS.

(d) The saloon temperature of each car shall be monitored in real time and reported to the TIMS.

(e) In order to reduce the inrush current due to simultaneous starts of the air conditioning units, a sequence start arrangement shall be provided to control the starting sequence of the air conditioning units of the train via the TIMS.

(f) ~~The TIMS shall monitor and record when there is a faulty detector or dirty~~ detector identified by the system (refer to PS 15.9.4).

The TIMS shall monitor and record when there is a faulty detector identified by the system (refer to PS 15.9.4).

(g) In the event that the smoke detection resumed normal, the train operator shall be informed and the damper system shall be resettable by the train operator via the TIMS.

10.5.6. Auxiliary Supply System

(a) The TIMS shall monitor the status of the auxiliary converter and record any failure (refer to PS 17.2.4(e) and 17.2.7(b)).

(b) The AC and DC supply shall be monitored by the TIMS particularly the battery charger output (refer to PS 17.4.1(g)). Whenever a fuse or circuit breaker is used, its status shall be monitored and recorded by the TIMS. Breakers and fuses critical to train operation will be monitored individually. Other breakers can be monitored by group through a breaker loop. Groups shall be defined to minimize time to restore operation (breakers within a group shall belong to a well defined location in the car) and shall be approved by the Engineer.

(c) In order to reduce the inrush current due to simultaneous starts of the auxiliary converters, a sequence start arrangement shall be provided to control the starting sequence of the auxiliary converters of the train via the TIMS.

10.5.7. Truck and Suspension System

(a) Passenger loading on a car basis shall be measured and fed back to the TIMS in real time for the controls of train systems, such as, traction and braking systems.

(b) The TIMS shall monitor the passenger loading feedback signal, the TIMS shall record and display when any abnormal passenger loading is detected.

10.5.8. Truck Sensors

(a) The TIMS shall monitor carbody mounted proximity switch in the event of a truck derailment (refer to PS 12.1.10).

(b) The TIMS shall monitor ~~the overrotation sensor (refer to PS 12.1.12)~~. The TIMS shall monitor the over-rotation sensor (refer to PS 12.1.11).

(c) In the event of any activation of the truck sensor, it shall be reported to train operator and logged into the Event Recorder.

10.5.9. Pneumatic System

The run time and duty cycle of each air compressors of a train shall be recorded for maintenance scheduling (refer to PS 10.6.2).

10.6 Maintenance Support

10.6.1. Train Fault Record

(a) The additional information of conditions/parameters when a fault is detected shall also be recorded for the purpose of assisting failure investigation, they shall include but not limit to the following types:

(i) Fault type,

(i i) Car type and number,

(i i i) Date and time the fault is detected,

(i v) Station name,

(v) Distance traveled,

(v i) Train speed,

(v i i) Date and time the fault is cleared (if applicable), and

(v i i i) Staff ID and run number (if it has been input by the train operator)

(b) In addition to the above train fault, the TIMS shall be able to detect and record

the significant variation of the critical train performance, such as, brake rate, door operating time and saloon temperature. Proposed detection scheme and type of performance variation to be recorded shall be submitted for approval.

(c) The memory shall be capable of storing a minimum of 1000 faults data per car.

(d) Algorithms shall be provided to prevent the repeated detection and recording of a permanent failure on the train which shall unnecessarily occupy the memory space.

(e) Options shall be provided for maintenance staff to overwrite the previous fault recorded based on a first-in-first-out principle, to stop the recording when the memory is full, or to record the first and the last few occurrences of the same fault only.

(f) Data recorded shall be retained for a minimum of 4 weeks with no external power supply present.

10.6.2. YMSS

(a) A yard (a.k.a. depot) based maintenance support system shall be provided to enable the maintenance personnel to:

(i) retrieve and view the fault log and performance parameter

(i i) generate graphical report from the recorded data

(i i i) analyze the failure trend of monitored equipment.

(b) For data transferring purpose, two types of operation, namely, Data Upload and Download Operations, shall be provided by the YMSS to upload the train information (for example, train faults) and download the commercial (for example, the advertisement data) and operational (for example, the train door operation profile parameters) information. The design of the TIMS shall facilitate the above operations.

(c) For maintenance convenience, the above upload and download operation shall

be able to be performed on a basis of fleet broadcast or individual trains.

(d) An automatic maintenance scheduling function shall be provided by the YMSS, such that when the train data (for example, mileage of traction motor, run time of the air compressor) are downloaded, an associated maintenance schedule shall be automatically produced to state the required maintenance tasks. The Contractor shall provide a complete maintenance schedules of train, system, equipment and component in order to facilitate the above scheduling functions according to the maintenance requirements (refer to PS 26.9.1).

(e) Requirements stipulated in Appendix I Annex 4 Section: 3.1, 3.2, 3.3 and 3.4 shall be met.

10.7 Man-Machine Interface (MMI) Requirements

10.7.1. General

(a) The purpose of MMI of the TIMS display terminal is to achieve effective, efficient and safe train control through integration of the train operator into the train control system.

(b) The train operator shall be provided with a display unit, namely, the TIMS display terminal, inside the driving cab in order to inter-react with the TIMS.

(c) The display unit shall integrate with an input device, such as, programmable key pad or touch screen display, to receive commands from the train operator.

(d) The display unit shall provide an user friendly work environment to minimize factors which degrade the train operator's performance or increase error.

(e) MMI design shall be such that operator workload, accuracy, time constraint, mental processing and communication requirements do not exceed the operator capabilities.

(f) MMI design shall also minimize personnel and training requirements within the limits of time, cost, and performance trade-offs.

(g) MMI design shall taken into consideration of the differences in roles and duties between the two types of train operators i.e. the motorman and guard. The associated TIMS functions shall be properly assigned and split between the above two roles.

(h) TIMS Display terminal shall receive display control commands (for example, brightness setting, selection of page/menu) from the train operator.

(i) Receive TIMS control command (for example, air conditioning temperature setting) from the train operator.

10.7.2. TIMS Display Terminal

The TIMS display terminal shall be provided with an input device, such as, key pad or touch screen, so that the TIMS is able to:

(a) receive display control command (for example, brightness setting, selection of page/menu), and

(b) receive TIMS control command (for example, air conditioning temperature setting) from the train operator.

10.7.3. Control Requirements

(a) ~~As long as the DC circuit (refer to PS 17.4) is started up, the display control functions (refer to PS 10.8.2) of the train operator display terminal shall be~~ remained operative irrespective of the state ~~of the driving mode~~.

As long as the DC circuit (refer to PS 17.4) is started up, the display control functions (refer to PS 10.8.2) of the TIMS display terminal shall be remained operative irrespective of the state of the driving mode

(b) ~~Once the driving mode is being selected (refer to PS 9.5) in a driving cab, it becomes the active cab and the control functions of the train operator display terminal of the active driving cab end shall be remained operative. In the~~ non-~~active cab end, only the display control functions of the train operator display terminal shall be operative~~.

Once the driving mode is being selected (refer to PS 9.5) in a driving cab, it becomes the active cab and the control functions of the TIMS display terminal of the active driving cab end shall be remained operative. In the non-active cab end, only the display control functions of the TIMS display terminal shall be operative

(c) If it is attempted to select a driving mode ~~at both cabs apart from the shut-down mode (refer to PS 9.5.2(a)), only the display control function (refer to PS 10.8.2) of the train operator display terminal shall be available at both cab ends~~.

10.7.4. MMI Proposal

(a) The proposed MMI shall be submitted in the form of a detailed description document and a simulation program.

(b) ~~The simulation program shall be run on an IBM® compatible PC operating under MS Windows® XP (or later version, if approved) or an alternative specified by the Engineer~~.

(c) The simulation ~~program shall be able to show exactly the MMI as proposed~~

~~for the actual train operator display terminal control functions except that the control of the touch screen or key pad may be simulated by the keyboard or mouse function.~~

As long as the DC circuit (refer to PS 17.4) is started up, the display control

functions (refer to PS 10.8.2) of the TIMS display terminal shall be remained operative irrespective of the state of the driving mode.

10.8 Testing Requirements

10.8.1. The Contractor shall perform comprehensive testings on the TIN and TIMS to demonstrate full compliance with the Specification. The Contractor shall make reference to ISO 9646-1 in preparing the test specification and test coverage.

10.8.2. The following, as a minimum, shall be tested:

(a) TIN network performance including the real time network protocol, network traffic and throughput, loading and resource spare capability

(b) Each TIN equipment functional and performance requirements including System Sub-Networks, Train Consist Network, CPU, LPU, Gateway, ATC / Communications Gateway, Event Recorder and Control Interface

(c) All data transmission services and modes of Data Management

10.8.3. A three stage testing strategy shall be adopted to verify and validate the TIMS functionalities:

(a) Prototype Test and TIMS System Integration Test

(i) Prototype test and TIMS System Integration Test shall be conducted prior to the commencement of SEMP Stage 4.

(ii) All TIMS main components including: LPU, Display terminal, Control Interface and Network Devices of a consist shall be set up establish a simulated TIMS to verify the functions and performance of the TIN as stipulated in PS 10 and this Standard.

(iii) Train subsystems shall be simulated to provide the same data input / output characteristics as the real equipment. The number of simulated train subsystems shall be the same as the real train to simulate the actual traffic conditions.

(iv) Simulation of the YMSS shall be provided to allow testing of the wireless LAN transmission link interface, the automatic train preparation (refer to PS 10.3.2), automatic train shutdown (refer to PS 10.3.3) and data download / upload (refer to PS 10.6.2(b)) facilities

(b) TIMS Sub-System Interface Test

(i) TIMS system interface test shall be conducted by the end of SEMP Stage 3.

(ii) Each sub-system interfacing with the TIMS shall be tested to verify the TIMS functions and performance as stipulated in PS 10 .

(c) TIMS Vehicle Level Test

(i) TIMS vehicle level test shall be conducted by the end of SEMP Stage 4.

(i i) Tests conducted during TIMS system integration test shall be repeated on a complete train fitted with all the TIN equipment and all train subsystems to verify the functions and performance of the real TIMS as stipulated in PS 10 and this specification.

10.9 Maintenance Requirements

10.9.1. A maintenance port employing either RS 232 serial interface shall be provided for each TIN equipment including LPU, Gateway, ATC / Communications Gateway, Event Recorder and Control Interface and each microprocessor based train subsystems interfaced with the TIMS. These maintenance ports shall enable connection with the maintenance terminal (a.k.a. Portable PC) to provide the following maintenance functions:

(a) Downloading of fault logs (all types of fault detected including critical fault, operating event, maintenance event, record and notice (refer to PS 10.3.6(b)) and historical operation data in either binary format or in commercial database format of Oracle DataBase for Window® or an alternative specified by the Engineer.

(b) Adjustment of operating and control parameters

(c) Fault diagnosis of equipment for identification of the faulty part down to the LRU level (refer to PS 26.2.5)

10.9.2. The maintenance terminal shall be in the form of a portable notebook or palmtop computer (PC) (refer to PS 24.3.11) and shall be able to be connected to each of the equipment as stipulated above.

10.9.3. Protocol analysis software shall be provided in the maintenance terminal to allow it to function as a protocol analyzer that can:

(a) Analyze the Train Consist Network and System Sub-Networks traffic including data throughput and data transmission failure rate

(b) Analyze the data exchange on any selected interface connection on the TIN (for example analyze traffic between LPU and Gateway, between LPU and Control Interface) with detailed information on the timing, sequence and content of data sent and received

10.10 Design Requirements

10.10.1. SEMP Stage 1

The Contractor shall prepare and submit the following for approval during SEMP Stage 1:

(a) The overall architecture of the TIMS including Train Consist Network, System Sub-Networks, CPU, LPU, Gateway, ATC / Communications Gateway, Event Recorder and Control Interface

(b) The real time operating system and network protocol to be adopted together with their predicted performance and high level functionality

(c) A high level data management document that list all the predicted network traffic and their volume under all operating scenarios

(d) The predicted resource spare capacity for all the equipment

(e) Detailed design specifications of all hardware and software interfaces with subsystems connecting to the TIMS

10.10.2. SEMP Stage 2

The Contractor shall prepare and submit the following for approval during SEMP Stage 2:

(a) Calculation and quantitative analysis of the network traffic and the delay-throughput characteristics for each type of data transmission service (periodic and sporadic data transmission)

(b) A detailed data management strategy document that list all the predicted network traffic together with their assigned data transmission service and priority

(c) A MMI prototype with a description document and simulation program to allow the operator to explore its operability

(d) A detailed questionnaire on the prototype MMI for collecting feedback of operators and then perform all necessary changes to the MMI based on the collected feedback

10.10.3. SEMP Stage 3

The Contractor shall prepare and submit the following for approval during SEMP Stage 3:

(a) Test specifications for the three stage testing to demonstrate the full compliance with the specification

(b) Test reports for the prototype test and TIMS system integration test

(c) MMI with description document and simulation program for final verification

10.10.4. SEMP Stage 4

The Contractor shall prepare and submit the test report for the TIMS vehicle level test for approval during SEMP Stage 4.

10.10.5. SEMP Stage 5

The Contractor shall consolidate into a single document all the testing results, calculations, theoretical analysis and design studies to demonstrate the full compliance with the Specification and submit the document for approval during SEMP Stage 5.

Item	Position of the Traction Brake Controller	Motor Signal	Brake Signal
1	Coasting: The Traction Brake Controller handle is at 0o (with detent)	0	0
2	Limited Motoring (a.k.a. Inch): The Traction Brake Controller handle is moved to the +10o detent	1	0
3	Motoring (a.k.a. Series): The Traction Brake Controller handle moved beyond the +10o detented position	1	0
4	Motoring (a.k.a. parallel): The Traction Brake Controller handle is moved beyond the +10o detented position is between +10o to +45o	1	0
5	Full Motoring: The Traction Brake Controller handle is at +45o (with detent)	1	0
6	Minimum Braking: The Traction Brake Controller handle is moved to -10o (with detent)	0	1
7	Braking: The Traction Brake Controller handle is moved between -10o to -40o	0	1
8	Full Service Braking (default position): The Traction Brake Controller handle is moved to -40o (with detent)	0	1
9	Emergency: The Traction Brake Controller handle is stayed at -45o (with detent)	0	1

Table 10-2 Logic Table for the Traction Brake Controller

Shutdown	Reverse	Standby	Forward	SCS	Forward Signal	Reverse Signal
1	0	0	0	0	0	0
0	1	0	0	0	0	1
0	0	1	0	0	0	0
0	0	0	1	0	1	0
0	0	0	0	1	1	0
0	0	0	0	0	1	0

Table 10-3 Logic Table for the Mode Selector

Motor Signal	Brake Signal	Forward Signal	Reverse Signal	Status1	Result
0	0	0	0	fault	as previous state
0	0	0	1	normal	as previous state
0	0	1	0	normal	as previous state
0	0	1	1	fault	as previous state
0	1	0	0	normal	as previous state
0	1	0	1	normal	brake in Reverse
0	1	1	0	normal	brake in Forward
0	1	1	1	fault	as previous state
1	0	0	0	fault	as previous state
1	0	0	1	normal	motor in Reverse
1	0	1	0	normal	motor in Forward
1	0	1	1	fault	as previous state
1	1	0	0	fault	as previous state
1	1	0	1	fault	as previous state
1	1	1	0	fault	as previous state
1	1	1	1	fault	as previous state

Remarks:

1: For any status of "fault" shall be reported to the train operator and logged into the event recorder.

Table 10-4 Logic Table for the Control Commands

Item	Train Status	Data Received	Information Displayed by EIDS/LIDS
1	Train departed from station X-1	Station code updated to X.	1. The station name X-1 disappears. 2. The station name X appears.
2.	Train is traveling	Platform side code other than "undefined" state received.	1. The correct door indication appears.
3.	Train stop at station X and passenger doors	Door status code - door open signal	1. The station name X appears. 2. The correct door indication appears.
4.	Passenger doors closed	Door status code - door close signal Platform side code reset to a state of undefined.	1. The station name X disappears. 2. The door indication disappears.

Table 10-5 Presentation Style for Normal Station Running

Item	Train Status	Data Received	Information Displayed by EIDS/LIDS
1	Train departed from station X-1 to interchange	Station code updated to X.	1. The station name X-1 disappears. 2. The station name X appears.
2.	Train is traveling to interchange	Platform side code other than "undefined" state received.	1. The correct door indication appears.
3.	Train stop at station X and passenger doors	Door open status - door open signal	1. The station name X appears. 2. The correct door indication appears.
4.	Passenger doors closed	Door open status - door close signal Platform side code reset to a state of undefined.	1. The station name X disappears. 2. The door indication disappears.

Table 10-6 Presentation Style for Interchange Station Running

Item	Train Status	Data Received	Information Displayed by FSM's
1.	Train departed from station X-1 to terminal station X	Station code updated to X.	1. The station name X-1 disappears. 2. The station name X appears.
2.	Train is traveling to terminal station X	Platform side code other than "undefined" state	1. The correct door indication appears.
3.	Train stop at station X and passenger	Door status code - door open signal	1. The station name X appears. 2. The correct door indication appears.
4.	a. If passenger doors remain open in the terminal station.	TIMS determines the next route, next station and terminal station based on the information of last journey, and initializes the PIS	1. The previous terminal station name X disappears, and door indication disappears.
	b. If the train enters head shunt for	No data shall be received from TIMS.	
5.	Open up in the other cab	PIS re-initialized in accordance with PS 10.4.2(c)	

Table 10-7 Presentation Style for Terminal Station Running

Item	Train Status	Data Received	Information Displayed by EIDS/LIDS
1.	Train departed from station X-1 to terminal station	Station code updated to X.	1. The station name X-1 disappears. 2. The station name X appears.
2.	Train is traveling to terminal station X	Platform side code other than "undefined" state	1. The correct door indication appears.
3.	Train stop at station X and passenger	Door status code - door open signal	1. The station name X appears. 2. The correct door indication appears.
4.	a. If passenger doors remain open in the terminal station.	TIMS determines the next route, next station and terminal station based on the information of last journey, and initializes the PIS Platform side code reset to	1. The previous terminal station name X disappears, and door indication disappears.
	b. If the train enters head shunt for	No data shall be received from TIMS.	
5.	Open up in the other	PIS re-initialized in accordance with PS 10.4.2(c)	

Table 10-8 Presentation Style for Terminal and Interchange Station Running

SECTION 11 TRACTION AND BRAKING EQUIPMENT 2

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Section 11 Traction And Braking Equipment

11.1 General

11.1.1. The traction and braking system proposed shall be of proven design suitable for the specified performance levels. The design of the power converter shall comply with IEC 61287-1:1995 and shall be tested to IEC 61377:1996 and IEC 61377-3:2002.

11.1.2. An AC traction motor system shall be utilised. The AC traction motors and associated drive system proposed shall be designed to perform all normal and emergency duties as specified in PS 4, without damage or deterioration to the motors or their associated connections which may lead to subsequent premature failure.

11.1.3. The traction and braking system shall meet performance under all conditions of wheel wear including up to 6mm (0.25”) of wheel diameter mismatch on axles in the same truck.

11.1.4. The system shall be designed for optimum performance in terms of reliability and maintainability and with minimum energy consumption.

11.1.5. The specific energy consumption shall be guaranteed and verified during the testing stage. Requirements for the verification and validation of the energy consumption shall be as specified in Appendix C.

11.2 System Configuration

The traction and braking equipment shall have the following characteristics:

11.2.1. Two truck frame mounted 3-phase AC induction motors per motored truck.

11.2.2. A 3-phase self-ventilated traction converter control system with dynamic braking (both regenerative and rheostatic) capability, each powering the two

parallel connected motors of one motored truck. All traction converters shall be identical, interchangeable and underframe mounted.

11.2.3. Separate and independent slip/slide control for each truck and detection for each axle.

11.2.4. Separate friction brake interface and brake blending control for each truck.

11.2.5. An energise-to-release, fail-safe, pneumatic friction emergency braking system.

11.2.6. The electro-pneumatic service and emergency brakes shall operate the same brake actuators.

11.2.7. An automatic spring-applied, air-released parking brake.

11.3 Control Interface

11.3.1. The modes of operation shall be as defined in PS 9.5. No change of travelling direction shall be allowed unless the train speed is less than 1 km/h (0.62 MPH).

11.3.2. A screened twist pairs train line shall be provided to transmit the tractive effort/braking effort demand in the form of pulse width modulation to the traction and braking equipment. The signal transmission of the above tractive effort/braking effort demand shall be independent with the TIMS operation.

11.3.3. The above demand shall be generated in the form of a pulse width which shall be modulated by the traction brake controller. The circuit shall be designed in a manner that the PWM signal of the tractive effort/braking effort command shall only be available from the traction brake controller of the selected driving cab

11.3.4. The demand level received by all the traction and braking equipment on the train shall be identical.

11.3.5. The tractive effort/braking effort output from the traction and braking equipment shall be according to the demand level received from the traction brake controller and within the normal working range of the control signal as shown in the following table:

	Traction					**Brake**				
Effort level	error	0	0 to 100 (linear)	100	error	error	0	0 to 100 (linear)	100	error

PWM rate (%)	0 to 3	3 to 10	10 to 90	90 to 97	97 to 100	0 to 3	3 to 10	10 to 90	90 to 97	97 to 100

11.3.6. An alternative design according to the IEEE-std-1475 type 3 network signals, or equivalent, could also be use for the traction/braking effort modulation signal transmission at the place of the PWM signal (type 2) as described in PS 11.3.2 to 11.3.5.

11.3.7. In the event of an abnormal demand signal, default traction effort which is equal to zero effort, and default braking effort which is equal to maximum effort, shall be applied.

11.3.8. A load weighing signal which is proportional to car mass and passenger load, shall be provided. This signal shall be suitably damped and provide the mean value of air suspension pressures from the air springs on the two sides of a truck over the full working range of the air spring pressure.

11.3.9. The tractive effort/braking effort demand signal shall be adjusted by the load weighing signal individually at the related car and assure the appropriate train acceleration/deceleration levels.

11.3.10. In the event that the load weighing signal is lost, the tractive effort/braking effort demand signal shall be modulated assuming the fully laden condition (refer to PS 4.5.3).

11.3.11. During normal operation, the dynamic braking shall be the default braking system and the friction brake system shall be capable of continuous blending to ensure a full service brake rate.

11.3.12. The control response time which is defined as the time elapsed between initiation of the control command signal (for example, motoring, coasting and braking) and on-set of the change of state of the traction/braking circuit, shall be within 0.5 secs.

11.3.13. A failure within the traction and braking equipment shall not cause a failure of friction brake operation.

11.3.14. Not Used

11.3.15. For the purpose of accelerating the fault recovery, the location of the faulty traction and braking system shall be identified and reported by the TIMS. In addition, a remote traction and braking system isolation function on a truck basis shall be provided to isolate the above identified faulty traction and braking system via the TIMS.

11.3.16. The integrity of all speed sensing devices shall be continuously monitored.

Any abnormality detected shall be reported to the train operator via the TIMS and this event shall be logged in the event recorder.

11.3.17. Diagnostic and Fault Logging Facility

(a) The traction converter shall provide self diagnostic and fault logging facilities, to facilitate maintenance and identification of the faulty part down to the LRU level (refer to PS 26.2.5).

(b) A control interface shall be provided between the traction converter and the TIMS to enable status monitoring of the unit.

11.4 Mode of Operation

11.4.1. The traction equipment shall be capable of operation in various modes according to PS 9.5. The traction equipment shall respond to the traction brake controller handle positions. The characteristics of the tractive effort/braking effort output versus the traction brake controller position shall be referred to PS 9.6.

11.5 Power Contactors Control

For safety purpose, the following arrangements for initiating the traction or braking circuit shall be provided:

11.5.1. The initial setting-up of the traction circuit for motoring or dynamic braking shall be controlled in all cases by two separate train lines.

11.5.2. Whenever zero tractive or braking effort is demanded, ~~the current in the traction motors shall be ramped to zero under jerk rate control and if necessary the power contactors shall open after a time delay~~.

Whenever zero tractive or braking effort is demanded, the tractive effort in the traction motors shall be ramped to zero under jerk rate control.

11.5.3. ~~The time delay shall be provided to prevent the switching of the power contactors in the event of changing mode of operation from motoring to braking and vice versa.~~ Changing mode of operation from motoring to braking and vice versa should not require operation of the power contactor.

11.5.4. De-energising ~~either of the appropriate two master train lines for a duration~~ longer than the time delay shall ~~cause the traction equipment to be disconnected from the supply~~. De-energising either of the appropriate two master train lines shall cause the traction equipment to be disconnected from the supply.

11.5.5. A stray feed onto any one control wire, not necessarily a train line, shall not

prevent the traction equipment from being disconnected from the supply.

11.5.6. To avoid any contact tip wear due to arcing, the motor current shall be ramped to zero before the power contactors open under normal conditions.

11.5.7. Any of the following events shall cause the traction converter to switch off immediately without jerk limit control and the power contactors to open immediately:

(a) emergency brake is demanded;

~~motoring or braking circuit overload;~~

(b) motoring or braking circuit overload

Any of the following events shall cause the power contactors to open, but allow rheostatic braking to be provided, if in brake mode

(c) overvoltage or undervoltage in regenerative brake; and

(d) Rail gap detected.

11.5.8. ~~The motor/brake and forward/reverse commands shall be provided by means of a dedicated hardwired trainlines to configure the power circuit according to the selected mode of operation.~~ Forward/reverse commands shall be provided by means of a dedicated hardwired trainlines to configure the power circuit according to the selected mode of operation. Motor/brake commands shall be provided by means of TIN network.

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11.5.9. Changes of state of forward/reverse commands shall only be allowed when zero velocity is proved by the traction and braking system. And the zero velocity is proved by the Zero Velocity Relays status. Two Zero Velocity Relays shall be provided and controlled by both the traction and braking systems independently. And the Zero Velocity Relay shall be energised when the train speed which shall be independently measured by both the traction and braking systems, is below 1 km/h (0.62 MPH).

11.5.10. Except for conditions as specified in PS 11.5.7, the jerk rate limit of 0.8m/s shall be applied to all changes of state of motor/brake including coasting commands.

11.6 High Tension Circuit

11.6.1. Current Collector Equipment

(a) The traction power supply shall be collected from the third rail power supply with the running rails utilised for traction return. The detailed interface requirements for the high tension power collection and the traction supply system shall comply with Appendix I Annex 2.

(b) Not Used

(c) Collector shoe Assembly

(i) The third rail collector shoe devices shall be purchased from the Named Supplier, installed, interfaced, tested and commissioned as stipulated below. Provision shall be made to mount the third rail collector shoe devices on the

side of the truck. The collector shoe shall be sliding contact type using spring pressure for the purpose of collecting current from the 600 V DC side-contact ~~third rail system.~~

(ii) ~~An insulating shield and arc guard as shown on the Contract Drawings No.~~ NST 045 shall be provided to prevent the possibility of a flash-over ~~from the collector shoe devices to any grounded metal parts on the truck~~.

An insulating shield and arc guard as shown on the Contract Drawings No. NST 22029 and 22030 shall be provided to prevent the possibility of a flash-over from the collector shoe devices to any grounded metal parts on the truck.

(iii) Each truck shall be provided with two collector shoe assemblies, one located on each side of the truck and between the axles. The collector shoe assembly includes a top running, spring loaded sliding contact, insulating bracket, fuse, arc guard, shop supply receptacle and other items as shown in the Contract Drawings No. NST 047. Provision shall be made for automatic wheel and shoe wear adjustment in order to ensure the correct shoe force is acted on the third rail.

(iv) Provision shall be made for the fine adjustment of the collector shoe position, in order to comply with the nominal height requirement of the third rail above the running rail and the nominal distance from the centre of the third rail to the track gauge line. Typical dimensions are shown on the Contract Drawings No. NST 005.

(v) Due consideration shall be given to prevent any lived part, except the siding contact, to be exposed to the maintainer after installation of the collector shoe assembly to the truck when the train is energized. Similar design of fibreglass, non-conducting shroud which is used in the existing trains, shall be provided to cover the lived part.

(vi) A traction gap detection shall be provided on a car basis in such a way that, when a traction gap (refer to Clause 4.3 of Appendix I Annex 2) is detected, ~~within 150 ms, all collector shoes of that car shall be isolated within 150 ms~~ and remained isolated until the 600VDC is resumed ~~on the third rail. During the above collector shoes isolation period, no voltage originating from the car, above 50 VDC shall be presented at any part of the collector shoe which is exposed to the track maintainer.~~ all collector shoes of that car shall be isolated within 150 ms and remained

isolated until the 600VDC is resumed on the third rail. During the above collector shoes isolation period, no voltage originating from the car, above 50 VDC shall be presented at any part of the collector shoe which is exposed to the track maintainer.

(d) Carhouse Receptacles

(i) An adequately rated female receptacles of proven design, sealed to IEC 60309 with IP 67 and compatible arrangement with the existing carhouse supply male contact, shall be provided on each collector shoe assembly for maintenance purpose inside the carhouse (refer to Appendix I Annex 5 and Contract Drawing No. NST 047 for an overview of the carhouse receptacle of the T1 cars).

(i i) A fuse box assembly containing a fuse of a proven type and capacity shall be provided adjacent to each collector shoe on the truck and connected between the collector shoe and the truck wiring. The fuse box assembly shall be fitted with suitable protective shielding to prevent flashing to truck or to carbody grounded metal. An indicator shall be provided with the fuse to allow visual identification when the fuse is operated.

(i i i) An isolation and test switch which shall be of similar design, operation and performance of the existing T1 train and as far as practicable interchangeable with T1 train, shall be provided which shall be located on the side of the underframe equipment box, so that it can be easily accessed by the maintainer when the train is stayed over maintenance pit (refer to Appendix I Annex 5 and Contract Drawing No. NST 048 and NST 049 for the typical arrangement of the isolation and test switch of the T1 cars). The isolation and test switch shall be equipped with the following three positions and functions:

Position	Items Connected	Item isolated
1. RUN	1. Collector Shoe 2. Auxiliaries	1. Shop receptacle
2. OFF	1. None	1. All Items
3. SHOP TEST	1. Shop receptacles 2. Auxiliaries, except	1. Collector Shoe 2. Traction

(iv) The isolation and test switch shall include means to lock the switch in the OFF position to prevent the inadvertent application of high tension powers. The test switch shall be a rotary, totally enclosed type and located in a weatherproof box. Status of the above switches shall be monitored by the TIMS and any

operation of these switches shall be reported to the Train Operator and recorded in the Event Recorder.

11.6.2. High Voltage Fuses and Cabling

(a) ~~The use of high tension fuses in the power circuit is not permitted except for~~

the collector shoes and the auxiliary converters (refer to PS 17). The use of high tension fuses in the power circuit is not permitted except for the collector shoes, the traction converters and the auxiliary converters (refer to PS 17).

(b) The cabling to the collector shoe shall be correctly sized so that a train can operate continuously without electrical or thermal distress to the collector shoe or the associated cabling during the worst case operating condition.

(c) Special provision shall be made to protect the 600 VDC cable between the collector shoe and the power contactor. The length of this section of high tension cable shall be kept to minimum.

(d) No intercar cable routing of the 600Vdc collector shoe cable is allowed except those under the protection of the power contactor (refer to PS 11.6.3) and the auxiliary converters.

11.6.3. Power Contactors

(a) A power contactor shall be used for the following purposes:

(i) fault rupturing;

(i i) fault isolation; and

(i i i) protect the traction equipment against circuit faults, such as, traction power

supply short circuit during regenerative braking.

(b) In the event that the fault is proved to be cleared, the power contactor shall be either automatically reset or by the intervention of the train operator to re-close it.

(c) A second contactor in series with the power ~~contactor shall be provided to satisfy rail gap isolation capability required in PS 11.6 (vi).~~

The power contactor shall also be used to satisfy rail gap isolation capability required in PS 11.6 (vi)."

11.6.4. Not Used

11.6.5. Protection

(a) Protection shall be included in the power circuit to ensure that circulating currents through motor bearings or pinion cannot occur under any condition, for example, motoring, braking, coasting, wheel slip or towing a defective unit.

(b) Electronic and mechanical overload protection shall be provided in both motoring and braking. The overload protection shall also be capable of protecting the semiconductor devices against all foreseeable faults.

(c) The misfiring of a traction converter or short-circuit failure of a semiconductor device shall not cause consequential damage to other equipment.

(d) Over and under voltage protection shall be provided such that the power circuit ceases to operate outside the limits.

(e) Protection shall be provided to ensure that the equipment cannot be damaged in the event of line voltage transients as defined in appendix I annex 2.

(f) A system shall be provided for detecting an earth fault. The design shall be of high integrity so as not to affect the availability of the train by nuisance tripping.

(g) All high voltage capacitors shall be equipped with a separate discharge paths to ensure they are discharged to 50V within 15 minutes, after high voltage is removed from the circuit.

11.6.6. Input Filter

(a) An input filter shall be provided in the propulsion unit for the following purposes:

(i) To attenuate train generated harmonics to a safe level, particular attention shall be paid to ensure no excessive train generated harmonics shall occur at the signalling frequencies as specified in the Appendix I Annex 3; and

(ii) To prevent damage to solid state equipment due to possible large transient voltages from the traction power supply system.

(b) The Contractor shall ensure the distortion factor of motor ripple current due to traction converter operation for all conditions of motoring and braking has no adverse effect on the traction and braking equipment.

(c) The use of fuses in the filter capacitor or inductor circuit is not permitted.

(d) If an iron cored inductor is used, the Contractor shall provide an impedance versus current curve, up to a current of:

$$720 \times \frac{C}{L}$$

or full load current, whichever is greater. In the above expression, L and C are the inductance and capacitance of the input filter respectively.

(e) The filter initial charging current shall be limited to a safe level.

11.6.7. Power Component

(a) Power semiconductors shall use isolated modules with snubbing and protection components, if necessary.

(b) The Contractor shall demonstrate that the limits of electrical and thermal rating for all power components under all conditions of motoring and braking will not be exceeded.

(c) Accurate and detailed computer simulations of single power component failures shall be provided at an early stage in the design of the equipment. These shall show the consequences of every predictable single power component failure and demonstrate the system's ability to adequately clear the fault.

(d) Semiconductor Temperatures and Cooling

(i) The maximum air temperature within any equipment case shall not exceed 65°C (149°F) under all conditions of normal and emergency duties specified in PS 4.

(i i) In order to ensure sufficient safety margin is provided, the maximum junction hon-

temperature of all power semiconductors shall be at least 10 ºC below the manufacturers maximum allowable junction temperature under worst case service duty cycle conditions. For emergency and towing conditions junction temperatures may approach manufacturers maximum allowable.

(iii) ~~Semiconductor cooling shall use natural air convection and earthed heatsinks~~

~~with all insulating surfaces enclosed in clean conditions. Chlorofluorocarbon~~ or other fluid-based ~~cooling systems shall not be used with the exception of sealed heat pipes containing non chlorofluorocarbon based fluids. Tanks~~ containing cooling liquid shall not be used. The point of heat exchange ~~with the atmosphere shall be external to the sealed enclosure. Heat sink fins shall be supplied on more than one exterior walls of the enclosure. Alternatively, if liquid or phase change cooling is employed for the power semiconductors, a~~

~~type cooling system shall be provided~~.

Semiconductor cooling shall use natural air convection and earthed heatsinks with all insulating surfaces enclosed in clean conditions. Chlorofluorocarbon or other fluid-based cooling systems shall not be used with the exception of sealed heat pipes containing non chlorofluorocarbon based fluids. Tanks

containing cooling liquid shall not be used. The point of heat exchange with the atmosphere shall be external to the sealed enclosure. Heat sink fins shall be supplied on one or more exterior walls of the enclosure. Alternatively, if liquid or phase change cooling is employed for the power semiconductors, a non-immersion type cooling system shall be provided.

(i v) Forced air cooling shall not be used.

(v) The designed life of the cooling system shall not be less than 20 years. Cleaning, other than normal undercar washing, and other maintenance shall not be required at periods of less than 1 year.

(e) Electrolytic capacitors in the power circuit shall not be used.

(f) Unless otherwise specified in the manufacturers data sheet, the maximum instantaneous temperature of any power resistor element when performing the normal traction and braking duties shall not exceed 470°C (878°F). The maximum instantaneous element temperature shall not exceed 550°C (1022°F) when operating under any of the emergency duties as specified in PS 4.

11.6.8. Braking Resistors

(a) The braking resistors shall comply with IEC 60322 : 2001.

(b) The resistors shall be provided with over-temperature protection. Mechanical temperature switches shall not be used. Temperature of the resistors shall be calculated from accumulated power into the resistors or some other non mechanical means.

(c) The resistor groups shall be double insulated and adequately protected against wheel splash, flying ballast/debris. At least one level of insulation shall be non hydroscopic high temperature insulation equivalent to glazed ceramics.

(d) The braking resistor shall be installed so as to prevent over-heating of adjacent equipment, wiring or underframe structure.

(e) An grounded screen shall be provided for the braking resistor bank to prevent contact by maintenance personnel with electrically live or thermally hot resistor elements.

(f) Thermal insulation shall be provided between the resistor enclosure and the underframe. The top of the resistor shall include a stainless steel heat shield.

11.6.9. Traction Motor and Associated Drive System

(a) The traction motors and associated drive system shall be designed for all

normal and emergency duties as specified in PS 4, without damage or deterioration to the motors or their associated connections which may lead to subsequent premature failure.

(b) The traction motor shall be resiliently mounted to the truck frame.

(c) The traction motor shall be of robust construction and proven in the railway environment. The motor shall comply with the requirements of IEC 60349-1 : 2002 and IEC 60349-2 : 2002.

(d) The motor shall be adequately rated such that its operating temperature will be one class below operating temperature permitted by the class of insulation employed whilst fully meeting all specified performance requirements.

(e) The stator windings shall have a design average insulation life of more than 35 years and be rated Class B or better.

(f) The rotor construction shall be robust and be capable of withstanding all foreseeable high vibration and impact loads. The rotor resonant frequency shall not coincide with harmonic frequencies of the inverter.

(g) Protection shall be provided to prevent the motor from dropping onto the track should the motor become disconnected mechanically from the frame.

(h) The motor should be self-ventilated or totally enclosed.

(i) If self-ventilated the motor draws the ventilating air from underneath the car, careful consideration shall be given to the positioning of the air inlet to the motor so as to minimise pick-up of dust and to prevent objects from dropping into the inlets. Provisions shall be made, according to the motor modification of the existing T1 trains, to connect an air hose through the end housing to facilitate blow out of dust during preventative maintenance.

(j) A simple means of excluding dirt and rain water from the machines shall be provided.

(k) Air filters shall not be used.

(l) The insulation system shall be carefully designed to enable the motor to operate with the uncleaned air which will be used to cool it.

(m) Any inspection covers shall be robust and designed for quick and easy removal/replacement and have secondary retention to prevent loss. Inspection openings shall be as large as possible to facilitate inspection and maintenance.

(n) All grease lubricated bearings shall run between overhauls without replacement.

(o) Protection shall be provided to prevent current flow through the bearings in normal and under fault conditions. At least one of the motor bearings shall be of the insulated type.

(p) The coupling of the gearbox shall accommodate all relative movements between the motor and the gearbox, including that caused by a free standing truck, without damage to the coupling.

(q) The gearbox case design shall give due consideration to minimising weight.

(r) The design of the motor installation shall permit the motor to be removed from, and refitted to, the truck from above, without any need to disturb the axle and any truck mounted equipment.

(s) Means shall be provided, by using a wheelskate or similar device, to quickly and safely remove a train with a seized motor, gearbox, or axle, from any point of the main running line back to the depot. To facilitate such operations, jacking points shall be provided beneath the axleboxes.

(t) Where cables pass through holes in the traction motor frame or sealed water tight junction box, oil resistant resilient bushes suitably clamped shall be provided to prevent chafing of cables and to seal against the ingress of oil and water.

(u) There shall not be any permanent flying lead attached to the motor. All connections to the motor shall be bolted, torque tightened and marked.

(v) Clearly marked terminals at the junction boxes on the motor frame and on the car underframe adjacent to the motor shall be provided to ensure the motor is electrically connected to the car wiring correctly. Connection or disconnection of the cable terminal shall take not more than ten minutes for one person.

(w) The junction boxes shall be arranged for easy accessibility and colour coded for easy identification. They shall include strain relief provision to ensure that connections are not mechanically stressed.

(x) The cables shall be secured to prevent chafing with other equipment or connections and have sufficient freedom of movement to prevent stressing or fouling of other equipment during the full envelope movement of the truck.

(y) If speed sensors are fitted to motors, these shall:

(i) be the same for all motor mounting positions; and

(i i) be capable of being replaced with the motor in-situ on the train.

11.6.10. Earthing Equipment

(a) It is a safety requirement that on each car, all power and auxiliary circuits shall be capable of being isolated and all capacitors discharged to allow maintenance access in complete safety.

(b) Each circuit negative or neutral shall be earthed at one discrete point only on the train in order to prevent the passage of traction current through negative train or unit wires.

(c) Under no circumstances shall circuits be earthed to equipment cases.

(d) Each car shall be provided with a protective earthing (grounding) circuit and a high tension Return current circuit. Those circuits shall follow the general rules of EN-50153 standard, adapted to North American practices in the railway industry.

(e) Unless otherwise approved by the Engineer, all high tension equipment shall have its metallic enclosure, frame or container connected to carbody as part of the Protective grounding scheme. For the low tension equipment, the connection to the carbody can be done through the mechanical attachment of the enclosure.

(f) The Protective grounding circuit and the high tension return circuit shall be connected to the carbody through distinct grounding plates. Ground plates located close to each truck shall connect the carbody with Return/Earthing cables to the trucks' grounding plates. Each axle of a truck shall be provided with a earthing (grounding) brush box. All the ground brushes will be connected in parallel to the truck grounding plate to provide a very low impedance path for the return and protective grounding currents. This configuration shall provide 2 independent paths for the carbody current to return to the running rails. .

(g) Each brush box shall be provided with a protective cover which can be easily removed for inspection and replacement of brushes. If the axle end type earthing brush box is proposed, design consideration shall be given to ensure that the earthing brush box can be easily removed and replaced by a trained maintainer within 15 mins.

(h) One earthing brush group shall be rated to carry all the return current assuming 50% of the brushes are missing.

(i) With only 50% of the car grounding brushes functional on the car, the carbody voltage drop to the running rail shall not exceed 50Vdc under normal and ground fault current condition.

(j) Equipment using 600Vdc input voltage shall return their current with a

distinct and insulated cable connected to a high tension carbody mounted grounding plate.

(k) The high tension grounding plate shall use a separate terminal bolt for each connection, and one spare, all mounted accessibly on the underframe. The high tension return current grounding plate shall be distinct from the low tension negative circuit grounding plate.

(l) The Contractor shall ensure that there are no extraneous return current paths through any motor gear or axle bearing and that each current return brush group is adequately rated to carry the entire traction return current drawn by that car.

(m) All low tension negative circuits shall be wired to separate terminals on a return bus bar, with one spare terminal. The return bus bar shall be insulated from the other voltages including the carbody. It shall be connected to ground at a low tension grounding plate, with a single cable. The battery negative shall be connected at the same grounding plate on a separate terminal, or be connected directly at the return bus bar.

(n) As much as possible, a single point earthing arrangement shall be provided for the low tension circuit. The low tension return current circuit shall be grounded at a single location in the unit. The low tension circuit on the other cars shall be connected to ground through the low tension negative/return cable: the return bus bar will not be connected to the local carbody ground plate.

11.6.11. Energy Measurement

(a) The Contractor shall provide means to record usage of energy with an accuracy of ± 5% for motoring, regeneration and auxiliaries separately and independently.

(b) The record of cumulative energy shall be in units of kilowatt-hours.

(c) The energy data shall be non-volatile, easily accessible and monitored by the TIMS.

11.6.12. Traction Tests

(a) Traction Control Test

(i) The equipment shall be capable of a train operator initiated static test which shall detect incorrect operation of all major semiconductors, all electronics racks, the input filter, all power protection devices and all contactors.

(ii) During the test, a default friction brake shall be applied and power shall only

be applied to the traction motors when the line contactors are proven to be opened.

(iii) Charging of the filter capacitor and gating of the main devices will be permitted provided the power contactors are proven to be opened before any power devices are gated.

(iv) Any fault detected shall be logged and reported to the TIMS.

(b) Traction Power Test

(i) The equipment shall be capable of a train operator initiated power test which shall cause the train to motor against its brakes.

(i i) During the test, a default friction brake shall be applied and the traction equipment shall operate according to the demand signal. If wheel rotation is detected, the power shall be shut off on the car concerned.

(i i i) The results of this test shall be reported to the TIMS.

11.7 Electro-Magnetic Compatibility (EMC) Requirements

11.7.1. The traction and braking system shall comply with the stipulated EMC requirements.

11.7.2. The switching frequencies selected for the traction converter shall be so as to preclude any possibility of electromagnetic interference adversely affecting the functioning of other train borne and trackside equipment particularly the signalling and communications equipment.

11.7.3. The Contractor shall design and install the wiring for all underframe mounted equipment in a manner such that it will minimise conducted or radiated magnetic fields. The ground lead from the traction motor shall be routed back to the inverter box ground.

11.8 Dynamic Braking Requirements

11.8.1. The dynamic brake shall be continuously available from 85km/h (53 MPH) down to 5 km/h (3 MPH) or less for the purpose of minimising the brake pad or block wear and maximising the regeneration of energy within the limits of adhesion.

11.8.2. The dynamic braking shall consist of regenerative and rheostatic braking, which shall complement each other, depending on the third rail receptivity and braking priorities as specified below:

(a) Under normal circumstances, regenerative braking shall have the first priority in the braking process and provide the full braking effort requested. In order to

optimise the size of the traction motor and inverter, a dynamic brake taper above 45 KPH is permitted.

(b) In case the line voltage transiently increases up to 720VDC, regenerative braking shall be transferred to rheostatic braking without noticeable change of brake effort, i.e. the blending of regenerative and rheostatic brake shall be smooth, continuous and reversible. The rheostatic braking resistor shall have transient thermal capacity to absorb all of the dynamic brake energy, for one station stop with W4 passenger loads from maximum speed. This will ensure smooth braking transition from the above transient over-voltage conditions. However, the thermal capacity of the rheostatic brake resistor shall assume continuous 50% line receptivity, followed by a worst case station stop with 0% line receptivity, without exceeding 650 ºC. The regenerative and rheostatic brakes transferring process shall be continuously reversible provided the temperature limit of the braking resistor is not exceeded. Control software shall predict the temperature of the rheostatic brake resistors and transition smoothly to friction braking at 600 ºC. Once temperature predictions fall to safe levels, dynamic braking shall be maximized.

(c) If the third rail system is totally receptive , dynamic braking shall be rated at a line voltage of 660 VDC minimum.

(d) Should the third rail system continue to be either partially or totally non-receptive, dynamic braking shall still be maximised by a smooth transition of regenerative/friction brake blending or revert totally to pneumatic service brake respectively without loss of brake effort until the receptivity of the third rail system is resumed. The short term braking resistor may be used to ensure smooth braking transition from receptive to non receptive conditions and vice versa.

(e) When there is no dynamic brake available, the total required brake force shall be provided by the friction brake.

(f) Any increase in receptivity during blended brake application shall result in a reduction in the level of friction or rheostatic braking and a resultant increase in the regenerated energy. For detailed requirements of brake blending shall refer to PS 11.12.

11.8.3. The motor unit associated with the trailer car shall provide the dynamic brake

for the combination of motor and trailer cars such that the regeneration is maximised and the wear of the friction brake equipment is minimised.

11.8.4. The braking effort shall be regulated among the combination of motor and trailer cars such that the maximum use of the available adhesion is achieved in meeting the demanded braking effort.

11.8.5. Due consideration shall be given to avoid excessive stress build up in the

mechanical structure particularly the coupler between the trailer and motor cars caused by the above combination of braking efforts.

11.8.6. Response times during brake blending shall be minimised to facilitate a smooth and non jerky operation.

11.8.7. Within the jerk limits specified, the electric brake shall be built up as rapidly as possible to maximise regeneration and minimise wear of the friction brake.

11.8.8. The regenerative braking shall not cause the line voltage to exceed 720VDC.

11.8.9. The Contractor shall submit for approval a system study indicating the effect of regenerative braking on the third rail fault level at the design stage. This shall confirm that the regenerative brake shall not cause the fault rupturing capacity of the protective equipment of the cars to be exceeded.

11.9 Friction Brake

11.9.1. The friction braking shall be achieved by means of a friction brake and shall be rated to meet the specified braking performance without assistance from the electrical brake.

11.9.2. The Contractor shall demonstrate by theoretical study, such as, finite element analysis, that the thermal stress built up on the wheel and braking equipment, for example, the brake pad or block, due to frequent friction braking operation according to the conditions specified in PS 11.9.3 below shall not exceed the recommended values given by the suppliers.

11.9.3. The friction brake block shall be capable of a series of 3 consecutive emergency brake applications from maximum speed down to standstill on a crush laden vehicle. The vehicle shall accelerate at its maximum rate up to maximum speed after each stop then immediately undergo an emergency brake application down to a standstill whereupon the train shall be immediately restarted. This shall not cause the wheel any damage and block material to change its friction or wear characteristics and shall not cause excessive wear of the friction material.

11.9.4. The friction brake actuation system shall be in accordance with the following general requirements:

(a) It shall be capable of reliable operation in service without the need for any routine attention between overhaul periods.

(b) It shall be capable of functioning satisfactorily without the need for routine lubrication between the overhaul periods.

(c) The design of the friction brake equipment shall permit the equipment to be

removed from, and refitted to, the truck from above (by crane) or below (using a lift table), without any need to disturb the axle or truck.

(d) An automatic slack adjustment system shall be provided to compensate for the wear of the fric~~tion braking material.~~

11.9.5. In addition to the load weighing signal specified in PS 11.3.7, a pneumatic load compensating device which shall be able to regulate the emergency braking effort on a car basis according to the associated car mass and ~~passenger load, shall be provided. This load compensating device shall be remained operative even the train is in a shutdown mode and auxiliary off state. Also, it shall require no additional power input other than the available pneumatic supply.~~ on a truck basis according to car mass and passenger load at the associated truck, shall be provided. This load compensating device shall be remained operative even the train is in a shutdown mode and auxiliary off state. Also, it shall require no additional power input other than the available pneumatic supply.

11.9.6. In the event that the load weighing feedback signal for the above pneumatic load compensating device is lost, the emergency braking effort shall be regulated assuming the tare laden condition (refer to PS 4.5.3).

11.10 Brake Response Times

11.10.1. The brake response time is defined by the following equation:

$$t_R = t_0 + t_1$$

where

t_R = brake response time

t_0 = dead time (time elapsed between initiation of the brake actuating signal either by the ATC system or by the train operator and the

brake cylinder pressure starts to built up)

t_1 = brake built-up time (until the required brake cylinder pressure or braking force have been reached whichever gives the greater braking energy response)

11.10.2. The following brake response times shall be achieved on any single car of a train:

(a) Service brake application: 2.0 secs

(b) Emergency application: 1.6 secs

11.11 Combined Brake Control Principles

11.11.1. The combined braking between the dynamic and friction brake shall be carried out smoothly and within the jerk limits in normal operation.

11.11.2. The friction brake shall be used to supplement the difference between the required brake demand and dynamic brake achieved.

11.12 Brake Blending

11.12.1. Dynamic braking and friction braking shall be continuously blended to provide the required deceleration rates defined in PS 11.14.

11.12.2. Throughout dynamic braking process, the friction brake shall be such that the brake block is just touching the wheel tread or disc for the purpose of improving the adhesion between the wheel tread and rail and reducing the brake response time.

11.12.3. The dynamic braking shall be preferential and the friction braking shall be applied only under the conditions specified in PS 11.8.2.

11.12.4. The blending control between dynamic brake and friction brakes shall be continuously reversible and carried out automatically.

11.12.5. The blending control between dynamic and friction braking shall not cause any loss of braking effort.

11.12.6. Prior to the final stop, the brake control system shall provide a brake fade out function to facilitate a smooth and non jerky stop. Friction brake blending control during dynamic brake fade, shall ensure no more than a ±5% change of total braking effort relative to the demanded braking effort.

11.12.7. The brake blending at some lower speed when the electric brake fades out

shall be smooth.

11.12.8. Fade shall occur at the lowest practical speed applicable to the above requirement. The speed at which electric brake fade occurs shall not be more than 10 km/h.

11.12.9. The Contractor shall ensure that effective wheel slide protection is adequately provided throughout the brake blending process.

11.12.10. ~~If wheel slide is detected then electric brake effort shall be smoothly ramped~~ down and smoothly reapplied as soon as wheel slide has been ~~corrected. At the same time, the friction brake shall also be suitably controlled to prevent excessive braking during the correction process~~.

If wheel slide is detected then electric brake effort shall be removed in a non-

jerk limited manner and smoothly reapplied as soon as wheel slide has been corrected. At the same time, the friction brake shall also be suitably controlled to prevent excessive braking during the correction process.

11.13 Wheel Slip and Slide Protection

11.13.1. A wheel slip/slide protection system shall be provided to minimise damage to the wheel sets and prevent damage to the traction motors/transmissions during wheel slip or slide. The following definitions shall be applied to the design of the wheel slip/slide protection system:

(a) At a coefficient of adhesion of 0.07 or greater, the efficiency of the wheel slip and slide protection system shall be at least 75 percent in acceleration and braking over the speed range between maximum speed and 10 km/h.

(b) The wheel slide efficiency shall be defined as the ratio of the actual braking rate to the theoretical braking rate from an initial brake entry speed to a lower speed.

(c) The wheel spin efficiency shall be defined as the ratio of the actual accelerating rate to the theoretical accelerating rate, from an initial speed to a higher speed.

(d) The theoretical rate is that which is obtained by continuously utilizing the available track (wheel-to-rail) adhesion.

(e) Efficiency shall be calculated over the slip-affected portions of operation.

11.13.2. The wheel slip/slide protection, if not an integral part of the traction and braking equipment, shall provide the signals, for example the slide signal, needed by the traction equipment and other systems.

11.13.3. The wheel slip/slide protection shall incorporate a means of detecting and indicating the health status of the speed sensing devices and any regulating valves. The fault status shall be reported to the TIMS (refer to PS 10).

11.13.4. Monitoring device shall be provided to identify a permanently locked axle and report this to the TIMS (refer to PS 10).

11.13.5. Wheel Slip Protection

(a) The wheel slip protection shall enable the optimum use of the available adhesion level during motoring and prevent any damage to the wheel sets, traction motors and transmissions, during wheel slip. The system shall be capable of detecting both individual axle slip and synchronous slip of all axles.

(b) If wheel slip is detected then tractive effort shall be smoothly ramped down and smoothly reapplied as soon as wheel slip has been corrected. The system shall be fully adaptive to varying adhesion conditions.

(c) The wheel slip correction shall act independently on each motor truck.

(d) The Contractor shall demonstrate that the correction process causes no ~~infringements of the signalling~~ compatibility requirements.

11.13.7. Wheel Slide Protection

(a) ~~The performance of the wheel slide protection equipment shall satisfy the~~ relevant requirements of UIC 541-05 ~~: 2005 but need not necessarily be approved by the UIC.~~ The performance of the wheel slide protection equipment shall satisfy the relevant requirements of IEE 1475 with a minimum permitted efficiency value of 75%.

(b) ~~Testing shall be carried out in accordance with section 2 of the UIC specification.~~

Testing shall be carried out in accordance with IEE 1475 with a minimum permitted efficiency value of 75%.

(c) It is required that the tests specified in PS 11.13.7(b) above shall be repeated on the Commission's premises.

(d) The above testing shall be carried out both in the open and in tunnel. The tests shall be conducted from a maximum speed of 80 km/h.

(e) The wheel slide protection shall enable the maximum use to be made of the available adhesion level at every axle during braking, at all times, such that the maximum braking effort, achievable with wheel slide, is obtained.

(f) The correction of slide shall act independently on each truck.

(g) The system should be fully adaptive to varying adhesion conditions.

(h) An independent circuit, not software based, is required to check the integrity of the wheel slide signal such that it will not continuously energise the correction system when a false continuous wheel slide signal is present.

(i) Additional requirements of the wheel slide protection for the friction braking system specified below shall be fulfilled:

(i) Digital wheel slide protection with gradable slide correction shall be provided

in all applications of friction brake for the following purposes:

(1) to minimise damage to the wheel sets; and

(2) to maximise the utilisation of the available adhesion.

(1)-
(2)
(i i) Not used

(i i i) Slide detection shall be on a per axle basis with correction on the following manners:

~~on a per car basis for friction brakes; and~~

~~on a per truck basis for dynamic brakes.~~

(1) on a per truck basis for friction brakes; and

(2) on a per truck basis for dynamic brakes.

(i v) The slide protection scheme provided shall be capable of detecting the severity of the slides and provide the appropriate level of slide correction.

(v) Automatic wheel wear compensation shall be incorporated in the wheel slide protection scheme.

(v i) The wheel slide protection system shall be designed for the following operations:

(1) During emergency braking which is commanded by the TBC (refer to PS 9.6.2(h)(iv)) only, the wheel slide protection system shall be operative. The Contractor shall ensure that the required safety level and system integrity specified in PS 25 are met under the worst case slide scenario during emergency braking. An ease mean which shall only be accessible by the maintainer, shall be provided to disable the wheel slide protection function for emergency braking operation by using the TBC; and

(2) During emergency braking as commanded by operation of the DSD, emergency stop pushbutton or the interruption of the brake loop circuit (for example, the trip switch is activated), the wheel slide protection system shall not be operative. An ease mean which shall only be accessible by the maintainer, shall be provided to enable the wheel slide protection function for

emergency braking operation by operation of the DSD, emergency stop pushbutton or the interruption of the brake loop.

(vii) The Contractor shall demonstrate that in the event of a single failure or malfunction of any component in the wheel slide protection system, sustained loss of braking effort shall be limited to one truck per train.

11.14 Rate of Deceleration

The following rates of decelerations excluding the brake response time shall be achieved for all speeds through the full range of wheel diameters with all loadings as specified in PS 4.5.3:

(a) The average service brake when braking into station stops will be 0.8 m/s^2 which shall be achievable on all gradients up to ± 3.5% and on both tracks of tunnel and open section;

(b) The maximum service brake rate on level tangent track shall be 1.35 m/s^2 ; and

(c) The minimum emergency brake rate on level tangent track shall be 1.40 m/s^2 applied with no jerk limit restriction (refer to PS 4.4.2). This shall be achieved by friction braking alone without the assistance of the electric braking.

11.15 Brake Rate Monitoring

11.15.1. A non-vital brake rate monitoring function shall be provided to compare the requested rate of deceleration with the actual braking performance and report detections of insufficient deceleration to the TIMS.

11.15.2. Due to the external conditions which can affect the deceleration rate of the train, such as wind, prevailing gradient, adhesion levels (slide correction), shoe friction variations and equipment failure condition (lost dynamic or cutout friction), the comparison criteria shall be adjusted during commissioning to a level which provides a useful monitoring function while avoiding nuisance indications of insufficient deceleration rate.

11.16 Friction Brake Isolation

11.16.1. ~~Friction brake cylinder isolation devices shall be provided in the Guard Control Panel (refer to PS 7.13) and underframe for brake isolation~~. Friction brake cylinder isolation devices shall be provided within the saloon area and underframe for brake isolation.

11.16.2. ~~Operation of the device shall release the friction brake on an individual truck only~~.

Operation of the device shall release the friction brake on a per car basis.

11.16.3. ~~The devices shall be properly locked with breakable seal, such that it shall not~~

~~be possible to release the brake without breaking the seal~~.

The devices shall be properly locked, such that it shall not be possible to release the brake.

11.16.4. The appearance of the devices shall be distinguished from other similar devices and shall be painted in red.

11.16.5. The device located inside saloon shall be inaccessible to passengers but accessible to the train operator/maintainer by using an approved key.

11.16.6. The exhaust of the device located inside saloon shall be directed to the underframe.

11.16.7. The device on the underframe shall be located so that it is operable from the side of the car.

11.16.8. For the purpose of accelerating the fault recovery, the faulty brake system location shall be identified and reported by the TIMS. In addition, a remote friction brake isolation function on a truck basis shall be provided to isolate the above identified faulty brake system via the TIMS.

11.16.9. The Contractor shall demonstrate that in the event of a single failure or malfunction of any component in the remote friction brake isolation system, sustained loss of braking effort shall be limited to one truck per train.

11.17 Parking Brake

11.17.1. Parking Brake Performance

(a) The parking brake force shall be adequate to hold a fully laden train on a 3.5% gradient.

(b) The parking brake force on individual axles shall not be so large as to inhibit emergency train recovery (refer to PS 4.4.11) or to give rise to locked wheels during recovery.
Item (b): (No specifications text modifications required.)

(c) In the case where the parking brake application is demanded by the train operator (refer to PS 9.12.6) the time for parking brake application shall not exceed 15 seconds.

11.17.2. The parking brake shall be an integral part of the friction brake actuation system.

11.17.3. Parking brake actuators shall incorporate automatic anti-compounding ~~devices to prevent applied braking forces from exceeding the larger of the individual~~ force produced by parking ~~or full service brake applications~~.

Parking brake shall incorporate automatic anti-compounding devices to prevent applied braking forces from exceeding the larger of the individual force produced by parking or full service brake applications.

11.17.4. The parking brake shall not give any additional frictional braking force when full service brake is applied.

11.17.5. Progressive application of the parking brake shall occur when the main reservoir air pressure falls below a specific pressure.

11.17.6. Automatic parking brake application shall follow an initial friction brake application with the parking brake applying as the air brake cylinder pressure leaks off. The design shall be such that the parking brakes will take effect prior to fade off of friction brake and shall ensure that the combined brake effort of the friction brake and parking brake is never less than the full brake effort of the parking brake alone.

11.17.7. Subsequent application of air pressure shall automatically release, and reinstate normal operation of the parking brake.

11.17.8. Application and release of the parking brake shall also be controllable from the driving cab (refer to PS 9.12.6).

11.17.9. A means for manual release of each parking brake which can be accessed from track level without the need to reach underneath the car shall be provided.

11.17.10. Under conditions of a dragging parking brake under normal adhesion, no damage shall be caused to the braking system or any truck component, with the exception of abnormal pad or block wear.

11.18 Friction Braking Materials

11.18.1. The choice of friction braking material shall ensure the following requirements are met:

(a) The required braking power is provided under all influential factors, such as, temperature, moisture, dirt and grease;

(b) The wear life shall be maximised to demand minimum maintenance.

(c) Only asbestos-free brake materials shall be used. The braking material shall be of split type composite brake block suitable for railway application, for example, stable friction coefficient over full range of operating speed and also in wet conditions, good temperature and wear resistances, with smooth judder free low noise braking and low weight.

(d) The performance of the friction braking material shall be consistent throughout its life.

(e) The high-friction sintered brake block, which shall be a specially formulated mixture of iron powder and friction materials, shall be used in order to provide an efficient wheel cleaning process and hence increase in wheel-to-rail adhesion. The sintered material shall be able to continuously remove minor

wheel tread damage and improve the condition of the tread.

(f) The brake block which shall be interchangeable with the T1 train, shall be provided.

11.18.2. Due consideration shall be given to minimising life costs of brake equipment and the generation of noise and odour when selecting friction braking material.

11.18.3. The friction braking materials shall be able to be easily, quickly and safely changed by unskilled personnel without the need for special tools.

11.18.4. It shall be possible to easily inspect pads or blocks "in situ" without the need to remove or dismantle any components.

11.18.5. The life of the friction braking material in normal service shall not be less than 6 months.

11.18.6. A common friction braking material shall be used for all truck types and shall be interchangeable between all car types.

11.19 Burst Hose Protection

11.19.1. Burst hose protection shall be provided for all truck brake hoses (refer to PS 13.9).

11.20 Drive System Analysis

11.20.1. By the end of SEMP stage 3 (refer to PS 21.3.4), the Contractor shall perform an analysis of the traction and drive system, using well accepted modelling techniques, which shall demonstrate that the system does not contain any resonances, or similar undesirable features, which would cause noise, vibrations or structural damage to the drive, the vehicle or any part of the vehicle. The analysis shall include all relevant components from rail level up

to the vehicle body, all component and structural stiffness and all excitation forces and frequencies which could excite the system.

11.20.2. The analysis, together with details of the modelling system and the mathematical model of the drive system shall be submitted for approval.

11.20.3. During SEMP stage 4, the model shall be updated as design information becomes available until final verification can be confirmed during testing of the vehicles at SEMP stage 5.

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Section 12 Trucks And Suspensions

12.1 General

12.1.1. The trucks (also known as, bogie which includes all components from the bolster to wheels), shall be of two axle, non-articulated and bolster type with conventional H-frame arrangement. The trucks shall be designed for a life as defined in PS 4.5.4 without rebuilding, repair or strengthening of structural members.

12.1.2. The trucks shall be of a design well proven in a similar service environment.

12.1.3. The characteristics of the suspension shall give a low transmissibility of vibration to the car body and minimise both impact and vibration noise. The suspension frequencies shall be sufficiently separated from the fundamental body frequencies to ensure that resonance does not occur.

12.1.4. The Contractor shall ensure that as many parts as possible are identical and interchangeable between the various truck types.

12.1.5. Overall length of the completely assembled truck shall not exceed 3960 mm (13 feet), overall width shall not exceed 2740 mm (9 feet) and the wheel base shall not exceed 2130 mm (7 feet). All trucks types shall have an identical wheel base.

12.1.6. All trucks shall be subjected to Type and Routine testing in accordance with the requirements of PS 22.

12.1.7. The unsprung mass of the wheel/axle assembly shall not exceed the values of T1 trains, within 30 kg (66 lb).

12.1.8. Except for the wheels, collector shoes and trip switch, all truck parts shall clear the Track Equipment Gauge Line as shown on the Contract Drawings

No. NST 005 by at least 12 mm (0.5 inch) with full wear of the wheels and running rail and with primary springs deflected to their stops.

12.1.9. The following design information including the packaged weight and suspension data, shall be submitted for approval prior to manufacturing:

(i) Primary spring stiffness (N per mm per journal box) in three directions at both W1 and W4 loadings.

(i i) Vertical static deflection of the primary spring (mm) at both W1 and W4

loadings.

(iii) Secondary spring stiffness in both vertical and lateral direction (N per mm per

bag) at both W1 and W4 loadings.

(iv) Manufacturer's data sheets of air bags.

(v) Air bag pressure (kPa) and volume (L) at both W1 and W4 loadings with auxiliary reservoir volume (L).

(vi) Roll stiffness of the secondary suspension including any elements additional to air bags (Nmm per degree).

(vii) Damper characteristics (force, N vs. piston velocity, cm/s) for hydraulic, air-orifice or other dampers used.

(viii) Spring constant (N per mm) or load-deflection curves of all resilient truck components other than the afore-mentioned suspension elements.

(ix) Weight, moment of inertia and centre of gravity location for the wheel/ axle set including journal boxes and gear boxes, a truck assembly less wheel/axle sets and a Subway Car assembly less truck assemblies.

(x) Truck dimensions pertinent to the suspension system.

12.1.10. Provision shall be made on the truck frame to mount a profiled block in order to activate the carbody mounted proximity switch in the event of a truck derailment (refer to Section 10.5.8).

12.1.11. An overrotation sensor shall be provided in such a way that when the truck rotates by more than 9 degrees in either direction, the sensor contact opens, and activates the emergency brakes.

12.1.12. To facilitate an efficient truck replacement, a quick-disconnect connector which shall be specifically and well proven designed for truck application,

shall be provided for all truck wirings.

12.2 Ride Performance

12.2.1. Stability

(a) The car shall be dynamically stable under all operating conditions.

(b) The Contractor shall submit calculations for approval to demonstrate that the car will achieve a minimum of 5% of critical damping under all combinations of the following conditions:

(i) Velocity from 25 km/h (16 MPH) to 88 km/h (55 MPH).

(i i) Conicity from 0.05 to 0.45.

(iii) 0.1 to 0.50 creep.

(iv) Suspension parameters at the most disadvantageous limits of their tolerance bands, taking into account plausible combination of manufacturing variations, ageing effects, temperature, and deterioration due to normal wear as far as the maintenance limits.

12.2.2. Ride Quality

(a) The ride quality shall be determined and evaluated according to ISO 2631-1:1997(E). The RMS acceleration values for each measurement point shall not exceed 0.315 m/sec2 for seated and standing passengers. Also, the vibration total value (root sum of squares summation) for each measurement point shall be calculated, and shall not exceed 0.5 m/sec2.

(b) The ride performance shall be achieved under all loading conditions when travelling throughout the range of operating speeds and cant deficiencies prevailing in normal passenger service.

(c) Ride quality shall be evaluated under W1 load condition. Instrumentation capable of measuring the magnitude of the vertical, longitudinal, and lateral shocks and vibrations experienced, shall be provided and monitored by the Contractor. Sensing units shall be located on the car floors above the intersection of the car longitudinal centerlines and a truck transverse centerlines, at the center of the cars between trucks, and at three seat locations to be determined by AUTHORITY. The ride quality shall be evaluated with new wheels on non-corrugated welded rail. Journey average shall be the arithmetic mean of the weighted r.m.s. accelerations evaluated at 10 second intervals over the full length of the running lines in both existing railway and new extension. Accelerations shall only be measured when the car is travelling at speeds above 25 km/h (16 MPH).

(d) The track characteristics over which the cars will operate are given in Appendix I Annex 1.

(e) Contractor shall submit for approval calculations, by using well accepted computer modelling techniques, such as VAMPIRE®, to demonstrate that the requirements of PS 12.2.2 are achieved under all track and suspension

conditions from new until reaching the maintenance limit.

12.3 Wheel Wear

12.3.1. The wheels shall achieve a minimum of seventy five thousand miles (or 120 700 km) before reprofiling of the wheels is necessary. This corresponds to an average tread reduction (tread wear rate combined with wheel material removal) not exceeding 0.003" (or 0.076 mm) per 1000 miles (or 1609 km)

for the wheel, whilst operating on the routes as specified in Appendix I Annex 1. The target performance requirement stated above shall be achieved by at least 90 % of all wheels of the trains and exclude any performance reductions caused by: wheel flats or other thermal damage, indentation damage, inadequate and ineffective flange lubrication, crash damage, derailment damage, willful damage, improper rail head management, non-adherence to the maintenance handbook, use of incorrect spare parts, use of non-specified brake shoes, infrastructure irregularities and the consequential effects of associated component failure.

12.3.2. A lubrication system which directs lubricant onto the rail gauge face, shall be fitted on the train. Comprehensive details of the proposed system shall be submitted for approval including but not be limited to design drawings and evidence to show that the system has been well proven under similar conditions on other railways.

12.3.3. The Contractor shall submit for approval curving calculations to demonstrate L/V less than Nadal values with a 0.5 coefficient of friction.

12.3.4. Wear limits before reprofiling of the wheels shall refer to Contract Drawing No. NST 044.

12.4 Stability Against Overturning and Derailment

12.4.1. The car shall be designed to operate safely under the worst combinations of cant excess or deficiency and wind loading as defined in PS 5.2 and PS 5.4.

12.4.2. The Contractor shall submit calculations for approval to demonstrate that the requirements of PS 12.4.1 have been achieved.

12.5 Wheel Off-loading on Twisted Track

12.5.1. Equalization shall be such that, with the truck on level track and under W1 loading, jacking one wheel 25 mm upward will not cause load on any other wheel to change more than 25%. The nominal static wheel load is defined as each individual wheel load with the car standing on straight and level track. This shall be achieved for all operating conditions, including deflated air

suspension and over inflated air suspension.

12.5.2. The Contractor shall demonstrate, by calculation, what will be the expected wheel unloading. The wheel offloading performance shall be achieved with the suspension components at the extreme limits of the manufacturing tolerance and taking into account changes in stiffness due to ageing and temperature effects.

12.5.3. The Contractor shall submit calculations for approval to demonstrate that the requirements of PS 12.5 have been achieved.

12.5.4. The variations in wheel and axle loads shall meet the requirements as specified in IEC 61133, Clause 5.3.6.

12.5.5. All completed vehicles shall be weighed in both the inflated and deflated conditions to demonstrate that the requirements of PS 12.5.4 have been achieved.

12.6 Truck Rotational Resistance (X-factor)

12.6.1. The truck rotational resistance (X-factor) shall be equal to or less than 0.08 when the car is negotiating the minimum radius curve. This requirement shall be achieved for a truck rotational speed of 0.2 degrees per second, under all loading conditions, and for all suspension conditions, including normal inflation, deflation and over inflation of the air suspension.

12.6.2. X-factor is given by the following formula:-

$$X\text{-factor} = \frac{T}{2Q * 2a}$$

Where T = *Torque to rotate the truck*

$2Q$ = *average axleload on the truck being rotated*

$2a$ = *truck wheelbase*

in a consistent set of units.

12.6.3. The Contractor shall submit calculations for approval to demonstrate that the requirements of PS 12.6.1 have been achieved.

12.7 Suspension Heights

12.7.1. The nominal floor height of the car shall be 1 105 ± 13mm mm (43.5 ± 0.5”) above rail level. This shall be achieved under normal operation with the car in the tare (W1) loading condition.

12.7.2. The car floor height shall not fall below the nominal height of the platform of 1 070 mm (42”) under all loading conditions up to fully laden (W4), with the air suspension operating normally, and with the car standing in a station on new wheels.

12.7.3. Packing of the suspension to accommodate wheel wear shall be achieved by packing at the primary or secondary suspension and shall not be necessary at a period of less than that of half wheel life.

12.7.4. The Contractor shall submit for approval his detailed procedure for setting vehicle heights together with calculations to demonstrate that the requirements of PS 12.7.1 and PS 12.7.2 have been achieved.

12.8 Maintainability

12.8.1. General

(a) Maintenance of the truck shall be consistent with the car maintenance philosophy given in PS 26. In particular truck components shall have a minimum design life equal to the maintenance period of the truck and preferably a multiple of the maintenance period.

(b) Grease guards generally as shown on the Contract Drawings shall be mounted on the truck frame to prevent track grease being flung from the wheels to the carbody.

(c) Provision shall be made for alignment of the truck and the car- body when replacing the truck such that damage does not occur to any component.

(d) The truck design shall permit wheels to be turned to a minimum diameter of at least 635 mm (25”) using the Commission's existing wheel turning machines.

(e) All truck lubrication fittings are to be accessible without removing other equipment or removing the truck from the Subway Car.

(f) For all pneumatic valves of which maintenance access is required, for example, adjustment of suspension level, shall be easily accessible from the side without removing other equipment or removing the truck from the Subway Car.

(g) For all electrical connections with the exception of third rail high-voltage cables and carbody ground, shall be connected by a quick-disconnect type of connector. This connector shall allow easy and quick disconnect of all truck wiring in order to facilitate truck removal and replacement. Connector type and method of support shall be submitted for approval.

12.8.2. Truck Changing

(a)

(b) Trucks shall be capable of being disconnected and reconnected easily and with a minimum of operations by personnel working in pits or alongside the trucks. It shall be possible to easily inspect for correct reconnection without the need for special tools or instruments.

The design of the truck shall provide for ease of interchanging. The truck suspension shall be integral with the truck and allow complete truck suspension adjustment prior to installation under a Subway Car. It shall be possible to change either truck on a Subway Car and release the Subway Car for service using existing Commission shop facilities within three hours using two trained maintainers. Trucks shall be completely interchangeable between cars without the need to adjust suspension components. The Contractor shall

demonstrate to the satisfaction of the Commission by physical exercises that the above three hours time for truck removal and replacement can be achieved according to 26.2. A prototype truck shall be provided to facilitate the above demonstration according to PS 21.5.

(c)

The design shall provide ease of truck changing using the Commission's existing hoisting facilities. Following a truck changeout, it shall be possible to restore the Subway Car to a condition fit for service operation at the same location as the truck changeout occurred.

12.8.3. Inspection

It shall be possible for personnel working in pits or alongside the truck to visually inspect the condition of truck components, such as brakes and wheel treads, easily and without the use of special tools.

12.8.4. Cleaning

(a) The trucks shall be capable of being cleaned using high pressure hot water and steam jet cleaning equipment, with and without high efficiency detergents. All closed sections and pockets shall be self draining or sealed against water intrusion.

(b) Lubricated bearings shall be adequately sealed to ensure that water and cleaning fluids shall not enter during the cleaning process.

12.8.5. Wheel Turning

(a) To permit wheel turning, axleboxes shall be designed to accommodate a holding down device when wheel turning on an under-floor wheel lathe.

(b) The truck shall be provided with towing eyes which shall be sufficiently strong to allow the multiple units to be positioned over the underfloor wheel lathe using ropes and a capstan.

12.8.6. Handling

(a) Lifting attachments shall be provided for handling a complete truck or a truck frame alone.

(b) The attachments between the body and the truck shall be such that if the car is lifted without disconnecting the trucks, the trucks, traction drives and wheelsets shall be retained captive to the car without the need for additional restraints at the time of lifting. No damage shall result to any of the connections as a result of this action.

(c) Refer to Appendix I Annex 6 for additional maintenance requirements with

the existing carhouses.

12.9 Truck Structure

12.9.1. General

(a) The truck structure is defined as the truck frame, truck bolster and all other truck mounted structural components with the exception of wheelsets.

(b) Air springs shall be provided to control horizontal displacement.

(c) Traction transfer device shall be provided at the virtual rotational centre of the truck for transmitting the tractive force to the carbody.

(d) Provision shall be made to mount the trip switch as specified in Appendix I Annex 3 Clause 2.2.2(c). Trip switch bracket fasteners shall be easily accessible.

(e) The truck frame and truck bolster shall be grounded. Design consideration shall be given to ensure that the above grounding connection shall not be prone to fatigue and failure either from continued use, or from physical impact with external objects along the railway route.

(f) The carbody and the bolster shall be positively secured together by a split-locking centre pin plus a bracket on the pin or with lifting hooks that must be accessible from the car side. This pin shall be able to prevent the separation of the carbody from the bolster when the car is jostled vertically.

(g) A lateral guide which shall be a low friction with vertical guiding surfaces, shall be provided to keep the bolster at right angles to the truck frame.

12.9.2. Manufacture

(a)

(b)

edges shall be finished to a standard to be defined by the Contractor in accordance with the requirements of PS 20.

All machined surfaces and cut plate

After fabrication the truck frame and truck bolster shall be stress relieved to ensure dimensional stability.

12.9.3. Loads

(a) Proof

The truck structure shall withstand the following static load cases without permanent deformation or any form of damage or deterioration.

(i)

Vertical : Twice the sum of the maximum crush laden (W5) static pivot load

(ii)

(ii)

(iii)

(iv)

(b)

(i)

centre of gravity, which is sufficient to cause overturning of the car. The car shall be assumed to be in the condition of loading and air suspension inflation/deflation which requires the greatest lateral load to cause overturning.

Longitudinal : 5g times the total truck mass applied longitudinally in equal parts at the axles and reacted at the body/truck connection. The maximum static pivot load shall be applied at the same time.

Twist : Diagonally opposite wheels of the truck shall be unloaded by 60% of the maximum crush laden (W5) static wheel load. The maximum static pivot load shall be applied at the same time.

Fatigue

~~Assessment of fatigue for fabricated steel structures shall be in accordance with BS 7608:1993 using the mean minus 2 standard deviation~~ S-N ~~data (i.e. a probability of survival better than 97.7%). For materials not covered by BS 7608:1993 the method of fatigue assessment shall be submitted for approval.~~

~~The fatigue damage shall be assessed separately for each of the vertical, lateral and twist load cases given below, and also for any load cases arising from the requirements of the additional loads in PS 12.9.3(c). The total~~ damage ~~resulting from the combination of the individual damages, in accordance with Miners Rule (ref. BS 7608:1993), shall be less than unity~~.

Assessment of fatigue for fabricated steel structures shall be in accordance with Eurocode 3, Part 1, Chapter 9: Fatigue. For materials not covered by Eurocode 3, Part 1, Chapter 9: Fatigue, the method of fatigue assessment shall be submitted for approval.

The fatigue damage shall be assessed separately for each of the vertical, lateral and twist load cases given below, and also for any load cases arising from the requirements of the additional loads in PS 12.9.3(c). The total damage resulting from the combination of the individual damages, in accordance with Miners Rule (ref. Eurocode 3, Part 1, Chapter 9: Fatigue, shall be less than unity.

Vertical : ±25% of the fully laden (W4) car body weight applied vertically for 10 million cycles.

Lateral : The load equal to that applied to a truck when the car is subjected to a load, applied at the car and the truck sprung mass. The load shall be applied vertically in equal parts at the secondary suspension points and reacted at the axles.

Lateral : ±15% of the fully laden (W4) car body weight applied laterally for

10 million cycles.

(iii)

Twist : 10 million complete reversals of the wheel off-loading which results when a car with the air suspension normally inflated and in the fully laden (W4) loading condition passes over the track twist defined in PS 12.5.

(iv)

Traction/Braking : 10 million complete reversals of the loads applied to the truck when a fully laden (W4) vehicle accelerates and decelerates under its maximum tractive effort and decelerates at emergency brake rate.

(c)

Additional Loads

The Contractor shall ensure that any other loads that may arise on the truck due to the particular configuration chosen are adequately taken into account. These additional loads shall include, but not be confined to those caused by the effects of motor inertia, equipment inertia loads, damper loads, and the effects of passenger loading and unloading.

(d)

Truck Mounted Equipment

Items of equipment mounted on the truck frame, including their mountings shall be designed to withstand the forces associated with the following accelerations:-

(i) Proof

Vertical	±20.0g
Transverse	± 3.0g
Longitudinal	± 5.0g

(ii) Fatigue

10 cycles of

Vertical	±10.0g
Transverse	± 1.5g
Longitudinal	± 0.5g

(e) Axlebox Mounted Equipment

Items of equipment mounted to axleboxes, including their mountings, shall be designed to withstand the forces associated with the following accelerations:-

(i) Proof

Vertical	±50.0g
Transverse	± 5.0g

Longitudinal ± 5.0g
7

(ii) Fatigue

10 cycles of

Vertical ±25.0g

Transverse ± 3.0g

Longitudinal ± 3.0g

(f) The accelerations and loads given in PS 12.9.3 do not include the effects of locally generated loads or accelerations caused by the configuration of equipment or resonances. The Contractor shall ensure that any such conditions are adequately considered.

(g) The Contractor shall submit detailed finite element calculations for approval to demonstrate that the requirements of PS 12.9.3 have been achieved.

12.10 Wheelsets

12.10.1. General

The wheel tread profile shall be as shown on Contract Drawing No. NST 044 and the wheel shall be interchangeable with the T1 trains as far as practicable.

12.10.2. Axles

(a)

(b)

Axles shall be designed, using well accepted principles, to meet the requirements of the specification for the full life of the vehicle, without attention, other than routine maintenance and non-destructive testing.

(c) ~~Axles shall be made of forged steel conforming to the requirements of AAR~~ M-101, ~~Grade F (double normalized and tempered), developing a minimum tensile strength of 610 MPa (88,000 lb/in2), a minimum yield strength of 345~~ MPa (50,000 lb/in2), with an elongation ~~of not less than 22% in 5 cm (2 inches) and a reduction of area of not less than 37%~~.

(d) Axles shall be made of steel to AISI/SAE 4140 heat treated to develop a minimum tensile strength of 700 Mpa (100 000 lb/in2), a minimum yield strength of 550 Mpa (80 000 lb/in2), with an elongation of not less than 20% in 5 cm (2 inches) and a reduction of area of not less than 50%.

s

The manufacturer shall maintain a record of details of the heat, by number, from which each axle was produced. The heat number, together with a serial number shall be permanently stamped on one end of each axle.

All axles shall be ultrasonically inspected for internal flaws in accordance

(e)

(n)

(f)

(g)

(h)

(i)

(j)

(k)

(l)

(m)

assembly seat and ground ring seat shall be concentric within 0.025 mm (0.001") Total Indicator Reading (T.I.R.).

The journal bearing seat relative to the adjacent wheel seat shall be concentric within 0.0125 mm (0.0005") T.I.R.

The out-of-straightness of the journal bearing axes defined by the two journal bearing diameters shall not exceed 013 mm (0.012") T.I.R.

The surface finish of the major parts of the axle shall be as follows:

(i) 3.2 micrometres (125 micro inches) for wheel seats, gear assembly seat, ground ring seat and seal wear ring seats.

(ii) 1.6 micrometres (64 micro inches) for journal bearing seats.

(iii) 0.4 micrometres (16 micro inches) for journal bearing grooves.

with ASTM A-21, latest revision. All axles rejected because of detected flaws shall be scrapped.

Fillets of not less than 25 mm (1") radius shall be used at all changes of section, except as otherwise specifically agreed. The quality of the axle finish, cold rolling and the measurements of the critical diameters of some sampled axles shall be agreed by the Engineer.

Cold rolling of axle fillets and relief grooves shall be identical with the T1 trains.

Both ends of each axle shall be machined to accept wheel lathe centres.

All straightening operations shall be completed before the final heat treatment.

All machined surfaces of finished axles shall undergo wet magnetic particle inspection such as "Magnaglo" inspection and shall be accepted or rejected in accordance with ASTM A-21, latest revision. When a finished axle has passed a wet magnetic particle inspection, the letter "M" shall be stamped on one end of the axle. Some sample axles shall be magnetic particle tested in the presence of the Engineer. The axle supplier shall furnish via the Contractor to the Commission a certificate that each finished axle is free of defects.

The journal bearing seat, gear

Wheels and gear quills shall be mounted on the axles with an agreed interference fit. Force vs. distance diagrams of such pressings together with the wheel and gear inspection data sheets showing the maximum forces achieved, interference fits used and wheel gauge measurement shall be

supplied to the Commission. Axles which are galled or otherwise scored when pressing on the wheels or gear quills shall be rejected. In the absence of

visible evidence of such scoring, the use of an excessive pressing force shall be taken as evidence for rejection of the assembly.

(o)

All surfaces of the axle which remain exposed after assembly of the gear box, journal bearings, ground ring and wheels shall be coated with Kendall RP-5 rust preventative.

(p)

The axle ground ring shall be made of steel and be of a proven transit application design in combination with the selected ground brush.

(q)

Axles shall be designed for at least 10 million cycles where the axle is not in contact with other components and at least 100 million cycles where the axle is in contact with other components (i.e. may suffer fretting, e.g. at the wheel/axle interface).

(r)

A static stress analysis shall be provided to indicate a maximum stress expected in critical sections of the axle under W5 loading conditions in the vertical direction. It shall also include the lateral load which augments the stress due to the vertical load and which is equivalent to 70% of the maximum vertical load. Furthermore, a stress concentration factor appropriate for the physical dimensions of the critical section shall be included to arrive at a resultant maximum stress which shall not exceed the yield strength of the axle as defined by the 0.2% permanent strain method.

(s)

In the static analysis, the weight of the gear box and the axle may be excluded if they contribute negligibly to the stress.

(t)

In the axle life analysis the following factors shall be considered:

(i) A dynamic factor of 1.75 for the maximum vertical load.

(i i) Lateral loads on the wheel shall be based on track curvature factors proposed by Brewer Engineering Laboratory, passenger loading history and percentage survey of tangent and curved track; all of which will be supplied by the Commission. Lateral loads on the axle are produced by the guard rail on the wheel flange and augment the stress caused by the vertical load. Lateral and longitudinal friction forces may be ignored.

(iii) Miner's Rule of Cumulative Damage shall be used to predict the axle life at the critical section. Any other widely accepted analysis may be submitted for review.

(u) Magnetic particle inspection of axle wheel seats and bearing journals, including transition radii, shall be performed whenever the wheels are removed from the axle. More frequent visual and ultrasonic inspection shall be carried out if necessary due to previous failures, the service conditions, high failure consequences, or as recommended by the axle designer. Visual

inspection of the bearing journal fillets for corrosion, dents and cracking shall be performed whenever bearings are removed from the axle. The Contractor who is carrying out ultrasonic or magnetic particle inspection shall be trained and qualified to be competent in identifying the formation of fatigue cracks in the axles. Evidence that axles are inspected on a systematic basis and that records are kept for each axle shall be maintained.

12.10.3. Wheels

(a) Wheels shall be of monobloc type and of similar design with the T1 trains.

(b) Wheels shall be of solid wrought steel or pressure poured steel.

(c) The difference in diameter of the two wheels on the same axle shall not exceed 0.6 mm (0.024"), or 1/2 tape.

(d) Wheels shall be inherently balanced to within 0.5 kg (1 lb) at the centre of the back face of the rim when machined.

(e) Wheels shall be Class C and shall be machined to 6.4 micrometres (250 micro inches) as set out in A.A.R M-107 or M-208, latest revision.

(f) Wheel plates shall be shot-peened to A.A.R specification and shall be wet magnetic particle inspected for surface cracks.

(g) Wheel markings shall be imprinted on the front face of the hub as set out in A.A.R. M-107 or M-208, latest revision. Each wheel shall have an individual wheel serial number.

(h) Wheel tread and flange shall be completely coated with a protective coating of clear linseed oil.

12.10.4. Wheelset Assemblies

(a) The axle ground brush shall be as set out in Section 11.6.10.

(b) Axles shall be protected during handling, transportation, maintenance and storage to prevent damage prior to installation in a vehicle. Protection of axles is typically provided by:

(i) Preventing hard objects or surfaces coming into contact with the axle

(i i) Preventing corrosion on exposed machined seat surfaces

(c) The cavities formed by wheel and gear hubs overhanging their respective seats, shall be protected by a rust inhibitor which shall protect the axle against corrosion for at least the interval between truck overhauls.

(d) The Contractor shall submit for approval comprehensive details of the

wheelset design. The submission shall include, as a minimum, axle detail drawings, axle design calculations, wheel detail drawings, wheel design calculations, details and description of any noise damping measures and wheelset assembly drawings and procedures.

(e) Noise damping device shall be provided and fitted to the wheel to achieve the requirements of PS12.10.3 (c) and the specified noise performances. Comprehensive details of the proposed device shall be submitted for approval including but not be limited to noise calculations to demonstrate the effectiveness of the device, design drawings and evidence to show that the device has been well proven under similar conditions on other railways.

(f) The design of wheelsets shall be such that the inner wheel bosses and gearwheel bosses overhang their respective seats on the axle by a minimum of 6 mm to minimise the possibility of fretting corrosion.

(g) Assembly of wheels and gear wheels onto the axle shall be by cold press which shall be compatible with the existing press of the U shop.

(h) Dynamic balancing shall be required (UIC 813 Section O Paragraph 4.2.3).

(i) Electrical resistance test shall be required (UIC 813 Section O Paragraph 4.2.2).

(j) Ultrasonic inspection of the axle of the assembled wheelset shall be required (AAR M-101).

12.10.5. Non-destructive Testing

(a) Easy access shall be provided to both ends of all axles to allow ultrasonic testing of the axles. It shall be possible to carry out ultrasonic testing with the wheelset in situ under the vehicles.

(b) The Contractor shall submit for approval separate non-destructive testing procedures for testing of a free-standing assembled wheelset and for testing of a wheelset in situ under a vehicle. Additionally, the Contractor shall define

appropriate inspection periods based on critical defect sizes and crack growth rates for all areas of the axle where cracking is possible. Calculations and data shall be provided to support this information.

12.10.6. Axlebox Bearings

(a) Grease lubricated cartridge bearings shall be used. The bearing shall be such that no attention is required between truck overhauls.

(b) The front and rear seal shall prevent the ingress of water and/or cleaning fluids to the bearing both during normal running and during cleaning.

(c) Contractor shall carry out bearing life calculations to demonstrate that the selected size of bearing is adequate for the required duties.

(d) Due consideration shall be given on the axle bearing to prevent premature fatigue particularly water contamination which will cause corrosion of the surfaces, and disrupt or degrade the mechanism of lubrication. Protection against vehicle washing shall be provided. The bearing shall be designed to prevent any bearing movement or creep in its housing which will result in allowing fretting debris to enter the bearing and cause damage.

12.11 Air Suspension

12.11.1. The truck shall be fitted with air suspension which shall maintain a constant floor height in the car under all conditions of loading (excluding primary suspension deflection).

12.11.2. In the event of a fault resulting in over inflation or deflation of the airsprings, the car shall be able to operate safely at its normal operating speeds. Under these conditions the truck acceleration levels shall not exceed 0.4g RMS for 2 seconds when measured in accordance with 49 CFR 213.333 prescriptions. Also the weighted journey average ride both in the vertical and lateral directions shall not be worse than the existing T-1 Cars. This shall be achieved without the use of extra features, e.g. dampers, which would not be required to achieve the ride requirements in the normally inflated condition.

12.12 Pipework and Hoses

12.12.1. Brake-pipes, hoses and conduits shall be installed such that risk of damage such as from flying ballast is minimised.

12.12.2. Brake-pipes and conduits shall be supported with suitable cleats at intervals of not greater than 300 mm (12”). Cleats shall be positioned so as to avoid high stressed areas of the truck frame.

12.12.3. It shall be physically impossible for flexible hose connections to be mismatched.

12.13 Primary Suspension

12.13.1. The primary suspension shall be self-retained, and shall not dislodge when a wheel set is replaced from below.

12.13.2. If achieved at the primary suspension, an easy mean shall be provide to adjust the height of the primary suspension in order to compensate for wheel wear. The above height adjustment shall be able to carry out in a maintenance pit where no drop table or hoist equipment is available.

12.13.3. If chevron type spring is used as the primary suspension, a positive mean of

axle containment shall be provided to prevent derailment when the chevron spring is collapsed (for example, due to the excessive heat built up as a result of journal bearing seizure).

12.14 Traction Gear Units And Drive Couplings

12.14.1. Gear unit shall be provided to transmit the torque from the traction motors to the Subway Car axles.

12.14.2. Parallel drives arrangement shall be provided. The gears shall be lubricated by a direct oil splash system.

12.14.3. A flexible couplings shall be provided in the drive train in order to accommodate the relative movement of the drive train components. The motors shall be fully suspended in all instances, such that all the motor weight shall be sprung, and drove the gear unit through ring gears. The unsprung mass of the motor/gear unit assembly shall be kept to a minimum.

12.14.4. Due consideration shall be given to the design of the motor mounting in such a way that there shall be no failure leading to motor fell to the track and causing the derailment, say, due to bearing failure in the gearbox results in very high loading on the motor fixing bolts. The safety brackets shall be able ~~to fully retain~~ing the motor.

12.14.5. Suitable orifices and plugs shall be provided in the gear units for lubrication adding and draining; the filler hole shall be positioned at the maximum fill level. A breather or labyrinth type seal shall be provided and arranged to prevent the entrance of water.

12.14.6. The gear unit shall be designed to prevent oil leakage around the high and low speed shafts.

12.14.7. ~~When assembled, the gears and pinions shall be adjusted to bear with the~~

proper amount of back-lash ~~which shall have been indelibly marked on the~~ gear ~~at the point of manufacture. Adjustment of the clearance shall not be required in service~~.

When assembled, the gears and pinions shall have the proper amount of back-lash. Adjustment of the clearance shall not be required in service.

12.14.8. The drive coupling from the traction motor to the gear unit shall be suitably balanced so that no objectionable noise or vibration is produced within the Subway Car at speeds up to 88 km/h (55 MPH) with wheels ranging from new to fully worn. The design of the gear unit shall be able to accommodate lateral, vertical, longitudinal and angular motion of the axle relative to the traction motor as required without imposing stress on its armature bearings.

12.14.9. ~~The gear units shall be so designed that under all operating conditions, adequate lubrication will be provided to all gears and bearings. The design of the shaft and the seal shall be suitable for corrosive environments. A quill type~~ arrangement (corrosion resistant sleeve) shall be used for assembly ~~of the gear unit to the axle. Due consideration shall be given on the lip seals to prevent the pumping effect i.e. either pumping contaminants into the gearbox, or pumping lubricant out~~.

12.14.10. Magnetic plugs shall be installed in the drain holes of the gear units.

12.14.11. The design of the gear unit shall be able to prevent dangerous rotation of the gear unit should the torque arm break or become detached. Also, the design of the gear unit shall be able to prevent a drive coupling from contacting the road bed or causing damage to truck equipment should it become unintentionally detached.

12.14.12. System approach shall be provided on the design problems of the gear unit e.g. lubrication, shaft deflections, thermal instability etc. The Contractor shall identify all external forces and moments applied to the gear unit and held discussion between the Sub-contractors of, traction motor, gear unit and truck. Overall system dynamics shall be checked to ensure the design parameters (which shall include power, power density, speed, size, environment etc.) are well within the successful existing systems of the same type.

12.14.13. An inspection opening shall be provided on each gear unit for inspection of the gears.

12.14.14. Each finished gear unit shall be run on a test stand in both directions and checked for noise, oil leaks, heating and excessive vibration. The test procedure shall be submitted for approval.

SECTION 13 PNEUMATICS AND AIR DISTRIBUTION SYSTEMS 2

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Section 13 Pneumatics And Air Distribution Systems

13.1 System Requirements

13.1.1. The train shall provide a compressed air supply system which shall comprise a self-contained air supply system for each 6 cars train consist.

13.1.2. The system for each train shall comprise at least two compressors and a through Main Reservoir Pipe of sufficient capacity.

13.1.3. All pneumatic sub-systems shall be adequately supplied from the Main Reservoir Pipe.

13.1.4. Automatic connection of the through Main Reservoir Pipe shall be provided following the coupling at each autocoupler end.

13.1.5. The compressed air shall be treated by an air drying system.

13.1.6. The Contractor shall propose and submit for approval the system design with schematic layout and air flow consumptions for the pneumatic system.

13.1.7. The nominal Main Reservoir Pipe air pressure shall be 9.31 bar (135 PSI).

13.1.8. Not Used.

13.1.9. All equipment shall be constructed in a sufficiently robust manner and arranged so as not to suffer deterioration, wear or damage due to vibration or shocks encountered in normal service.

13.1.10. The pneumatic air system shall be designed and constructed so as to minimise leakage.

13.2 General Requirements

13.2.1 Arrangements shall be provided for individual isolation of the compressed air supply to each sub-system with facilities to vent the residual air.

13.2.2 Consideration shall be given to group the relevant components on a module basis for easy replacement.

13.2.3 Exhaust of compressed air into either the passenger saloon area or Train Operator's cab shall not be allowed, unless performance of the system or accessibility to service proven equipment justify otherwise.

13.3 Main Air Compressor

13.3.1 The low maintenance oil-less scroll or reciprocating type of compressor shall be used which shall be proven for railway application. Compressor bearings shall be: external to the air compression chamber, shall be all serviceable for the designed compressor life, fully encapsulated and electrically insulated. If oil-less scroll type of compressor is proposed, it shall be oil-less rotary scroll, single stage, air-cooled oil-less construction with no oil needed for operation. The rotary design shall be rated for 100% continuous duty. Tip seals shall be of a composite PTFE material and be adequately rated.

13.3.2 The compressors shall be adequately sized and shall be submitted for approval, taking into account the consumption of various sub-systems, charging up time and recovery requirements (refer to PS 4.4.3(a)).

13.3.3 The Contractor shall submit for approval the duty cycle of the compressor in ~~order to d~~emonstrate the compressor performance is optimised.

13.3.4 The time required for charging up the train from empty (i.e. all reservoirs and equipment at zero pressure) to full Main Reservoir Pipe pressure with all compressors working normally shall be less than 20 minutes.

13.3.5 ~~The system shall be maintained within its service working pressure range~~ when there is only one compressor working normally in a train. In this ~~case,~~ the 20 minutes pump-up ~~time (refer to PS 13.3.4) is not applicable~~.

The system shall be maintained within its service working pressure range when there is one compressor failure in a train.

13.3.6 Not used.

13.3.7 Not used.

13.3.8 The air compressor shall be suspended beneath the car a resilient mountings arrangement (within frame of air compressor).

13.3.9 In the event of failure of either one or all resilient mountings the air compressor unit shall remain secure.

13.3.10 All bolted connections between the air compressor unit, resilient mountings and mounting brackets and between the mounting brackets and the carbody, shall be provided with a method of secondary locking to prevent loosening or loss of any component due to vibration.

13.3.11 Not used.

13.3.12 If a cooling fan is required, it shall be directly driven from the air compressor unit without using belts or other detached drive system. If additional fans are required, they should be installed not to require additional belts or power supply.

13.3.13 The compressor shall have a useful working life at least equal to the life of the train.

13.4 Construction of the Compressor

13.4.1 The compressor shall be directly driven from the associated motor.

13.4.2 The compressor shall be AC driven and be powered by the Auxiliary Converter (refer to PS 17.3.1).

13.4.3 Consideration shall be given to motor selection to match the auxiliary power supply load distribution and stability (refer to PS 17.1 and PS 17.3.1).

13.4.4 Not used.

13.4.5 The design of the compressor and the associated equipment shall minimise the transmission of vibration to the saloon floor.

13.4.6 Means shall be provided to identify correct wiring connection and motor rotating direction of the compressor.

13.4.7 Not used.

13.5 Compressor Control

13.5.1 Each compressor on the train shall be equipped with an associated air pressure governor to regulate the Main Reservoir Pipe air pressure on the whole train.

13.5.2 Compressor control shall include both a local control pressure switch and a trainline pressure control. The local control pressure switch shall independently control the local compressor to maintain the local pressure within the allowable limits. The trainline pressure control shall be part of a train-wide air compressor control system and shall be the normal means of starting and stopping compressors. ~~When any car senses reduced air pressure, a limited number of compressor(s) in the train shall run until the air pressure is increased to the selected level. The number of air compressors that will run shall be selected to provide sufficient air capacity while optimizing drying time. The controls shall select the compressor(s) to run such that, over time, the duty is shared equally among the compressors in the train.~~

When any car senses reduced air pressure, a limited number of compressor(s) in the train shall run until the air pressure is increased to the selected level.

The number of air compressors that will run shall be selected to provide sufficient air capacity while optimizing drying time. The controls shall select the compressor(s) to run such that, over time, the duty is shared equally among the compressors in the train. An alternative air compressor control scheme, to be approved by the Engineer, can be proposed.

13.5.3 The compressor shall start automatically to maintain the specified main reservoir air pressure.

13.5.4 All compressor controls on the train shall be powered by the auxiliary control supply from the appropriate controlling cab or gangway cubicle and protected by an independent MCB.

13.5.5 The compressor control circuit shall be designed to ensure that batteries cannot be coupled together.

13.5.6 Each compressor control circuit shall remain fully operational for at least 60 minutes following the failure of the normal supply.

13.5.7 Isolation controls shall be provided for each compressor system, to enable electrical isolation under fault conditions whilst not affecting the operation of the remainder of the train compressor system. The isolation controls shall not be accessible to passengers.

13.5.8 The run time and duty cycle of each compressor shall be recorded by the TIMS (refer to PS 10.5.9).

13.6 Air Drying System

13.6.1 An air drying system shall be provided to ensure delivery of high quality compressed air, of class 3 to ISO 7183-2: 1996 or based on other standard such as ASTM D-2986-95A or APTA SS-M-011-99, to the main air reservoir.

13.6.2 An air dryer shall be provided for each compressed air system and the air

dryer shall be manufactured and tested to ISO 7183: 1986 or based on other standard such as ASTM D-2986-95A or APTA SNS-M-011-99.

13.6.3 The air dryer shall be a self-contained unit mounted in the vicinity of the main compressor.

13.6.4 The air dryer shall be re-generative type with automatic change-over feature.

13.6.5 The air dryer shall be coordinated with the compressor control system in order to achieve the optimised compressor performance.

13.6.6 ~~Indication shall be provided to indicate the degree of dryness of the desiccants.~~

Indication shall be provided to indicate the degree of dryness of the desiccants, or a time base assessment can be provided as an alternate.

13.6.7 The life of desiccant shall not be less than the time between the planned air dryer overhaul period.

Item (13.6.7): (No specifications text modifications required.)

13.6.8 Silencer shall be provided if purging is used for re-generation to meet the specified noise requirements.

13.6.9 All equipment shall be mounted in one frame as a single unit.

13.6.10 The control of the air dryer shall be either electrical or pneumatic or a service proven electro/pneumatic type.

13.7 Control Equipment

13.7.1 Air Cylinder

All air cylinders (other than brake cylinders), pistons and pneumatic valves shall be of a type which does not require lubrication between overhauls.

13.7.2 Electro-pneumatic Control Valve

13.7.2.1 The valve shall not significantly change its speed or operational performance over the range of temperatures experienced by the equipment in operation.

13.7.2.2 The relays or electro-pneumatic valves used on the various systems shall be capable of operation without malfunctioning under the influence of vibration or impact as encounter in the AUTHORITY network. Vibration and shock design, analysis and test levels and frequency ranges for all mounted equipment shall be in accordance with IEC 61373.

13.7.2.3 To reduce the noise of valve in operation, all exhaust ports shall be fitted with a metal type silencer to the following requirements, unless performance of the system or accessibility to service proven equipment justify otherwise:

(a) The silencer shall not reduce the flow capability of the valve by more than 5%.

(b) The silencer material shall be capable of being cleaned and re-used. Porous plastic silencers will not be acceptable.

13.7.2.4 Spool type valves shall be installed so that the axis of the spool lies across the width of the car and the solenoid armatures are vertical, unless performance of the system or accessibility to service proven equipment justify otherwise.

13.7.2.5 Poppet type valves shall be installed so that both the axis of the valve and the solenoids are vertical, unless performance of the system or accessibility to service proven equipment justify otherwise.

13.7.2.6 All control valves shall be sub-base mounted.

13.8 Air Reservoirs

13.8.1 All reservoirs shall be designed, manufactured and tested in accordance with either 49 CFR229.31 or ASME boiler and pressure vessels standard.

13.8.2 All test certificates shall be submitted for approval.

13.8.3 The capacity of the Main Reservoir shall be designed to achieve the following requirements when the reservoir is at minimum Main Reservoir Pipe air pressure without any compressor running except (d) below:

(a) It shall enable all pneumatic equipment to be operable.

(b) It shall account for normal leakage of the system.

(c) It shall enable the train running safely from one station and stop accurately at the next station with friction brake only.

(d) It shall enable a fully operational train to assist for recovery and to charge up a defective train from 5 bar (72.5 PSI) within 20 minutes.

13.8.4 Brake supply reservoir shall be fitted on each car to provide a protected supply to the friction brake equipment of that car.

13.8.5 The brake supply reservoir installation shall meet the following requirements:

(a) When the pressure in the brake supply reservoir is at maximum Main Reservoir Pipe air pressure and the Main Reservoir Pipe is at zero pressure, the brake supply reservoir pressure drop shall not be more than 0.1 bar (1.45 PSI) within 5 minutes due to normal leakage.

(b) With the brake supply reservoir is at minimum operating Main Reservoir Pipe air pressure and the Main Reservoir Pipe is at zero pressure, it shall be possible to make two Emergency Brake applications at crush laden (W5) condition.

13.8.6 Not Used.

13.8.7 Reservoirs shall be of low alloy steel coated inside and outside to resist corrosion.

13.8.8 The maximum working pressure shall be the same as the Main Reservoir Pipe safety valve "open" setting.

13.8.9 The main reservoir shall be fitted with a manual drain valve and shall have capacity not less than ten times the maximum air volume consumed by the equipment per minute.

13.8.10 All reservoirs, other than the brake supply reservoirs, shall be provided with drain valves.

13.8.11 The brake supply reservoir shall have a plugged drain.

13.8.12 The plugged drain shall be able to release any air pressure inside the reservoir before it is fully unplugged.

13.8.13 All drain valves fitted shall be easily accessible.

13.8.14 All drain valve handles shall point downwards in the closed position.

13.9 Piping And Fittings

13.9.1 Quick release test points for measuring system pressures shall be provided in readily accessible positions.

13.9.2 The positions for the test points shall be submitted for approval.

13.9.3 Protective covers shall be provided for the quick release test points when they are not in use.

13.9.4 Automatic connection of the Main Reservoir Pipe air through the automatic coupler shall be provided as required by PS 14.3.

13.9.5 Individual manual isolation of the Main Reservoir Pipe shall be provided at each autocoupler end (refer to PS 14.3.1(d)).

13.9.6 Check valves at all intercar couplings and check valves at all compressor flexible hoses shall be provided to minimise the effect of a burst flexible hose.

13.9.7 Flow restricting devices shall be located in the Main Reservoir Pipe adjacent to branch connections, to avoid excessive air flow in the event that a piping failure or equipment malfunction occurs.

Item 13.9.7: (No specifications text modifications required.)

13.9.8 Not Used.

13.9.9 The pipework and fittings shall be designed to withstand a pressure of 1.5 times the Main Reservoir Pipe safety valve pressure setting.

13.9.10 The various parts of the whole system and the equipment supplied shall be subdivided into sections, each section being provided with a vented isolating valve and a strainer. Where a check valve is incorporated in the system means of venting the system shall be provided.

13.9.11 As far as possible pipe runs shall be direct, short and straight, avoiding unnecessary use of bends and fittings. Pipe bends shall be of as large a radius as possible (minimum of 3 times the pipe diameter), particularly on safety critical systems.

13.9.12 Drain point(s) shall be provided in the piping system and shall be located at the lowest point of the relevant section to effectively drain off any accumulated condensate within the system.

13.9.13 The air pipe shall conform to ASTM A 53, either Schedule 40 or 80 seamless pipe.

13.9.14 Nylon pipe of not more than 12 mm outside diameter may be used for short runs where replacement of the pipe can be carried out without removal of other equipment. The application of nylon tube shall be submitted for approval.

13.9.15 Flexible elastomer hoses shall be used only for drophoses and intercar connections and to connect the air compressor to the car piping.

13.9.16 ASTM B 88, Type "K" annealed copper tube may also be used, provided it is protected from any potential impact damage from track debris by means of equipment or approved steel guards, especially in the truck area. Where suitable protection in damage-prone areas is not possible or practical, approved steel piping sections shall be provided.

13.9.17 All pipes shall be cut with correct pipe cutting tools in order to avoid introduction of metal particles into the system. All pipework shall be thoroughly blown out and cleaned before service.

13.9.18 Taper-threaded pipe connections shall be sealed with a proprietary sealing compound used in accordance with the manufacturer's instructions.

13.9.19 Parallel thread fittings shall be sealed with a proprietary sealing washer.

13.9.20 PTFE tape and fibre washers shall not be used.

13.9.21 All pipes shall be adequately secured and cleated to prevent failure from sagging and vibration. The cleats shall incorporate a resilient surface to

prevent chafing and fretting of the tubing. Cleats shall not be positioned in highly stressed areas.

13.9.22 All fittings, valves and components shall be non ferrous or stainless steel.

13.9.23 Fittings for metallic tubing shall be made of the same materials as the pipework. Brass fittings shall be acceptable for copper piping.

13.9.24 The strainers, check valves and isolating valve shall be grouped in an easily accessible location.

13.9.25 Equipment other than strainers and cutout valves, shall be mounted such that it can be removed for maintenance without breaking pipe joints.

13.9.26 Diaphragms and air valve seals shall be of the non metallic type, unless performance of the system or accessibility to service proven equipment justify otherwise. The use of leather as a gasket, seal or packing material will not be accepted.

13.9.27 Life of diaphragms and seals shall be at least 5 years. Exceptions to this requirement may be made for cutout valves and compressor check valves, which shall operate in air temperatures of up to 150°C (302°F).

13.9.28 The types of fitting used shall be submitted for approval.

13.10 Safety Valves

13.10.1 The Contractor shall provide safety valve to be installed in each compressed air supply system to protect the associated main reservoirs against over pressure.

13.10.2 The safety valve capacity shall be at least 50% greater than the compressor delivery.

13.10.3 The safety valve shall operate at a pressure not less than 0.5 bar and not more than 1.0 bar above the maximum operating system air pressure.

13.10.4 The safety valve setting shall be submitted for approval.

13.11 Pressure Indication

13.11.1 A duplex pressure gauge shall be provided in each cab (refer to PS 8.8.4(b)) to indicate the pressure of Main Reservoir Pipe in red colour and Local ~~Brake Cylinder in white colour.~~

13.11.2 The Main Reservoir Pipe pressure and brake cylinder pressure of each car shall also be recorded by Event Recorder (refer to PS 10.7) through the TIMS.

13.11.3 The duplex pressure gauge shall be operable at all times and shall not require the presence of an electrical control signal to indicate the correct pressure.

13.11.4 The pressure indication shall be taken from a point upstream from the brake cylinders.

13.11.5 No pneumatic devices shall be mounted between the pressure indicator and the brake cylinders.

13.11.6 The dial faces of the duplex pressure gauge shall be black in colour with primary lettering in white for kPa and secondary lettering in yellow for PSI. The pressure gauges shall maintain an accuracy of 2% of full scale deflection between 10-90% of full scale deflection and an accuracy of 3% of full scale deflection over 0-10% and 90-100% of full scale deflection.

13.12 Brake Isolation

13.12.1 Brake isolation device shall be provided in accordance with PS 11.16.

13.13 Pressure Governors

13.13.1 All pressure governors shall be of an approved type.

13.13.2 The pressure governors shall be able to withstand a pressure not less than the 'open' pressure of the main safety valve without causing any damage or deterioration.

13.13.3 The Contractor shall submit all pressure governors settings for approval.

13.14 Horn

13.14.1 Electro-pneumatic or electrical horn shall be fitted in accordance with PS 6.9.3. Additional horn shall be provided in the middle of the train i.e. at one of the intermediate car end.

13.14.2 For those horns that are fitted at the cab end, the horn shall generate an audible warning, measuring at 1.6 m (5.25’) above rail top level along the car centreline to achieve a minimum sound pressure level of 80 dB(A) at a distance of 150 m (492’) from the car end but not to exceed 130 dB(A) at a distance of 1 m (3.3’) from the car end. For those horn that is fitted at the intermediate car end, the horn shall generate an audible warning, measuring at 1.6 m (5.25’) above rail top level along the car centreline to achieve a minimum sound pressure level of 40 dB(A) at a distance of 150 m (492’) from

the car end but not to exceed 65 dB(A) at a distance of 1 m (3.3') from the car end.

13.14.3 The horn shall emit a sound with the fundamental frequencies in the range of 1 to 2 kHz, either in a single frequency or combination of frequencies.

13.15 Air Hose

13.15.1 Compressed air hose shall be of an approved type stamped with the manufacturing date to be used for all applications.

13.15.2 Air brake hoses shall be manufactured, tested and inspected in accordance with the latest revision of AAR Specification. Specifications of all hoses which are used for flexible connections in the air system and between the carbody and truck, shall be submitted for approval.

13.15.3 Air brake hoses shall be tested and inspected in accordance with the requirements of BS 3682 or equivalent.

13.16 Accessories

13.16.1 Pressure Regulators

(a) The workable range of the pressure regulators shall be selected to have a range for the working pressure setting to be adjusted.

(b) Pressure regulators shall incorporate a simple device on the adjustment to prevent tampering by unauthorised persons.

13.16.2 Pressure Switch/Governor

(a) The pressure switch/governor shall be proven type for railway application.

(b) Suitable working range of the pressure switch/governor shall be selected to match the pressure of the system to be controlled.

(c) The pressure switch/governor shall be capable to withstand for the maximum pressure of the system without damage.

(d) The pressure switch/governor shall have maximum sensitivity within the working range.

(e) The setting of the pressure switch/governor shall be easily adjustable without using any special tools.

(f) Means shall be provided to prevent drifting of the setting.

(g) All settings shall be submitted for approval.

(h) The pressure switch/governor shall be sealed to IP 65 as defined in IEC 60529, or other approved equivalent standard.

13.16.3 Pressure Transducer

(a) The pressure transducer shall not require frequent calibration and be selected to achieve reliability and maintenance requirement target.

(b) The accuracy of the pressure transducer shall be ±1%, unless by its function, less accuracy is acceptable.

(c) The output of the pressure transducer shall be linear in either voltage or current and protected against short circuit, incorrect polarity and overload up to 50 Vdc.

(d) The pressure transducer shall be compact and sealed to IP 65, or other approved equivalent standard.

(e) The pressure transducer shall be capable to work in railway environment, industrial grade piezo-resistive type will be preferable.

13.16.4 Pressure Gauges

(a) Pressure gauges shall not require an electrical supply in order to provide a pressure reading of the required accuracy.

(b) All pressure gauges shall be glazed and sealed to IP 54, or other approved equivalent standard.

(c) All pressure gauges shall be installed so that the gauge glazing may be cleaned easily, to maintain legibility, without requiring any components to be dismantled.

(d) Any pressure gauges shall be installed so that they can be replaced within 15 minutes after the appropriate isolation has been made.

(e) All gauges shall, unless otherwise specified, provide analogue pressure readings with an accuracy of ± 5%.

(f) All pressure gauges shall be capable of operating to the specified accuracy for a period of 10 years without adjustment unless performance of the system or accessibility to service proven equipment justify otherwise.

(g) Brake Pressure Gauge

(i) The gauges shall have a range equal to the maximum regulated Main Reservoir Pipe pressure.

(ii) The gauge shall be calibrated in 1 bar increments or 20% of full scale increment, whichever is greater.

(h) Sub-System Gauges

(i) A pressure gauge or an approved test point per PS 13.9.1 shall be provided for each major sub-system within each car which normally operates below Main Reservoir Pipe pressure.

(i i) The gauges shall have a range equal to the maximum regulated Main Reservoir Pipe pressure.

(iii) The gauge shall be calibrated in 1 bar (14.5 PSI) increments or 20% of full scale increment, whichever is greater.

13.16.5 Isolating Valve

(a) All isolating valves shall be clearly labelled to identify the function of the valve.

(b) Isolating valves shall be of the ball valve type which operate through a nominal angle of 90°.

(c) Isolating valve handles shall be of the simple lever type (but not 'T' handle) and shall be arranged so that the longitudinal axis of the handle is nominally parallel to the direction of air flow when the isolating valve is open (different orientation may be considered for the air receiver drain valves).

(d) Isolating valves shall be installed so as to permit their replacement within 15 minutes.

(e) The valve handles shall be coloured for easy identification. If any brake isolation valve to be fitted, it shall be coloured in a way to distinguish from others.

13.16.6 Drain Valve

(a) Drain valve handles shall point vertically downwards when the valve is closed. All other valves shall be open when the handle is along the line of pipe, and shall either have a vertical spindle, or the handle shall fall to the open position. Other orientations may be considered providing that an equivalent level of easiness for inspection and security can be achieved.

13.16.7 Chokes

(a) Pneumatic chokes shall be provided, if necessary, to protect equipment from damage or to minimise the consequences of equipment failure.

(b) Protection chokes shall be installed immediately upstream of the item of equipment being protected.

(c) Chokes shall be easily accessible and removable.

(d) Variable chokes shall not be used.

13.16.8 Air Compressor Vacuum Indicator

(a) Pneumatic chokes shall be provided, if necessary, to protect equipment from damage or to minimise the consequences of equipment failure.

(b) It is a requirement that a positive indication of air compressor filter restriction shall be provided in a convenient location for the maintainer to view when change of the intake filter is necessary.

SECTION 14 - GANGWAYS AND COUPLERS 2

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Section 14 - Gangways And Couplers

14.1 General

14.1.1 The cab end shall be fitted with an automatic coupler.

14.1.2 The non-cab ends of each cars shall be fitted with semi-permanent bar couplers and semi-permanent gangways.

14.1.3 The semi-permanent bar coupler shall be compatible with the gangway fitted to that end of the car in all aspects including coupling/uncoupling and normal operations, taking into account the gangway guidance, gangway and passenger load.

14.1.4 The autocoupler, together with the pneumatic connection, shall be mechanically compatible with the existing T1 car couplers (refer to Contract Drawing No. NST 084 for outlined dimensions). The lubricant used for the coupler surface shall be Molykote Dry Film Lubricant compatible.

14.1.5 The couplers and gangways shall be designed to meet the door pitch requirements as specified in Contract Drawing No. NST 006.

14.1.6 An adequately rated flexible earth bond shall be provided across the moving joints of the inter-car gangways/couplers in order to ensure that the earthing circuits of all car bodies are continuously connected.

14.2 Operation Requirements

14.2.1 The automatic coupler shall be capable of coupling with another on any track layout as specified in Appendix I Annex 1.

14.2.2 Under these track conditions coupling shall be achieved with the most adverse mismatch of car heights caused by wheel wear, passenger loading, air spring deflation and tolerances.

14.2.3 Emergency Push-out Requirements

(a) A cab end coupler shall be capable of mechanical and pneumatic coupling to the cab end of other train for emergency push out operation (refer to PS 4.4.4(a)).

(b) In order to accelerate the recovery process, an autocoupler pneumatic isolation valve shall be provided on the driving cab for selectively isolating the pneumatic coupling connection (refer to PS 9.7). The default position of the

pneumatic isolation valve shall be in the isolated position.

(c) The cab end coupler and all inter-car couplings shall be capable of transmitting the forces necessary to pull or push an unpowered train with fully laden passenger load and all parking brakes applied up or down a 3.5% gradient at any speed up to 25 km/h (16 MPH) under all track layout as specified in PS 4.4.

14.3 Automatic Coupler

14.3.1 General

(a) The automatic coupler shall incorporate the following connections.

(i) Mechanical connection

(i i) Pneumatic connection

(b) The automatic coupler shall automatically effect mechanical and pneumatic coupling as specified and permit separation of the units either manually from track side or remotely from the train operator cab.

(c) When uncoupled, the pneumatic connection shall be automatically protected against physical and mechanical damage and shall be sealed against the ingress of water from rain and from washing plant, and general dirt and detritus from the environment.
Item (c): (No specifications text modifications required.)

(d) Auto coupler pneumatic isolation valve shall be provided to isolate and vent the automatic coupler from the main line air supply. The operation of the isolation valve shall be easily accessible to the train operator from the cab and the underframe.

(e) Equipment to centralise the automatic coupler to allow ease of coupling shall be fitted.

(f) The design of the automatic coupler and its components shall have no failure to couple mechanically for a minimum of 2,500 couplings.

(g) The coupling requirement in PS 14.2.1 shall be achieved under the following minimum coupler misalignment conditions:

- parallel and vertically misaligned only,

  +90 ± 5 mm and -90 ± 5 mm

- parallel and horizontally misaligned only,

  +170 ± 10 mm and -170 ± 10 mm

<u>(No Specification text modifications)</u>

14.4 Bar Couplers

14.4.1 The connection and disconnection of bar couplers will take place in depot only.

14.4.2 The bar coupler shall incorporate all ~~necessary pneumatic connections.~~

The bar coupler shall incorporate all necessary pneumatic connections or approved equal.

14.4.3 The bar coupler, shall be designed so that assembly/disassembly, including gangway separation and necessary jumper connection/ disconnection, can be completed in 30 minutes by two persons, and with a minimum of operations by personnel working in pits or alongside the cars. It shall be possible to easily inspect for correct assembly without the need for special tools or instruments.

14.5 Coupler and Draftgear

14.5.1 Draftgear

Coupler draftgear shall be suitably damped, and be designed to prevent the occurrence of unduly large dynamic deflections and associated forces in all normal and specified emergency train operating conditions.

14.5.2 Coupler and Draftgear Mounting Requirements

(a) The couplers shall be mounted so that the coupler is free to move and not be impeded by body structure under any operating condition.

(b) The coupler and draftgear shall incorporate a form of adjustment to ensure compliance in accordance with PS 14.2.1 and 14.2.2 as necessary.

(c) Coupler fasteners and fastener security devices used to connect the couplers shall be positioned so that they can be easily inspected as well as enabling the

tooling, required to install and secure the fasteners, to be easily operated.

(d) The height of the centre of the autocoupler locking pin shall be 654.05 ± 12.7 mm (25 ¾ ± ½ ") from the rail head level in order to enable coupling with the existing T1 Train (refer to Contract Drawing No. NST-006) under the specified coupler misalignment conditions in PS 14.3.1(g).

14.5.3 Coupler and Draftgear Strength Requirements

(a) The coupler and draftgear shall be designed to accommodate all forces generated under normal operating conditions at all track layout and to withstand all steady state and dynamic forces generated under the specified emergency push out/pull out conditions for all coupler angles.

(b) There shall be no in service failure of any coupling, automatic or bar type, throughout the life of the train, when subjected to the forces mentioned in PS 14.5.3(a).

(c) Compliance with this strength requirement shall be demonstrated by analysis during the design phase and subsequently verified by type test.

(d) The coupler and draftgear shall be suitable for repeated coupling/uncoupling between trains with impact speeds not exceeding 5 km/h (3 MPH) and for the emergency train recovery operation as specified in PS 4.4.

(e) In the event of adverse service conditions imposing excessively high tensile forces on the automatic coupler, the design shall be such that failure shall ensure a positive interruption of pneumatic continuity.

(f) The bar couplers shall be designed to ensure that they do not fail before the automatic couplers.

(g) The system shall be designed to ensure that, in the event of a burst hose or similar malfunction, uncoupling of the coupler cannot occur.

14.5.4 Energy Absorption

(a) In addition to the draftgear for normal service operation, the couplers shall incorporate an emergency energy absorption feature which shall operate only when the buffing load exceeds a predetermined level.

(b) The energy absorption capacity and the load at which the emergency energy absorption device begins to operate shall be as high as practicable commensurate with the requirements of PS 6.4.3.

(c) The design of the energy absorption element shall be such that it shall not be caused to operate or to deteriorate in any way under normal train operating conditions.

14.6 Inter-car Gangway

14.6.1 General

(a) Inter-car gangways shall be provided at all car ends except the cab end.

(b) The minimum dimensions of the internal passageway shall be 1500 mm wide and 1800 mm high.

(c) The gangways shall provide a safe means of passage between cars for standing passengers and staff under all depot and running line operating conditions.

(d) The gangway interior shall be free of any protrusions and devoid of any gaps that may be exposed during gangway movements and which would be a danger to passengers or staff.

(e) The gangway shall be fully weatherproofed.

(f) All gangways shall meet the requirements of the interior design, as specified in PS 7.

(g) The gangway shall withstand the loads and aerodynamic effects encountered in service up to the maximum operating speed without permanent deformation or premature fatigue failure and without any deflection of the gangway internal lining surfaces.

(h) The gangway shall be sufficiently thermally and acoustically insulated to ensure that the overall air conditioning performance (refer to PS 15) and noise performance (refer to PS 21.8) of the train are achieved.

(i) The splitting arrangement of the gangway shall be at the middle such that each half gangway is the same.

(j) The gangway shall not interfere with the carbody end structure under normal operations.

(k) If clamping devices are fitted to the gangway at the bar coupler end, they shall be inaccessible to passengers and shall be easily and quickly operable by authorised personnel, without the aid of tools, from track level.

(l) All gangway materials shall meet the fire performance requirements as specified.

(m) The gangway interior design shall be flat along the vertical surface from the ceiling down to the floor level in order to avoid any protrusion from obstructing the standing passengers.

14.6.2 Gangway Floor

(a) The interior and the floor surface shall match with that of the saloon as far as possible.

(b) When the train is in service there shall not be any interruption of the walking floor level which would present a hazard to passengers or staff.

(c) The flooring shall be provided with an anti-slip surface.

(d) If there is any movement between floor sheets, easily replaceable wear pads shall be incorporated to take up any abrasion wear.

(e) The standing floor shall be strong enough to hold a load of 8 passengers/m 2 . The strength calculation shall be submitted for approval.

14.6.3 Gangway Panel

(a) Gangway panels are required at the gangway internal vertical surfaces and the ceiling.

(b) The gangway panels shall meet the following requirements:

(i) The surface of the panel shall match to the saloon panel surface.

(i i) The panel surface shall be easily clean.

(i i i) It shall not cause any injury to the passenger when the train is in motion.

14.6.4 Flexible Rubber Element

(a) The stiffness of any flexible rubber elements used on the floor and the passage sides shall provide sufficient support to passengers under all operating conditions.

(b) The design shall not allow any water accumulated inside.

(c) The life of the flexible rubber element shall not be less than the mid-life period of the train.

SECTION 15 HEATING, VENTILATION AND AIR CONDITIONING SYSTEMS 2

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Section 15 Heating, Ventilation And Air Conditioning Systems

15.1 System Requirements

15.1.1 The Heating, Ventilation and Air Conditioning (HVAC) system shall comprise saloon and cab heating, air conditioning, emergency mechanical ventilation and equipment ventilation.

15.1.2 The Contractor shall design and submit the type and number of HVAC units per car for approval taking into account, but not be limited to, the requirements of cooling performance, noise, RAM requirements, space and saloon ceiling heights.

15.1.3 The Contractor shall submit the system design supported by schematic layouts, equipment sizing and selection, air flow distributions, cooling load estimation and psychometric charts to meet the saloon environmental requirements including, but not be limited to, temperature, relative humidity and noise requirements.

15.2 HVAC system Requirements

15.2.1 The HVAC system which comprised of heating, cooling and ventilation sub-systems shall be capable to achieve the saloon design condition as specified below throughout the life of the car:

(a) The heating control shall be operated as follows on rising temperatures (refer also to PS 10.5.5 for loading and seasonal adjustments, up to the system limit capacity):

(i) Stand-by Heating (a.k.a. Layover mode) - emergency brake applied for greater than one hour:

(1) Below 10°C (50°F): Baseboard heaters "ON".

(2) At 10°C (50°F): Baseboard heaters "OFF".

(ii) Normal Heating - Not in emergency brake or emergency brake applied for less than one hour:

(1) Below 15°C (60°F): Baseboard Heaters "ON".

- Overhead Heaters "ON".
- Overhead Fans "ON".

(2) At 15°C (60°F): Baseboard Heaters "OFF".

- Overhead Heaters "ON".
- Overhead Fans "ON".

(3) At 18°C (63°F): Overhead Heaters "OFF".

- Overhead Fans "ON".

(b) The cooling controls shall be operated as follows on rising temperature:

(i) Stand-by Cooling (a.k.a. Layover mode) - emergency brake applied for greater than one hour:

All temperatures: Condenser Fans “OFF”, Overhead Fans “OFF”

(ii) Normal Cooling - Not in emergency brake or emergency brake applied for less than one hour.

(1) Below 22.5°C (73°F) - Cooling "OFF"
- Evaporator Fans "ON".

(2) At 22.5°C (73°F) - Reheat cooling mode
- Overhead Heaters “ON”
- Evaporator Fans “ON”

(3) At 23.5°C (74°F): Cooling begins - Minimum
- Evaporator Fans "ON".

(4) From 23.5°C (74°F): Cooling power increases to maximum.

To 24.5°C (76°F) - Evaporator Fans "ON".

(5) Over 24.5°C (76°F) - Cooling power - Maximum.

- Evaporator Fans "ON".

(c) The temperature controls for both heating and cooling shall be operated as follows:

The saloon condition of 25.5°C (78°F), 55% R.H. as measured at the return air grille, shall be achieved for the trains operating under specified conditions in cooling (summer) mode, while 18.0ºC (63ºF) is required in heating (winter) mode.

(d) The ventilation controls shall be operated as follows:

(i) The saloon shall receive the maximum necessary air circulation rate, in line with the other requirements of this specification, such as air distribution, temperature uniformity, noise, etc, and under all modes of operation (except emergency mode, refer to PS 15.7.2).

(i i) An adequate rate of fresh air intake under emergency mode of operation (refer

to PS 15.7.2) shall be provided to prevent excessive CO_2 built-up (max of 5,000 ppm). An appropriate means of control, for example, a progressive air flow off-loading on a car basis as controlled by the TIMS, shall be provided in order to minimize battery sizing. Default mode shall be provided in case of TIMS unavailability to perform control, on which case the air flow shall never fall under the level determined to be adequate to maintain the CO^2 level.

15.2.2 The minimum cooling capacity shall not less than 53.0 kW per car. And the minimum heating capacity shall not less than 24 kW (i.e. 14 kW of overhead heater and 10 kW of baseboard heater) per car.

15.2.3 The HVAC unit shall allow full cooling operation without the influence of modulation control with external ambient temperatures up to 40°C (104°F).

15.2.4 ~~The system shall also remain in operation with capacity of the HVAC unit not dropping by more than 50% with an ambient temperature rise of up to 56°C.~~

<u>The system shall also remain in operation, with reduced capacity, with an ambient temperature rise of up to 56°C.</u>

15.2.5 Unloading facility shall be provided to meet the part load and high pressure unloading conditions.

15.2.6 The proposed system shall be microprocessor controlled with self-diagnostic capabilities and interfaced with the TIMS (refer to PS 10).

15.2.7 The system shall have automatic temperature control and manual override via

the TIMS (refer to PS 10). And the system shall report the saloon temperature to the TIMS (refer to PS 10.3.5 and PS 10.5.5).

15.2.8 An example of the control concept of both normal and layover modes is provided at Figures 15-1 and 15-2. It is a requirement that the temperature sensors shall offer accuracy in the range of ±0.3°C

15.3 General Requirements

15.3.1 The units shall not infringe the specified Kinematic Envelope and Equipment Gauge under any combinations of operation conditions.

15.3.2 Minimum number of fixings shall be used for installation. Gasket or sealing means between the HVAC unit and the car structure shall be selected and installed to prevent water, snow or other to penetrate inside the vehicle under all types of straight and curved track, and passenger loading.

15.3.3 The system shall be driven by AC motor.

15.3.4 Two self-contained roof mounted units per each car shall be used to facilitate easy and efficient replacement for maintenance (refer to PS 26) within the time specified in PS 25.9.1.

15.3.5 The Contractor shall co-ordinate the supply air outlets and return air grille with the interior fittings to optimise the air conditioning performance while maintaining the train styling.

15.4 Design Conditions

15.4.1 The Contractor shall submit the saloon condition (refer to PS15.2.1(c)) for:

(a) In cooling mode:

(i) The trains operating under the congested tunnel condition with bulk air surrounding the condenser of the HVAC unit shall be 40ºC (104ºF) 40% RH.

(i i) The outside air temperature entering the unit in surface condition shall be 35ºC DB (95ºF) / 24ºWB (75ºF).

(b) During the heating condition, the ambient temperature shall be -26ºC (-15ºF)

15.5 Cooling Load Estimate

15.5.1 The Contractor shall carry out cooling load estimates for all conditions with the use of internationally recognised reference data, such as, ASHRAE.

15.5.2 The HVAC units shall be designed for a minimum of 200 passengers with all equipment being operated.

15.5.3 ~~The Contractor shall take into consideration to allow the effects of door opening and closing at stations and the piston and infiltration effects for the train moving in tunnel. For design purposes, cycling shall be assumed as door open for 30 seconds at every 3 minutes.~~

The Contractor shall take into consideration to allow the effects of door opening and closing at stations and the piston and infiltration effects for the train moving in tunnel. For design purposes, cycling shall be assumed as door

open for 30 seconds at every 3 minutes. Infiltration due to door opening can be considered as part of the total fresh airflow.

15.5.4 The sensible and latent thermal emission per person shall be taken as 70 W and 60 W respectively.

15.6 Supply Air Distribution

15.6.1 The Contractor shall carry out the air flow rate and distribution analysis to achieve even distribution of conditioned air throughout the whole length of the saloon including the extreme car ends.

15.6.2 The air distribution shall not produce any dead zone in the saloon, excluding the naturally hidden region such as under passenger seats.

15.6.3 Return and fresh air shall be filtered.

15.6.4 The Contractor shall submit an air flow distribution schematic for approval.

15.6.5 The Contractor shall submit the air flow measurement procedure for approval which shall be in accordance with CIBSE or ASHRAE standards or equivalent.

15.6.6 The Contractor shall carry out air flow type and routine tests in accordance with Appendix B.

15.6.7 The air velocity experienced by passengers shall not be more than 0.4m/sec.

15.7 Emergency Mechanical Ventilation System

The mechanical ventilation shall be provided in accordance with the following matrix:

Mode	Heating/Cooling	Fresh Air	Return Air
Ventilation	not required	available	available
Emergency	not required	full	not required
Outside Smoke	available	not required	full
Inside Smoke	not required	not required	not required

15.7.1 Ventilation Mode

(a) In the event of failure of an HVAC unit to provide cooling, the system shall provide mechanical ventilation with normal fresh air intake and return air circulation.

(b) The failure shall be reported to and recorded by the TIMS (refer to PS 10.3.6).

15.7.2 Emergency Mode

(a) In the event of normal supply failure, emergency ventilation (refer to PS 17.1.4) shall be provided and powered from battery (refer to PS 17.4.2) for an agreed time duration.

(b) The emergency ventilation shall inhibit cooling/heating and deliver adequate fresh air to the saloon.

(c) The HVAC system shall automatically restore normal operation if power supply returns to normal.

(d) Operation of the emergency mode ventilation shall be reported to and recorded by the TIMS (refer to PS 10.3.6).

15.7.3 Outside Smoke Mode

(a) In the event of smoke being detected intake into saloon by the system, the system shall shut off the fresh air intake and provide a full (100%) recirculation of return air within the saloon.

(b) The system shall maintain supply of heating / cooling to the saloon, understanding that performance could be affected (namely humidity and internal CO2 level).

(c) In the event of a loss of the emergency power supply, the dampers system shall default to the specified mode.

(d) Indication for smoke alarm and trigger of dampers shall be provided on local control panel which shall not be visible to the passenger.

(e) The dampers shall be reset by the train operator via the TIMS if the system resumes normal.

(f) The dampers shall be capable of being reset locally from the saloon if remote reset has failed.

(g) Operation of the smoke mode ventilation shall be reported to the TIMS (refer to PS 10.5.5).

15.7.4 Inside Smoke Mode

(a) In the event of smoke being detected inside the saloon by the system, the system shall shut off the fresh air intake and provide no recirculation of return air within the saloon.

(b) Supply of heating / cooling to the saloon shall not be required.

(c) In the event of a loss of the emergency power supply, the dampers system shall default to the specified mode.

(d) Indication for smoke alarm and trigger of dampers shall be provided on local control panel which shall not be visible to the passenger.

(e) The dampers shall be reset by the train operator via the TIMS if the system resumes normal.

(f) The dampers shall be capable of being reset locally from the saloon if remote reset has failed.

(g) Operation of the smoke mode ventilation shall be reported to the TIMS (refer to PS 10.5.5).

15.8 Equipment Ventilation

15.8.1 ~~Equipment ventilation, as required, shall make use of exhaust air and shall not degrade the air conditioning performance.~~

Equipment ventilation, as required, shall make use of exhaust air (to the car interior or the car exterior) and shall not degrade the air conditioning performance.

15.8.2 The Contractor shall provide ventilation to the ATC cabinet for sufficient cooling of trainborne ATC equipment.

15.9 Smoke Detection

15.9.1 The Contractor shall design a smoke detection system suitable for railway application, using an agreed list of contaminants. Each car shall be equipped with two smoke detection systems: one detection system shall be located to detect smoke inside the passenger area and the other to detect smoke outside the vehicle.

15.9.2 The detection system shall be designed to give a fast and accurate response with minimised nuisance activation.

15.9.3 The detection system shall be able to distinguish between dusty tunnel environment and other smoke/fume sources such as diesel fumes from smoke being caused by tunnel fire.

15.9.4 ~~Faulty or dirty detector shall be reported to the TIMS (refer to PS 10.5.5).~~ Faulty detector shall be reported to the TIMS (refer to PS 10.5.5).

15.9.5 The detection system shall be able to be checked, calibrated and replaced from the saloon including the sensitivity test.

15.9.6 The detection system shall be designed to require no maintenance or adjustment between overhauls of the HVAC unit as specified in PS 25.9.2.

15.10 Control

15.10.1 High and low pressure cut-out devices shall be provided to shut down operation if the refrigerant pressure exceeds the preset limits.

15.10.2 In the event of high pressure cut-out being activated by malfunction of the air conditioner, means shall be provided to inhibit further operation of the compressor and prevent self-reset of the cut-out device.

15.10.3 In the event of the high pressure being built up due to temporary abnormal high ambient temperature, the system shall unload without tripping the compressor MCB and permit the high-cut device to be self reset when conditions resume normal.

15.10.4 The Contractor shall submit all pressure switch settings with the associated conditions.

15.10.5 If required by the selection of compressor type (refer to PS 15.14.1), unloading device shall be provided to cater for part load conditions and relief of high refrigerant pressure due to the ambient temperature exceeding the design temperature.

15.10.6 The Contractor shall submit the unloading arrangement for approval.

15.10.7 In the event that all conditions revert to normal without malfunction in the system, the unloading device shall be reset and the system shall load up automatically.

15.11 Temperature Settings and Control

15.11.1 The saloon temperature setting shall be controllable through both the TIMS (refer to PS 10.5.5) or the local communicating port to the control unit.

15.11.2 Due consideration shall be given to the control system design in order to prevent hunting of the temperature control apparatus, for example, under normal operation, two-stages cooling as provided for the saloon HVAC unit with an on/off differential between each stages to be approximately 1 to 2°C (2 to 3°F). Each temperature control point shall be adjustable to a temperature of 5°C (9°F) lower or higher than specified herein.

15.11.3 Thermistor sensors shall be provided in both the fresh air and the return air inlet to sense the ambient and saloon temperature.

15.11.4 The sensors shall be easily accessible from saloon to facilitate maintenance.

15.11.5 The temperature control shall provide ~~quick and accurate response to achieve the specified saloon conditions within 30 minutes, from a soaked vehicle condition (defined in PS 15.4.1) and using system sensors measurement.~~

The temperature control shall provide quick and accurate response to achieve the specified saloon conditions within 73 minutes for heating and 78 minutes for cooling, with the minimum power consumption, from a layover vehicle condition (defined in PS 15.02.01 (a) (i) and 15.02.01 (b) (i)) and using system sensors measurement. Fresh air dampers shall be closed during warm-up and pull-down for that purpose.

15.12 Control Equipment and Pressure Control Panel

15.12.1 The Contractor shall design the location to contain the control equipment for each air conditioner without affecting the interior styling of the saloon.

15.12.2 The control equipment shall be arranged to prevent overheating and ingress of water and dirt.

15.12.3 Faults shall be reported to the TIMS (refer to PS 10.3.6) to enable diagnosis via the TIMS, locally through a portable PC or remotely through the YMSS.

15.12.4 The control shall be achieved by means of modular programmable electronic controller to enable changing of parameters to be downloaded from a portable PC or YMSS.

15.12.5 ~~All control equipment including the MCB's shall have modular arrangement~~ and shall be able to be accessed from the front panel.

15.12.6 A pressure control panel shall be provided for each HVAC unit which shall ~~be located for easy maintenance and containing pressure switches and gauges with refrigerant shut off valves to enable easy replacement~~.

15.13 Constructional Requirements and Mounting Details

15.13.1 The HVAC unit shall be designed and constructed to meet the specified noise and vibration requirements.

15.13.2 The compressor, unloading device (if any), motors and pressure switches shall be weatherproof to IEC 60529 IP65, or other approved equivalent standard such as IP56 and IP54 for non-exposed and filtered air area.

15.13.3 Connections for electrical and compressed air, if any, shall be designed for quick disconnection.

15.13.4 The connectors shall be arranged to be protected from damage during removal and permit placement on a flat surface, without sacrificing ease of access.

15.13.5 The condenser coil and evaporator coil shall be located so that it can be cleaned using water from the outside by removing the external covers only.

15.13.6 The condenser and evaporator coils tubes shall be constructed ~~from copper and fins shall be constructed from either copper or epoxy coated aluminium~~.

The condenser coil tubes shall be constructed from copper and fins shall be constructed from either copper or epoxy coated aluminum or polyurethane coated aluminum. The evaporator coil tubes shall be constructed from copper and fins shall be constructed from either copper or epoxy coated aluminum or hydrophilic acrylic coated aluminum.

15.13.7 All external grille shall be designed to prevent water ingress resulting from adverse weather or train washing.

15.13.8 Exhaust grille shall be designed to prevent external outside air to be diffused into the saloon when the train is moving up to the maximum speed.

15.13.9 All mounting rails used inside the control cubicle shall be DIN type, or other approved equivalent type.

15.13.10 Lifting lugs shall be provided at suitable positions to achieve balanced lifting.

15.13.11 The HVAC unit frame and enclosure shall be constructed from aluminium.

15.14 Compressor

15.14.1 The compressor shall be fully-hermetic horizontal scroll type.

15.14.2 The Contractor shall design the overheating and overloading protection arrangement for the compressor motors and submit for approval.

15.14.3 Arrangements shall be made to recover any oil lost from, and automatically return it to, the compressor.

15.14.4 ~~Sight glass shall be provided to check the oil level with maximum and minimum levels clearly marked and visible without removing any other components.~~

15.14.5 The compressor shall be capable of restarting after previously having shut down without a carry out pumping down cycle.

15.15 Refrigerant Circuit

15.15.1 A refrigerant of zero ozone depletion potential index in accordance with Montréal Protocol shall be used and the Contractor shall submit details of the proposed refrigerant for approval.

15.15.2 A sight glass shall be fitted in the refrigerant liquid line to show the refrigerant flow and be visible from the saloon area through an inspection hole accessible from the return air plenum.

15.15.3 Non-ferrous and corrosion resistant material shall be used for the associated piping and fittings in the refrigerant circuit.

15.15.4 Screw couplings will be permitted only where necessary to disconnecting the refrigerant circuit for maintenance. Automatic shut off facilities shall be provided with the couplings to prevent loss of refrigerant for the disconnection. All other connections shall be of a permanent type.

15.15.5 The refrigeration piping system shall be effectively dehydrated prior to charging.

15.15.6 A dehydration device shall be installed in the refrigerant circuit and shall have sufficient capacity to absorb any moisture entering the system during overhaul. The dehydrator shall not require servicing between overhauls.

15.15.7 High sensitivity moisture indicator shall be provided with colour change to indicate the status.

15.15.8 Means shall be provided to avoid loss of refrigerant to atmosphere during charging and extraction.

15.15.9 Facilities shall be provided to allow the refrigerant to be pumped down partially to the liquid receiver and partially into the condenser coil before shut down of the system (refer to PS 9.3.2).

15.16 Condensate Drainage

15.16.1 The Contractor shall submit the sizing and arrangement of condensate drainage to adequately collect and drain condensate without spillage.

15.16.2 Outlets of the condensate drain shall be arranged to avoid dripping on the running rails.

15.16.3 The Contractor shall take into consideration the drainage arrangement in depot

as specified in Clause 2.3 of Appendix I Annex 5.

15.16.4 For those roof-mounted equipments, they shall seat on a sealed arrangement designed to avoid any water getting into the saloon area, under any operating or non-operating condition.

15.16.5 The floors of any unit shall be as flat as possible, and without obstruction which could lead to the collection of pools of water. The floors and sides of the units shall be completely sealed, and adequately drained to prevent penetration of water into the saloon.

15.16.6 The exterior of the drain pan and drain pipes shall be insulated to prevent condensation on the cold surface.

15.16.7 ~~The use of flexible hose to connect the drainage pipes from the HVAC unit to the carbody is not permitted~~.

The use of flexible hose to connect the drainage pipes from the HVAC unit to the carbody is to be minimized and secured from any leakage possibility.

15.16.8 The drainage arrangement shall be integrated with the sealed pan design and shall avoid any blockage by debris.

15.17 Ventilation and Condenser Fans

15.17.1 Fan and motor shall be directly coupled.

15.17.2 No greasing shall be required for any part of the motor and fan coupling.

15.17.3 Each fan and motor assembly shall be dynamically balanced.

15.17.4 The assembly shall be tested to BS 848: Pt 1: 1997, or other approved equivalent standard.

15.18 Ducting

15.18.1 Ducting shall be provided so that each cab is provided with either heating / cooled (under normal operation) or ventilating (under emergency or smoke modes of operation) air for the comfort of the Operator. A suitable manual control shall be provided for easy adjustment of the air flow (refer to PS 8.12.1). The cab shall have a minimum air circulation rate of 170 m^3/h (100 ft^3/min) under all modes of operation

~~15.18.2 The saloon ducting shall be designed to achieve uniform discharge along the~~ whole length of the car. The supply air speed shall be limited to avoid

discomfort due to direct draughts.

15.18.3 The ducts shall be thermally and acoustically insulated. No condensation ~~shall occur on the duct exterior surfaces, ceiling panel or air supply outlets. The insulation arrangement shall be submitted for approval. The ducts and plenum chambers shall be designed to avoid dust traps~~.

The ducts shall be thermally and acoustically insulated as required to maintain interior heating and noise level requirements. No condensation shall occur on the duct exterior surfaces, ceiling panel or air supply outlets. The insulation arrangement shall be submitted for approval. The ducts and plenum chambers shall be designed to avoid dust traps.

15.18.4 The ducting installation shall be in accordance with CIBSE or ASHRAE or equivalent in particular the duct leakage requirements.

15.18.5 The Contractor shall construct a full scale air duct mock-up to demonstrate that adequate consideration has been given to the ducting installations in respect of both air distribution and acoustical performances during preliminary and detailed design phases in accordance with SEMS (refer to PS 21). The Contractor shall carry out necessary combined tests prior to manufacturing by integrating the HVAC unit with the above air duct mock-up to demonstrate the specified ventilation and acoustical requirements are met. Results of mock-up tests will be used for HVAC subsystem design and ~~qualification.~~

15.19 Air Filter

15.19.1 The air filter element shall be non-combustible ~~and manufactured to BS EN 799: 1996 class F8 or better, or other approved standard~~.

The air filter element shall be non-combustible and manufactured to BS EN 799: 1996, class G4 or better, or other approved standard.

15.19.2 The air filter shall provide effective filtering between scheduled maintenance without causing significant increase to air flow resistance.

15.19.3 ~~The air filter element shall be washable type. Disposable filters are not permitted~~.

The air filter element shall be washable or disposable types.

15.19.4 Air filters shall be replaceable from inside the saloon without accessing from the roof.

15.19.5 Means shall be provided to avoid soiling of interiors during replacement of air filters.

15.19.6 The air filter shall not be accessible to passengers.

15.19.7 There shall not be any shrinkage of the air filter due to washing or normal use.

15.19.8 Air filters to clean both fresh and re-circulated air, shall be provided and located in such a manner that it (they) may be easily replaced/installed from within the saloon or cab by maintenance staff (refer to PS 15.6.3).

15.20 Noise and Vibration

15.20.1 The system shall be acoustic and vibration isolated to prevent emission of perceptible or objectionable hum, noise or vibration.

15.20.2 In the event that the Contractor considers that acoustic internal duct lining is necessary in order to achieve the noise levels requirements, the Contractor shall provide the duct lining at no extra cost to the Employer to meet the following requirements:

(a) The acoustic internal duct lining, if fitted, shall be mat-faced duct liner with anti-fungus treated and firmly bonded to the duct with a fire resistant adhesive.

(b) The acoustic lining shall not delaminate or be loosened by the air stream or release any fibre to the air stream under normal operating conditions or impart any odour to the supply air even if wet.

(c) The leading edge of the lining exposed directly to the air stream shall be sufficiently protected to prevent erosion, de-lamination and leakage.

15.20.3 The Contractor shall demonstrate that consideration has been given to prevent the acoustic panel, if fitted, for the HVAC unit from damage such as accumulation of condensate and ingress of water during in situ cleaning of the unit.

15.20.4 The Contractor shall demonstrate to pass mechanical endurance, vibration and shock type tests to the HVAC unit.

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15.21 Heating System

15.21.1 Heating for the cab and saloon shall be provided by baseboard heaters and overhead heaters. In addition to these heaters, the cab area shall be also

provided with a forced-air heater unit. The saloon baseboard heaters shall be located along the side of the car and underneath the seats. Due consideration shall be given to the design of the baseboard heater air grille, such that the air grille surface shall be easily cleanable and the edges shall integrate with the floor smoothly to ensure no dirt traps are present. For those seats that are located at the gangway end, if seat plinth is provided, the baseboard heater shall be located inside the seat plinths and the air grills shall be aesthetically integrated with the seat plinth. Additional heater shall be provided for the door threshold. For safety reason, all heater temperatures shall not exceed 55 C.

15.21.2 The baseboard and overhead heaters shall be automatically controlled by the HVAC system control unit with over-temperature protection provided. The

cab forced-air heater shall be independently operated and thermostatically controlled.

15.21.3 Baseboard heaters shall be limited in power such that the temperature of the surface which can, under normal conditions come in contact with passengers shall not exceed 55°C (131°F) at nominal supply voltage in an ambient temperature of 18ºC (65°F). Localized hot spots which may be contacted by a passenger may not exceed 60°C (140°F).

15.21.4 The overall design of the baseboard heaters and the air grills shall be such a way that there shall be no entry of combustible material, such as newspaper and other material commonly found in transit vehicles, to the element from any direction. The heater enclosure shall be easily removable for cleaning out any debris on regular basis. The securing fasteners shall be stainless steel.

15.21.5 The interior heating element of the baseboard heaters shall attain a surface temperature of not greater than 200°C (392°F) at nominal supply voltage in an ambient temperature of 18°C (65°F).

15.21.6 The heating equipment shall be easily accessible inside the saloon for maintenance and removal, but inaccessible to the passengers.

15.22 Maintainability

15.22.1 General

(a) Maintenance of the HVAC system shall be consistent with the car maintenance philosophy given in PS 26. In particular HVAC components shall have a minimum life equal to the maintenance period of the truck and preferably a multiple of the maintenance period.

(b) Apart from unit replacement, no periodic maintenance access from the roof shall be required. For those equipments that are mounted in the saloon, for example, air return filter, shall be accessible from inside the saloon.

15.22.2 HVAC system Changing

(a) The HVAC system shall be capable of being disconnected and reconnected easily and with a minimum of operations by personnel working in roof. It shall be possible to easily inspect for correct reconnection without the need for special tools or instruments.

(b) The design of the HVAC system shall provide for ease of interchanging. It shall be possible to change either HVAC unit on a Subway Car and release the Subway Car for service using existing Commission shop facilities within three

hours using two trained maintainers. HVAC units shall be completely interchangeable between cars without the need to adjust any components.

(c) The design shall provide ease of HVAC unit changing using the Commission's existing hoisting facilities. Following a HVAC system changeout, it shall be possible to restore the Subway Car to a condition fit for service operation at the same location as the HVAC unit changeout occurred.

15.22.3 Inspection

It shall be possible for personnel working in pits or alongside the HVAC system to visually inspect the condition of components easily just by opening the unit cover, and without the use of special tools.

15.22.4 Cleaning

The unit arrangement shall be designed to allow equipment such as coil, of being cleaned using high pressure hot water and steam jet cleaning equipment, with and without high efficiency detergents. All closed sections and pockets shall be self draining or sealed against water intrusion.

15.22.5 Handling

Lifting attachments shall be provided for handling a complete HVAC unit.

Figure 15-1 Temperature Control Chart Sample - normal mode (ventilation fans "ON" all the time)

Figure 15-2 Temperature Control Chart Sample - layover mode (ventilation fans "OFF" all the time)

SECTION 16 - DOORS 2

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Section 16 - Doors

16.1 General

16.1.1 Layout and Arrangement

(a) Four pairs of electrically powered passenger sliding doors shall be provided on each side of each car.

(b) An emergency detrainment door shall be provided at the front of each driving cab (refer to PS 8.16).

(c) A partition door shall be provided between each driving cab and the saloon.

(d) One pair of manually operated cab bodyside doors shall be provided on each side of each cab (refer to PS 8.15.4).

(e) The passenger doors shall be designed to using for reference the AUTHORITY T1 door

pitch. An acceptable variation from the current dimension which shall be taken into consideration the seating spatial arrangement as described in PS 7.6.1, shall be submitted for approval.

(f) Apart from replacement of door panel, no maintenance access shall be required from the outside of the saloon.

16.1.2 Construction

(a) Reference in this Section to power supplies means the electrical supply required for door power operation and control functions.

(b) The exterior doors shall be of robust design and construction, capable of withstanding the specified design loadings, and be impact resistant (refer to

PS 16.2.5(a)) and durable with minimal maintenance requirements.

(c) All components and equipment that are accessible to the passengers during any part of the door operating cycle shall be vandal resistant.

(d) The doors shall be designed to prevent ingress of water in severe storm conditions which are usually encountered in the CITY area and during washing in an automated wash plant.

(e) Gutters shall be provided above all bodyside doors to protect staff, passengers, saloon and cab interiors, and door operating mechanisms, from water running off the roof.

(f) Under no circumstance shall it be possible for the doors to become jammed or

fail to close under any condition of car loading.

16.1.3 Safety

(a) The design of the door system as a whole, together with the interfaces with carbody, shall not cause any injury to the passengers, train operator or station operator under any normal operating conditions. Due consideration shall be given to minimising the possibility of human error causing injury due to mis-operation.

(b) Door control and operating arrangements shall be designed to fail to a safe condition with no hidden failure.

(c) No single component failure shall result in an unsafe failure mode, such as a door being powered open in the absence of a valid "open" command.

(d) The Contractor shall demonstrate, by a combination of attention to the design detail of the leading edge of the door and appropriate actuation and control facilities, the ability of the door systems to reduce the risk of entrapment to a minimum and eliminate the risk of a train being released to start with an obstruction between any door leaves.

(e) The Contractor shall ensure that the doors will be operated within the specified kinematic envelope under all normal operating conditions.

(f) The status of each door shall be monitored by the TIMS which shall detect and report emerging door problems (refer to PS 10.5.4).

(g) The door system, in particularly the carbody and door leaf interface, shall be designed to prevent passenger injury due to the entrapment of body during the opening and closing movements of the doors.

16.1.4 Acoustic and Vibration

(a) Consideration shall be given in the design of the doors to the overall acoustic

performance of the train as specified.

(b) The doors installation shall be quiet in operation and shall be free of all "rattle", "squeak", "whistle", "slamming" and other inappropriate operationally generated noise, or train movement induced noise.

(c) All elements of the doors installation (fixed and moving) shall be sufficiently rigid to avoid generation of noise by panel excitation as a result of train or air movement.

(d) All arrangements for movement shall incorporate noise and vibration control wherever practicable. Details of the proposed noise and vibration control

measures shall be submitted for approval prior to commencement of fabrication.

16.1.5 The design and operating features of all types of doors shall be submitted for approval.

16.2 Passenger Bodyside Door

16.2.1 Spatial Arrangement

A clear opening of not less than 1 524 mm (5') wide and 1 930 mm (6' 4") high, shall be provided on each passenger door of each car.

16.2.2 Door Panel Construction

(a) The exterior and interior surfaces of the doors shall be finished in accordance with the agreed external livery and interior design (refer to PS 6).

(b) The door panel shall be resistant to normal detergents and chemicals such as dilute phosphoric and oxalic acids or similar, used for internal and external car cleaning.

(c) The doors shall be free from surface defects such as dimples, warping, spot welding depressions and blemishes.

(d) The doors shall be provided with fixed flush fitted single glazed windows to the colour specified in PS 6.

(e) The door panel shall be designed to avoid the possibility of any ingress of water into, and the formation of condensate within, the door structure.

(f) No electrical equipment shall be located on any door panel.

(g) The maximum weight of a saloon door panel shall not exceed 50 kg.

(h) The door panel shall be designed to last for the life of the train without major refurbishment required. In designing to achieve this the Contractor shall give due consideration to the climatic conditions in CITY as specified.

16.2.3 Sealing Arrangement

(a) The sealing arrangement between the door leaves and the carbody shall avoid any finger trapping or causing any injury to passengers during door opening or closing operations.

(b) The doors shall be fully sealed when closed to meet the specified acoustic

requirements and the water tightness requirement as stated in PS 16.1.2 (d).

(c) The door panel seals shall be non-contact when the door is moving.

(d) The seals shall not impede operation of the door and they shall have adequate operating clearances and adjustment to ensure that scuffing of the bodyside and panels of the doors does not occur in operation.

(e) The seals shall be securely fixed by an approved means, avoiding the use of loose fasteners or adhesive. They shall be easily replaceable and adjustable and shall not allow the build up of dirt or moisture. All fixings to door seals shall be concealed.

(f) The door nose rubber shall be designed in such a way that they shall be easily replaceable and adjustable without removal of the door panel from the car.

16.2.4 Door Operating Mechanism Construction

(a) All components and systems, such as rollers, racks, gears and pinions, not intended for passengers use, shall be inaccessible to passengers at all times, including during the door operating cycle.

(b) The mechanism shall be simple with the number of moving parts kept to a minimum.

(c) The door mechanism including guides shall be arranged so that no objects can become trapped and prevent door operation.

(d) For all operating modes and under all power supply conditions, door movements shall be smooth, controlled and without jerks or any violent motion.

(e) No part of the doors, door installation, door control systems or any other door system components shall be damaged, or have their service life shortened by repeated or continuous stalling by obstructions, or pushing back of the doors by passengers.

(f) Each mechanism shall be mounted on a rigid frame that can be adjusted for alignment in situ, and removed from the car as an integral unit.

(g) The operating mechanism shall be housed inside the car and the design shall provide for ease of access for maintenance.

16.2.5 Strength

(a) Each door panel, associated mountings and structural support shall, with the door correctly mounted and in the closed position, be capable of meeting the

following requirements without permanent deformation, damage or failure:

(i) A maximum deflection of 7.6 mm (0.3"), a force of 880 N (200 lbs). applied on an area of 600 mm x 300 mm (24" x 12") with the long axis parallel to the door, 50 mm (2") in from the door edge and centred within the height of the door.

(i i) After test (i) above, the door shall be immediately capable of normal operation and there shall be no apparent damage or displacement of the window and the glazed parts of the door shall remain intact and in position throughout application and removal of load.

(i i i) The effect of pressure pulses as specified in PS 6.11.3.

(b) Displacement of door panel from the door suspension and door panel delamination shall not occur in the above conditions.

16.2.6 Door Control Unit

(a) Each doorway shall be provided with a single door control unit for local control and monitoring. The purpose of the door control unit is to provide the local control for door operation and a central connection point for door sensors and door drive.

(b) The door control unit shall provide all the logic and operational control upon receipt of

EITHER the hardwired command signals from the door controls in the active cab, the local manual release device (refer to PS 16.2.10) and the door isolation device (refer to PS 16.2.8).

OR the coded command signals from the TIMS communication link

(c) The hardwired command signals to the door control unit shall include:

(i) DOORS OPEN

A hardwired signal from the active door control panel of the driving cab or the local manual release device to initiate the door open procedure in accordance with the PS 16.2.6(e). The open signal from the active cab shall be initiated from the door open pushbutton (refer to PS 8.8.6) in conjunction with the DOOR ENABLE SIGNAL (refer to PS 9.8). The DOORS OPEN signal shall be latched until DOORS CLOSE signal is received.

(ii) DOORS CLOSE

A hardwired signal from the active door control panel of the driving cab or the local manual release device to initiate the door close procedure in accordance with the PS 16.2.6(e). This shall unlatch the DOORS OPEN signal.

(iii) ZERO VELOCITY

This signal will be initiated from the traction and braking systems under the train conditions as specified in PS 9.8.11.

(d) The coded command signals from the TIMS communication link to the door control unit shall include:

(i) Remote door isolation function (refer to PS 16.2.13(c)(ii))

(i i) Maintenance of door operational parameters (refer to PS 16.2.12 and 16.2.13)

(e) Assuming that the doorset has not been isolated, the door control unit shall open or close the corresponding doorset in accordance with the following conditions (refer to PS 16.2.10 for Local Door Release requirements):

Hardwire Commands					Next Door State
ZERO VELOCITY	OPEN	CLOSE	OPEN (Local Door Release: Manual Release Device or Local Door Release Switch)	CLOSE (Local Door Release Key Switch)	
1	1	0	X	X	OPEN
1	0	1	0	0	CLOSE
0	X	X	0	0	CLOSE
X	X	X	1	0	OPEN
X	X	X	X	1	CLOSE

Hardwire Commands	Next Door State

ZERO VELOCITY	OPEN	CLOSE	OPEN (Local Door Release: Interior Manual Release Device or Exterior Local Door	CLOSE (Local Door Release Key Switch or Local Crew Switch)	
1	1	0	X	X	OPEN
1	0	1	0	0	CLOSE
0	X	X	0	0	CLOSE
1	X	X	1	0	OPEN
1	X	X	0	1	CLOSE

(Table Modified)

Legends:

- "1" means the corresponding command is requested.
- "0" means the corresponding command is forbidden.
- "X" means don't care.
- Any other combination shall be considered as invalid, with the only exception of the event that, the command input of the Manual Release Device is conflicting with the Local Door Release Key Switch, the command input of Local Door Release Key Switch shall prevail.

(f) The door control unit shall validate the logic of various command signals and report any fault to the TIMS. For example:

Commands		Door State	Remark
OPEN	CLOSE		
1	1	As previous state	Report fault to the TMS
0	0	As previous state	

"1" means the corresponding command is requested.

"0" means the corresponding command is forbidden.

(g) The Contractor shall provide all the alarm and condition monitoring of all applicable system components in order to observe system performance, and fault diagnostics and aid the timely provision of preventive maintenance as necessary to comply with the door system performance requirements described in the PS. The Contractor shall submit the monitoring parameters for approval.

(h) The Contractor shall provide the facility for local interrogation via a serial link at each doorset, by the use of portable computer. Details and performance of the serial link shall refer to PS 10.

(i) Each door control unit shall process and transmit the operational monitoring signals to the TIMS via the communication link (refer to PS 10) under all conditions irrespective of the door isolation status (refer to PS 16.2.8).

(j) Each door control unit shall be able to verify the door status. When the door is proved to be in a fully closed and locked state, the door control unit shall send a door FULLY CLOSED signal to the Door Proving Loop as specified in PS 16.2.9(f).

(k) The door control unit shall have a self test function on power up that can check the system healthiness (refer to PS 16.2.13(b)). It shall be able to provide indication of alarm status should any irregularities be detected. The results of the self test (including the alarm status if there are irregularities detected from the door control units) shall be reported to the TIMS via the

communication link.

(l) Prior to door is commanded to close, the flashing yellow LED light fixtures (refer to PS 7.9.1(n)) shall be activated to flash at a frequency of 0.25Hz for 2 secs in order to warn the passenger that the door is about to close. Audio warning in a form of door closing chime shall also be provided (refer to PS 18.4.12(d)(iii)).

16.2.7 Mechanical Lock

(a) Each door shall incorporate a heavy duty lock which engages automatically when the door is fully closed, irrespective of the availability of power.

(b) The lock shall positively engage both door leaves and be able to release automatically when the door open controls are legitimately operated or when the manual release device is operated (refer to PS 16.2.10).

(c) The operation of the lock relative to the door opening cycle shall ensure release before the commencement of the cycle and engagement on closure, with or without the availability of power. Door status shall be monitored by the individual door control unit.

(d) When the lock is released, it shall be possible to push/slide open the door from inside or outside the saloon.

(e) The door leading edge seals shall be configured in such a way, utilizing interlocking mating arrangements, that the locking devices shall not engage in the presence of small obstruction of maximum thickness 3 mm at any height of application using the measurement gauge as shown in the Contract Drawing No. NST 077.

(f) Each mechanical lock shall be fitted with a sensor to prove that the door is locked. The status of the mechanical lock shall be monitored by the TIMS.

(g) The mechanical lock shall not require lubrication between overhauls.

(h) The mechanical lock shall be spring loaded and energised to release.

16.2.8 Door Isolation Device

(a) ~~Each doorway shall be fitted with a manual door isolation device which shall engage a mechanical lock holding both panels in the closed position and~~ isolate the door drive from the power supply when operated with ~~the AUTHORITY's staff key~~.

Each doorway shall be fitted with a manual door isolation device which shall

engage a mechanical lock holding both panels in the closed position and isolate the door drive from the power supply when operated with the AUTHORITY 's Square SRT Key.

(b) Operation of the door isolation device shall bypass the corresponding door from the Door Proving Loop (refer to PS 9.9.7) so that :

(i) the door FULLY CLOSED signal as specified in PS 16.2.9(f) shall be isolated from the Door Proving Loop.

(ii) the door control unit shall not respond to any door open or close control commands.

(c) Operation of the door isolation device shall not disrupt the transmission of any monitoring information to the TIMS.

(d) The door isolation device shall be accessible from inside the saloon without removing or opening any interior panels.

(e) The status of the door isolation device shall be monitored by the TIMS.

16.2.9 Door Sensors

(a) Door close sensor shall be provided for each door leaf which shall provide a positive door closed indication only when the gap between the door leaves is less than the specified value of 3mm.

(b) Door open sensor shall be provided for each door leaf which shall provide a positive indication when the front edge of the door leaf is greater than or equal to the full opening width as measured from the centreline of the doorway.

(c) The sensors shall be positioned such that they are not affected by lateral or longitudinal displacement of the door by normal wear of any part of the door in service.

(d) A doorset shall be defined FULLY CLOSED when:

(i) both door leaves are proved closed as indicated by the door close sensors, and

(i i) the mechanical lock is engaged as indicated by the mechanical lock sensor

(refer to PS 16.2.7(f)).

(e) A doorset shall be defined FULLY OPENED when both door leaves are proved fully opened as indicated by the door open sensors.

(f) The door control unit shall send a door FULLY CLOSED signal to the Door Proving Loop (refer to PS 9.9.7) when the door is FULLY CLOSED as defined in PS 16.2.9(d).

(g) The selection of the door sensors shall ensure that overall reliability

requirements shall be met.

16.2.10 Local Door Release

(a) An interior manual release device shall be fitted to each doorgear and shall comply with the following requirements:

(i) It shall be operable from inside the car.

(i i) It shall be possible to permit a passenger to open the door from the saloon, in the event of emergency, by the pushing out of an emergency access panel on the door coving panel (refer to PS 7.5.8) and operate the manual release device through the opening.

(iii) The manual release device shall be visible to the passenger through the emergency access panel opening.

(iv) The emergency access panel shall be easily pushed out by a force of 80 - 200 N.

(v) Refitting of the emergency access panel shall be done in 15 minutes by one maintainer.

(vi) Instructions which shall be written in English with the aid of graphical illustration, simple and easy to understand, for operating the manual release device shall be provided and prominently displayed.

(vii) The device shall be flush mounted at the door coving panel.

(viii) When the device is operated, it shall release the mechanical lock and send an open command to the corresponding door control unit to power open the door automatically. The Door Proving Loop shall be interrupted as a result of the release of the mechanical lock (refer to PS 16.2.9(f)).

(ix) Should power not be available, the device when pulled further shall unlock the doors to allow these to be manually opened.

(x) When the device is reset, it shall send a close command to the corresponding door control unit to close the door automatically.

(xi) Irrespective of the position of the door isolation device (refer to PS 16.2.8), the manual release shall always perform its intended operation.

(b) An exterior local door release device shall be fitted to the doorways of nos. 1/2 and 15/16 (refer to Contract Drawing No. NST 072 for naming convention) and shall comply with the following requirements:

(i) ~~It shall be a key switch and operable from outside of the car by using the AUTHORITY's staff key~~. It shall be a key switch and operable from outside of the car by using the AUTHORITY's Square SRT Key.

(ii) ~~The key switch shall have the following three valid sequential positions of~~ Open, OFF and Close ~~to facilitate emergency door operation. Also, the key switch shall be spring biased towards the OFF position when unattended~~: The key switch shall have the following three valid sequential positions of Open, OFF and Close to facilitate emergency door operation.

(1) Open. Clockwise rotation, as view from outside of the car facing the switch, of the key from centre shall issue a local open command to the door control unit of the adjacent door to open the door automatically.

(2) OFF. The OFF position shall be the default position and no command shall be issued.

(3) Close. Anti-clockwise rotation, as view from outside of the car facing the switch, of the key from centre shall issue a local close command to the door control unit of the adjacent door to close the door automatically.

(iii) The device shall be flush mounted at the external carbody panel, equipped with a flagged spring-biased cover to avoid accidental actuation and protect against water ingress during car wash.

(c) If power is unavailable, operation of any device shall enable the door to be manually opened or closed easily by a normal 5th percentile Canadian female.

(d) TIMS shall monitor the status of both devices. Operation of any device shall be reported to the train operator and record in the event recorder.

16.2.11 Bodyside Indicator Light

(a) On each side of each car, a red coloured LED lamp of tamper proof design shall be provided (refer to 6.10.4) which shall lit when:

(i) any non-isolated door is not proved fully closed (refer to PS 16.2.9(d) on that car, or

(i i) any internal/external manual release device is operated on that car, or

(i i i) ~~any passenger alarm device is operated on that car~~.

Item iii deleted

(b) On each side of each car, a white coloured LED lamp of tamper proof design shall be provided (refer to 6.10.4) which shall lit when any Door Control Master Switch (PS 8.8.6.(a)) is operated on that car.

(c) On each side of each car, an amber coloured LED lamp of tamper proof design shall be provided (refer to 6.10.4) which shall lit when any passenger alarm device is operated on that car.

(d) The sealing of the indicator shall be protected to IEC 60529 IP65.

(e) The brightness, size and location of the illuminated bodyside indicator light shall ensure clear visibility from any position on the platform.

(f) All the lights on one side shall be visible down the length of the train, on straight track, when viewed from either cab side door position on that side of the train.

16.2.12 Door Opening and Closing Profiles

(a) Door Open/Close Speed

(i) The two door panels at each doorway shall be synchronously controlled and driven through the use of a sympathetic screw drive motion to give equal distance of opening from the door centre line throughout the operation.

(ii) All timings specified relate to the open and close times for the door system as a whole, the times being measured from the activation of the door actuation device to the completion of the movement of the door panel.

(iii) The passenger doors shall open fully within 2.1 to 2.5 seconds and shall close fully within 2.5 to 3.0 seconds. The velocity and the panel mass shall be limited by dynamic safety considerations.

(iv) The limiting maximum velocity shall be 0.5 m/s for the door leaf open/close speed. Final value shall be dependent on the Contractor's design for dynamic safety.

(v) ~~The design parameters, including the speeds, acceleration or deceleration, shall be easily adjustable by the maintenance staff through the TIMS remotely from the driver's console via the Train Communication Network, and through the door control unit via the serial link~~. As per 10.5.4 (e), the door profile parameters shall be changed from YMSS or by using Door PTE.

(vi) Door opening and closing parameters shall not be drifted and shall be

maintained at the preset values between overhaul periods.

(b) Door Closing Force

(i) The end of the door opening and closing strokes shall be safely damped.

(i i) The maximum door closing force shall be 300 N reducing to 150 N over the

final 200 mm (i.e. 100 mm per door leaf) of door travel. The force required to prevent a door from closing shall not cause any acute pain to a passenger who is trapped between the two door leaves in the closing cycle, and the force shall not exceed the tolerance limits for impact injury in children and older adult. Design for low energy door operation according to ANSI/BHMA A156.19-2002, where applicable, shall be followed.

(i i i) The door closing force shall be carefully designed to ensure that the door can be fully closed under crush laden conditions whilst not introduce excessive slamming force onto the passengers.

(i v) The design parameters mentioned in PS 16.2.12(b)(ii) above, including the normal force, the reduced force and the location where it is applied, shall be easily adjustable by the maintenance staff through the TIMS remotely from the driver's console via the Train Communication Network, and through the door control unit via the serial link.

(v) The door closing force shall be removed when an obstacle is detected and shall be rebuilt after a predetermined time or once the obstacle is removed (refer to PS 16.2.13(e)).

(c) The Contractor shall demonstrate the following:

(i) The effectiveness and safety of the opening and closing cycles;

(i i) Appropriate diagrams, supported by tests results, to detail the relationship between the door velocity, acceleration, deceleration, kinetic energy, force and the door position in the operating cycles.

(i i i) Particular attention shall be paid to zones of acceleration in terms of dynamic

loadings to the door operating equipment and the kinetic energy to be dissipated in the event of a door leaf meeting an obstruction.

16.2.13 Protection Logic

(a) The door system shall be provided with protective systems to cater for probable faults or failures. This Section provides details of the primary protective systems that shall be inherently part of the operational procedure.

(b) Startup /Shutdown Logic

(i) The door system shall shutdown in response to designed trips or equipment failure in a safe and orderly fashion so as to ensure minimum disruption to the system operation.

(i i) Automatic startup equipment check shall be conducted to ensure that the door system returns to service in an orderly fashion.

(i i i) The door system shall be returned to the DOOR CLOSED state during startup.

(i v) Any failure found in the automatic startup test shall be reported to the TIMS.

(c) Failure to Close

(i) In the event that the ALL DOORS CLOSED signal is not confirmed for a predetermined time period after the initiation of the DOOR CLOSE command signal by the train operator, the door(s) which have not proved FULLY CLOSED (refer to PS 16.2.9(d)) shall stop and back off by a predetermined amount and then reclose automatically. Restoration of the closing force shall not result in a slamming action of the doors. This action shall be repeated for a predetermined number of reclosing attempts, after which the door(s) which have not proved closed remain in stalled position and a fault signal shall be reported to the TIMS. The train shall be prevented from leaving unless the Door Proving Loop Cut Out Switch is operated (refer to PS 9.9.7(h)) or the concerned door is isolated.

(i i) In case it is necessary to electrically isolate the concerned door(s), the train operator shall be able to isolate the door close signal remotely from the driver's console via the Train Communication Network and a predetermined fault message shall be provided to the Passenger Information System (refer to PS 10.4.2). If the door panels need to be mechanically isolated, the door isolation device (refer to PS 16.2.8) should be used.

(i i i) The Door Proving Loop shall be hardwired through all system elements.

(i v) The design parameters mentioned in PS 16.2.13(c)(i), including the back off distance, waiting time and the number of re-closing attempts, shall be easily

adjustable by the maintenance staff through the TIMS remotely from the driver's console via the Train Communication Network, and through the door control unit via the serial link.

(d) Failure to Open

In the event that the DOOR OPENED signal (refer to PS 16.2.9(e)) is not confirmed for a predetermined time period after the initiation of the DOOR OPEN signal by the train operator, a warning signal shall be sent to the TIMS.

(e) Obstruction Detection

(i) Upon encountering an obstruction, the corresponding door shall stop and back off by a predetermined amount and allow a manual push back by personnel to occur of up to full open width with reduced opposing force and reclose automatically after a predetermined period of time. Restoration of the closing force shall not result in a slamming action of the doors. This action shall be repeated until the obstruction is removed or a predetermined number of re-closing attempts has been reached, after which the door(s) which have not proved FULLY CLOSED (refer to PS 16.2.9(d)) shall remain in stalled position and a fault signal shall be reported to the TIMS. The train shall be prevented from leaving and thus attracting the attention of the train operator to take appropriate action.

(ii) The obstruction detection function as specified in PS 16.2.13(e)(i) shall be operative upon the presence of a small object of 75 mm high held between, and perpendicular to the door panel, creating an obstruction greater than 3 mm at any height of application except the uppermost and lowermost 3 inches of the nosing seal.

(iii) The method proposed for preclusion of entrapment shall be drive resistive sensing. Leading edge design is not encouraged unless it is proved to be very reliable and maintenance free.

(iv) The design parameters mentioned in PS 16.2.13 (e) (i) above, including the back off distance, reduced closing force, waiting time and the number of re-closing attempts, shall be easily adjustable by the maintenance staff through the TIMS remotely from the Train Operator Console via the Train Communication Network, or through the door control unit via the serial link.

(f) Door Opened

If the DOOR CLOSED signal is removed when the door system is not in the open procedure, then a fault signal shall be sent to the TIMS.

(g) System Failure

Under a full system failure due to loss of power, or control failure, any open doors shall return safely to the closed position without the need for staff intervention. Manual release device as specified in PS 16.2.10 shall be operated to open the door.

16.2.14 To prevent snow / ice build-up during the winter and obstructing the door operation, an appropriate heater shall be provided uniformly over the door threshold and two door sides at each double doorway (refer to PS 15.21).

16.3 Emergency Door

An emergency door shall be fitted to the front of the cab as specified in PS 8.16.

16.4 Cab to Saloon Partition Door

16.4.1 General Arrangement

(a) The cab to saloon partition door is a single door located in the centre of the cab rear bulkhead to permit access between the cab and the saloon.

(b) The doorway shall have a clear width of 1080 mm (42.5”) with the door leaf opening into the cab.

(c) The door shall not be forced open or prevented from opening due to pressure of passengers.

(d) A surveillance window shall be provided and located at the centre of the top-half of the door, so that the operator can view the whole passenger compartment from the cab in the seated position. The window size shall be identical with the end door window as shown in the Contract Drawing No. NST 013. The window shall be tinted and have a mirrored finish.

16.4.2 Normal Operation

(a) The cab to saloon partition door shall be hinged on the RHS when viewed from the passenger compartment and shall open into the Subway Car.

(b) The cab to saloon partition door shall be able to move through latch to the adjacent Train Operator Console at about 90º of movement.

(c) The cab to saloon partition door shall be provided with the necessary stops and latches to prevent unlatching during normal service operation. The latch type shall be submitted for approval.

(d) The cab to saloon partition door shall automatically lock when closed or latched to the adjacent Train Operator Console and unlock from the passenger area side with the AUTHORITY's cab door key. When closed, it shall be opened from the inside by a simple handle. Handles for opening the door shall be provided on both sides and shall be as recessed flush as possible with the door surface on the passenger side.

(e) The cab to saloon partition door shall be constructed of high-pressure decorative laminate having an integrally coloured melamine facing and protected by a plastic surfacing material on both sides, the total thickness to be not less than 13 mm (1/2 inch). The colour shall match the corresponding colour scheme of the passenger compartment and shall be the same colour and

texture on both sides to prevent warping.

16.4.3 Emergency Operation

(a) Provision shall be made to permit a passenger to open the door leaf from the saloon, in the event of emergency, by the pushing out of an emergency access panel on the door leaf and operate the door handle on the cab side through the opening. Alternate arrangement which can achieved the similar efficiency and effectiveness for emergency evacuation, shall be submitted for approval.

(b) The door handle shall be visible to the passenger through the emergency access panel opening.

(c) The emergency access panel shall be pushed out by a force of 80 - 200 N.

(d) Refitting of the emergency access panel shall be done in 15 minutes by one competent maintenance staff.

(e) Instructions which shall be written in English with the aid of graphical illustration, simple and easy to understand, for operating the door handle shall be provided and prominently displayed.

16.4.4 The cab main light shall be turned on automatically when the cab to saloon partition door is opened.

16.5 Life Expectancy and Maintenance

16.5.1 The doors shall not require maintenance, adjustment or resetting between overhauls (refer to PS 27).

16.5.2 The design life of the doors system as a whole shall be equal to the life of the train.

16.6 Prototypes and Testing

16.6.1 Fully operational prototype for two passenger bodyside doors, two cab bodyside doors and one emergency door shall be constructed in the cab and saloon mock-up (refer to PS 7.2 and PS 8.2).

16.6.2 The prototypes shall be constructed to demonstrate the appearance and operation of complete door installations. In this respect the trial installation is required to reflect, as far as possible, the conditions and support arrangements in the train. The prototypes shall incorporate all fixings, ironmongery, seals, finishes attachments, details and appurtenances to fully reflect the "as-installed" condition.

16.6.3 Testing shall be conducted in accordance with Appendix B Clause 2.11.

16.6.4 Testing procedures submitted shall demonstrate all the safety related facilities of the doors installation.

SECTION 17 AUXILIARY ELECTRICAL SUPPLY 2

17.1 ..... *General* *2*

17.2 ..... *Auxiliary Converters* *2*

17.3 ..... *Alternating Current (AC) Circuit* *7*

17.4 ..... *Direct Current (DC) Circuit* *9*

Section 17 Auxiliary Electrical Supply

17.1 General

17.1.1. Apart from the traction equipment (refer to PS 11), the electrical power supplies of the other electrical equipment, such as the auxiliary converters and air compressor, if it is not driven by an alternating current (AC) motor, utilised by the train shall be derived from the traction supply. Interface requirements according to IEEE Std 1476-2000 "IEEE Standard for Passenger Train Auxiliary Power Systems Interfaces" shall be met.

17.1.2. The auxiliary converters and air compressor (if appropriate) shall be independently supplied from the traction supply, via the line contactors. The requirements as stipulated in PS 17.2.3 shall apply to both auxiliary converters and air compressors.

17.1.3. All the auxiliary electrical equipment that are not supplied directly from the traction supply, shall be powered from the low voltage auxiliary power supplies provided by the auxiliary converters during normal operation (refer to PS 17.2.1(a)).

17.1.4. All emergency systems which shall include but not be limited to the following systems/equipment:

- friction brake system (refer to PS 11.9),
- communications system (refer to PS 18.1.4),
- interior emergency lighting (refer to PS 7.11.4),
- door equipment (refer to PS 16.2.6),
- emergency ventilation (refer to PS 15.7),
- TIMS except the passenger information system (refer to PS 10.4), and
- DC supplied operation and control circuits (refer to PS 9) including the head and tail lights (refer to PS 9.9.11)

shall continue to operate for at least 1 hour after a power failure due to loss of traction or auxiliary power supply. The proposed list of equipment of the emergency systems shall be submitted for approval. In order to meet the 1 hour duration on battery power, load shedding is allowed during that period.

17.1.5. Final circuits for the above emergency systems shall be electrically separate from one another and from other circuits.

17.2 Auxiliary Converters

17.2.1. General Requirements

(a) The auxiliary converter shall be either:

(i) a direct current (DC) to alternating current (AC) converter based power supply system for the AC power supply distribution approach; or

(ii) DC to DC converter based power supply system plus an appropriate DC to AC inverter sub-system for the DC power supply distribution approach.

By SEMP 1, the finalised power supply distribution approach shall be submitted for approval.

(b) The auxiliary converter shall provide an auxiliary power supply sources of AC three phase output for supplying the AC circuit (refer to PS 17.3) and a DC output through a battery charger (refer to PS 17.4.2(d)) for supplying the DC circuit (refer to PS 17.4).

(c) The AC output provided by the auxiliary converters, shall be such that:

(i) in the event of one auxiliary converter failure, it shall not cause the loss of more than 1/3 of the saloon lighting and 1/2 of the air conditioning system, in any one car.

(i i) Traction gaps (refer to Clause 4.4 of Appendix I Annex 2) shall not cause the loss or reduction of performance of any load on the train, under normal operating conditions.

(d) The DC output provided by the auxiliary converters, shall be arranged to ensure that neither the control or battery charging supplies are not lost in the event of a failure of an auxiliary converter.

(e) When a DC distribution approach is adopted, an appropriate number of Intermediate DC Voltage Power Supply (IVPS) system which shall be a DC to DC converter sub-system connecting in parallel on a train-wide bus, shall be provided with the following functions:

(i) The IVPS shall be able to provide a stabilized and filtered input voltage source for supplying the DC power to a distributed inverters system at each major AC load of the train.

(i i) A 3 phases, variable voltage variable frequency (VVVF) type of DC to AC inverter system shall be provided at each major AC loads, including the air compressor and the HVAC sub-systems. It is acceptable to use one inverter to feed the 2 HVAC units of a given car. The single phase, 120Vac, 60Hz output can be derived from the HVAC inverter, through an isolation step-down

transformer.

(iii) The inverter system shall be integrated into the train control system, and shall provide an output voltage at the proper voltage and frequency for the associated AC loads.

(iv) The voltage waveform shall be fully compatible with the loads needs.

(v) The low voltage DC power supply (LVPS) system shall be provided independently, in similar manner of the IVPS, by using an appropriate number of LVPS system which shall be a DC to DC converter sub-system connected in parallel on a low voltage train-wide bus.

(vi) The LVPS and IVPS systems shall be an integrated power supply systems of which the LVPS and IVPS converter shall be physically integrated within the

same enclosure whilst these converters shall be functionally independent, and shall be powered from the 600Vdc traction supply. If an air compressor converter is used, it shall be integrated with the same enclosure.

(vii) The number of paralleled DC to DC converters as used for the IVPS and LVPS, shall be adequately rated for supplying continuously all the loads on the train with one LVPS and/or one IVPS converter(s) defective(s) or unavailable.

(f) When an AC distribution approach is adopted, the DC to AC converters which shall be adequately rated to enable the supply of an additional load imposed by the cab car, shall be provided.

(g) All auxiliary converters of the same application shall be identical and interchangeable. The converters shall be underframe mounted, except for those distributed inverters that are used for supplying the AC power, shall be mounted inside the associated converter unit.

(h) All internal items of the equipment shall be easily accessible and detachable, with the converter "in situ", to facilitate maintenance. For those converters/inverters that are small and compact in both size and power level, they can be considered as a single LRU (refer to PS 26.2.5).

(i) For those equipment cases that are underframe mounted, shall be sealed to IP 65 as defined in IEC 60529. The other converters/inverters shall have a protection index level adapted for the intended operating environment; the protection level shall be approved by the Engineer.

(j) The efficiency of the auxiliary converter shall be higher than 80 % for all combinations of load over the full load range except when the total load is less than 10 % of full load.

(k) The auxiliary converter shall be capable of withstanding the full voltage range of the traction supply and still maintain the outputs as specified.

(l) High voltage spikes or transients on the traction supply shall not be transmitted to the auxiliary converter outputs. The auxiliary converter shall not suffer any damage or malfunction, when subjected to surges and transients

as specified in RIA 12 and the worst case surges, such as, the surge produced by the traction high speed circuit breaker when rupturing fault currents.

(m) In the event of a failure of the DC output (refer to PS 17.2.1) from the auxiliary converters, the DC circuit (refer to PS 17.4) shall still continue to operate correctly by power automatically supplied from the battery.

(n) In the event of a failure of one LVPS, the low voltage output bus shall be able to power continuously all the low voltage loads on the unit. In that case, during traction gap, it is acceptable to have some contribution from the

floating storage batteries to temporarily sustain the load until the LVPS in the gap is powered again. However, the batteries shall not discharge in average.

(o) In the event of a failure of one IVPS, the IVPS bus shall be able to power continuously all the Inverters on the train. In that case, during traction gap, it is acceptable to temporarily reduce the output power at the load during the power loss at the IVPS input. This power reduction shall be controlled locally at the distributed inverters.

(p) The design of the auxiliary converter shall comply with the IEC 61287 part 1 : 1995.

17.2.2. Control Requirements

(a) The starting, stopping and fault resetting control requirements of the auxiliary converters are specified in PS 9.2 and 9.3.

(b) To avoid loss of auxiliary power supply at gaps in the third rail, due consideration shall be given to design of the auxiliary converter control, in such a way that, the auxiliary converter shall be able to function continuously when:

(i) any one car of the train is operating in a traction gap; and

(i i) the traction gap detection has been activated to isolate the collector shoes of that car (refer to PS 11.6.1(c)(vi)).

17.2.3. Protection and Cooling

(a) The Contractor shall demonstrate to the satisfaction of the Engineer that adequate protection is provided by the auxiliary converters against fault conditions, such as, overloads, surges and transients.

(b) Cooling System

(i) Semiconductor cooling shall use appropriate cooling system of natural convection or forced air method. When forced air cooling of the semiconductor is used, it shall be supplied together with a maintenance free cyclone filter system and earthed heatsinks with all surfaces that require insulation enclosed in clean conditions. The cyclone filter which shall use centrifugal force to collect the dust, shall be equipped with an easy mean to check the level of dust and empty the dirt. It shall also provide a consistent suction power by filtering big and heavy dust first before the dust container becomes full. With the DC distribution approach, it is permitted for the Inverter to be in the HVAC unit to take advantage of the specific local environmental conditions, especially the presence of air flow on the heat sink fins, coming from the HVAC blower fans. No additional cooling blower shall be added for that purpose. The cooling system shall insure proper operation

under all HVAC and inverter module's transient and steady sate operating modes and conditions.

(i i) The design life of the cooling system shall not be less than 20 years.

(i i i) Cleaning and other maintenance shall not be required at periods of less than 5 years. Cleaning period for the air filters used in the forced cooling system shall be at least 90 days.

17.2.4. Operation Under Fault Conditions

(a) The auxiliary converter shall be automatically isolated from the traction supply line, or the IVPS supply line for the DC distribution scheme, by tripping a line contactor (refer to PS 17.2.5(a)) in the event of general fault conditions, such as current overloads, output over voltage and output frequency out of range.

(b) Only in the event of critical fault conditions, such as, short circuit fault, shall the auxiliary converter be automatically isolated from the traction supply line by rupturing of the fuse (refer to PS 17.2.5(b)).

(c) A reset facility (refer to PS 17.2.2) shall be provided, to enable the auxiliary converter to be re-started after a trip of the line contactor. Repeatedly operating this reset facility shall not cause any damage to the auxiliary converter. However, it may be considered as acceptable for a converter to not resume its power conversion duty if there are still thermal conditions or persistent failures which could endanger the life of the equipment or the powered loads.

(d) In the event of one auxiliary converter not operating, the DC output shall prevent discharging of the battery (refer to PS 17.2.1(c)).

(e) Failure of an auxiliary converter shall be visually indicated to the train operator in the controlling cab.

17.2.5. Power Circuit

(a) Line Contactor

(i) Individual line contactors shall be provided to connect each auxiliary converter to the traction supply, or the IVPS supply (if used).

(ii) The line contactors shall be able to operate frequently at the maximum breaking capacity without abnormal or premature deterioration.

(iii) Activation of the individual contactor shall only isolate the associated auxiliary converter.

(iv) The auxiliary converters shall have an inrush limiting current circuitry to softly connect on their input supply. The inrush current shall be limited below the nominal full load current of the converter.

(b) Fuses

(i) Adequately rated fuses at the traction supply side and at the IVPS supply side shall be provided to the auxiliary converters power input for critical fault isolation. Circuit breaker as used on the IVPS supply line, instead of the fuse, shall be submitted for approval.

(ii) These fuses shall be located in a position where the inter-car connections can also be protected, when it is considered as appropriate with the power distribution scheme of the car and the train.

(c) All high voltage capacitors shall be equipped with a discharge paths to ensure they are discharged to 50V within 5 minutes, when the input power is OFF, or the input contactor is isolating the converter from the input supply.

(d) An isolation transformer shall be provided to isolate the auxiliary converter output and the AC circuits (refer to PS 17.3). The primary and secondary windings of the isolation transformers shall be separated by an earthed screen. With a DC distribution scheme using IVPS supply, only the LVPS and the 120Vac output voltage shall be galvanically isolated with an isolation transformer whilst galvanic isolation between the IVPS and the distributed inverters is not required.

17.2.6. Diagnostic and Fault Logging Facility

(a) The auxiliary converter shall provide self diagnostic and fault logging facilities, to facilitate maintenance for identification of the faulty part down to the LRU level (refer to PS 26.2.5).

(b) A control interface shall be provided between the auxiliary converter and the

TIMS to enable status monitoring of the unit. For distributed inverters which are integrated into the associated equipment (for example, the HVAC or air compressor units) in a form of LRU, the above control interface with the TIMS can be provided by the controller of the associated equipment.

17.3 Alternating Current (AC) Circuit

17.3.1. General

(a) The AC output shall be three-phase 60 Hz, 208 V r.m.s. line-line supply regulated to within ± 5 % of the nominal voltage and frequency over the full load range shall be adopted on the AC circuit. For a distributed inverter

scheme, the output voltage level and frequency shall be tailored to the load device being supplied. The IVPS converters shall provide a 350 VDC nominal voltage.

(b) The linear ratio of voltage and frequency shall be kept constant in order to cater for the load voltage regulation.

(c) For the AC distribution scheme, the total harmonic distortion shall not exceed 8 % for a balanced full load, with a lagging power factor of 0.85.

(d) For the AC distribution scheme, the output shall be sinusoidal under all conditions of load. For the DC distribution scheme, the distributed inverter output voltage shall be properly filtered, with a combination of differential and common mode filters. The voltage waveform seen at the motor terminals shall not impact the life and the performances of the driven loads, neither create unacceptable audible and EMI noise levels.

(e) For the AC distribution scheme, each auxiliary converter shall supply half the main lights and one air conditioning unit on each of the 2 or 3 cars. For the DC distribution scheme, the main passenger lights shall be powered from the low voltage DC supply, and the air conditioning units (HVAC) shall have their motors driven by their local inverter, supplied from the train-wide IVPS line.

(f) For the AC distribution scheme, one of the car auxiliary converter shall normally supply the battery charger. For the DC distribution scheme, each LVPS converter shall also provide the battery charging function.

(g) For the AC distribution scheme, in the event of a loss of supply from one auxiliary converter, the battery charger supply shall automatically change over to the other auxiliary converter of the unit of train. Definition of unit of train is specified in PS 4.5.1(b). For the DC distribution scheme, in the event of a loss of one LVPS, the battery charging function shall be provided by the remaining LVPS converters connected on the LVPS supply line.

(h) For the AC distribution scheme, a similar automatic changeover system shall be provided for any essential loads, such as, the passenger information systems (refer to PS 10.4.2(e), 10.4.3(d), 10.4.4(d) and 10.4.5(d)). The proposed list of equipment of the essential loads shall be submitted for

approval.

(i) For the AC distribution scheme, the equipment shall be interlocked and controlled to avoid paralleling the outputs of the auxiliary converters, so that the above change over functions are automatically performed.

(j) Fault protection on any equipment fed from the auxiliary converter shall have adequate discrimination to ensure that a fault cannot cause shutdown of one

auxiliary converter, followed by shutdown of the second auxiliary converter after the above automatic changeover. The IVPS and LVPS converter units shall have output with voltage-current characteristic promoting the load sharing between the units. Current limiting capability allowing continuous operation under such condition shall also be provided.

(k) Single phase loads with three phase supply shall be evenly and reasonably distributed among the phases.

(l) The neutral conductor of a single phase circuit shall not be shared with any other circuit.

17.3.2. AC Socket Outlet

(a) To enable the use of portable electrically operated equipment within each driving cab and saloon, each car shall be equipped with a single phase AC switched socket outlet.

(b) The socket outlet shall be mounted within each saloon in a position that is easily accessible to maintenance staff but inaccessible to passengers.

(c) The supply to the AC outlet shall be the regulated and isolated single phase voltage of 120VAC, 60Hz with a rating of 15 A. Detailed requirements of the power socket shall refer to PS 8.10.7.

17.4 Direct Current (DC) Circuit

17.4.1. General

(a) The DC output of the auxiliary converter or associated battery charger shall be 37.5VDC, over the range specified in IEEE Std 1476-2000. for providing the control supply to the DC circuits and battery charging supply to the battery set (refer to PS 17.4.2(a)).

(b) The DC supply shall be regulated to within ± 5 % of the nominal rated value over the full load range, including no-load.

(c) The ripple voltage content shall not exceed 2% peak to peak under all load conditions.

(d) For the AC distribution scheme, the DC output of the auxiliary converter shall directly supply a primary DC circuit via a dedicated wire for starting up or back up purpose. For the DC distribution scheme, the LVPS shall be equipped with a dead battery start power supply, for starting purpose.

(e) The DC output of the auxiliary converter shall also supply a secondary DC circuit which shall be fed by wire as specified in PS 17.4.1(d) above via

another dedicated wire through a Battery Isolating Contactor.

(f) The Battery Isolating Contactor shall be controlled by a battery voltage monitoring device which shall cause it to drop out and pull in at the voltages as specified below:

(g) The Battery Isolating Contactor shall drop out at 23 V ± 2 V and pick up at 28 V, and these values shall be adjustable over a range of not less than ± 5 V.

(h) The battery charger output shall be monitored by the TIMS.

(i) The DC negative and the neutral of the low voltage converter input AC or DC supply shall be separately earthed. The earthing requirements are specified in PS 11.6.10.

17.4.2. Battery Equipment

(a) General Battery Requirements

(i) The battery shall provide standby power to the equipment of the emergency system (refer to PS 17.1.4).

(i i) The battery shall meet the emergency duties (refer to PS 17.1.4) for a period

of 1 hour before its voltage falls below 25 V.

(iii) The Contractor shall demonstrate that at the end of the declared battery life-

time and with the charging system provided, the above emergency duty requirement can still be fulfilled.

(i v) The maximum charging and discharging current that the battery shall withstand without endangering its life and reliability shall not be less than 100 A.

(v) The configuration and arrangement of the battery shall be compatible with the battery box and tray as specified in PS 17.4.2(b).

(b) Battery Box

The battery shall be carried in a weatherproof container beneath the Subway Car. The container shall provide maximum space above the cells and shall be adequately protected against the effects of spilled electrolyte. The battery container shall be adequately ventilated and drain holes shall be provided in locations which prevent drips falling on other apparatus. The battery cover shall be completely removable without tools and be guided by cover retaining strips to be easily placed in the closed position. The battery shall be installed in a stainless steel tray, which can be easily and completely pulled out for battery maintenance. The tray shall have an automatic locking mechanism in

the extended and stowed positions. The tray shall be easily detachable from the slides to allow the entire battery removal from the box container.

(c) Battery Protection and Isolation

(i) Protection of the battery shall be provided, with adequately rated circuit breaker opening/connecting both the positive and negative poles.

(i i) Circuit breaker enclosure shall be sealed to IP 65 in accordance with IEC 60529. This breaker box shall be installed aside the battery box.

(i i i) The circuit breaker will be used to manually disconnect the battery from any car wiring electrically when required.

(i v) A thermal sensor will be use to shunt trip the circuit breaker in case of overheating.

(v) Facility shall be provided to lock the circuit breaker in the isolated position, and also be clearly identifiable when it is operated.

(v i) Earthing shall be as defined in PS 11.6.11, and as close as possible to battery box and low voltage converter.

(d) Battery Charger

A battery charger shall be provided if it is not an integral part of the auxiliary converter and shall comply with the following requirements:

(i) The converter providing the battery charger function shall be 37.5 VDC constant voltage type with current limiting function to protect against overload and short-circuit conditions.

(ii) The battery charger shall be simple and robust in design and it shall not require any maintenance at a periods of less than 5 years.

(iii) The converter providing the battery charger shall be mounted adjacent to the battery boxes (refer to PS 17.4.2(b)).

(iv) For the AC distribution scheme, the battery charger shall be protected by a 3-phase MCB on the input side. For the DC distribution scheme, the LVPS powered from the traction supply line, shall be protected by an input fuse and an isolating contactor. In all cases, a fuse on the positive output lead shall be used.

(v) The battery charger fuse, MCB and diodes and other equipment associated with the circuit shall be mounted within the same equipment case and be easy to access for maintenance.

17.4.3. Specific Battery Requirements

(a) Type of Battery

(i) ~~The battery shall be of the nickel cadmium type and shall comply with the~~ specifications of IEC 60993 (1989) and IEC 60623 (2001).

"The battery shall be of the nickel cadmium type and shall comply with the specifications of IEC 60993 (1989) and IEC 60623 (2001) as applicable.

The Contractor shall submit relevant test certificates to demonstrate a full compliance of the requirements."

(ii) The Contractor shall submit relevant test certificates to demonstrate a full compliance of the requirements.

(b) Case Material

(i) The cell case of the battery shall be made of stainless steel.

(i i) The use of alternative material for the cell case may be submitted for approval. However, the alternative material to be used shall possess the following characteristics.

(1) high impact resisting,

(2) non-absorbent,

(3) alkaline resisting,

(4) anti-corrosive,

(5) flame retardant,

(6) ~~halogen, sulph~~urous and phosphorous compound free,

(7) ozone & ultra-violet resisting, and,

(8) produce low smoke and minimal toxic fume such as carbon monoxide in the event of fire or short circuit.

(c) Normal Daily Load Duty

(i) The daily loading of the battery set on the trains shall be assumed to be shallow discharging.
Item (i): (No specifications text modifications required.)

(ii) ~~By design, considering 20° C for charging, and the sizing temperature range for discharging, the battery set and battery charging system must allow for up to 4 charging – discharging cycles a day. It is acceptable to consider that the~~ LVPS output will be available ~~continuously (never stopped) to maintain the battery properly charged. The Contractor shall provide details of the load cycle according to the design of the 32VDC circuit~~.

It is acceptable to consider that the LVPS output will be available continuously (never stopped) to maintain the battery properly charged. The Contractor shall provide details of the load cycle according to the design of the 32VDC circuit.

(d) Normal Annual Load Duty

For maintenance purpose, the battery shall be discharged twenty (20) times per year at the emergency load duty stipulated below.

(e) Emergency Load Duty

(i) The battery shall be designed to supply the emergency loadings, such as, lighting and ventilation, of the train for a period of 1 hour.

(ii) Throughout this one hour discharging period, the discharging current shall be specified by the Contractor with respect to the emergency loading according to the design of the 32VDC circuit and the terminal voltage of the battery shall not fall below 25VDC or 1V/cell.

(iii) For the purpose of calculating the required battery capacity, the Contractor shall assume that, before performing the emergency load duty, the battery is being continuously float charged and has reached a capacity of 80% for the AC distribution scheme, and 90% for the DC distribution scheme of the maximum fully float charged capacity. The state of charge shall be subject to approval by the Engineer. Guidelines according to the "IEEE Std 1568-2003, IEEE Recommended Practice for Electrical Sizing of Nickel-Cadmium Batteries for Rail Passenger Vehicles" can be considered as an alternative method for battery capacity calculation.

(iv) A train-wide battery temperature compensation function shall be provided in order to improve the charge level at low temperature for all the battery sets floating on the LVPS power line, and be able to use a higher SOC (up to 0.95) and/or to reduce the temperature derating factor for battery sizing purpose, in-line with the battery supplier recommendations.

(f) Compatibility with the Charging System on the Train

The battery shall be compatible with the charging system on the Train.

(g) Maximum Charging and Discharging Current

The battery shall be designed to withstand a maximum charging and discharging current of not less than 100A with no adverse effect on its life and reliability.

(h) Battery Capacity

(i) The battery shall be able to comply with the normal and emergency load duties as stipulated above throughout its expected life.

(i i) The expected life of the battery shall not be less than 15 years after installing on the train.

(i i i) The battery shall be able to operate with the charging system of the train and operating environment throughout its design life. To determine the battery capacity, the lowest electrolyte operating temperature of 0 C can be used.

(iv) The Contractor shall submit capacity calculations to demonstrate a full compliance of the required load duties. For this purpose, the Contractor shall submit data including but not be limited to the following:

(1) Discharge voltage ~~characteristics of the battery from 80 % of fully float charged condition at 45A down to 1.0 V per cell~~.

Discharge voltage characteristics of the battery from 90 % of fully float charged condition at 45A down to 1.0 V per cell.

(2) Aging factor of capacity against its life time.

(3) The maximum available capacity of the battery (as a percentage of the fully float charged capacity) when the battery is under the float charge arrangement of the train.

(4) Expected life of the battery when it is subject to the load duties and the charging arrangement.

(5) Variation of battery capacity against operating temperature.

(6) Charge/discharge cycle life

(7) Total battery service mass (with tolerance) including cells, trays and relevant accessories.

(v) Maintenance Requirement

(1) The battery shall require minimal maintenance and attendance throughout its design life. In case of vented battery and with the charging arrangement of the train and at an ambient temperature of 30°C (86°F), the battery shall not require the topping up of electrolyte for more than once in every 6 months.

(2) The Contractor shall estimate the water consumption rate against years of

service and specify the electrolyte reserve in c.c. of the battery cell and the average internal gas recombination efficiency factor

(3) The Contractor shall specify the recommended maintenance schedule (monthly check, yearly check, etc.) and procedures (electrolyte refilling, capacity testing, etc.) for the battery.

(4) A constant current battery charger and discharger shall be provided and installed in the yard. The battery charger and discharger shall be adequately rated and able to fully charge and discharge two (2) complete set of fully discharged battery equipments at the same time. During battery discharging process, it shall be possible to convert the discharging energy into AC and feed back to the AC shore supply. The current distortion limits according to Canadian Standards Association 22.2 No. 107.1 shall be complied with.

(5) The requirements of using special tools and equipment for maintenance purpose shall be specified.

(6) To facilitate a quick, safe and accurate operation of re-filling the electrolyte with distilled water, a centralised water filling system shall be provided, such that the complete set of battery can be top up at the same time. When the maximum electrolyte level is reached in a battery cell, an individual electrolyte level detection shall be provided to stop the water filling process in order to prevent over topping up. Due consideration shall be given on the water hose and pipe-work of the system particularly on meeting the specified electrical and fire safety requirements. The system shall be of proven design and maintenance free. Four sets of on-ground filling station which shall be compatible with the above centralised water filling system, in a form of portable cart complete with water tank, battery operated water pump and re-chargeable battery set shall be provided.

(vi) General Arrangement of Cells

(1) The general arrangement and layout of cells in the battery trays shall comply with the requirements stipulated in clauses F.1, F.2 and F.3 in appendix F of BS 2550, "Design of batteries for use on electric vehicles and industrial trucks" (if not applicable, replacement by BS EN 60254-1:2005 and BS EN 60254-2:1997 is acceptable). The purpose of quoting a lead acid batteries specification for the nickel-cadmium battery is to make reference to the philosophy stated in the BS 2550 in installing the cells in the battery tray.

Where the original BS 2550 refers to "acid-resisting" materials, they shall be read as "alkaline resisting". Alternative cell arrangement shall be submitted for approval.

(2) When calculating the minimum internal plan dimensions of the tray, the maximum cell dimensions shall be used.

(3) The battery shall be housed in one or two identical steel crates. The Contractor shall submit the dimensions of each cell together with a layout diagram showing the arrangement and connection of the cells inside the crates.

(vii) Capacity Guarantee

(1) The battery shall be capable of meeting the emergency load duty after in service for 15 years.

(2) The Contractor shall guarantee that, without renewing the electrolyte, the 5-hour rated capacity of the battery shall not be less than 90% of its rated capacity at the end of the first 5 years service.

(3) The Contractor shall declare and guarantee that the percentage decrease of the 5-hour rated capacity shall not exceed 5% of the 5-hour rated capacity after 2 years of service without renewing the electrolyte.

(4) The Contractor shall submit calculations to demonstrate a full compliance of the capacity guarantee criterion stipulated above.

(5) At the end of the Defects Liability Period, the Contractor shall undertake to carry out a capacity verification tests in accordance with IEC 60623 on an agreed numbers of cell samples which are randomly selected from those 2 years old batteries. The acceptance test criterion stipulated in IEC 60623 shall be modified in line with the declared remaining available capacity after 2 years of service.

(viii) Testing Requirements

(1) Shock and Vibration

The batteries and trays shall comply with the requirements on the vibration and shock tests stipulated in RIA20.

(2) Acceptance Test

The batteries shall be tested in accordance with the requirements stipulated in IEC 60623.

SECTION 18 COMMUNICATIONS 2

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Section 18 Communications

18.1 General

18.1.1 Communications equipment shall be provided on train which shall provide an integrated system of audio and data communication between the passengers, train operator, transit control centre (TCC), yard train controller (YTC) and yard control centre (YCC). The way to use the existing communications equipment is described in the AUTHORITY's Manual which is available for Contractor's reference. Due consideration shall be given to achieve similar way of operation for the various communications equipment.

18.1.2 The following communications equipment shall be provided:

(a) Train Radio to be purchased from the Named Supplier, installed, interfaced, tested and commissioned as stipulated in PS 18.2.

(b) Video Surveillance Systems (VSS) to be designed, installed, interfaced, tested and commissioned as stipulated in PS 18.3.

(c) Digital Voice Announcement System and Public Address (DVAS and PA) including Cab-to-Cab Intercom and Passenger Assistance Intercom System (PAIS) system to be designed, installed, interfaced, tested and commissioned as stipulated in PS 18.4.

(d) Passenger Information System (PIS) communication equipment to be designed, installed, interfaced, tested and commissioned as stipulated in PS 18.5.

(e) Wireless LAN for Yard Maintenance Support System (YMSS) to be designed, installed, interfaced, tested and commissioned as stipulated in PS 18.6.

18.1.3 All the communications equipment shall include a self test facility that allow automatic checking of the equipment healthiness. The self test facility shall be

able to be initiated either by the train operator or by the Train Information Management System (TIMS, refer to PS 10). The result of the self test shall be able to be transmitted to the TIMS and then to the YMSS as described in the automatic system initialisation process (refer to PS 10.3.2).

18.1.4 ~~All communications equipment as stipulated in PS 18.1.2 shall remain fully operational in accordance with PS 4.4.5(a) following the loss of traction or auxiliary power supply.~~

<u>All communications equipment as stipulated in PS 18.1.2 shall remain fully</u>

operational in accordance with PS 4.4.6(a) following the loss of traction or auxiliary power supply.

18.2 Train Radio

18.2.1 General

(a) The Contractor shall purchase from the Named Supplier of Train Radio and install the trainborne radio equipment (including train mobile unit with antenna isolator and power supply, control head, loudspeaker and handset), antenna and associated interconnection cables as stipulated in Appendix I Annex 4.

(b) The Contractor shall liaise with the Named Supplier of Train Radio to purchase / provide and install all connectors, interfacing plugs and sockets, earthing connections and all associated equipment housings and mounting materials.

(c) The Contractor shall provide accommodation including mountings, equipment cabinets and cable access for installation of all the trainborne radio equipment. Typical dimensions and location of the equipment are detailed in Appendix I Annex 4.

(d) The Contractor shall provide the appropriate DC power supplies including the power supply interface and the protection device to the trainborne radio equipment. The Contractor shall ensure that the power supply arrangement can fulfil the emergency power supply requirement as stipulated in PS 18.1.4. A time delay off (30 seconds and ± 30 seconds adjustable) power supply circuit shall be incorporated to maintain the power supply of the Train Radio during shutdown and open up operation by the train operator.

(e) The Contractor shall ensure and demonstrate that all the interface requirements as stipulated in Appendix I Annex 4 are satisfied.

(f) The Contractor shall be responsible for the test and commissioning of all the installed train radio equipment.

18.2.2 Each driving cab shall be fitted with the train radio equipment which allows two way communication between the train operator and the TCC.

18.2.3 The Train Radio system shall be able to switch to a yard channel to enable the train operator to communicate with the yard controller.

18.2.4 The Train Radio system shall be able to receive PA messages from the train operator / TCC and relay the received audio message to the DVAS and PA system for broadcasting to all passengers.

18.2.5 The "Red Emergency " mode of radio operation which shall be compatible with the existing Train Radio system, shall be provided.

18.3 Video Surveillance Systems (VSS)

18.3.1. The Contractor shall provide the VSS including trainborne video display, camera, VSS communication network, digital video recorder, removable hard drives which shall form part of the event recorder, Offboard Playback Unit (OPU) completed with video playback and editing software, and trainborne video displays.

18.3.2. The Contractor shall provide and install all VSS equipment, control and power cables, all connectors, interfacing plugs and sockets, earthing connections and all associated equipment housings and mounting materials.

18.3.3. The Contractor shall provide accommodation including mountings and cable access for installation of all the trainborne VSS equipment.

18.3.4. The Contractor shall provide the appropriate DC power supplies including the power supply interface and the protection device to the trainborne VSS equipment.

18.3.5. Particular requirements for the VSS communication network:

(a) The TIN shall be used to support the IP-based video communication network between the cameras and the trainborne video displays.

(b) A video server which shall form part of the above communication network, shall be provided to digitize the analog video signals into a form of commonly acceptable video compression standards (e.g. Motion JPEG or MPEG-4) and send digital images directly over the IP network. The server shall turn an analog video system into a network video system and enable the train operator to view live images in realtime by using the trainborne video display with a user-friendly application software. It shall allow train operators of both cab to

simultaneously access images from the same analog camera(s).

(c) A switch / multiplexer shall be provided to connect the cameras, switch / multiplex the frame images from the cameras area and transmitted serially and sequentially over the above dedicated trainline to the digital video recorder and display the images on the trainborne video displays.

(d) Standard, off-the-shelf removable hard drives shall be used to store the image data in a disk mirroring manner. At least two disks shall be used for duplicate data without striping. All disks shall be readable at the same time. An alternate method of providing data integrity with no single point of failure may be proposed, subject to the approval by the Engineer.

(e) It shall be possible to automatically download evenemential data (example: recording when a PAIS is activated), using the YMSS Wireless Lan when in Carhouse/Yard. It shall also be possible to manually download short video duration, based on the time, date and car number, through the same channel. Scheduled downloads, operations to take place later in time if the car is not present on the wireless LAN at the time of the command, based on the time, date, car number, duration and camera id shall also be possible.

18.3.6. The Contractor shall be responsible for the test and commissioning of all the installed VSS equipment.

18.3.7. Particular requirements for the VSS Display Control

(a) PAA strip control interface for display of video images shall be provided as follows:

(i) Whenever a PAA strip is activated, a split-screen shall be automatically showed the two camera image of the particular car of which the PAA strip has been activated.

~~(1)~~

(ii) The above split-screen shall remain until the train operator selects other display function (refer to PS 10.2.7).

~~(2)~~

(b) PAIS system control interface for display of video images shall be provided as follows:

(i) ~~Whenever a PAEH is activated, a~~ split-screen ~~which shall be automatically showed:~~

A large image of the multi-purpose ~~area camera near the particular PAIS of which the PAEH has been operated; and~~

~~Two smaller camera images of the particular car of which the PAEH has been operated~~.

(i) Whenever a PAEH is activated, a quad split-screen which shall be automatically showed:

(1) The four camera images of the PAEH activated car will be displayed on the guard VSS display. The guard shall be able to select any camera image by ~~pressing on it to maximize it into a full screen image.~~

Item (2) Text Deleted

(ii) The above split-screen shall remain until the train operator selects other display function (refer to PS 10.2.7).

(iii) Once the PAEH is activated, the above image of the built-in camera of the PAIS and the audio record of the conversation between the passenger and the train operator, shall be recorded in the removable hard drives of the VSS (refer to PS 10.2.7(c)(iv)) until the PAEH is reset.

18.4 Digital Voice Announcement System and Public Address (DVAS and PA)

18.4.1. General

(a) The Contractor shall provide the DVAS and PA equipment including Cab-to-Cab Intercom and Passenger Assistance Intercom System (PAIS).

(b) All cables, connectors, interfacing plugs and sockets, earthing connections and all associated mounting materials shall be provided by the Contractor.

(c) The Contractor shall provide accommodation including mountings, equipment cabinets and cable access for installation of all the DVAS and PA equipment in accordance with the requirements as stipulated in PS 7 and 8.

(d) The Contractor shall ensure and demonstrate that all the interface requirements as stipulated in Appendix I Annex 4 are satisfied.

(e) The Contractor shall include in his supply, a maintenance terminal and a portable maintenance terminal able to modify / add any pre-recorded announcements in the Digital Voice Announcement Unit.

18.4.2 The DVAS and PA system shall consist of:

(a) The following equipment, as a minimum, in each driving cab:

(i) A Digital Voice Announcement Unit (DVAU) including the Door Chime Tone Generator

(i i) A Master Control Panel with loudspeaker and microphone

(i i i) An Auxiliary Control Panel with loudspeaker and microphone

(i v) ~~A Public Address Unit with Public Address amplifier~~

A Public Address Unit with Public Address amplifier integated into the CCU

(v) A DC Voltage Regulator Unit

(vi) An Interface Unit

(b) The following equipment, as a minimum, in each car:

(i) Public Address amplifier(s)

(i i) Ceiling mounted loudspeakers

(i i i) Passenger Assistance Intercom System (refer to PS 18.4.14, for number and location refer to PS 7)

18.4.3 The following modes of communication shall be provided by the DVAS and PA:

(a) Public Address (PA) to passengers including:

(i) Manual Broadcasting in which train operator can make live announcements to all passengers

(i i) Radio Broadcasting in which traffic controller in TCC can make live announcements to all passengers via Train Radio

(i i i) Broadcasting of pre-recorded announcements initiated by the train operator (including the door chime)

(iv) Broadcasting of pre-recorded announcements based on real time information received via the interface with TIMS

(b) Cab-to-Cab Intercom which provides intercom function between the two driving cabs

(c) Passenger Assistance Intercom System (PAIS) which enable half duplex communication between the train operator and passenger who has operated the Passenger Alarm Emergency Handle (PAEH) via the ceiling or PAIS ~~mounted loudspeakers and PAIS microphone situated adjacent to the activated~~ PAEH.

(d) ~~The PAIS microphone shall be a moving coil microphone (dynamic) type with unidirectional directivity and ability to reduce acoustic feedback in railway vehicle application. An alternate configuration may be proposed, subjected to approval by the Engineer~~.

The PAIS microphone shall be a moving coil microphone (dynamic) type with omni directional directivity. ✓ ✓ ✗

✓ ✓ ✗

18.4.4 The DVAS and PA shall only be operative when one of the ~~Door Control Master Switch (DCMS) (refer to PS 8.8.6(a)) is activated. Since the PA loudspeaker line is shared with the radio, the availability of the different~~ modes of communication in the active and non-active ~~cab shall be according~~ to the following table:

DCMS	Radio	Public Address	Cab-to-Cab	Passenger Assistance
X			X	*
X			X	*

~~Legends:~~

~~* No interface between the Radio and Passenger Assistance Intercom System shall be required due to the interface constraints of the existing Radio~~

~~Device activated~~

~~Device is not activated~~

~~X Don ’t care~~

All mode of operations (OTPA, OTG, PAIS and radio) shall always be operative at all time in both cab MCCP. All mode of operations (OTPA, OTG, PAIS) shall always be operative at all time in both cab ACCP. (No replacement table)

18.4.5 The different modes of communication (Public Address, Cab-to-Cab Intercom ~~and Passenger Assistance Intercom System) shall have different priority~~ which shall be determined by the operability studies (refer to PS 21.5).

18.4.6 ~~The first priority communication mode has the highest priority while the sixth priority communication mode has the lowest priority. Higher priority~~ communication mode shall ~~interrupt and stop communication modes with~~ lower priorities (except during broadcasting of pre-recorded ~~emergency messages that shall played repeatedly - the broadcast of emergency messages~~ shall be stopped for those higher priority mode and then continue ~~to be played repeatedly)~~.

The first priority communication mode has the highest priority while the sixth priority communication mode has the lowest priority. Higher priority communication mode shall interrupt and stop communication modes with lower priorities (except during broadcasting of pre-recorded emergency messages that shall played repeatedly.

18.4.7 The stability and operation of the DVAS and PA equipment shall not be affected by the driving cab EMI environment.

18.4.8 ~~The DVAS and PA shall have a self test function on power up that checks the~~

~~system healthiness. Sensing equipment shall be provided for each power amplifier and ceiling mounted loudspeaker which can check its healthiness (i.e. audio signal actually present at amplifier output). It shall be able to provide indication of alarm status should any irregularities be detected. The result of the self test (including the alarm status if there are irregularities~~ detected) shall be reported to t~~he TIMS via the interface unit~~.

The DVAS and PA shall have a self test function on power up that checks the system healthiness. Sensing equipment shall be provided for each power amplifier which can check its healthiness (i.e. audio signal actually present at

amplifier output). It shall be able to provide indication of alarm status should any irregularities be detected. The result of the self test (including the alarm status if there are irregularities detected) shall be reported to the TIMS via the interface unit.

18.4.9 The DVAS and PA shall be equipped with automatic sensing and adjustment devices to sample and detect the ambient noise in each saloon and automatically adjust the output level of PA amplifiers in order to maintain the threshold sound level of broadcast messages above that of the ambient noise as stipulated in PS 18.4.18(b).

18.4.10 Manual Broadcasting

~~The train operator shall be able to make live announcements to passengers via~~ either of the microphone ~~on the TIMS display terminal or TIMS display terminal~~. The 'Press-To-Talk' ~~(PTT) switch on the microphone shall be pressed during the announcement to enable the broadcast to passengers.~~

18.4.11 Radio Broadcasting

(a) Traffic controller in TCC shall be able to make live announcements to passengers via Train Radio and the DVAS and PA interface.

(b) ~~A separate indicator in the TIMS display terminal shall be illuminated during the course of radio broadcasting~~.

A separate indicator in the RCP shall be illuminated during the course of radio broadcasting.

18.4.12 Broadcasting of Pre-recorded Announcements

(a) All the pre-recorded announcements shall be stored in the Digital Voice Announcement Unit (DVAU) and shall be able to be selected and generated as audio signal to the Public Address Unit for broadcasting.

(b) The DVAS and PA shall store, select and broadcast all the required messages for the Existing Subway Lines and new Spainda Extension as well as meeting the expansion requirements as stipulated in PS 18.4.15(d).

(c) There shall be one type of pre-recorded announcements in English stored in the DVAU:

(i) Door messages for all stations, for example

"Please stand clear of the doors"

(ii) Station messages for particular stations, for example

"The next station is A"

(iii) Special messages, for example

"Attention please, there shall be a short delay because of train service regulation. Please accept our apologies for any inconvenience caused."

(iv) Emergency messages, for example

"Attention please. This train is unable to move because of a technical problem. Please walk to the front of the train. The train operator shall escort you to the next station. Please accept our apologies for any inconvenience caused."

(d) The broadcast of pre-recorded announcements shall be able to be triggered by:

(i) reception of real time station information from the SCS and messages shall be automatically broadcast

(ii) manual selection and activation by the train operator via the TIMS display terminal

(iii) the operation of the door close push button for door closing chime

(iv) the operation of the door open push button for door opening chime

(e) On operation of the door close push button (refer to PS 8.8.6 and 8.9.8), the

door closing chime shall be automatically broadcast. At the same time, a command shall be sent via the TIMS interface to all the PIS display panels (including EIDS and LIDS) to broadcast door closing announcement in textual format. Activation of the door closing chime shall be easily ~~configured (active / inactive, triggered by door close push button, time delay) via the portable maintenance terminal (refer to PS 18.4.16(h)), the interface with TIMS (refer to PS 18.4.20) or YMSS~~

Activation of the door closing chime shall be easily configured (active / inactive, triggered by door close push button) via the portable maintenance terminal (refer to PS 18.4.16(h)), the interface with TIMS (refer to PS 18.4.20) or YMSS

(f) On operation of the door open push button (refer to PS 8.8, 8.10 and 8.11), the door opening chime shall be automatically broadcast. At the same time, a command shall be sent via the TIMS interface to all the PIS display panels

~~(including EIDS and LIDS) to broadcast door opening announcement in~~ textual format. ~~The activation of the door opening chime shall be easily configured (active / inactive, triggered by door open push button, time delay)~~ via the portable maintenance terminal (refer to PS 18.4.16(h)), ~~the interface with TIMS (refer to PS 18.4.20) or YMSS~~

The activation of the door opening chime shall be easily configured (active / inactive, triggered by door open push button) via the portable maintenance terminal (refer to PS 18.4.16(h)), the interface with TIMS (refer to PS 18.4.20) or YMSS

(g) All the special and emergency messages shall be selected and initiated by the train operator via the TIMS display terminal. Different indicators shall be provided on the TIMS display terminal to indicate the broadcast of special and emergency messages.

(h) Emergency messages shall be broadcast repeatedly to the passengers. A 'reset' button shall be provided in the TIMS display terminal to terminate the broadcast of emergency messages. The repeating broadcast of emergency message shall also be terminated if a higher priority communication mode is activated (refer to PS 18.4.5).

(i) The DiCU (refer to PS 18.4.3) shall be pre-loaded with all pre-recorded announcements for the DVAS and PA (refer to PS 18.4.11(c)) in the corresponding textual format. Synchronization of audio and textual announcements shall be achieved such that the message broadcast (either triggered by the train operator or by SCS via TIMS) by the DVAS and PA is also displayed by all the PIS display panels in the corresponding textual format at the same time. This shall be applicable to all types of messages i.e. door, station, special and emergency messages except for those emergency messages requiring detrainment via the emergency door (from the front cab or from both the front and rear cab) as described in (j) below. ~~This audio and~~ textual announcement synchronization feature ~~shall be able to be deactivated via the portable maintenance terminal (refer to PS 18.4.16(h)) or YMSS~~. This audio and textual announcement synchronization feature (ability to enable only the audio or text or both) shall be able selectable by the operator from the TIMS display.

(j) In case detrainment of passengers via the front emergency door is required, once the front emergency door is deployed, an emergency message informing such arrangement shall be able to be selected by the train operator and

broadcast to passengers. At the same time, a command shall be sent via the TIMS interface to all the PIS display panels (including EIDS and LIDS) to stop the display of all other information and show a big green arrow directing passengers to detrain via the front cab emergency door. The word "EMERGENCY EXIT" in red shall also be displayed on the top of the arrow.

For those EIDSs that are facing the non-emergency existing end i.e. the emergency door is not deployed, a big red bar sign shall be displayed to directing passengers to stop going this end. For detrainment via both the front and rear cab emergency doors, the same arrangement shall be applied except that the PIS display panels shall show big green arrows directing passengers to detrain via either the front or rear cab emergency doors. Once the emergency message has been selected by the train operator, it shall be reported to the Event Recorder via the interface with TIMS.

(k) ~~On selecting the correct line and starting station message via the 'line/station select', 'forward' and 'reverse' button on the TIMS display terminal, the train operator shall be able to initiate the broadcasting of the correct station~~ message. After t~~he announcement, the selected message shall be automatically switched to the next station message ready for the next station broadcasting.~~ The sequence and control shall take into account of the turn-around ~~of trains at all the terminus stations~~.

On selecting the correct destination, the station announcement shall automatically start. In case on system malfunction (lost of tag or distance miscalculation) the train operator shall be able to re-synchronize the system using the TIMS display while the train in stopped inside a station. Upon reaching the terminal station, the train operator will need to select a new destination in order to re-initialize the automatic station announcement. The sequence and control shall take into account of the turn-around of trains at all the terminus stations on all lines.

(l) Real time information including the name of the next station, door opening side and the destination of train shall be received from the TIMS (refer to PS 10.2.8.(a)(iv)(4)) or via the TIMS interface from the trainborne ATC equipment (refer to Appendix I Annex 3). Based on these information received, correct station messages shall be automatically selected and broadcast. A separate control button and indicator shall be provided on the ~~TIMS display terminal to activate and in~~dicate the automatic broadcast of pre-recorded announcements triggered by either TIMS or trainborne ATC equipment.

(m) ~~In the event of failure of the automatic broadcast of announcements triggered by either TIMS or trainborne ATC equipment, it shall be possible to program~~ a particular sequence of messages with pre-set ~~time intervals between messages and then manually triggered to be broadcast by the train operator~~. ~~In the event of failure of the automatic broadcast of announcements triggered~~ by either TIMS or trainborne ATC equipment, it shall be possible to re-synchronize while stop at any station to re-initialize the automatic dead

reckoning station announcement.

(n) A separate button on the TIMS display terminal shall be provided that allow the train operator to repeat the broadcast of the previous announcement.

18.4.13 Cab-to-Cab Intercom

(a) The Cab-to-Cab Intercom shall enable two way communications between the two driving cabs. The train operator on either driving cab shall be able to initiate the ~~Cab-to-Cab Intercom~~ function via either the MCP or ACP.

(b) A separate indicator shall be provided on both the MCP and ACP to indicate the activation of the Cab-to-Cab Intercom function.

(c) The Cab-to-Cab Intercom shall only be established ~~when one of the Door Control Master Switch (refer to PS 8.8.6(a)) is activated~~.

18.4.14 Passenger Assistance Intercom System (PAIS)

(a) A Passenger Assistance Intercom System (PAIS) consisting of Passenger Alarm Emergency Handles (PAEH), PAIS microphones and ceiling or PAIS mounted loudspeakers shall be provided to enable passengers to alert and communicate with the train operator.

(b) ~~By activating the PAEH (refer to PS 7.11.5) in the saloon, passengers shall be able speak to the train operator of the active driving cab immediately via the PAIS microphone (refer to PS 7.11.3) situated near to the PAEH. Only the PAIS microphone situated near to the activated PAEH shall be available for~~ half-duplex ~~operator controlled communication~~.

By activating the PAEH (refer to PS 7.11.5) in the saloon, passengers shall be able speak to the train operator answering the PAIS call via the PAIS microphone (refer to PS 7.11.3) situated near to the PAEH. Only the PAIS microphone situated near to the activated PAEH shall be available for half-duplex operator controlled communication.

(c) A separate indicator in the TIMS display terminal shall be provided to indicate

that PAEH has been activated and identification of the activated PAEH shall be displayed on the TIMS display terminal. The train operator can select the activated PAEH and initiate talk back to the passenger. Only the loudspeaker(s) responsible for coverage of the selected PAEH area shall be activated and the voice of the train operator shall only be broadcast to this loudspeaker.

(d) ~~The identification(s) of the activated PAEH shall also be displayed on the TIMS display terminal and selection of which alarm to talk back shall also be~~

~~able to be performed via the TIMS display terminal~~.

The identification(s) of the activated and selected PAEH shall also be displayed on the TIMS display terminal.

(e) In case more than one PAEH have been activated, the ~~list of activated PAIS shall be displayed and the train operator can select a single PAIS or multiple PAIS he wants to talk back~~.

In case more than one PAEH have been activated, the list of activated PAIS shall be displayed on the TIMS display and the train operator can cycle through all activated PAEH by pressing the MCCP/ACCP¨PAIS button multiple times.

(f) Any operation of the PAEH shall interrupt the door proving loop (refer to PS 9.9.7) and report to the Event Recorder via the interface with TIMS.

18.4.15 Digital Voice Announcement Unit (DVAU) including the Door Chime Tone Generator

(a) The DVAU shall be of the solid state type and capable of storing announcements in English. All messages in memory shall be randomly and instantly available.

(b) The time taken from the confirmation of any selected message to the resultant message being broadcast in saloon shall be 1 sec maximum. This shall be applicable for all four types of messages, i.e. door, station, special and emergency messages.

(c) The DVAU shall be able to store a minimum of 40 minutes announcements comprising the following four types of accumulated length of messages:

~~(ii) Distortion at 1 kHz: < 1%~~

~~(iii)~~

(i) Door and station message: 30 min

(i i) Special message: 5 min

(i i i) Emergency message: 5 min

(d) The DVAU shall be able to be expanded, with the addition of hardware / software, to store 60 minutes of announcements in memory.

(e) The stored messages of the DVAU shall be delivered naturally in speech tones and shall meet the following performance:

(i) ~~Bandwidth: 300 Hz -~~ 7 kHz (-3 ~~dB)~~

~~Dynamic range: 80 dB minimum~~

(i) Bandwidth: 300 Hz - 7 kHz (+/-6.5 dB)

(ii) Distortion at 1 kHz: < 1%

(i i i) Dynamic range: 80 dB minimum"

(f) ~~The door chime tone generator shall be an integral part of the DVAU. The door chime tone shall be identical with the T1 train. The duration of the door chime tone shall be around 3 - 5 seconds to be approved and shall be adjustable via the portable maintenance terminal (refer to PS 18.4.16(h)) or YMSS~~.

The door chime tone generator shall be an integral part of the DVAU. The door chime tone shall be identical with the T1 train. The duration of the door chime announcement shall be around 3 - 5 seconds to be approved and shall be adjustable via the portable maintenance terminal (refer to PS 18.4.16(h)) or YMSS

(g) The DVAU shall not at any time generate any incorrect message and shall not interfere with station PA broadcasts under any circumstances.

(h) A portable maintenance terminal in the form of an IBM® compatible portable PC shall be provided that enable a technician to customize the DVAU and manage the stored messages. The interface to the DVAU shall employ RS 232 serial interface or other standard industrial interface subject to approval. It shall also enable the upload / download of digitized messages to the trainborne DVAU. The location of the interface port shall be in the driving cab and be readily accessible.

(i) A message maintenance terminal shall be provided that has the following functions, as a minimum:

(i) Ability to create, delete and record any messages in English.

(i i) System configuration and programming

(i i i) Fault diagnosis of the DVAU

(i v) Downloading / uploading of digitised messages to the YMSS or portable maintenance terminal via standard RS 232 serial interface (or other standard industrial interface subject to approval)

(v) External audio interfaces for digital recording which shall include microphone, handset and recorder inputs

18.4.16 ~~Master Controller Panel (MCP) with Loudspeaker and Microphone~~

(a)

(b)

The MCP shall be located ~~on the driving console.~~

~~It shall be equipped with the following virtual pushbutton on the screen, as a minimum:~~

(i) 'cab-to-cab ~~intercom' button -~~ initiates and indicates a cab-to-cab ~~intercom request~~

(i i) 'radio broadcasting' indicator ~~- indicates radio broadcasting is active~~

~~(iii) 'self test' button - initiates and indicates the self test function~~

(iv) ~~Loudspeaker with volume adjustment device~~

(v) ~~Microphone with removable socket that can be unplugged and replaced~~ easily

Master Communication Controller Panel (MCCP) with Loudspeaker and Microphone

(a) The MCCP shall be located on the driving console.

(b) It shall be equipped with the following pushbutton, as a minimum:

(i) 'OTG' button - initiates and indicates a cab-to-cab intercom request

(ii) 'RADIO' indicator - indicates radio broadcasting is active

(iii) 'OTPA' button - initiates an operator to Public Address announcement

(iv) 'PAIS' button - answer a PAEH communication request

(v) Loudspeaker dedicated to the radio system with volume adjustment device

(vi) Microphone with removable socket that can be unplugged and replaced easily

18.4.17 Auxiliary Control Position (ACP) with loudspeaker and microphone

(a) The ACP shall be located on the auxiliary driving console as stipulated in PS 8.9.9.

(b) ~~It shall be equipped with the following, as a minimum:~~

(i) 'cab-to-cab intercom' button - initiates and indicates a cab-to-cab intercom request

~~(i i) Loudspeaker with volume adjustment device~~

(i i i) Microphone with removable socket that can be unplugged and replaced

easily 18.4.17 ~~Auxiliary Communication Control Panel (ACCP) with loudspeaker and~~ microphone

~~(a) The ACCP shall be located on the auxiliary driving console as stipulated in PS 8.9.9.~~
~~(b) It shall be equipped with the following, as a minimum:~~

(i) ~~'OTG' button -~~ initiates and indicates a cab-to-cab ~~intercom request~~

(ii) ~~'OTPA' button -~~ initiates ~~an operator to Public Address announcement~~

(iii) ~~'PAIS' button - answer a PAEH communication request~~

(iv) ~~Loudspeaker~~

(v) ~~Microphone with removable socket that can be unplugged and replaced easily~~
18.4.17 Auxiliary Communication Control Panel (ACCP) with loudspeaker and microphone

(a) The ACCP shall be located on the auxiliary driving console as stipulated in PS 8.9.9.
(b) It shall be equipped with the following, as a minimum:

(i) 'OTG' button - initiates and indicates a cab-to-cab intercom request

(ii) 'OTPA' button - initiates an operator to Public Address announcement

(iii) 'PAIS' button - answer a PAEH communication request

(iv) Loudspeaker

(v) Microphone with removable socket that can be unplugged and replaced easily

18.4.18 Public Address Unit and Public Address Amplifier

(a) The Public Address Unit shall accept the audio signal from either the DVAU or the microphone and broadcast it to the saloon loudspeakers.

(b) ~~The following performance shall be met:~~

(i) Sound Pressure Level

~~The sound pressure level measured in all areas where the train operator or passengers can sit or stand in the driving cab or saloon at a height between 1 metre and 2 metres above the floor level shall be 9 dB ± 1 dB above the ambient noise measured at the same area and height range, provided that the~~ Public Address system shall not be able to deliver a sound level that can injure ~~the passengers. This Sound Pressure Level parameter shall be able to be adjusted by means of the portable maintenance terminal.~~

The sound pressure level measured in all areas where the passengers can sit or stand in the saloon at a height between 1 metre and 1.63 metres (50% US Male) above the floor level shall be 9 dB ± 1 dB above the ambient noise measured at the same area and height range, provided that the Public Address system shall not be able to deliver a sound level that can injure the passengers. This Sound Pressure Level parameter shall be able to be adjusted by means of the portable maintenance terminal."

(iii) ~~Bandwidth: 50 Hz to 7kHz (-3 dB)~~

(iv)

(v)

(vi)

(ii) Differential Sound Pressure Level

~~The Sound Pressure Level between maximum and minimum along the length of each saloon measured as in (i) above shall not be greater than 3 dB within each saloon.~~

~~Total Harmonic Distortion: less than 1% at 1 kHz at rated output~~

~~Signal to noise ratio: greater than 60 dB~~

~~Hum level: -80 dB at full rated output~~

The Sound Pressure Level between maximum and minimum along the length

of each saloon measured as in (i) above shall not be greater than 6 dB within each saloon.

(iii) Bandwidth: 300 Hz to 7kHz (+/-5 dB)

(iv) Total Harmonic Distortion: less than 1% at 1 kHz at rated output

(v) Signal to noise ratio: greater than 60 dB

(vi) Hum level: -80 dB at full rated output"

18.4.19 Interface Unit

The Interface Unit shall provide the following interfaces with TIMS, PIS and Train Radio:

(a) An interface with TIMS shall be provided to allow:

(i) the transfer of system status, message displayed in the PIS display panels

(i i) the receipt of SCS location information

(i i i) the receipt of door open/close status

(i v) the reporting of activated Passenger Alarm Emergency Handles as stipulated in PS 18.4.14

(b) An interface with PIS shall be provided to allow:

(i) the transfer of route, station and message information

(i i) receipt of message displayed in the PIS display panels and PIS system fault data

(c) An interface shall be provided with Train Radio for radio broadcasting. A balanced audio output and a dry contact closure shall be provided to the

DVAS and PA system for broadcasting the PA message to the passengers by the Train Radio.

18.4.20 Pre-recorded announcements

(a) The messages for the existing lines shall be transferred and stored in the DVAS and PA and shall be fully operational. The numbers of messages to be transferred are 130 typical and 200 maximum.

(b) The messages for new extension shall be based on the existing messages with modification / addition. The list of messages shall be submitted for approval.

18.4.21 Operating Description

(a) Startup

(i) The DVAS and PA shall start to operate as soon as possible and within the time specified in section 10.2.1(b)(vii) after power is available.

(i i) The DVAS and PA shall carry out a self test to verify its healthiness and the status shall be sent to the TIMS. The self test can also be initiated by pressing the 'self test' button on the TIMS display terminal.

(iii) ~~The train operator shall need to select the correct line via the 'line select', 'forward' and 'reverse' button of the TIMS display terminal~~.

The train operator shall need to select a destination that will include a direction with the associated line color (i.e. I-C North Bond in yellow) and confirm the selection using the 'line select', 'forward' and 'reverse' button of the TIMS display terminal.

(b) Manual Broadcasting

(i) Live announcements can be made via either of the microphone on the MCP or ACP.

(i i) The PTT switch on the microphone shall be pressed to enable broadcast to passengers.

(c) Radio Broadcasting

(i) Traffic controller can make live announcements to passengers via the Train Radio and interface with DVAS and PA.

(i i) The 'radio broadcasting' indicator on the TIMS display terminal shall be illuminated during the course of radio broadcasting.

(iii) The audio signal received from Train Radio shall be transmitted to the Public Address amplifiers for broadcast in saloon.

(d) Broadcasting of Pre-recorded Announcements

(i) On pressing the door open push button, the door opening chime shall be broadcast automatically.

(ii) On pressing the door close push button, the door closing chime shall be broadcast automatically.

(iii) The train operator shall be able to select the correct line and starting ~~station message by means of the 'line/station select', 'forward' and 'reverse' button on the TIMS display terminal. The name of the line and station together with the~~

~~message content (in English) shall be displayed on the TIMS display terminal~~.

The train operator shall be able to select the correct destination and starting station by means of the 'destination select', 'forward' and 'reverse' button on the TIMS display terminal. The name of the line, destination and station together with the message content (in English) shall be displayed on the TIMS display terminal

(i v) Having selected the correct line and starting station, the train operator can use the 'station message' button on either the TIMS display terminal to broadcast the correct station message. After completion of the message, the next station message shall be displayed on the TIMS display terminal.

(v) The train operator can use the 'repeat' button to repeat the previous announcements.

(v i) ~~The train oper~~ator can press the 'Auto triggered' button to initiate the automatic broadcast of station messages on reception of real time station information via the TIMS interface. If the link with TIMS (or future trainborne ATC equipment- provisional only) is healthy, the button shall be illuminated otherwise it shall be blinking.

(v i i) ~~The train operator can select special message by means of the 'special message', 'forward' and 'reverse' buttons on the TIMS display terminal. The~~ message is selected on pressing ~~the 'ENTER' button and shall be broadcast on pressing the 'special message' button again.~~

(iv) ~~The train operator can select emergency message by means of the 'emergency message', 'forward' and 'reverse' buttons on the TIMS display terminal. The message is selected on pressing the 'ENTER' button and shall be broadcast on pressing the 'emergency message' button again. The broadcast of emergency message shall be stopped by pressing the 'reset' button on the TIMS display terminal.~~

The last automatic announcement (station or in route or special) shall be displayed on the main TIMS screen ready to be repeated upon selection.

(vi) The station announcement will always be in automatic broadcast except when both ATC tags and distance calculation will fail. While in this degraded mode no automatic announcement will be available, operator will need to announce the station manually using OTPA.

(vii) The train operator can select special and emergency message by means of the 'special/emergency message selection screen'. Train operator can select message by 'forward' and 'reverse' buttons on the TIMS display terminal. The message is selected on pressing the 'ENTER' button and shall be broadcast on pressing the 'play selected message' button again. The broadcast of emergency message shall be stopped by pressing the 'reset' button on the TIMS display terminal

(e) Cab-to-Cab Intercom

(i) ~~The calling train operator~~ press the 'cab-to-cab ~~intercom' button on either the~~ TIMS display terminal or ACP and press the press-to-talk ~~button on the microphone~~.

The calling train operator press the OTG button on either MCCP or ACCP to initiate an OTG call request.

(ii) The 'cab-to-cab intercom' button on both the active and non-active ~~TIMS display terminal and ACP shall be illuminated.~~

The Operator to guard (OTG) MCCP and ACCP LED shall be blinking in both cabs while an OTG call is being requested. The TIMS display will report an OTG call request.

(iii) The receiving train operator can press the 'cab-to-cab intercom' button on either the receiving MCP or ACP to start the conversation.

(f) Passenger Assistance Intercom System

(i) The passenger can pull any one of the Passenger Alarm Emergency Handle inside saloon and be able to speak to the train operator directly via the corresponding PAIS microphone.

(ii) The identification of the Passenger Alarm Emergency Handle shall be displayed on the TIMS display terminal with the 'Passenger Alarm Emergency Handle' indicator illuminated.

(iii) The train operator can select the 'Passenger Alarm Emergency Handle' he wants to talk back and a point-to-point communication with the passenger who has operated the Passenger Alarm Emergency Handle can be established.

(iv) In case more than one Passenger Alarm Emergency Handles have been activated, the train operator shall be fully informed and be able to select which alarm to talk back.

(v) In order to permit a trainer to listen to the trainee communication with a distress passenger, it is a requirement that the PAIS shall permit other MCP or ACP to listen to an active PAIS call which has already been answered.

18.4.22 Interface with DVAS and PA

(a) ~~Physical layer specifications~~

~~The DiCU shall interface with the DVAS and PA installed in the driving cab via a RS 422 serial link. An alternate method for interfacing the DiCU with the DVAS and PA may be proposed. The physical layer specification shall be as follows:~~

(i) RS 422 asynchronous balanced two-wire ~~serial link~~

(i) ~~Baud rate: 1200~~

(iii) ~~Number of data bits: 7~~

(iv) ~~Number of stop bits: 1~~

(v) ~~Parity: even~~

(vi) Simplex transmission medium

(vii) ~~No handwired handshake~~

(viii) ~~Female DB9 pin connector shall be used in the DiCU~~

(ix) ~~Least significant bit (LSB) shall be transmitted first~~

The DiCU shall interface with the DVAS and PA via the TIN.

(b) The Contractor shall provide all necessary cables and connectors for connecting the DiCU to the DVAS and PA.

(c) Control message types

The DiCU shall receive the following control messages ~~through the serial link~~ (refer to sub-clause ~~(a) above)~~:

<u>The DiCU shall receive the following control messages</u>

(i) Station code

(i i) Route code

(i i i) Emergency message code

(i v) Special message code

(v) Status code

(d) The DiCU shall receive the above control messages when:

(i) The train door open/close status changes; or

(i i) The station message button or repeat button on the TIMS display terminal of the DVAS and PA page is pressed; or

(iii) The special message button on the TIMS display terminal of the DVAS and PA page is pressed; or

(iv) The emergency message button on the TIMS display terminal of the DVAS and PA page is pressed.

For the last two cases, the message code shall be reset to "20 HEX" after transmitting the message code to the DiCU for 5 seconds.

(e) ~~The control messages shall be continuously sent to the DiCU via the RS-422 serial link at approximately 5 times per second~~.

The control messages shall be continuously sent to the DiCU at approximately 5 times per second

(f) The DiCU shall get the next transmission update either by pressing the station message / special message / emergency message buttons of the TIMS display terminal or when the train door status changes.

(g) Communication Protocol

Hex Code
218..7F

~~The control mess~~ ~~DiCU shall be in the following format~~:

The control messages sent to the DiCU format shall be defined by the car builder

Byte no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Description	STX	Messages	Status	NUL	Route	Station	ETX
Content	02	(a)	(b)	00	(c)	(d)	03

The details of item (a), (b), (c) and (d) are described as follows:

(i) Message Code

(ii) Status Code

bit-6	bit-5	bit-4	bit-3	bit-2	bit-1	bit-0
0	1	Spare	Door Status	Spare	Spare	Spare

Code	Contents	Status
Door	Door open/close status	1: Door closed

(iii) Route Code

Hex Code	Route	Terminal Station	Line name
20	M-Northbound	A	C-D-
21	M-Southbound	B	
22	BLD-Eastbound	G	I-J
23	BLD-Westbound	H	
24	SHE-Northbound	NN	N Line
25	SHE-Southbound	N	
26...7F	Future Provision		

(iv) Station Code

The Contractor shall determine the required station codes according to the above AUTHORITY's routes. The DVAS and PA shall be interfaced with the TIMS in such a way that when the SCS is functioning normally, the station code shall be consistent with the physical location of which the station information or train position is provided by the SCS via the built-in Station Stop Announcement System of the Communication System (refer to Clause 2.2.1 of Appendix I Annex 3).

(h) The interface between the DVAS and PA and the SCS shall be designed such that normal operation of the DVAS and PA shall not be affected by failure of the connected SCS and vice versa.

18.5 PIS Communication Equipment

18.5.1 General

(a) The Contractor shall provide the PIS equipment including FSM, EIDS, LIDS, ETND and EDD.

(b) All cables, connectors, interfacing plugs and sockets, earthing connections and all associated mounting materials shall be provided by the Contractor.

(c) The Contractor shall provide accommodation including mountings, equipment cabinets and cable access for installation of all the PIS communication equipment.

(d) The Contractor shall provide the appropriate power supplies including the power supply interface and the protection device to the PIS communication equipment. The Contractor shall ensure that the power supply arrangement can fulfil the emergency power supply requirement as stipulated in PS 18.1.4.

(e) The Contractor shall ensure and demonstrate that all the interface requirements as stipulated in Appendix I Annex 4 are satisfied.

(f) The Contractor shall be responsible for the test and commissioning of all the installed PIS communication equipment.

18.5.2 Each train shall be fitted with redundant trainborne transceiver to facilitate communication with the Bulk Data Transmission Facilities via the YMSS (refer to PS 18.6).

(a) Trainborne Transceiver

(i) Redundant trainborne transceiver shall be installed in each train.

(i i) The trainborne transceiver shall be installed at a location to be determined during design reviews, one in each of the two cab cars.

(iii) The rear driving cab trainborne transceiver shall be turned on only when the "door open signal" of the train stopping at the target platform is received and it shall turn off immediately when the "door close signal" is received.

(i v) The effective radiated power of the trainborne transceiver shall be less than 0 dBm.

(v) The type and the location of the directional antenna shall be properly chosen such that it complies to the EMI control plan. The quasi-peak level field strength measured with 25kHz bandwidth shall be no more than 63dBµV/m at the following locations (regardless train(s) is/are present on the associated track(s) or not):

(1) at all locations above the centre line of the track of the adjacent platform(s);

(2) at all locations in front of the opposite driving cab of the same train; and

(3) at 600 m (1,969’) from the trainborne transceiver along the track in the reverse direction of travel towards the previous station.

18.6 YMSS Wireless LAN system

18.6.1 General

(a) The YMSS Wireless LAN (WiLAN) System shall be provided and requirements according to ANSI/IEEE Std 802.11 - 1999 shall be met. The Contractor shall supply the YMSS Wireless LAN equipment including:

(i) Wireless LAN hub(s) complete with antenna(s) for full coverage particularly the K Carhouse including stabling tracks, maintenance tracks, yard arrival and yard departure tracks

(ii) Interface with the Bulk Data Transmission Facilities and the YMSS computer.

(b) All cables, connectors, interfacing plugs and sockets, earthing connections and all associated equipment housings and mounting materials shall be provided by the Contractor.

(c) The Contractor shall provide accommodation including mountings, equipment cabinets and cable access for installation of all the Wireless LAN equipment for YMSS.

(d) The Contractor shall ensure and demonstrate that all the interface requirements as stipulated in Appendix I Annex 4 are satisfied.

18.6.2 Bulk Data Transmission Facilities

(a) ~~Six Bulk Data Transmission Facilities according to the IEEE 802.11 standard shall be provided, and located at the U Carhouse, B station, L station, Union station, I station and A Station, for the purpose of a transmission mean to send and receive scheduling list,~~ advertising ~~messages (in graphic files format) and other information generated by the Media Team Workstation to the trainborne DiCUs of the PIS~~.

<u>Six Bulk Data Transmission Facilities according to the IEEE 802.11 standard</u>

shall be provided, and located at the K Carhouse, B station, L station, Union station, I station and A Station, for the purpose of a transmission mean to send and receive scheduling list, advertising messages (in graphic files format) and other information generated by the Media Team Workstation to the trainborne DiCUs of the PIS.

(b) The Bulk Data Transmission Facilities shall interface with the YMSS wireless LAN and provide seamless LAN connection from the Media Team Workstation to the trainborne DiCUs.

(c) The Bulk Data Transmission Facilities shall be self-recovery. Every equipment shall be able to restart and resume normal operations automatically after power interruption.

18.6.3 Operating Description of Bulk Data Transmission Facilities

(a) Startup / Login

The Bulk Data Transmission Facilities shall be available at all times and there is no need to undertake any startup / login process.

(b) Download of scheduling list / advertisements / other information in Existing Subway Lines and New T Extension

(i) The Media Team workstation shall be an IBM®© compatible PC equipped with a software to generate the scheduling list / advertisements / information. This software shall be compatible with the operating system of Microsoft© Window® XP (or later version, if approved).

(i i) The Media Team workstation shall generate the scheduling list /

advertisements / information and these shall be transmitted to the Bulk Data Transmission Facilities transceivers situated on certain station platforms of the existing Lines and new extension. When a train is within the coverage area of the transmitter, these information shall be automatically downloaded to the DiCU.

(iii) Upon receipt of the information, the DiCU shall broadcast the data received to each of the PIS display panels.

18.6.4 YMSS® Computer

(a) One YMSS Computer shall be provided, and located at the K Carhouse.

(b) A Wireless LAN transmission link shall be employed by the YMSS in the K Carhouse area to provide two way exchange of data / control between the

train and the yard control centre (YCC). The Bulk Data Transmission Facilities and the YMSS computer shall be able to operate normally at the same time.

(c) The YMSS Computer shall enable the transfer of information received from the TIMS in a commercially available database format of Oracle DataBase for Window or an alternative specified by the Engineer.

(d) The YMSS Computer shall enable trains to receive a subset of the new / modified operation and control parameters for all trainborne equipment / sub-systems except safety related control parameters. The operation and control

parameters shall be transmitted first to the TIMS and then subsequently to each of the destinated trainborne equipment / sub-system.

(e) Download of operation and control parameters in the yard area:

(i) The YCC controller shall issue a "download" command via the Wireless LAN to a train when it has been successfully started up.

(ii) The TIMS shall check the validity of the command through a handshaking process.

(iii) Upon confirmation of the command, the TIMS shall start to download the new / modified operation / control parameters from the YMSS and then transmit the data received to the destinated trainborne equipment / subsystem.

(f) Error checking mechanism (such as cyclic redundancy check sum for each data package, byte truncation and data field length) shall be employed and all necessary control information such as source and destination address, cyclic redundancy check sum and data field length shall be appended by the interface for transmission.

(g) Conversion of text message into audio message:

(i) A file conversion facility which shall form part of the YMSS computer, shall be provided to convert a text message into a audio message for the use of DVAS and PA.

(i i) The converted audio message shall be of high fidelity and true to real human voice. Selection of gender i.e. either female or male for the audio message shall be provided.

18.6.5 Specific YMSS Software Requirements

(a) The Yard YMSS positions shall be separate from the PIS Mainline positions in order to simplify the YMSS operation. The source code shall be a contract deliverable according to PS 29.

(b) It shall be possible to install the YMSS application software onto the existing AUTHORITY's work stations, provided they meet the YMSS computer minimum configuration requirements.

(c) The YMSS application software shall be designed to facilitate each user's setup with permission according to different levels, for their own purposes to send requests for the YMSS to execute.

(d) The YMSS application software shall be designed to run from a queue based on multiple user demands based on different levels of priority. Priority levels

shall be the restrictions to prevent automatic system interruption. For example, the automatic download of Train Event data which shall be a standalone function of another user with its own high level of priority. Flexibility shall be given to re-establish various levels of priority by the maintainer in order to ensure the system functions properly.

(e) The YMSS application software shall maintain from both user profile setups through a system administration feature. A status of which Trains have been recently downloaded shall be a maintained and be accessible by the users.

(f) The YMSS application software shall be designed to generate various number of printable reports.

18.6.6 The YMSS shall be designed to provide the functions:

(a) Automatic Stand alone maintenance data download and transfer of vehicle event data. This includes SCS downloads.

(b) Provide a menu based interface for user control with restrictive permissions based on user setup.

(c) Provide an interface for the YCC functions to verify RUN number prior to release for service.

(d) Provide an interface for the YCC functions to verify Train Health prior to release for service.

Train health status shall be derived from the correspondence of Events to Register of Train Failure (RTF) criteria. Status shall be provided to the YMSS to inform and facilitate operations-related decision making by the AUTHORITY.

(e) Provide a secure upfront loadable software upgrade for TIMS display terminal and Local Processing Unit (LPU).

(f) Maintain an accessible log of wayside to vehicle transactions.

(g) Maintain a user profile rights library file with secure level of permissions.

(h) Provide a daily time\date broadcast feature.

(i) Maintain a historical transaction file of all transmissions by type and train

successful\fail

(j) Using the AUTHORITY work order system Event data file structure produce Events based on System health.

(k) A man/machine interface to allow specific TIMS commands to be sent to vehicle. This could include manual intervention of event data downloads, fault counter resets, onboard clock updates, standby power attributes for power conservation, etc. This feature must provide the ability to process both fleet and individual vehicle command messages. Power consumption curves (i.e. performance limits imposed on the propulsion system to limit its power consumption) must be maintainable through this wayside with a secure high level permission only.

(l) A mean to automate the YMSS computers maintenance by AUTHORITY's IT personnel shall be provided. This could be performed by a network watch dog file feature (i.e. each computer periodically updating a file to notify a AUTHORITY IT monitoring application or its presence) so that AUTHORITY can implement an Unicenter TNG for system health monitoring.

(m) Interface with a vehicle status dbase file so that release of Trains into service whose status is on hold, on a current Schedule for maintenance that day or unfit for service is annunciate on the YCC user display. Authorisation to override will be through forepersons only.

18.6.7 Particular Requirements

18.6.7.1 System Description

(a) The YMSS shall consist of, but not be limited to, the following major equipment:

(i) ~~A single Computer in K Yard shall provide the WiLAN antenna interface for Vehicle TIMS (including PIS) and VSS~~

~~Not Used~~

(iii) A single ~~Computer shall be the Yard Control Operator Interface for RUN number verification & Train Health Check initiation and response.~~

(iv) ~~A single Computer shall be the K Yard Technical Staff Interface located in their Office area.~~

(v) A single Computer located ~~in a secure area elsewhere shall act as Server with data archive facility for both TIMS , VSS storage & retrieval and PIS library functions.~~

(vi) ~~A single Computer located in RC&S Procedures sect. shall act as an interface to manage PIS functions & Vehicle Recover Procedure revisions.~~

(viii) ~~A number of Computers (6) will also be strategically located at different Mainline Stations for VSS, PIS & TIMS support, as part of the Bulk Data~~ Transmission Facilities. Refer to 18.6.2 (a) for exact computers locations TBD. ~~AUTHORITY to provide Ethernet connections. This will be based on system needs~~ ~~evaluation to be approved by AUTHORITY Engineer~~

(viii) ~~10 identical portable Laptops shall provide the services for vehicle onboard~~ sub-system interface for test, trouble shooting and sub-system ~~software~~ ~~upgrades.~~

(i) Two Computers shall be the TCC Technical Staff Interface to the Fleet Maintenance Management Database (FMM) and PIS located in their Office area.

(ii) Two Computers shall be the Marketing Staff Interface to the PIS and Multimedia located in their Office area at the W Headquarters.

(iii) A single Computer shall be the Special Constable Interface to the VSS for video playback located in the Office area at the W Headquarters.

(iv) Two Computers shall be the K Yard Technical Staff Interface to the FMM located in their Office area.

(v) A single Computer, along with Networking Equipment and Networking Security Equipment, located in a secure area at the W Headquarters shall act as Server with data archive facility for both TIMS , VSS storage & retrieval and PIS library functions.

(vi) A single Computer shall be the W Yard Technical Staff Interface to the FMM located in their Office area.

(vii) Wireless Networking Equipment to ensure wireless coverage will be strategically located at different (5) Mainline Stations for VSS, PIS & TIMS support, as part of the Bulk Data Transmission Facilities. Refer to 18.6.2 (a) for exact wireless networking equipment locations TBD. AUTHORITY to provide Ethernet connections. This will be based on system needs evaluation to be approved by AUTHORITY Engineer

(ix) A YMSS Fixed Ethernet LAN.

(x) 1 Color Laser Printer with LAN connection (HP Color Laser Jet 4600 PCL 5c or equivalent)

(xi) Standard UPS equipment to support continuous uninterrupted operation for 10 minutes and then long enough for a controlled shut down.

(b) The Contractor shall be responsible for the installation of all YMSS hardware

including Ethernet Cabling.

18.6.7.2 System Operation

(a) The YMSS shall be a client server system.

(b) The computer LAN interface of YMSS WLAN shall enable the transfer of trainborne subsystems / equipment information to AUTHORITY's intranet and the transfer of commands from the yard terminals to train(s) in the K Carhouse area. The detailed requirements of the computer LAN interface of YMSS WLAN are stipulated in Appendix I Annex 4.

(c) The YMSS shall provide data archive facility for archiving the VSS. Removable optical media shall be employed for the off line storage of Video.

(d) The YMSS shall operate user name and password protection of its functions with the following user id's as follows;

(i) System administrator - all functions including the configuration of the data dictionary and other system settings and setup of user id's along with System Maintenance.

(ii) YMSS VSS Operator(s) – to access and play back Video and voice based data recorded on the YMSS server by Train Run Number, date & time stamp.

(i i i) YMSS TIMS Yard Controller – to setup and verify RUN number designation, and perform Health check of entire Train with status response.

(i v) YMSS Technician(s) – to access Vehicle Train recovery procedures. Specifically request download of Trains Event data on request and perform health checks with response and verification.

(v) YMSS PIS – to access and setup PIS information for DiCU, FSM, LIDS, EIDS, DVAS, EDD, ETND for pre-recorded messages/announcements for Doors, Stations, Special Messages, Emergency messages and Door Chimes.

(v i) YMSS VSS WiLAN – a stand alone function of VSS download

(v i i) For the YMSS TIMS WiLAN – a stand-alone function of continuous upload and download of vehicle TIMS data and the transfer of Event data to AUTHORITY's Work Order System along with processing the queue from administrator, Yard Control, Technician(s) & PIS YMSS computers. Refer to Appendix J for the requirements of data structure.

(v i i i) Updates to Vehicle TIMS Upload and configuration control for Vehicle TIMS fault recovery information contained in the O&M manual via the yard terminals.

(ix) Automatic train fault reporting function which shall automatically display the train subsystems / equipment fault log together with the corresponding fault diagnosis results and the recommended maintenance actions on the yard terminals and maintenance terminals.

(e) The YMSS shall be a networkable application through static IP addresses The main executable shall run from the off-site Server. All computers running YMSS user id's shall be accessible by AUTHORITY's support services for remote assistance through AUTHORITY's information technology service (ITS) help desk.

(f) The YMSS WiLAN's for VSS and TIMS along with all computers need to be fully supported by AUTHORITY ITS and therefore security features must be approved through AUTHORITY's Engineer.

(g) The YMSS shall accommodate the creation of 20 additional user id's for future expansion.

(h) Ten maintenance Laptops shall be provided to allow maintenance staff to perform diagnosis of equipment faults as specified in 18.6.7.1 (a) (viii).

(i) These will be loaded will all Sub-system interface programs and ready to communicate complete with interface cables, carrying case and spare battery. They shall be of a rugged design suitable for the environment being used.

18.6.7.2 Performance Requirements

(a) The Data Comm~~unication Service shall deliver the following performance~~ requirements:

(i) Any train operation command entered via the various user id's shall be managed and transmitted by the respective WiLAN network and ~~an appropriate output shall be presented to the input port of the computer LAN interface of YMSS WiLAN within 5 seconds maximum. A queued process would be acceptable with priorities defined by the AUTHORITY Engineer.~~ Output to the YMSS shall be presented using a visual notification of time when required. A queued process would be acceptable with priorities defined by the AUTHORITY Engineer.

(ii) Any trainborne equipment diagnostic and performance data and fault log presented to the gateway via the computer LAN interface of YMSS WLAN shall be captured and updated in the maintenance database within 5 seconds maximum. This shall be measured from the time the data appears at the input port of the gateway until the maintenance database is updated.

(iii) Any data corruptions or transmission errors shall be manipulated by necessary

recovery procedures and shall not lead to any un-safe condition to the control of Trains and all YMSS equipment. The recovery procedures shall be well-defined in the transmission protocols and shall be submitted for the Commission's approval.

(b) The YMSS database server shall deliver the following performance requirements:

It shall be able to store all the trainborne equipment diagnostic and performance data and fault log of all Trains for 12 months before archiving is required.

18.6.7.3 Computer System Requirements

(a) System Architecture and Platform

(i) The YMSS shall adopt a client server architecture using standard off the shelf hardware and software wherever possible.

(i i) The server component shall operate on Windows® XP (or higher version as approved) servers

(i i i) The relational database engine employed shall be ISO Structured Query Language (SQL) compliant and shall be Oracle.

(i v) The client component shall operate on any IBM® compatible PC capable of running Windows® XP (or higher version as approved).

(b) System Expansion Capability

The YMSS shall be designed in a manner such that, by the addition of more hardware, its capacity can be extended to cater for additional Trains.

(c) Software Expansion Capability

(i) The Contractor shall employ modular design method to enable the software to be easily modified to cope with additional functionality, I/O dialogues, peripheral equipment and LAN equipment.

(i i) All database shall be defined in a central data dictionary. The dictionary shall contain information of each data element and its characteristics such as data type and field size.

(iii) The database employed shall be designed to cater for ease of expansion. A

minimum of 25% spare capacity for the total number of data element and the number of field attributes for each data element shall be provided. A password protected data dictionary editor shall be provided in the yard terminals which allow the operator to change the definition of a data element and to add extra field(s).

(d) Hardware Expansion Capability

(i) The Contractor shall employ hardware platform which allow the following two types of expansion:

(1) spare capacity within the hardware delivered

(2) spare capacity provision which can be easily added / upgraded during the operation of the system

(ii) Spare capacity requirements shall apply to the following resources:

(1) primary memory consisting of all memory used for run time processing and storage of data

(2) disk storage consisting of fixed disk equipment and also removable optical media

(3) communication links including ethernet LAN ports, serial and parallel ports and peripheral equipment such as printers and modems

(4) I/O capacity including spare ports, bit rate capacity and channel capacity.

(5) The amount of spare capacity requirements for the above resources shall be:

Resource	Spare capacity of delivered	Additional upgradeable
Memory	20 %	70 %
Disk storage	40 %	70 %
Communication links	20 % or 2 (whichever is	70 %
I/O capacity	20 %	70 %

(e) Resource Loading

(i) For all the database server, yard terminal, maintenance terminal, gateway, computer LAN interface of YMSS WLAN, the processor loading shall not exceed the following figures:

(1) Processor loading not exceeding mean - 50 % of the processor time

(2) Processor loading not exceeding peak - 80 % of the processor time

(ii) For the YMSS WLAN, the YMSS Fixed LAN and the wireless connection of maintenance terminals to the YMSS Fixed LAN, the loading of the networks shall not exceed the following figures:

(1) Network loading not exceeding mean - 40 % of the network time

(2) Network loading not exceeding peak - 60 % of the network time

(f) LAN Data Rate

(i) The YMSS Fixed LAN shall be an ethernet LAN and the data rate shall be 100 Mbps minimum.

(g) Antivirus and System Integrity Check Function

(i) A pertinent version of antivirus software (with respect to the delivery date) shall be provided which shall prevent all computer viruses to intrude any YMSS computer and LAN equipment by:

(1) Detect and report any computer virus on system start up

(2) Detect the presence of any computer virus in external data source including both floppy diskettes and LAN connections and stop copying of external data

(i i i) A system integrity check function shall be provided in the yard terminals which shall allow the checking of all the YMSS equipment healthiness. The healthy status of each of the YMSS equipment shall be checked and the result shall be reported to the yard terminal which initiate the checking.

(i v) The system integrity check function shall be activated on every system start up and re-initialization to indicate the status of the YMSS system.

(v) The activation of the system integrity check function shall be programmable via the yard terminals.

(h) Yard Terminal

(i) The yard terminals shall serve as client terminals and the configurations shall be complied with PS 18.6.7.3(a)(iv).

(i i) The yard terminals shall provide with a hard disk at least 40 GByte in memory space.

(iii) The yard terminals shall each be provided with one LCD 19" monitor capable of displaying graphical information at a minimum resolution of SVGA (1024 x 768 pixels) in true color.

(i v) A minimum 20X CD R/W +/- drive shall be provided for each yard terminal.

(v) The yard terminals shall be provided with keyboard and mouse for control.

(i) Laptop’s

(i i) Each Laptop shall provide with a hard disk at least 40 GByte in memory space.

(i i i) Each Laptop shall be provided with one minimum 10.4" display capable of displaying graphical information at a minimum resolution of SVGA (1024 x 768 pixels) in true color.

(iv) A minimum 20X CD ROM drive shall be provided for each Laptop.

(j) Color Laser Printer

(i) One colour laser printer shall be networked to the YMSS Fixed LAN and installed in the Tehnicians office.

(ii) The printer shall be capable of producing A3 size colour print.

18.6.8 Data Communication Service

18.6.8.1 General

The coverage of the bi-directional data transmission link shall include all the K Carhouse stabling tracks, maintenance tracks, under-floor wheel lathe area, running maintenance workshop and overhaul workshop.

18.6.8.2 Data Download

(a) The operator via the yard terminal of YMSS shall be able to transmit a "data download" command to particular train(s) or all trains in the K Carhouse. The information to be downloaded shall be pre-selected by the operator and appended with the command.

(b) Upon receipt of the "data download" command, the train(s) will check the validity of the command. Upon confirmation of the validity of the command, the train(s) will start to download the information appended with the "data download" command via the YMSS WLAN.

18.6.8.4 Data Upload

(a) The operator via the yard terminal of YMSS shall be able to transmit a "data upload" command to particular train(s) or all trains in the K Carhouse. The information to be uploaded from train(s) shall be pre-selected by the operator

and appended with the command that includes the train RUN number.

(b) Upon receipt of the "data upload" command, the train(s) will check the validity of the command. Upon confirmation of the validity of the command, the train(s) will start to transmit the required information to the YMSS via the YMSS WLAN.

18.6.8.5 Train Healthiness Test

(a) The operator via the yard terminal of YMSS shall be able to transmit a "train healthiness test" command to particular train(s) or all train(s) in the K Carhouse. An invalid, duplicate or non existing RUN number is one such criteria for healthiness.

This "train healtiness test" shall be implemented as specified in 10.3.2 (a) herein.

(b) Upon receipt of the "train healthiness test" command, the train(s) will check the validity of the command. Upon confirmation of the validity of the command, the train(s) will start to check its status, collect software / parameter versions and will start the initialization of train systems if required.

(c) If no system malfunction has been registered (for train(s) already initialized) or is detected (for newly initialized train(s)), the train(s) will transmit a "train healthy" signal back to the YMSS yard terminal via the YMSS TIMS WLAN. Otherwise, respective fault data and diagnostic messages will be transmitted to the YMSS yard terminal.

18.6.9 Laptops

IBM® compatible notebook PC running Windows® XP (or higher version as approved), as specified in 18.6.7.1 (a) (viii), shall be used be able to withstand the harsh environment in the K Carhouse without affecting any of its function and performance. CD ROM drive shall be provided for running the O&M Manual which will be delivered in a CD ROM format.

18.6.9.2 Fault Diagnosis Support Function

(a) Fault diagnosis support function shall be provided in the YMSS which shall be able allow generation and modification of the diagnosis rules (refer to PS 10.3.7), to assist the Driver & Line Mechanic to perform diagnosis of equipment / component fault by using the TIMS display terminal. This rules shall be able to update to each train through the YMSS TIMS WiLAN.

(b) The fault diagnosis decision support function shall be based on analysis made by the Contractor and/or AUTHORITY to deduce the possible causes of equipment / component fault and suggest a list of recommended corrective actions. The diagnosis shall be based on the equipment / component status as recorded in the maintenance database and the fault diagnosis knowledge base.

(c) A summary report containing the list of recommended corrective actions and the rules / procedures applied shall be able to be generated and printed out as hardcopy from the YMSS computer. The summary report shall be able to be exported to external media via the external data interface (refer to PS 18.6.9.5).

(d) A fault diagnosis knowledge base shall be developed which shall capture rules / procedures that shall apply in the diagnosis of equipment / component fault. The course content of the Defect Recovery Training for both operation and technical staff developed by the Contractor shall form the basis for the initial development of the knowledge base. The Contractor shall be responsible to

update the knowledge base based on all the actual faults encountered during the Defect Liability Period.

(e) A facility shall be provided that allow the fault diagnosis knowledge base to be easily modified without any software and hardware modification. The facility shall allow the input / update of diagnosis rules / procedures by the Commission's staff with no programming experience. The actual update of the diagnosis rules / procedures of the on-board TIMS shall be done using the Portable PC and/or YMSS computer.

(f) The storage space for the knowledge base shall be able to keep up to 10 years' expansion of diagnosis rules / procedures.

18.6.9.3 Automatic Train Fault Reporting Function

(a) When a train is returned to the K Carhouse after completion of revenue operation, the train shut-down function (refer to PS 18.6.8.4) will be initiated by the operator and all diagnostic and performance monitoring data and fault log recorded shall be transferred to the YMSS database server.

(b) The automatic train fault reporting function shall then be automatically invoked after completion of the train shut-down function which shall:

(i) report any detected train subsystem / equipment fault and the associated symptoms

(i i) automatically invoke the fault diagnosis decision support function (refer to PS 18.6.9.2) to deduce the possible causes of equipment / component fault and the list of recommended corrective actions

(iii) automatically invoke the preventive maintenance forecast function (refer to PS 18.6.10.3) to report any required preventive maintenance activities based on defined scheduling criteria and generation of the associated work orders

(c) A summary window / page of all the information as stipulated in PS

18.6.9.3(b) shall be displayed on the YMSS yard terminal upon request. The information to be displayed on the summary window / page shall be organized by train to facilitate easy reading and understanding. Facility shall be provided to allow scrolling of the information on the summary window / page in case the number of train subsystem / equipment faults detected cannot be fitted on a single window / page.

18.6.9.4 Library and Train Configuration Statistics Function

(a) A configuration and statistics facility shall be provided in the YMSS which allow the data request to TIMS via the WiLAN and the displaying and printing of the query results. It shall meet the following requirements:

(i) A configuration of each trains PIS functions that includes an exception report contrary to current defined configuration.

(ii) A configuration of each trains Fault recovery procedures that includes an exception report contrary to current defined configuration.

(iii) A summary status of each trains TIMS sub-sytem Event Data downloads so that Trains not downloading or communicating can easily be identified.

(i v) A summary status of each trains VSS downloads so that Trains not downloading can easily be identified.

(v) These reports shall be able to be printed and / or stored as a local PC file in three formats of comma delimited, columnar and tab delimited.

18.6.9.5 VSS Data Archive Facility

(a) Data archive facility shall be provided which shall be able to archive or copy files based on CD ROM or similar optical technology. This facility shall meet the following requirements:

(i) It shall allow backup of the VSS data.

(i i) The default backup frequency is once per year and shall only be modified via the YMSS administration user id and shall be password protected.

(iii) View facility shall be provided which allow the archived VSS to be viewed.

18.6.9.6 External Data Import Function

(a) An external data import function shall be provided for the YMSS yard terminal which shall meet the following requirements:

(i) External data stored in floppy diskettes or CD ROM shall be able to be downloaded to the YMSS database server and update the maintenance database.

(i i) The external data shall be stored in a pre-defined format as defined by the Commission for downloading to the YMSS database server.

(i i i) The external data shall first be copied to a temporary area and shall be compared with the maintenance database in the YMSS database server. A

report containing the difference between the external data and the maintenance database shall be generated.

(i v) Based on the report, the operator shall be able to select which part of data in the maintenance database shall be overwritten by the external data.

(v) An undo function shall be available for reverting the maintenance database back to the previous version.

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Section 19 Driving Cab Simulator

19.1 General

19.1.1 The Contractor shall be responsible for the design, manufacture, supply, delivery, installation, testing, commissioning, training, documentation, defects liability and design warranty of the Driving Cab Simulator (CABSIM) in accordance with all the requirements as stipulated in the Specification.

19.1.2 The CABSIM shall provide simulations of the train operation for the purpose of training. There are two major areas of training: firstly on basic train operations including train preparation, platform duties, changing end, driving skills and route familiarisation; and secondly interactive defect handling by simulating incidents, defects and abnormal situation for trainees to drill on the recovery procedures.

19.1.3 The CABSIM shall consist of, as a minimum, the following equipment:

(a) Two simulator driving cabs which shall be replicas of the train driving cab with fully operational control and display elements

(b) An instructor's console with control and monitoring equipment including an instructor's terminal, cab monitoring terminals, repeat monitors for track and platform view, TIMS repeat monitors, a communication control console and an auxiliary instructor station for the simulation and training process

(c) A visual simulation and display system providing true-to-scale reproduction of track view and platform view for each simulator driving cab

(d) An audio simulation system generating a realistic driving cab sound environment for each simulator driving cab

(e) Relevant equipment / facilities outside each simulator driving cab including headwall units, passenger door and control switches outside the cab

19.1.4 The CABSIM shall be capable of logging all events into data memory and produce performance report of the trainee based on the preset criteria.

19.1.5 The CABSIM shall provide an exercise evaluation facility to evaluate trainee's performance on exercise run. The assessment shall be based on both objective assessment on the trainee's performance on routine operations and defects handling, and subjective assessment based on observed performance on customer service attitude and effectiveness of communication and coordination.

19.1.6 The CABSIM shall be capable of replaying the trainee's actions together with the status of all controls and driver's indicators and instruments based on the logged data.

19.1.7 The Contractor shall provide operation and maintenance manuals, software maintenance manual and all software source code and listings, specifically designed for the AUTHORITY CABSIM, design and as-built drawings, interface and circuit diagrams.

19.1.8 The Contractor shall provide training on the operation, maintenance and software maintenance of the CABSIM.

19.1.9 The CABSIM shall include the necessary software tools and interfacing expansion capabilities for future system modification and expansion that would be carried out by the Commission. These software tools and interfacing expansion capabilities shall form part of scope of supply as stipulated.

19.1.10 The CABSIM shall be designed using the latest and proven techniques and technology. Modular design shall be adopted to allow future modifications and additions of simulator driving cabs with minimal changes to the computer hardware, software and interface architecture.

19.1.11 To facilitate the development of CABSIM and to cater for different training requirement at different phases, the CABSIM shall be implemented in three stages in accordance with the timeframe shown in the Engineer's Preliminary Programme and Project Calendar. All design changes of train during the various design stages shall be fully incorporated in the CABSIM as stipulated.

19.1.12 As part of the Contract, the Contractor shall build and deliver 2 engineering driving cab mock-ups with all associated control equipment which shall be identical to the approved equipment on the final full-scale engineering mock-up to the Cab Simulator Subcontractor by the specified date.

19.1.13 As part of the Contract, the Contractor shall provide all the required trains

characteristics, operation and control information, including but not limited to the following by the specified date to the Cab Simulator Subcontractor:

(a) Cab assembly drawings indicating driver's cab equipment list and mounting arrangements and cab structural dimensions (including the cab bodyside door and cab / saloon door)

(b) Driver's cab layout drawings with details of in cab-equipment and illuminated displays and panels

(c) Functional description of each item of driver's cab equipment including operating voltage / current and protocol of the software and hardware interfaces for devices possessing digital intelligence

(d) Train electrical circuit diagrams, circuit layout and circuit diagram and any microprocessor logic

(e) Description of train movement dynamics, compressed air system, train control and communication facilities.

(f) Description of the automatic train control system function including automatic train protection and automatic train operation

(g) Air piping diagram

(h) Static brake cylinder pressures for each brake selection for each passenger loading.

(i) Compressor charging / discharging cycle times and cut-in and out pressures.

(j) Gross and Net Weights and train length

(k) Tractive effort against speed curve (all position of traction brake controller)

(l) Braking force against speed curve (dynamic / air ,all stop)

(m) Dynamic / air, brake blending curves

(n) Energy consumption characteristic

(o) Regenerative braking data (e.g. line receptivity)

(p) Traction motor current characteristics

(q) Number of motors per motor car and their configuration

(r) Tunnel train resistance curves

(s) Train resistance to motion (equation or graph)

Any subsequent change to the above train information shall be submitted for approval according to the configuration control program.

19.2 System Description and Performance Requirements

19.2.1 The CABSIM shall be an exercise based simulator i.e. an exercise prepared in advance detailing the starting location, route, signal aspect, defect scenarios to be activated shall be used to control the running of each simulator driving cab. During exercise running, some parameters, for example, signal aspect, defect

scenarios to be activated shall still be able to be modified / added via the instructor's console.

19.2.2 One instructor's console comprising of an instructor's terminal, cab monitoring terminals, repeat monitors for track and platform view, TIMS repeat monitors, a communication control console and an auxiliary instructor station shall be provided for the overall control and monitoring of the two simulator driving cabs. The design and implementation of the instructor's console, particularly, the man machine interface, shall adopt the best practice in human engineering. In general, guidelines in ISO 6385 and MOD Defence Standard 00-25: Part 11 shall be adhered to. Anthropometric dimensions for the Canadian population shall be adopted.

19.2.3 One instructor's terminal shall be provided which shall be able to operate in two modes, namely off line and on line mode. Off line mode shall enable database management, preparation and editing of exercises while on line mode shall enable the overall supervision and control of the two simulator driving cabs.

19.2.4 The two simulator driving cabs shall be able to operate in different modes:

(a) Running independently of the other i.e. different exercise (such as different route, line) can be run on the two simulator driving cabs at the same time

(b) Linked together to form part of a train with one simulating the leading and the other non-leading cab and allow the non-leading cab to be used for driving (i.e. driving from the rear exercise)

(c) Assisting train scenario (both from behind and ahead) - one act as the assisting train and the other as the defective train

19.2.5 Each simulator driving cab shall be a replica of the train driving cab and equipped with fully operational control and display equipment replica. These shall include all the driving equipment, indications, fault alarms, seats, control consoles, interior panels, lighting, windows, vents, cab doors, communications equipment, Video Surveillance Systems (VSS) video display, TIMS display

terminal and the operating control functions that are available on a real train driving cab. All these equipment shall be simulated to respond as in the corresponding operational driving cab including all the emergency operations.

19.2.6 Each simulator driving cab shall also be equipped with communications

equipment which are essential for the normal train operations and for train defect recovery including the Video Surveillance Systems (VSS) video display, Digital Voice Announcement System (DVAS) and Public Address (PA) and Train Radio. All these equipment shall be simulated to respond as in the operational driving cab and shall be simulated to provide the same functionalities as in the operational systems.

19.2.7 Each simulator driving cab shall be equipped with a visual simulation and display system to provide a true-to-scale and flicker free display of track view covering both the existing Lines and the new E Subway Extension for the complete range of replay speeds from standstill to not less than 88 km/h (55 MPH) and to enable fault or incident scenario simulation. All power supply third rail, track, trackbed, lineside, tunnel and platform features shall be incorporated and displayed in a true-to-scale manner synchronized with the simulated train position and speed. All fixed signals and points shall be able to be changed / switched to simulate different traffic control and travel on different tracks.

19.2.8 Each simulator driving cab shall be equipped with an audio simulation system which can generate a realistic sound environment of driving cab synchronized with the simulated train speed, location and cab equipment operation.

19.2.9 A cab monitoring terminal shall be provided for each simulator driving cab which is responsible for reporting the status of all the controls, indications and alarms of the cab, speed and position of the simulated train, action of the trainee and status of the running exercise and system. All indications presented to the trainee shall also be displayed in full including those on the Train Radio, DVAS and PA and VSS.

19.2.10 Two repeat monitors shall be provided for each simulator driving cab. One shall be responsible for repeating the track view as displayed in front of the simulator driving cab and the other shall be responsible for repeating the platform view as displayed in the Platform Mirror display.

19.2.11 A TIMS repeat monitor shall be provided for each simulator driving cab. It shall repeat the display on the TIMS display terminal and indicate all the trainee's commands entered via the TIMS display terminal.

19.2.12 A communication control console shall be provided in the instructor's console that enable the instructor to talk to the trainees via simulated Train Radio or passenger alarm talkback and to hear the broadcast of live or pre-recorded announcements.

19.2.13 All the simulating components including the simulator driving cabs, audio simulation, visual simulation and display and instructor's console shall be linked through a computing network. A non-proprietary and industrially proven real time operating system and networking protocol shall be employed.

19.2.14 The CABSIM shall be able to deliver the following performance requirements:

(a) Any command entered via the instructor's console shall be processed and an appropriate output be produced within 2 seconds maximum. For those commands that may take long time to be processed, the Contractor shall

submit justification for approval.

(b) Any change of state of simulator driving cab condition shall be updated within 2 seconds maximum. This shall be measured from the time change is issued until the screen display of the cab monitoring terminal is updated. For those state changes that may take long time to be processed, the Contractor shall submit justification for approval.

(c) The system shall never become locked due to failure or non-operation of a selected command or exercise.

19.3 Train Behaviour Simulation

Each simulator driving cab shall simulate the full train behavior and the manner in which the train interface with both the Existing Lines. This shall include train dynamics, train subsystems, communications equipment, driving cab equipment, performance, functions, controls and displays. The following features, as a minimum, shall be included:

19.3.1 Train Dynamics Simulation

(a) As a minimum, the following factors affecting the running of trains shall be included in the simulation of train dynamics:

(i) gradient and curvature of track

(i i) aerodynamic resistance in open and tunnel section

(i i i) train consist including weight of train and passenger loading

(i v) traction current supply

(v) traction motors characteristics and status

(v i) dynamic (regenerative and rheostatic) and friction brake characteristics and status

(vii) brake blending and brake response time

(viii) third rail power supply line receptiveness

(ix) friction brake adhesion coefficient

(x) parking brake characteristics and application

(xi) wheel slip/slide condition

(xii) train operation mode

(b) The Contractor shall develop a model incorporating all the factors detailed in (a) above to accurately calculate the speed and position of the simulated train given the condition / status of each of the factors. The Contractor shall ensure that the model can cater for all possible value / status of the factors and can generate the correct simulated train speed and position.

(c) The complete model shall be integrated into the simulation software and be able to receive the value / status of the factors from the following sources:

(i) master database (for example track gradient and curvature)

(i i) Intrinsic value / status (for example train weight, traction motor characteristics) (iii) trainee's actions (for example selection of train operation mode)

(iv) instructor's console (for example instructor can trigger the activation of a defect scenario in which the traction current supply is turned off)

(d) The following factors shall be able to be controlled via the instructor's console:

(i) passenger loading - selectable from tare to crush laden

(i i) friction brake adhesion coefficient and the applicable area - selectable among dry and normal rail, wet rail due to raining and rail with lubrication oil

(i i i) third rail power supply line receptiveness - selectable between receptive, partial receptive and non-receptive with the applicable area

19.3.2 Train Operation Mode Simulation

(a) All modes of train operation as stipulated shall be fully simulated.

(b) The simulated train shall respond to the trainee's motoring, braking and coasting commands in all modes of operation.

19.3.3 Signal System Simulation

(a) All functions of the existing Signal System and SCS for the safety protection shall be fully simulated in all running lines and the specified depot areas. Upon request, the AUTHORITY's document titled "Identify & Understand Components of Subway Signals and switch Systems" which provided a brief description of the existing Signal System, is available for Contractor's reference. Access to AUTHORITY lines, control tower and operation procedures are also available on Contractor's request.

(b) The process of dispatching a train from depot areas to running lines via the depot departure track shall be fully simulated. Similarly, the process of withdrawing a train from running lines to depot via depot arrival track shall be

fully simulated. Relevantr procedures are available for Contractor's reference.

(c) The functions of the trackside fixed signals and equipment shall be simulated.

(d) Provide signal protection which triggers the application of emergency brake by the activation of the Trip Arm device on the trackside if the simulated train operator disobeyed the signal and moved the train more than the allowed distance

(e) Points shall be interlocked with the selected route and trackside fixed signal.

19.3.4 Simulation of Train Subsystems

(a) The Contractor shall develop models based on the actual electrical, pneumatic and electronic circuitry and software control module / program to accurately represent the logic and operation of each of the train subsystems. The Contractor shall ensure that the models are correct under all input and operating conditions. The train subsystems to be modelled shall include:

(i) traction and braking equipment

(i i) auxiliary electrical supply equipment

(i i i) pneumatics and air distribution equipment

(i v) doors equipment

(v) air conditioning and ventilation equipment

(v i) TIMS equipment

(b) Traction and Braking Equipment

(i) The control logic and functions of all the traction and braking equipment as stipulated including the power contactors, high tension circuit, traction motors, brake control units, friction brake isolation device, wheel slip/slide protection shall be fully simulated.

(ii) The traction motor characteristics, brake control, brake response time and brake blending shall be fully simulated and incorporated in the Train Dynamics Simulation model.

(c) Auxiliary Electrical Supply Equipment

(i) The control logic and functions of all the auxiliary electrical supply equipment as stipulated including the auxiliary converter, DC Circuit and AC Circuit shall be fully simulated.

(d) Pneumatic and Air Distribution Equipment

(i) The control logic and functions of all the pneumatic and air distribution equipment as stipulated including the main air compressor, main air reservoir,

brake supply reservoirs, safety valve and horn shall be fully simulated.

(e) Doors Equipment

(i) The control logic and functions of all the doors equipment as stipulated including the passenger bodyside door, cab/saloon partition door, emergency door (no opening is required), cab bodyside door, door control unit and isolation device shall be fully simulated.

(ii) One cab/saloon partition door identical to the ones used in the train driving cab shall be provided in each simulator driving cab which shall be fully functional.

(iii) Two pairs of passenger bodyside doors identical to those used in the train shall be provided which shall be fully functional. The instructor's console shall be able to select which simulator driving cab can control the operation of these pairs of passenger bodyside doors.

(iv) One pair of cab bodyside doors identical to those used in the train shall be provided in each simulator driving cab which shall be fully functional.

(f) Air Conditioning and Ventilation Equipment

(i) The control logic and functions of all the air conditioning and ventilation equipment as stipulated including air conditioning, emergency mechanical ventilation and cab air conditioning shall be fully simulated.

(g) TIMS Equipment

(i) The control logic and functions of all the TIMS equipment as stipulated including Train Control Network (TCN), Event Recorder, Control Interfaces and TIMS display terminal shall be fully simulated.

(ii) A TIMS display terminal replica identical in appearance and functionality to the one used in the train driving cab shall be provided in each simulator driving cab with the operating Man-Machine Interface (MMI) being simulated to provide full functionality.

19.3.5 Simulation of Communications Equipment

(a) The Contractor shall simulate the control logic and functions of the following communications equipment:

(i) Train Radio

(i i) VSS

(i i i) DVAS and PA

(b) Train Radio

(i) The following Train Radio equipment identical in appearance to that used in the train driving cab shall be provided in each simulator driving cab:

(1) a control head and retainer

(2) a handset

(3) a loudspeaker

(ii) The functions of the Train Radio as stipulated shall be fully simulated with the above equipment to deliver the same functions as in the real system.

(iii) All communication shall be routed to the communication control console which shall simulate the role of the traffic controller in Operation Control Centre (OCC) and the depot train controller.

(c) VSS

(i) A VSS trainborne video display identical in appearance to that used in the train driving cab shall be provided in each simulator driving cab.

(ii) The functions of the VSS as stipulated in PS 10.2.7 and PS 18.3 and shall be fully simulated with the above equipment to deliver the same functions as in the real system.

(iii) The saloon images to be displayed on the VSS shall be generated by the CABSIM visual simulation and display system. The display shall clearly show the seating, standing and moving passengers inside the saloon and outside the platform while the passengers during the loading and unloading conditions. Provision shall be made to ensure the synchronization of movements between the door images as shown in the VSS display and the actual door operation.

(d) DVAS and PA

(i) Those DVAS and PA equipment that are identical in appearance to that used in the train driving cab shall be provided in each simulator driving cab.

(ii) The functions of the DVAS and PA as stipulated shall be fully simulated with the above equipment to deliver the same functions as in the real system.

(iii) Broadcast of live or pre-recorded announcements by the trainee shall be routed to the communication control console. The communication control console shall enable the instructor to play the role of passengers who have operated emergency handle(s) and talk back to the trainee via the emergency microphone(s).

19.3.6 Simulation of Driving Cab Equipment

(a) All driving cab facilities, equipment and panels identical to those used in the train driving cab as stipulated shall be provided and installed in each simulator driving cab.

(b) All equipment shall be simulated to deliver the same functions as in the real train driving cab.

(c) The MCB's shall be provided with tripping feature such that each MCB can be remotely tripped by the instructor's console to simulate fault conditions. The tripping feature shall include two modes of operation - re-settable and unresettable mode. In re-settable mode, the MCB can be restored to its normal

position without further tripping. In unresettable mode, the MCB shall be tripped again when attempting to restore it to its normal position.

19.4 Visual Simulation and Display System

19.4.1 Track View

(a) The view as seen through the front windscreens on both sides of the driving cab shall be provided for each simulator driving cab and thereafter shall be referred as the track view. The track view shall be correct under all circumstances and shall fulfill all the requirements as stipulated below.

(b) The track view shall cover:

(i) All Existing Lines including all sidings, crossovers, overruns as stipulated.

(i i) All existing depots that are located at W, U and K which shall include the depot arrival and departure tracks.

(c) The track view shall cover all platforms of the existing running lines. The above track view shall be able to be selected to apply for an entire line or for particular station(s).

(d) The track view shall be provided by computer generated images (CGI) engine(s) based on the actual view as seen through the front windscreens of the driving cab and shall be close to real. All the images as stipulated in Clause (e) (iii) below shall be clearly legible and their texture, shape, size, position, orientation shall be correct as compared with the actual view.

(e) The track view shall meet the following requirements:

(i) Minimum 60 Hz refresh rate with 48 bit RGBA colour and minimum VGA non-interlaced display

(ii) Flicker free for the complete range of replay speeds from standstill to 90 km/h

(iii) Provide true-to-scale and correct images for:

(1) All third rail power supply line features such as third rail power supply line, open-cut construction, emergency exits, supporting posts including position numbers, feeder wires

(2) All track features such as rail, points, crossovers, turnouts

(3) All trackbed features such as concrete slab, ballast, beacons

(4) All lineside features such as trackside fixed signals with signal number plates, route indicators, block boundary indicators, limit of shunt indicators, stop indicators for depots and running tracks, floodgate indicators, speed restriction

indicators, train approaching indicators, wrong direction marker boards, landscapes, bridges, flyovers, buildings

(5) All tunnel features such as floodgates, cables running along tunnels, signal equipment boxes

(6) All platform features, trackside advertising boards, waiting passengers

(7) Adjacent track features such as all sidings, cleaning platforms, track and overhead features, moving and stationary train

(8) All those features that can be seen on the right hand side windows by the train operator including the platform Mirror to clearly show the alighting, boarding and waiting passengers at the platform and the passengers loading and unloading conditions

(9) Driving from the rear scenario when the simulated train is driven from the rear cab

(1 0) Assisting train scenarios (both from behind and ahead) for both the defective train and the assisting train

(iv) Synchronised with the speed, acceleration and deceleration of the simulated train

(v) Able to simulate the following attributes of the images:

(1) weather - sunny, overcast, raining, thunderstorm

(2) visibility - clear, foggy

(3) time of day - dawn, morning, afternoon, sunset, night

(4) headlight on/off

(vi) Able to overlay images to simulate the following incidents at any location:

(1) people falling on track

(2) obstacles on track

(3) people crossing track

(f) The different track view attributes as stipulated shall be able to be selected via the instructor's terminal in either the off line mode or on line mode.

(g) Where applicable, the different overlay images as stipulated shall be able to be selected via the instructor's console in either the off line mode or on line mode.

(h) The track view shall be projected onto screen(s) mounted in front of the windscreens of the simulator driving cabs covering the entire field of view of the trainee via industrial grade projectors. A minimum 230º projection wrap around screen (including the right hand side window) shall be provided for each simulator driving cab.

(i) The track view shall also be displayed for monitoring on the repeat monitor for track view on the instructor's console.

19.4.2 Platform View

(a) The platform views which shall form part of the track view, as seen on both the right hand side window and platform mirror, shall be simulated and shall be provided for each simulator driving cab.

(b) The platform view shall cover all platforms of the existing running lines. The above platform view shall be able to be selected to apply for an entire line or for particular station(s).

(c) The platform view shall be provided by computer generated images (CGI) engine(s) based on the actual images viewed by the platform mirror and shall be close to real. The Contractor shall take into account the position and filming angle of the cameras in generating the platform view. The simulator shall model all stations along the AUTHORITY track network. This modeling must be geographically and dimensionally accurate but the actual objects can be generic. Of these stations, 5 stations shall be accurately rendered, providing realistic photo-textured reproduction of the station environment and its specific visual cues or landmarks. All the images as stipulated in Clause (d) (ii) below shall be clearly legible and their texture, shape, size, position, orientation shall be correct as compared with the actual view.

(d) The platform view shall meet the following requirements:

(i) Minimum 60 Hz refresh rate with 48 bit RGBA colour and minimum VGA non-interlaced display

(ii) Provide true-to-scale and correct images for:

(1) alighting, boarding and waiting passengers at platform during peak (crowded platform) and non-peak hours

(2) platform features such as destination indicator, clock, escalators and staircases

(3) outside door indicators

(iii) Able to simulate the following scenarios:

(1) people trapped by train door

(2) objects trapped by train door

(3) train door unable to be opened

(4) train door unable to be closed

(5) emergency situations including platform on fire and station evacuation in progress

(iv) The movement of train doors and passengers shall be animated in a smooth manner both during normal situation and scenarios

(e) The different scenarios as stipulated shall be selectable via the instructor's console.

(f) The platform view shall also be displayed for monitoring on the repeat monitor for platform view on the instructor's console.

19.5 Audio Simulation System

19.5.1 An audio simulation system shall be provided for each simulator driving cab to provide a realistic sound environment of driving cab.

19.5.2 The audio simulation system shall meet the following requirements:

(a) Provide the following sound which shall be synchronised with the simulated train speed, location, status and cab equipment operation by adjusting the sound characteristics (such as amplitude, frequency, duration):

(i) Wheel / rail sound representing the noise created by train's wheel against the rail depending on:

(1) different types of track (jointed or continuous)

(2) speed of train(3)curvature of track

(4) crossing points / crossovers

(5) locked wheels

(6) flat wheels

(ii) Environment sound representing noise heard when train is in the following environment:

(1) passing another train

(2) passing by a platform

(3) running into a tunnel portal

(4) running in a tunnel or open section

(iii) Air exhaust sound representing noise heard when air escapes in the following situations:

(1) applying friction brake

(2) bursting of an air piping

(3) operation of a brake isolating device

(4) operation of the parking brake

(iv) Traction sound representing noise created by traction equipment in the following situations:

(1) powering

(2) braking

(3) coasting

(v) Warning horn sound when the horn button is pressed

(v i) Relay sound representing noise created by the operation of relays which can be heard in the driving cab

(vii) Compressor sound representing noise created by the main air compressor in the following situations:

(1) turning on

(2) running

(3) turning off

19.5.3 Industrially proven sound generation equipment shall be employed for the audio simulation system. It shall be capable of capturing samples of all the required noise as the basis of sound generation.

19.6 Fault Scenarios Simulation

19.6.4 The Contractor shall provide simulation of a comprehensive list of fault scenarios and abnormal situations for trainee to drill on the recovery procedures.

19.6.5 A minimum of 100 fault scenarios shall be able to be stored and run on the CABSIM.

19.6.6 Each fault scenario shall be controllable either by the pre-defined information in the exercise, or during the running of an exercise via the instructor's console.

19.6.7 Fault scenario shall have the following possible status:

(a) Inserted - fault scenario is inserted into the simulated train and shall become active when the activation condition(s) is met (for example train overrun shall become active when train starts to stop at a station)

(b) Active - activation condition(s) is met and effects of the fault scenario shall appear

(c) Overcome - correct recovery procedures taken but the root cause of the fault

scenario is not be removed (for example locked wheels with brake isolated)

(d) Cleared - correct recovery procedures taken and root cause of the fault scenario is removed (for example train stopped short and moved to correct stopping point in CM by trainee)

(e) Cleared by Instructor - correct recovery procedures not taken and fault scenario has been removed by the instructor via the instructor's console

(f) Cleared by System - correct recovery procedures not taken and fault scenario removed automatically by the system without instructor's intervention and applicable for exercise of training type only.

19.6.8 Each fault scenario shall have the following information fields:

(a) Activation Criteria - define the conditions including time delay upon which the fault scenario shall become active after it is inserted

(b) Symptoms - the audio, visual and train behavioural symptoms when fault scenario become active

(c) Overcome / Clear Criteria - define the recovery procedure (step or combination of steps with a particular sequence) to be taken in order to overcome / clear the fault active scenario

(d) Standard Time - standard handling time for performing the recovery procedure

(e) Tolerance Time - a percentage of the standard time which defines the maximum time beyond which defect handling time shall be given zero mark

(f) Extensive Delay Limitation - a percentage of the tolerance time beyond which exercise of qualification type shall be stopped automatically, and the trainee deemed to have failed.

A typical fault scenario with all the information fields is depicted in Table 19-1 for illustration purpose (not meant to be correct in content). The scenarios as listed in Table 19-2 were considered valuable for training purpose. The Contractor shall provide the required functionalities according to these scenarios. The Contractor may offer alternative scenarios or simulation functions which are able to achieve the equivalent or better training values than those herein, and which the Contractor shall justify to the satisfaction of the Commission.

19.7 Instructor's Console

19.7.1 Cab Monitoring Terminal

(a) A cab monitoring terminal shall be provided for each simulator driving cab and shall be situated on the instructor's console. A 19" diagonal colour monitor with minimum SVGA resolution (1024 x 768 pixels) and 1024 colour palettes shall be used.

(b) It shall provide all the necessary information of the simulator driving cab for the instructor's monitoring.

(c) The following information and status of the simulated train shall be provided on the cab monitoring terminal:

(i) speed

(i i) current track position, displayed in a diagrammatic manner

(i i i) operational mode

(i v) status of passenger doors

(v) main air pressure and brake air pressure as indicated

(v i) status of all cab controls and indications as stipulated

(v i i) status of all cab MCB's

(v i i i) Train Radio status including channel selected and text displayed

(i x) DVAS and PA status including mode of operation and text displayed

(x) elapsed time of exercise

(x i) mode of simulator driving cab

(x i i) type of exercise (training or qualification)

(x i i i) status of running exercise (normal, freeze, replay)

(d) All of the above information and status shall be displayed graphically by suitably coloured and chosen graphical images and supplemented by text if necessary. They shall be continuously updated to reflect the latest status through animation of the graphical images and text. Their colour, relative size, location, layout and animation method shall match with the actual equipment and driving cab.

(e) To provide an efficient operating environment for the instructor, multiple display pages shall be provided which can be called up easily by a single keystroke or click through the keyboard or pointing device.

The following pages, as a minimum, shall be provided:

(i) "TRACK PAGE" which shows the current simulated train position and the relevant track section, the simulated train speed, operation mode and the colour aspects of the approaching signals with the signal type

(ii) "FAULT PAGE" which shows all possible fault scenarios and their status (active, overcome, cleared).

(iii) "MCB PAGE" which shows the status of all the driving cab MCB's

(iv) "CAB PAGE" which shows all the simulator driving cab equipment status and train operator's actions

(v) "EXTENSIVE PAGE" which shows all the information as stipulated

(f) The maximum number of display pages required shall not exceed ten and the precise layout, operation logic and graphical icons which shall be clearly and logically laid out shall be submitted for approval.

19.7.2 Repeat Monitors

(a) Two repeat monitors for each simulator driving cab shall be provided to repeat the track view and platform view displayed. 14" diagonal colour monitors with resolution compatible with the track view and platform view resolution shall be provided.

(b) The repeat monitors shall be mounted near to the cab monitoring terminal to enhance the ease of monitoring. There shall be no disturbance in the colour and stability of display due to electromagnetic interference between the monitors.

19.7.3 TIMS Repeat Monitors

(a) A TIMS repeat monitor shall be provided for each simulator driving cab and shall be situated on the instructor's console. A 14" diagonal colour monitor with minimum SVGA resolution (1024 x 768 pixels) and 1024 colour palettes shall be used.

(b) The TIMS repeat monitor shall be able to display all the MMI of the TIMS and it shall repeat the display on the TIMS display terminal. All trainee's input and selection entered via the TIMS display terminal shall also be indicated on the TIMS repeat monitor.

(c) The TIMS repeat monitor shall be mounted near to the cab monitoring terminal to enhance the ease of monitoring. There shall be no disturbance in the colour and stability of display due to electromagnetic interference between the monitors.

19.7.4 Auxiliary Instructor Station

An auxiliary instructor station shall be provided that allow other four training instructor(s) / observers to observe the performance of trainees. The cab monitoring terminals, repeat monitors for track and platform view and the TIMS repeat monitors for the simulator driving cabs shall be able to be seen clearly from the station. It shall be designed and constructed in an ergonomic manner.

19.7.5 Instructor's Terminal

(a) The instructor's terminal shall be able to operate in two modes, off line mode and on line mode. The off line mode is firstly initiated when the system starts up and it provides exercise editing and system diagnostics functions. The on line mode is initiated when training exercise is being run and provides exercise control functions.

(b) Off Line Mode

The following functions shall be provided by the instructor's terminal in the off line mode:

(i) An exercise editor for creating / editing / deleting exercise. The exercise editor shall be designed in a way that no programming experience of any kind is required for operation. The exercise editor shall be able to define the following:

(1) Type of exercise, including training and qualification exercises

(2) Mode of simulator driving cab(s), including single cab, driving from the rear, assisting from ahead and assisting from behind

(3) Route of the train, selectable by clicking on the starting location and the destination on a graphical map which shows the geographical location of the four running lines and depots

(4) Passenger loading

(5) Friction brake adhesion coefficient

(6) Third rail power supply line receptiveness

(7) Signal aspect for each fixed signal on the selected route

(8) Track view attributes including weather, visibility, time of day and headlight on/off as stipulated

(9) Overlay images including people falling on track, obstacles on track and people crossing track and the required location as stipulated

(10) Platform view scenarios including people trapped by train door, objects trapped by train door, train door unable to be opened, train door unable to be closed and the required platform as stipulated

(1 1) Fault scenarios to be inserted and the required location / time and the location / time of fault scenarios become overcome / cleared by instructor (if applicable)

Default values / settings shall be provided for all of the above information and shall be used when no instructor choice / action is received.

(ii) The exercise editor shall allow the following control information for fault scenarios to be incorporated in the exercise:

(1) Reference to location - fault shall be controlled when simulated train reaches the defined location, either with reference to the starting location (for example

2000 m from starting location) or to a specified platform within the selected route (for example 200 m before / after a certain station)

(2) Reference to time - fault shall be controlled when the time elapsed reaches the defined moment, either with reference to the start of exercise (for example 15 min after start of exercise) or to the time past a specified platform (for example 1 min after passing a certain station)

(iii) The exercise editor shall allow the instructor to view the content of any

defined exercises and produce a printout of the exercise with all information as listed.

(i v) A minimum of 50 exercises shall be able to be pre-defined via the instructor's terminal. The date of creation / modification and the person who created / modified the exercise shall be recorded for exercise management purposes.

(v) A simulation database manager shall be provided to allow the creation / editing of all database information necessary for simulation. This shall include, as a minimum, the following database fields:

(1) Gradient and curvature of track

(2) Trackside fixed signal type and number of aspects

(3) Civil speed restriction

(4) Points / crossovers location

(5) Open / tunnel section

(6) Fault scenario standard, tolerance and extensive delay limitation time

(vi) An exercise and record manager shall be provided to manage the exercises, logs and exercise evaluation reports in the logging server. It shall provide the following functions:

(1) To enable query of the stored exercises, trainee exercise logs and exercise evaluation reports based on run date of exercise ran, name of trainee or exercise number

(2) Generate a summary report for query conducted.

(3) Housekeeping function for exercises, logs and exercise evaluation reports stored in the Logging Server including deletion, backup and sorting.

(vii) All the necessary software maintenance and debugging tools including a language compiler, on-line debugger shall be provided such that modifying and debugging of the simulation software can be performed.

(viii) Diagnostic facilities for both hardware and software of the CABSIM to identify and report any fault shall be provided. The facility shall be user friendly such that the instructor can get assistance in isolating a fault to the

lowest level. The area covered by the diagnostic facility shall include, as a minimum, the following:

(1) Visual simulation and display system

(2) Audio simulation system

(3) Driving cab equipment

(4) Cab monitoring terminals, repeat monitors and TIMS repeat monitors

(5) Instructor's terminal

The fault(s) shall be reported both on screen and in hard copy.

(ix) A backup facility using removable optical / magnetic media shall be provided with the following modes:

(1) Backup system software - Backup all the system software necessary for running of CABSIM to the removable media

(2) Restore system software - Restore CABSIM by reinstalling the system software from the removable media

(3) Backup exercise and exercise log - Backup all the selected exercises and the associated exercise logs to the removable media

(4) Restore exercise and exercise log - Restore all the selected exercises and the associated exercise logs from the removable media

(c) On Line mode

The following functions shall be provided by the instructor's terminal in the on line mode:

(i) To allow the instructor to select, start, terminate, freeze and restart any defined exercises on each of the simulator driving cabs individually.

(ii) To allow the instructor to view the content of the exercise during the running of the exercise.

(iii) To allow the instructor to change the following operating conditions of the exercise:

(1) The colour aspect of approaching signals

(2) Activation of manual train hold at platform

(3) Passenger loading

(4) Friction brake adhesion coefficient

(5) Third rail power supply line receptiveness

(6) Overlay images including people falling on track, obstacles on track and people crossing track, and define the required location

(7) Platform view scenarios including people trapped by train door, objects trapped by train door, train door unable to be opened, train door unable to be closed and define the required platform

(8) Fault scenarios to be inserted and the required location / time and the location / time of fault scenarios become overcome / cleared by instructor

(i v) Both types of exercise (training and qualification) shall be stopped automatically when critical mistakes with safety implications are performed by the trainee. The list of critical mistakes shall be prepared by the Contractor and submitted for approval.

(v) An extensive logging facility supported by a logging server shall be provided that can log all the required information of the exercise being run. The log shall be time and distance associated (i.e. time elapsed and location of train with reference to both starting point and to the nearest station if applicable) and shall include the following information:

(1) Initial status and change in state of all controls, indications in driving cab and all voice communications

(2) All trainee's actions

(3) All fault scenarios status (inserted, active, overcome, cleared, overcome by instructor, cleared by instructor)

Each particular logging can be printed out as a hardcopy for detailed checking and evaluation.

(vi) An exercise replay facility shall be provided to replay all the trainee's actions during an exercise. The train behaviour simulation, driving cab, visual simulation and display system and audio simulation system shall be activated synchronously by the trainee's exercise log to replay the progress of the exercise. The cab monitoring terminals, repeat monitors and TIMS repeat monitor shall also be simultaneously activated. This exercise replay facility shall be able to be performed independently on the associated simulator driving cab while the remaining simulator driving cab can still be used for

running exercise. In addition, the simulator shall include the ability to switch to an overhead helicopter view of the train and the surrounding environment. This overhead view will be used by Instructors during the playback mode to illustrate examples of trainee performance, such as: signal adherence, train acceleration and braking, and train position in relation to track level equipment, workers, station platforms and etc. The trainee Replay Run stored on the local recording media should be a maximum of 10 Trainee runs. Possibility to save and store Trainee Run on a remote storage media, to be played at a later time, should be available on the CABSIM.

(vii) To allow the system to be shut down in an orderly manner such that no useful information, for example, the trainee's exercise log, running exercise, shall be lost.

(d) Logging Server

(i) A logging server shall be provided to store all the exercises, logs of exercises run by trainees and exercise evaluation reports.

(i i) Sufficient memory shall be provided to store a minimum of 100 different exercises, exercise logs and evaluation reports for half year (based on 30 trainees per day each running 2 exercises).

(iii) A backup facility shall be provided by the logging server to transfer the selected exercises, logs and exercise evaluation reports to removable backup storage media.

(e) Printer

A laser printer capable of printing at 3 pages per minute with minimum 600 x 600 dpi resolution shall be provided to produce hard copies of all exercise content, evaluation reports, exercise logs and diagnostic results.

(f) Communication Control Console

(i) A communication control console shall be provided to support the functions of the simulated Train Radio and Passenger Alarm system.

(ii) The communication control console shall allow the instructor to perform simulated radio communication with any one of the simulator driving cab. Half duplex communication shall be provided.

(iii) The communication control console shall be able to simulate a passenger

operating an passenger alarm emergency handle(s) and talk back to trainee through passenger alarm microphone. Multiple operation of emergency handles shall also be able to be simulated.

(i v) For driving from rear exercises, the cab-to-cab intercom function between the two simulator driving cabs representing the two cabs of a train shall be simulated, with the support of the communication control console.

(v) A training intercom facility shall also be provided and controlled by the communication control console. The instructor shall be able to select a particular or both simulator driving cabs to initiate a half duplex intercom with the trainee(s).

19.7.6 Man Machine Interface (MMI)

(a) The proposed MMI for the cab monitoring terminal and instructor's terminal shall be submitted for approval in the form a detailed description document and a simulation program.

(b) The simulation program shall be run on an IBM® compatible PC operating under MS Windows XP®.

(c) The simulation program shall show exactly the same MMI as that proposed for the cab monitoring terminal and instructor's terminal together with all control functions and logic.

19.8 Exercise Evaluation

19.8.1 An exercise evaluation facility for the trainee's performance based on the exercise logs shall be provided. It shall be available in both on line and off line mode of the instructor's terminal.

19.8.2 A scoring evaluation method shall be employed which shall assign score in accordance with trainee's performance based on both objective and subjective assessment.

19.8.3 Every fault scenario introduced in an exercise shall be rated independently in accordance with the principles as stipulated. The overall score for the exercise shall be given by the sum of the marks for customer service plus the average marks for defect(s) handling procedure and defect(s) handling time of all the fault scenarios that have been introduced.

19.8.4 Defect(s) Handling Procedure

The maximum marks shall be allocated evenly for every step in the recovery procedure in overcoming / clearing the fault scenario. The marks assigned shall be the multiplication of the number of correct steps with correct sequence and the marks per step.

19.9 Simulator Driving Cab Structure

19.9.1 A support structure with all relevant interior parts including panels and components shall be provided for each simulator driving cab. All the control facilities, indications as stipulated and all interior panels shall be provided, which shall be the same as the production batch for the train.

19.9.2 Support Structure

(a) A support structure shall be designed and built for the mounting of cab interior panels, control facilities and indications.

(b) It shall be able to accommodate all the necessary interior components, control facilities and indications and have adequate strength for the purpose.

(c) The support structure shall be robust to ensure no permanent deformation under normal training use.

(d) Modular frame design is preferable for installation and future relocation if necessary.

(e) It shall be properly treated and painted to prevent corrosion. Where timber is used, it shall be of high quality hard wood.

19.9.3 Interior

(a) The interior environment shall be identical or equivalent in shape and in form to the train driving cab. All the interior panels shall be provided and installed onto the support structure.

(b) The installation shall fully reflect the real train driving cab.

(c) All driving equipment, indications, fault alarms, seats, control consoles, lighting, vents, communications equipment, VSS video display and TIMS display terminal that are available on a real train driving cab as stipulated, interior panels, fixture and mountings shall be provided and properly installed. The method of installation shall ensure ease of future replacement.

(d) A real cab / saloon door shall be installed.

(e) A pair of cab bodyside doors shall be fitted and aligned to be fully operative with door gear such that it can perform real cab door open and close functions.

(f) The emergency door shall only simulate the appearance and shall not be required to be operative.

(g) The real windscreen and windows shall be installed. Windscreen wipers shall also be installed but not functional.

(h) The cab air conditioner is not be required to be provided but the cab air conditioner control panel, supply and return vents shall be installed. A ventilation fan shall be provided for each simulator driving cab to draw the room conditioned air into the cab to provide a comfortable environment for two people running an exercise in the cab, typically for about one hour.

(i) An emergency cab bodyside door opening device with guarding cover shall be provided to enable a trainee to open the cab doors to prevent people from being trapped inside the simulator driving cab.

19.9.4 Exterior

(a) Modelling of the exterior shall be carried out to create an appearance similar to the appearance of the train.

(b) The exterior shall be panelled with metal or wooden sheets with sufficient strength.

(c) It shall be properly finished to give a smooth painted surface in the same colour as the train to the satisfaction of the Engineer.

19.9.5 Passenger Bodyside Doors

(a) A pair of real passenger bodyside doors with control facilities shall be provided, on each side of the CABSIM, together with the associated controls.

(b) They shall be mounted side by side with suitable strength mountings and fixture to allow them to perform open and close functions in accordance with the door open and close commands.

(c) An emergency passenger bodyside door opening device with guarding cover shall be provided to enable a trainee to open the passenger doors to prevent people from being trapped inside the area between the passenger doors.

19.9.6 In-Cab CCTV

(a) A full colour In-cab CCTV systems shall be provided to facilitate realtime monitoring of the trainee inside the cab by the training instructor. Video recording for 1 hour and playback function shall be provided to facilitate post-exercise review.

(b) Each driving cab shall be fitted with the In-Cab CCTV system. The CCTV camera shall installed at the back of the driving cab in such a way that it shall clearly show the movement of the trainee inside the cab.

19.10 Location of CABSIM

The CABSIM shall be installed inside the Training Centre in the K Carhouse. It is situated at the ground floor and the actual location of the room is subject to be confirmed before the target installation date. The typical layout plan is shown on Figure 19-1. The Contractor shall co-ordinate with the civil contractor of the K Carhouse Training Centre and submit for approval a method statement on installation of CABSIM.

19.11 Loading

19.11.1 Processor Loading

For all processor driven equipment / system, the processor loading shall not exceed the following figures:

(a) Processor loading not exceeding mean - 50% of the processor time

(b) Processor loading not exceeding peak - 80% of the processor time

19.11.2 Computer Network Loading

The loading of the computer network shall not exceed the following figures:

(a) Network loading not exceeding mean - 40% of the network time

(b) Network loading not exceeding peak - 60% of the network time

19.12 Resource Spare Capability

19.12.1 Memory and Input/Output Facilities

A minimum of 20% spare capacity of run-time processing power and memory storage shall be provided for each computer driven system.

19.12.2 The minimum spare capacities for input and output are shown in the table below:

Output Facilities	**Spare Capacities**
Digital Inputs	10 DC inputs per simulator driving cab 1 AC input per simulator driving cab
Analogue Inputs	2 analogue inputs per simulator driving cab
Digital Outputs	2 DC outputs per simulator driving cab
Analogue outputs	2 analogue outputs per simulator driving cab

Serial Interface	1 RS232 or RS485 port

She rating of all the digital and analogue inputs and outputs shall match with that used in the implementation of the CABSIM.

19.13 CABSIM Design Development

19.13.1 The CABSIM shall be designed, developed and delivered in two stages.

19.13.2 CABSIM Stage 1

Stage 1 shall cover the following scope of work to provide training before the first train Hand Over:

(a) All functions as stipulated except for reduced scope for track and platform view and fault scenarios simulation as stipulated in Clause (b) and (c) below.

(b) A part of track and platform view of the M Line including the K and Davisille depots departure and arrival tracks shall be provided.

(c) The preliminary set of fault scenarios submitted by the Contractor for defect recovery training shall be implemented in the CABSIM stage 1.

(d) The train shall be modelled based on the latest design information available in all the design stages, design submissions and subcontractors/ suppliers. The Contractor shall ensure that a detailed package of design information of train shall be prepared and transmitted for CABSIM stage 1 design and implementation. The package of design information shall be submitted for approval.

(e) All driving equipment, indications, fault alarms, seats, control consoles, interior panels, lighting, windows, vents, bodyside doors, communications equipment, VSS video display and TIMS display terminal as stipulated shall be installed onto the support structure.

(f) The passenger bodyside doors shall be installed.

19.13.3 CABSIM Stage 2

Stage 2 shall cover the following scope of work:

(a) All the existing Lines track and platform views including all depot area and depot departure and arrival tracks shall be provided.

(b) The Contractor shall review the operation of the train after the reliability test

run and commissioning in CITY to review the validity of the fault scenarios implemented in CABSIM stage 1, and correct any discrepancies. Furthermore, any new fault scenarios which have not been identified in stage 1 shall be incorporated into the system.

(c) All subsequent design changes of train during the various design stages including the manufacturing, test and commissioning stage managed under the configuration control program shall be incorporated during the CABSIM stage 2. If the design changes of train cause any modification / change in any of the hardware items as stipulated, the modification / change shall also be incorporated in the CABSIM. A detailed package of design information of train on all the items which have been modified / added shall be submitted for approval and transmitted for CABSIM stage 2 implementation.

19.14 Testing Requirements

19.14.1 For CABSIM stage 1, the Contractor shall conduct both a factory acceptance test and a site commissioning test to demonstrate that the CABSIM can deliver all the intended functions as stipulated in the Specification.

19.14.2 For CABSIM stages 2, only site commissioning tests shall be conducted to demonstrate that the CABSIM can deliver all the intended functions as stipulated in the Specification.

19.14.3 The Contractor shall submit all the test specifications (including factory acceptance test and site commissioning test) for approval at least three months before the target test date. The test specifications shall include the details of each test activities, sequence of testing activities, acceptance criteria and re-test schedule following a failure

19.14.4 The Contractor shall prepare exercises that demonstrate all the possible routings for the area covered in each CABSIM stage and shall be included in the factory acceptance test (if applicable) and site commissioning test.

19.14.5 The Contractor shall test all fault scenarios simulated in each CABSIM stage in the factory acceptance test (if applicable) and site commissioning test.

19.15 Special Tools

19.15.1 Test Harness Facility

The Contractor shall provide a test harness facility to facilitate future modification which shall be a software package capable of delivering the following functions:

(a) Simulate the status of all cab controls and feed into the master computer of the CABSIM for train behaviour simulation such that exercises can be run in the absence of the simulator driving cabs hardware

(b) Provide the status of all simulated train subsystems, equipment and driving cab indications

(c) Simulate running of exercises covering all modes of operation of the two simulator driving cabs and all instructor's terminal functions

19.15.2 Simulated Driving Cab Panel

The Contractor shall provide a simulated driving cab panel equipped with all controls and indications except the Train Radio and TIMS display terminal to simulate all the actual driving cab equipment to enable testing of the CABSIM in the absence of the actual driving cab equipment.

19.16 Software Requirements

19.16.1 The CABSIM software shall be developed in a multi-level top down modular approach. The modules of the application software shall be independent of each other such that change of one aspect of the software shall require change to the concerned module only.

19.16.2 The CABSIM software shall allow changes in values / parameters for control decisions without re-compilation of program being required.

19.17 Training Requirements

19.17.1 The Contractor shall provide training for both the operation and maintenance staff of the CABSIM.

19.17.2 Training courses shall be provided for each of the three stages of CABSIM development in accordance with the following timescales:

(a) CABSIM stage 1 training - to be started 3 weeks before the completion of CABSIM stage 1

(b) CABSIM stage 2 training - to be started 3 weeks before the completion of CABSIM stage 2

19.17.3 CABSIM Stage 1 Training

(a) Operation Training

(i) Objectives

To provide the CABSIM instructors with the skills and knowledge necessary to operate the stage 1 CABSIM.

(ii) Course Attendees

A total of 10 CABSIM instructors

(iii) Course Content

This training course shall provide attendees with skills and knowledge necessary to cope with the operation of stage 1 CABSIM for training and qualification. The operation and exercise control, man-machine interfaces, exercise editing, performance evaluation, special design features, fault handling / backup facilities available shall be described, explained and demonstrated. Hands-on practical training for all topics covered shall also be provided.

(b) Maintenance Training

(i) Objectives

This training course shall allow the Commission's maintenance staff to acquire the knowledge and skills necessary to maintain the CABSIM.

(ii) Course Attendees

A total of 10 maintenance and engineering design staff

(iii) Course Content

This training course shall cover:

(1) Background technical information of CABSIM such as general performance specifications, description and operating principles of all equipment / systems, special design features and man-machine interfaces. Detailed technical information and descriptions of each individual equipment / system with explanation of the circuitry / logic shall be included. The following equipment / systems, as a minimum, shall be covered:

- Instructor's console
- Driving Cab equipment
- Communications equipment
- Visual Simulation and Display System
- Audio Simulation System
- Headwall Unit Simulation
- Time Interval Clock Simulation

(2) Maintenance activities for each of the equipment / system as stipulated in Clause (1) above which shall include:

- preventive maintenance activities

- corrective maintenance activities
- procedures for replacement of major equipment / components
- testing and re-commissioning procedures after maintenance work

All installation procedures, testing procedures and the use of special tools and test equipment shall be covered to permit maintenance staff to perform preventive and corrective maintenance activities.

(3) Technical support activities to maintenance including:

- Fault analysis and investigation
- Use of the system backup and restoration facilities

19.17.4 CABSIM Stage 2 Training

(a) Operation Training

(i) Objectives

To provide the CABSIM instructors with the skills and knowledge necessary to cope with the running of the stage 2 CABSIM.

(ii) Course Attendees

A total of 10 CABSIM instructors

(iii) Course Content

This training course shall provide attendees with skills and knowledge necessary to cope with the operation of stage 2 CABSIM for training and qualification. The new features including all Existing Subway Lines track and platform view and revised and new fault scenarios shall be covered.

(b) Maintenance Training

(i) Objectives

This training course shall allow the Commission's maintenance staff to acquire the knowledge and skills necessary to maintain the CABSIM to the designed standards.

(ii) Course Attendees

A total of 10 maintenance and engineering design staff

(iii) Course Content

This training course shall cover the outlined course content as stipulated for all the new design and system changes.

(c) Software Training

(i) Objectives

This training course shall allow the Commission's software maintenance staff to acquire the knowledge and skills necessary to maintain the software of the CABSIM and to facilitate future modification. The training shall cover the software that is coded specifically for the AUTHORITY CABSIM, specifically:

(1) Vehicle Model

(2) Signal Logic

(3) CGI Database, Objects and Logic

(4) Vehicle behavior

(5) Vehicle Fault Logic

(6) Scenario edition and modification

(ii) Course Attendees

A total of 10 software maintenance staff

(iii) Course Content

This training course shall provide attendees with the knowledge and skills necessary for maintaining the software of the CABSIM. It shall include:

(1) overall software architecture with description of each module and their functions

(2) use of all software development tools such as compilers, debuggers and CASE tools, where applicable. As a minimum, editing tools for items listed in (i)

(3) procedures for re-compiling the source codes, where applicable

(4) procedures for parameterisation of the CABSIM and system management

(5) hands on practical experience on using the software tools, utilities and programming techniques being supplied with the CABSIM

The Contractor shall be responsible for providing all hardware and software required for software training.

(d) CGI Training

(i) Objectives

This training course shall allow the Commission's maintenance staff to acquire the knowledge and skills necessary to maintain the track and platform view of the CABSIM and to conduct future modifications.

(ii) Course Attendees

A total of 10 maintenance staff

(iii) Course Content

This training course shall provide attendees with the knowledge and skills necessary for maintenance and to perform future modification / addition to the CABSIM CGI for track and platform view. It shall cover:

(1) background technical information of the CGI engines

(2) tools and techniques employed in generating the track and platform view

(3) hands on practical experience of using the tools and CGI engine in adding / changing some of the track and platform view

The Contractor shall provide all hardware and software required for CGI training.

Fault Number	
Description	Lock Wheel - No 1 truck of leading cab car
Symptoms	1. Audio 1.1 Squeal sound 2. Visual 2.1 Wheel slip/slide indicator brightens when speed is x km/h or above 2.2 General Fault Indication brightens 2.3 Fault Indication panel indicates power fault 2.4 Slow acceleration due to deceleration force derived from a coefficient of adhesion of y and the adhesion weight of the axle
Recovery procedure	1. Press emergency push button to stop train at once and run at speed not over 22 km/h
Standard Time	3 min
Extensive Delay Limitation	50% of Standard Time

Table 19-1 Format of a Typical Fault Scenario

SUBWAY OPERATIONS

Normal Operations:

1. Include full AUTHORITY signal system simulation, with examples of all signal aspects, track switches, wayside devices and associated procedures (call-on, key-by, signal violations etc.).
2. Create modular simulations of the entire AUTHORITY track layout, including mainline, pocket and spare track locations, interchanges and yards. These discrete "packages" of track could be played in sequence to form an entire subway line or run as individual track sections.
3. Include basic operating skills exercises, such as signal recognition, acceleration and braking rates and stopping position.
4. Provide trainee with interactive audio and visual information (instructions, prompts and feedback) during initial operating sessions.
5. Ensure that all equipment and systems included in the simulator or represented in a training simulation react the same as their real life counterparts. As a result, any mistakes or incorrect actions performed by the trainee during a simulation should result in true-to-life consequences.
6. Allow for real-time insertion of Instructor initiated events, such as signal changes and train disablements into the basic simulation exercises.
7. Include routine communications between Operator/Guard, Transit Control and PA.
8. Simulate normal real-time operation, including entering and exiting service, peak and off-peak passenger loads, extended dwell times, in-traffic situations, SCS overspeed, turn-around at end terminals, use of number 2 platform, entering a station with blind trips, operation on another line, restricted speed zone, work zones, walking inspections, turn-backs, step-backs, etc.
9. Co-ordinate guarding duties with real-time train operation.
10. Simulate changing light conditions, including open-cut to tunnel transitions (and vice-versa), daylight, dusk and night conditions, weather effects and power out situations.
11. Include effects of weather on track conditions and wheel adhesion, including

snow, ice, rain, greasy rails and flooding.

12. Develop a standardized testing scenario to be used as a practical operation assessment tool.

Disablements and Emergency Situations:

1. Simulate signal system failures, including cascading signals, no aspects, delayed or conflicting aspects, track down, bobbing track, absolute block, hunting trip arm and track switch failure.
2. Simulate emergency communications between Operator/Guard, Transit Control and PA.
3. Include interactions with workers at track level using incorrect hand signals and encounters with poorly defined and/or incorrect work zones.
4. Include encounters with unauthorized personnel or objects at track level.

5. Simulate common air disablements, such as air leaks, low air pressure and air fault indications on the MTU (T-2 equivalent).

6. Simulate common electrical disablements, such as low or zero voltage, auxiliary power fault, loss of cab and/or passenger lighting, loss of propulsion and power supply fault indications on the MTU.

7. Simulate common door disablements, such as loss of green door light, loos of door supply light, door(s) fail to open or close on car or train, door fault indications on the MTU. Include cut-out or bypass procedures and installation of barricades.

8. Simulate common brake disablements, such as loss of EP brake light (T-2 equivalent), loss of dynamic or EP brakes, brakes fail to release on car or train, brake step missing from MC handle, brake fault indications on the MTU.

9. Simulate common emergency brake-loop interruption (T-2 equivalent) disablements, such as emergency brake application, emergency brake light illuminated, emergency brake fault indications on the MTU.

10. Simulate “train fails to start” situation.

11. Simulate power off situations at various locations, such as tunnel sections, open-cut areas, station platforms and yard areas.

12. Simulate the activation of the passenger assistance alarm and the passenger/guard emergency switch.

13. Simulate unsafe platform conditions, such as over-crowding, customers approaching platform edge, customers running for doors, objects extending beyond the platform.

14. Simulate customers holding doors and/or objects stuck in doors.

15. Simulate a disturbance at a designated waiting area (DWA).

16. Simulate priority one contact with the train.

17. Include scenarios with sick or injured persons onboard the train.

18. Simulate train evacuation in tunnel sections and station platforms.

19. Simulate bomb threat situations.

20. Simulate train operation with flat wheels.

21. Simulate roll back.

22. Simulate operating with trips isolated.

23. Simulate operating with ECOs.

24. Simulate operating with reduced braking ability.

25. Simulate operating with SCS failures, such as TOD failure, loss of positioning, VOBC halted and SCS bypass.

26. Simulate operation over broken or damaged track components, including interaction with emergency personnel at track level.

27. Simulate encountering a portable train stop.

28. Simulate someone attempting to stop the train by waving an object violently.

29. Simulate emergency coupling to another train.

30. Simulate pushing a disabled train.

31. Simulate rear cab operation, including monitoring duties in the lead car.

32. Simulate derailment of subway car(s).

Miscellaneous Items:

1. Provide motion feedback to the trainee to simulate track layout (inclines, curves, turnouts and crossovers), poor track geometry (surface, line, gauge and cross-level problems), acceleration/deceleration rates, emergency braking, flat wheels and track defects (rail batter, pumping ties, fastener failure, etc.).
2. Allow the two cabs to function as either a single train or two separate trains.
3. Record trainee performance and provide replay facilities with helicopter views of train operation.
4. Maintain an electronic record of trainee performance and provide a printed report.
5. Include easy-to-use scripting software for the development of additional simulations by the Instructors.
6. Include remote monitors to allow the gallery to watch trainee performance.
7. Include the current signal mock-ups in the new training facility.

SUBWAY MAINTENANCE

Additional Maintenance Functionality:

1. Include all the appropriate maintenance access panels, doors, bulk heads and compartments for equipment located in the Operator's cabs and passenger compartment.
2. Program actual door failures into the passenger compartment.
3. Incorporate the cascading effect and/or interactivity of disablements in maintenance simulations, including the consequences of improper or out-of-sequence remedial steps.
4. Include yard and carhouse locations in maintenance simulations.
5. Include functioning hand brake in the cabs.
6. Include functioning destination sign.
7. Include the ability to add smoke effects to the cab or passenger compartment.
8. Support radio change-over from yard to mainline channel upon leaving the yard.

Maintenance Scenarios:

1. Simulate dead head operation.

2 . Simulate operating a disabled train into the yard.

3 . Simulate parking a train in the yard.

4 . Simulate stopping at the end of track.

5 . Simulate trailing through a switch in the yard.

6 . Simulate a change-off, including inter-line operation.

7 . Simulate operation through the wash rack.

8 . Simulate entering and exiting the carhouse.

9 . Simulate SCS health check.

1 0 . Simulate acceleration and braking tests on the yard test track.

1 1 . Simulate loss of communication.

1 2 . Simulate truck over-rotation condition.

1 3 . Simulate interior checks for preparation and delivery of service procedure. 14. Simulate trip switch fouled on foreign object.

15. Simulate coupler separation.

16.	Simulate emergency recovery using various vehicles.

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Table 19-2 Typical Fault Scenario

Item	Description
1.	Driving Cab #1
2.	Driving Cab #2
3.	Common Saloon
4.	Visual Display Projectors Dark Room
5.	Instructor's Console
6.	Simulator Computer, Image Generator and Audio Generation Equipment

Figure 19-1 - CABSIM Conceptual Layout

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Section 20 Materials And Workmanship Requirements

20.1 General

20.1.1. This Section of PS covers materials and workmanship requirements for the train system.

20.1.2. The standards and practices detailed in this Section of PS shall be observed as the minimum requirements which are acceptable to the Engineer.

20.1.3. The Contractor may offer alternative standards which are equivalent to or better than those herein, and which the Contractor shall justify to the satisfaction of the Engineer.

20.1.4. The Contractor shall adopt the up-to-date best practice and workmanship to execute the Works to the highest standards and to the satisfaction of the Engineer.

20.1.5. Whenever the PS, Drawings or directions/instructions of the Engineer admit of a reasonable doubt about what is permissible and when they fail to state the quality of any work, the interpretation which requires the best quality of work is to be followed.

20.2 Materials

20.2.1. Materials used in the construction of the train shall not constitute a health hazard for passengers, staff or the public. Prohibited materials shall include but shall not be limited to the following:

(a) Asbestos

(b) Lead based pigment paints

(c) Halogens in greater concentrations than those specified in PS 21.10.

The use of all materials shall be submitted for approval.

20.2.2. All materials used on the vehicles shall be of a Limited Fire Hazard type to the requirements of PS 21.10 except fuel, transmission oil and lubricants.

20.2.3. The Contractor shall consider at all stages of SEMP, the specification of all materials with regard to their health and safety impact both in handling, use and disposal, and in this regard shall be incorporated into the Workplace Hazardous Materials Information System (WHMIS) according to Canada's hazard communication standard. The key elements of the WHMIS shall be

comprised of cautionary labelling of containers of WHMIS "controlled products", the provision of material safety data sheets (MSDSs) and worker education programs.

20.2.4. The Contractor shall consider at all stages of SEMP, the specification of all materials with regard to their environmental impact both in use and upon eventual disposal, and in this regard shall incorporate into the Environmental Management Plan according to PS 28.4.

20.2.5. A schedule of all materials used shall be regularly updated and submitted and shall include the following:-

(a) Composition

(b) Quantity (kg)

(c) Life Expectancy

(d) Items that would be re-cycled at mid-life refurbishment and at life expiry

(e) Means of disposal and environmental effect of this disposal

(f) Labelling with regards to composition and hazard

20.2.6. In addition to the materials used during construction the schedule (refer to PS 20.2.5) shall also list materials used in the maintenance and cleaning of the trains, their usage rates and disposal procedures.

20.3 Materials Testing

20.3.1. Fire Performance

(a) The Contractor shall supply and maintain a schedule of non-metallic materials used in the construction of the trains under the Configuration Management requirements (refer to PS 21.3.10(b)).

(b) This schedule shall give information in respect of the fire certification of the materials and groupings of materials in assemblies (copies of which shall be supplied), the national or international standard applicable to the material, its location, the amounts used and its calorific value including fire load and

average power output.

(c) The schedule shall include a fire load calculation for the train. This latter feature will be used to highlight materials with particular fire hazard potential so that special attention can be paid to the fire test results, with a view to ensuring that this potential is not realised.

(d) The schedule shall be audited periodically in line with the Systems Assurance Plan (refer to PS 25).

(e) Triplicate testing, generally to ISO 5660: Part 1 or ASTM E 1354, shall be carried out for materials/composites which form major and/or significant

surfaces within the saloons. To determine if surface is significant, use the NFPA 130 section 8.4.1.5.10 definition. The reports, if performed before NTP, must have been performed a maximum of 5 years before the NTP. The report shall be supplied with a letter confirming the material tested is identical, in composition and manufacturing process, to the material supplied for this contract. For reports performed after the NTP, the report shall include a photo showing the sample installation in the test arrangement.

(f) Where composites are used, eg. seat trim, these shall be tested at the maximum convenient thickness (25mm) and shall be as closely representative of the item concerned as possible.

(g) In addition to the standard test house report, the report will include the data from each test and shall be supplied in an electronic format on a CD-ROM.

(h) The materials/composites tested shall be representative of the surfaces listed below and shall be tested at the stated input radiation (flux). In each test the scan time shall be 2.0 s and the test duration shall not be less than 1200 s irrespective of the sample behaviour.

Surface	Flux kWm-2
Floor	20
Wall	35
Ceiling	50
Seat Shell Back	35
Seat Shell Base	50
Seat Trim Back	35
Seat Trim Base	20

20.3.2. Power Output on Flash-Over Fires

(a) The Contractor shall carry out prediction and final evaluation on the power output from flash over fire in the associated SEMP stages according to PS 21.10.8.

(b) An analytical method based on the summation of rates of heat release shall be used to determine the maximum power output of fire. Definition of heat release rate shall refer to NFPA 130 and the data of heat release rates of each material shall be obtained by an actual testing in the cone calorimeter.

(c) The total nominal heat release rate of all surface materials in a car, when summed together, shall not exceed 9 MW per car on flash-over fires.

(d) The Contractor shall submit for approval calculations, by using well accepted computer modeling techniques to demonstrate that the requirements of maximum power output of fire are achieved under all foreseeable worse case

scenarios. All assumptions that have been made in the above model shall be specified with justification. The initiation fire, or design fire, shall be 100kW according to BS 6853. Alternative definition of initiation fire shall be submitted for Approval.

(e) The modeling technique shall be based on the acceptable method, such as, ISO 9705 - Room Fire Test in which the walls and ceilings are lined with test materials to represent a section of a rail car and subjected to fires of controlled sizes, shall be adopted.

20.3.3. Suitability of Materials

(a) Where materials used in the construction of the vehicles are not specified to recognised standards samples of such materials shall, if instructed by the Engineer, be tested at an “Approved Laboratory” at the Contractor's expense.

(b) All materials or details represented by these samples, which are found not to be in accordance with this Specification, or are unfit for purpose will be rejected. The Contractor shall replace, at his own expense, any materials thus rejected, with a suitable alternative which shall be submitted for approval.

(c) The Contractor shall have submitted with its proposal a general precis of its procurement and quality assurance procedures. Not later than six months after placement of the order, full details shall be given so that the Engineer can arrange for an appropriate level of inspection at all stages of manufacture.

20.3.4. Certification

(a) All materials used in the construction of the vehicles shall be procured with a Certificate of Conformity in line with the Contractor’s Quality Control procedures.

(b) The documentation shall be held by the Contractor or its Subcontractor as appropriate and shall be made available to the Engineer at all reasonable times upon demand.

20.4 Workmanship

20.4.1. Standards/Reference

IEC 60077 : Part 1:1999 Railway applications - Electric equipment for rolling stock - Part 1: General service conditions and general rules

IEC 60136 : 1986 Dimensions of Brushes and Brush-holders for Electrical Machinery

IEC 60934 : 2000 Circuit-Breakers for Equipment (CBE)

IEC 60269 Part 1 : 2005 Low Voltage Fuses

IEC 60322 : 2001 Railway applications - Electric equipment for rolling stock - Rules for power resistors of open construction

IEC 60349 Part 1 : 2002 Electric traction - Rotating electrical machines for rail and road vehicles - Part 1: Machines other than electronic convertor-fed alternating current motors

IEC 60349 Part 2 : 2002 Electric traction – Rotating electrical machines for rail and road vehicles – Part 2: Electronic convertor-fed alternating current motors

IEC 60529 : 2001 Degrees of protection provided by enclosures (IP Code)

IEC 60990 : 1999 Methods of Measurement of Touch-Current and Protective Conductor Current

IEEE Std 315 : 1975 Graphic Symbols for Electrical and Electronics Diagrams

BS EN 287 : 1992 approval Testing of Welders for Fusion Welding

BS EN 288 : 1992 Specification and approval of Welding Procedures for Metallic Materials (if not applicable, replacement by BS EN ISO 15614-1:2004 and BS EN ISO 15614-2:2005 is acceptable)

BS EN 970 : 1997 Non-destructive examination of Fusion Welds - Visual Examination

BS 1574 : 1994 Split Pins, Inch Series

BS 2618 : 1975 Electric Traction Equipment

BS 2704 : 1978 Calibration Blocks for use in Ultrasonic Flaw Detection (if not applicable, replacement by BS EN 12223-2000 is acceptable)

BS 3019 : Part 1 : 1984 TIG Welding of Aluminium, Magnesium and their Alloys (if not applicable, replacement by BS EN 1011-4-2000 is acceptable)

BS 3403 : 1972 Indicating Tachometer and Speedometer Systems for Industrial, Railway and Marine use.

BS 3571 : Part 1 : 1985 MIG Welding of Aluminium, Magnesium and their Alloys (if not applicable, replacement by BS EN 1011-4-2000 is acceptable)

BS 3692 : 2001 ISO Metric Precision Hexagon Bolts, Screws and Nuts.

BS 3923 : Part 1 : 1986 Manual Examination of Fusion Welds in Ferritic Steel (if not applicable, replacement by BS EN 1714-1998 is acceptable)

BS 3923 : Part 2 : 1972 Automatic Examination of Fusion Welded Butt Joints in Ferritic Steels

BS 4174 : 1972 Self Tapping Screws and Metallic Drive Screws

BS 4183 : 1967 Machine Screws and Machine Screw Nuts. Metric Series

BS 4331 : part 1 : 1978 Methods for assessing the Performance of Ultrasonic Flaw Detection Equipment (if not applicable, replacement by BS EN 12668-3:2000 is acceptable)

BS 4570 : 1985 Fusion Welding of Steel Castings

BS 4579 : 1970 The Performance of Mechanical and Compression Joints in Electric Cable and Wire Connectors (if not applicable, replacement by BS EN 61238-1:2003 is acceptable)

BS 4794 Control Switches (Switching Devices, including Contactor Relays, for Control and Auxiliary Circuits, for Voltages up to and including 1,000 VAC and 1,200 VDC) (if not applicable, replacement by BS EN 60947-5-1-2004 is acceptable)

BS 4929 : 1973 Steel Hexagon Prevailing Torque Nuts

BS 5000:Part 10 : 1978 General Purpose Induction Motors (if not applicable, replacement by BS EN 50347:2001 is acceptable)

BS 5000:Part 11 : 1973 Small-power Electric Motors and Generators

BS 5135 : 1984 Arc Welding of Carbon and Carbon Manganese Steels (if not applicable, replacement by BS EN 1011-1:1998 and BS EN 1011-2:2001 is acceptable)

BS 5378:Part 1 : 1980 Safety Signs and Colours (if not applicable, replacement by BS 5499-5-2002 is acceptable)

BS 5996 : 1993 Acceptance Levels for Internal Imperfections in Steel Plate, Strip and Wide Flats, based on Ultrasonic Testing (if not applicable, replacement by BS EN 10160:1999 is acceptable)

BS 6072:1981 Method for Magnetic Particle Flaw Detection (if not applicable, replacement by BS EN ISO 9934-1:2001 is acceptable)

BS 7608:1993 Fatigue Design and Assessment of Steel Structures

BS 7724:1994 Split Pins. Metric Series (if not applicable, replacement by BS EN ISO 1234:1998 is acceptable)

BS 8118:1991 Structural Use of Aluminium

EN 50153:1997 Railway Applications - Rolling Stock - Protective Provisions Relating to Electrical Hazards

EN 50155:1995 Railway Applications - Electronic equipment used on rolling stock

RIA 12:1984 General Specification for Protection of Traction & Rolling Stock Electronic Equipment from Transients & Surges in DC Control Systems

RIA 13:1990 General Specification for Electronic Equipment Used on Traction & Rolling Stock

RIA 20:1995 Requirements for Vibration and Shock Testing of Equipment for Railway Vehicles

RIA 22:1990 The Technical Guide on EMC for Electronic Equipment Used on Traction and Rolling Stock

NF X 70-100:1986 Fire behaviour tests - analysis of pyrolysis and combustion gases - pipe still method

20.4.2. Definitions

The following definitions shall apply:

Heavy Current : Currents in excess of 30 A.

Light Current : Currents of 30 A or less.

High Voltage : In excess of 300 V, to earth.

Low Voltage : 300 V or less, to earth.

Auxiliary Contact : A contact in a low voltage circuit.

Power Contact : A contact which is not covered by the definition of auxiliary contact.

Enclosure : A closed space in which equipment is mounted.

Contact Enclosure : A small enclosure in which auxiliary contacts only are mounted.

Terminal : A fixed point to which a conductor can be attached to form a connection.

Termination : A device fixed to a cable or other conductor to enable it to be attached to a terminal.

20.4.3. General Requirements

(a) All equipment shall be constructed in a sufficiently robust manner, and arranged so as not to suffer deterioration, wear, or damage due to vibration or shock loads encountered in traction service.

(b) Equipment shall be arranged into groups where practicable, the items of any one group being mounted on a common frame or the equivalent, complete with such as wiring and piping.

(c) All equipment shall be protected against damage such as those caused by dirt, dust and moisture.

20.4.4. Corrosion Protection

(a) The Contractor shall submit for approval a system to provide corrosion protection for the life of the train.

(b) The Contractor shall take into consideration that all equipment shall be

operated under a prevailing severe weather and corrosive ambient conditions found in CITY.

(c) Where necessary, closed or inaccessible areas shall be internally covered with an adequate corrosion protection coating immediately after completion of fabrication.

(d) All corrosion protection measures shall be permanent without causing any contamination.

20.5 Interchangeability

20.5.1. The Contractor shall minimize the number of different equipment models on

the train. As far as practicable, the same model of equipment shall be used to fulfill similar functions at different applications. For example, the same relay model may be employed to fulfill similar switching functions in different circuits.

20.5.2. Equipment items or components of the same model shall be readily interchangeable. They shall be designed and manufactured so that no additional fitting, machining, adjustment or modification, other than those approved by the Engineer, would be necessary during replacement.

This is particularly important, such as in the case of covers, bearing caps, equipment mountings and door leaves, which will be replaced or interchanged frequently among different locations after maintenance work. At the request of the Engineer, the Contractor shall provide demonstration on any specified equipment to show that such requirement is satisfied.

20.5.3. In cases where the same mounting arrangement, such as an electrical plug or pneumatic valve, is provided on different equipment which are not interchangeable, the Contractor shall design the mountings so that the equipment will not be mixed up during installation.

This shall be achieved by providing suitable identification devices such as colour coding or special markings. The use of such devices shall be submitted for approval. Should the Engineer consider such devices inadequate, the Contractor shall provide a non interchangeable design to make wrong installation impossible.

20.5.4. The requirement in Clause 5.3 above shall also apply to cases where it is possible to install or assemble an equipment item in a number of different orientations, such as mating halves of a housing, non-symetrical cams on a shaft.

20.5.5. Any assembly, sub-assembly module or part which requires setting up, re-alignment or matching to restore full system capability, shall be identified and clearly highlighted in the related section of the maintenance manual.

20.5.6. Bolted Joints and Fasteners

(a) All fasteners supplied by the Contractor for vehicle assembly shall be in ISO Metric size. Proprietary equipment may use Imperial fasteners, subject to the approval of the Engineer. The following standards shall be applied where appropriate :

BS 3692 for hexagonal bolts, screws and nuts

BS 4183 for machine screws & nuts

BS 4174 for self tapping screws

BS 1574 for split cotter pins

BS 4929 for prevailing torque nuts

(b) Due consideration shall be given in the design stage to the tolerance of components to ensure interchangeability of components. The use of fitted bolts shall be minimise and shall only be used subject to approval.

(c) For permanent fixings connections or those where dismantling is unlikely, two piece rivets such as AVDELOK or HUCKBOLT or other similar fasteners shall be used subject to approval. Blind fasteners such as BOM rivets or similar shall be avoided for structural connections, and only used subject to the approval of the Engineer.

(d) For fixings connections which will be dismantled for maintenance, the following methods shall be used.

20.6 Bolt connection

20.6.1. Bolted connection shall use documented torque tightening procedures and shall be submitted for approval. Hexagon head bolts Grade 8.8 and nuts Grade 8 shall be used. Where secondary locking is required, which include all structural bolted joints and bolted joints subjected to high levels of vibration, prevailing torque nuts to BS 4929 shall be used.

20.6.2. Setscrews (Grade 8.8) and stud connections (Grade 8.8 studs with grade 8 prevailing torque nuts to BS 4929) shall only be used where it is not possible to make a bolted connection. The use and the proposed method of locking shall be submitted for approval.

20.6.3. Washers shall not be used except where the nut is tightened onto a soft surface or for connections designed for interchangeability i.e. slotted holes. Spring washers shall be avoided.

20.6.4. Mating surfaces shall be machined flat and shall be clean and free from paint or rust.

20.6.5. Suitable precautions, which shall be subject to approval, shall be taken to prevent corrosion in joints involving dissimilar metals.

20.6.6. Tapped holes in aluminium shall, in all cases, be provided with suitable thread inserts. Items of proprietary equipment which are normally supplied without wire thread inserts may be exempted from this requirement, subject to approval

20.6.7. Where tab washers are proposed the material chosen shall be sufficiently hard to prevent settlement of the joint and consequent loss of bolt preload. Mild steel tab washers shall not be used.

20.6.8. The Contractors torque tightening procedure shall include provision for marking torque tightened fasteners with coloured paint to indicate that the torque tightening procedure has been correctly carried out.

20.7 Welding

20.7.1. General

(a) All welding work shall be under the control of a suitably qualified welding engineer nominated by the Contractor as his representative.

(b) All welding equipment shall conform to relevant national or international standards which shall be subject to approval.

(c) Permanent backing strips shall not be used unless otherwise approved.

20.7.2. Standards

(a) Welding of carbon and carbon/manganese steel shall be to the requirements of BS 5135 (if not applicable, replacement by BS EN 1011-1:1998 and BS EN 1011-2:2001 is acceptable) for wrought steel and BS 4570 for cast steel.

(b) Welding of aluminium and aluminium alloys shall be to the requirements of BS 3019 : Part 1 and BS 3571 : Part 1 as appropriate (if not applicable, replacement by BS EN 1011-4-2000 is acceptable).

(c) Standards for materials and processes not covered by the specifications given in Clauses 7.2.1 and 7.2.2 shall be submitted for approval.

20.7.3. Materials

(a) All materials shall be clearly identified and shall have certificates of chemical composition and mechanical properties which shall be held by the Contractor.

(b) Materials shall be free from laminations and lamellar defects.

(c) Fusion faces in the areas to be welded shall be prepared for 25 mm surface and both side shall be free from paint, rust and other contaminants. Any solvents used to achieve this shall be thoroughly dried off prior to welding.

20.7.4. Critical Welds

(a) All welds which fall into any of the categories defined (a), (b), and (c), below, shall be designated as Critical Welds.

(i) Welded joints from which failure would represent a risk to safety of the car.

(i i) Welded joints which are designed with a Miner's Summation, evaluated in accordance with 'Miners Rule' (BS 7608 or BS 8118) and the relevant fatigue load cases from the car Particular Specification, greater than 0.7.

(i i i) Welds in load bearing members which are not readily accessible for inspection during maintenance or overhaul.

(b) Critical Welds shall be clearly identified on manufacturing drawings

20.7.5. Welding Procedures

(a) All welding shall be carried out in accordance with documented welding procedures. The suitability of the welding procedure shall be established by testing of test specimens in accordance with BS EN 288 : Parts 3 (if not applicable, replacement by BS EN ISO 15614-1:2004 is acceptable) and 4 and BS 4870 : Parts 3 and 4 (if not applicable, replacement by BS EN ISO 15614-8:2002 and BS EN 1418:1998 is acceptable). Following satisfactory completion of testing the procedure shall be submitted for approval.

(b) Welding consumable shall be such that the mechanical properties of the completed joint shall not be less than those specified for the parent materials.

(c) The requirements of Clause 7.5.1 shall apply to procedures for rectification of defects in welds.

(d) Welding on production units shall not commence until approval of the relevant welding procedures has been given.

20.7.6. Welder approvals

(a) All welders shall be approved in accordance with the relevant parts of BS EN 287. Destructive testing of the test pieces is required.

(b) The Contractor shall maintain records of welder approvals, together with full supporting evidence. This information shall be made available on request.

20.7.7. approval Testing and Witnessing

(a) Approval of all welding procedures shall be granted by a nationally or internationally qualified welding body, for example, the Canadian Welding Bureau (CWB), independent of the Contractor and subject to approval.

(b) All testing associated with welding procedure and welder tests shall be carried out by an independent nationally accredited test house, which shall be subject to approval prior to the commencement of testing.

20.7.8. Non-Destructive Testing (NDT)

(a) Visual inspection of all welded joints before, during and after welding, together with any additional examinations required by the welding procedures, shall be carried out.

(b) The Contractors NDT programme and procedures shall be subject to approval before the commencement of any testing.

(c) NDT procedure writers and NDT operators shall hold an appropriate valid certificate of competency from a recognised national or international organisation which shall be subject to approval.

(d) Detailed procedures, which shall include definitive acceptance standards, for all NDT examinations shall be prepared.

(e) Procedures for the examination of welds in steel shall conform to the following British Standards:-

Ultrasonic Testing of Welds BS 3923 : Parts 1 and 2

Ultrasonic Lamination Tests BS 5996 (if not applicable, replacement by BS EN 10160:1999 is acceptable)

Magnetic Particle Inspection BS 6072 (if not applicable, replacement by BS EN ISO 9934-1:2001 is acceptable)

Visual Inspection BS EN 970

Penetrate Flaw Detection BS 6443 (if not applicable, replacement by BS EN 571-1:1997 is acceptable)

For materials not covered by the above specifications the standards shall be subject to approval.

(f) Welds designated critical in accordance with Clause 7.4 shall be subjected to 100% volumetric NDT inspection during the start up of production. This shall be reduced to 10% of welds of each type when the Contractor has demonstrated, by consistently achieving the quality levels required by Clause 7.8.9, that he has control of the processes involved. A minimum of 3 production units shall normally be required to achieve this.

(g) If a Critical Weld is found during normal production (i.e. when 10% testing is taking place) to fall below the acceptance limits required by Clause 7.8.9, then the Contractor shall perform a 100% check on all similar Critical Welds

produced since the previous NDT inspection was carried out, and shall carry out rectification on any welds which do not achieve the required standard. The inspection level on subsequent units shall revert to 100% until it can be demonstrated that the required quality levels can be consistently achieved. Demonstration of the required quality levels shall be for approval.

(h) Where production runs are broken by a period of 3 months or longer then the requirements of Clause 7.8.6 shall apply when production is re-started.

(i) Acceptance levels for welds in steel and aluminium are given in Tables 20-1 and 20-2 respectively.

(j) Welds failing NDT examination shall be rejected or repaired using approved welding repair procedures. Details of the defects leading to the failure together with proposals for repair of the defect shall be submitted for approval. The Contractor shall investigate the causes of the defect and make proposals for remedial action in production. Repair of the weld shall not take place without prior approval.

(k) Results of all tests shall be recorded and made available on request. The records shall enable each weld to be identified. Hard stamping of the structure for this purpose shall not be allowed.

20.8 Labels and Rating Plates

20.8.1. Engraved plastic labels shall be black letters on a white background. Alternatively, black on to white background rear indented will also be accepted. Alternative arrangement of service proven design, shall be submitted for approval.

20.8.2. Unless otherwise stated, all safety labels shall comply with BS 5378:Part 1:1980 (if not applicable, replacement by BS 5499-5-2002 is acceptable).

20.8.3. Labels shall be legible and durable.

20.8.4. The use of insulation or adhesive tapes for the fixing of labels will not be

accepted. The use of self adhesive plastic or paper labels will again not be allowed.

20.8.5. Warning label shall be written in English.

20.8.6. Each character or letter printed or engraved on the label shall not be less than 5mm.

20.8.7. Apparatus shall be labelled with the maker's name and part numner.

20.8.8. The position in which apparatus is nearly mounted but not the apparatus itself, shall be labelled clearly with the circuit designation of the piece of apparatus there mounted without obstacles. Where a contactor, for example, is referred to as LS1, it will be sufficient to label the position with such reference. Such labels shall be clear and easy to be read and securely fixed adjacent to the mounting position. Covers, arc chutes, and similar removable interchangeable items shall not be labelled.

20.8.9. All enclosures containing equipment where voltage to earth exceeds 200 V shall be clearly marked.

20.8.10. All labels fitted to the exterior of equipment cases, and all warning labels shall be consistent in content and appearance between different items of equipment.

20.9 Bearings and Pivots

20.9.1. All bearings and pivots shall be of ample proportions to withstand shock loads and vibration in addition to the normal static and dynamic loads.

20.9.2. Plain bearings shall be of the dry type (incorporating graphite compound, P.T.F.E. or nylon, lubricant retaining bearing metal or similar).Plain bearings or pivots requiring periodic applications of oil or grease at inspections shall not be used. Lubrication or inspection, if required between overhauls, shall be subject to approval.

20.9.3. For truck applications, sliding bearings will only be accepted where it can be demonstrated that the application cannot be served by a suitably designed rubber bearing.

20.9.4. Rolling element bearings shall be of the prepacked pre lubricated and sealed type and shall run between overhauls without re lubrication or replacement.

20.9.5. Care shall be taken to ensure that brinelling does not occur.

20.9.6. Where prepacked bearings are not applicable, the arrangement shall be submitted for approval and the means of lubrication replenishment shall be fitted with Tecalemit Type ND6160 nipples or equivalent.

20.9.7. Replenishment interval shall not be less than 1 year and the recommended annual replenishment quantity of grease shall be stated.

20.9.8. For truck and traction motor applications, the bearing manufacturer proposed by the Contractor shall be reputable and has solid experience on electrified railway industry.

20.10 Mountings and Enclosures

20.10.1. General

All inside mounted equipment shall be arranged in self contained groups and enclosed to protect them from the effects of dirt, dust and moisture. Unless otherwise specified, all equipment mounted in the saloon area shall be sealed to IEC 60529 IP54 and all equipment mounted in the external area, such as underframe and roof, shall be sealed to IEC 60529 IP65.

20.10.2. Ventilation of Enclosures

(a) Air inlets, outlets and vents shall be fitted with louvres or otherwise designed so that ingress of rain or rubbish is prevented, irrespective of whether the car is moving or stationary and independent of the wind direction. In the case of forced ventilation the filter (if provided) or a suitable settling chamber may be relied on to remove any rain which passes the louvres provided that the complete system meets the requirement of efficient filtration. Any louvre or guard, intended to prevent the ingress of rubbish should not reduce the enclosure ventilation with guard or louvre 75% blanked off. The battery enclosures shall be prevented from the accumulation of explosive gases during charging.

(b) The term filter, in the context of this Clause, covers any device to remove dust, dirt, and rain drops from the air. Where filters are proposed, they shall be of the dry type and shall not require cleaning more frequently than any specified intervals under the conditions as stated in PS 26. Such cleaning shall be by knocking or blowing off the dirt. If washing of the filters is required, this shall not be at more frequent intervals than six months, and easy access for removal of the filter shall be provided.

(c) Inertial separators are permitted for traction equipment and other 600V machines, and shall be maintenance free between 5 years overhauls.

(d) Oil wetted air filters shall not be used.

(e) For equipment cases containing power equipment which could possibly

produce electric arcing during operation means shall be provided to prevent the production and accumulation of corrosive gases.

20.10.3. Mounting of Groups

(a) An equipment group may be mounted in a box or case, or on a frame or panel. The individual items of equipment shall be so arranged that they can be removed separately, or in sub groups as appropriate. Any group mounting

shall be self supporting when out of the car and sufficiently strong to be lifted out complete under normal workshop conditions.

(b) Equipment groups requiring the fitting of strengthening before lifting the group off the car will not be approved unless a significant weight saving can be demonstrated. All the equipment in one location shall be mounted in one group unless sub division is approved.

(c) Anti-vibration resilient mounts shall be incorporated on the fixings of the rotating machines, such as cooling fan, traction or inverter inductor, transformers to avoid the transmission of vibration onto the carbody or its structure.

(d) Underframe equipment mountings shall be designed such that, in the event of failure of any of the fixings, the equipment case or module shall be prevented from falling onto the track.

Item (d): (No specifications text modifications required. Item removed from Requisite Pro Database)

20.10.4. Wiring and Piping of Groups

(a) All groups shall be complete with internal wiring and pipe work.

(b) The connections to the group shall be taken to suitable terminal bars or connectors. Where suitable cable runs can be arranged, the Engineer may approve the running of heavy current cables direct to equipment and not via the group terminal bars, provided he is satisfied that the work of disconnection and reconnection is not thereby increased.

(c) Groups containing equipment which may produce arcs, such as heavy duty contactors or circuit breakers, shall have the low voltage terminals mounted in such a position that arcing to the terminals is prevented. Consideration shall be given to mounting such terminals in a separate enclosure.

(d) Cables entering equipment cases shall be limited to those connecting to equipment within that case, such case shall not be used as terminal boxes.

20.10.5. Types of Enclosure

(a) Inside and underframe mounted equipment shall be in sealed enclosures. Equipment mounted in such enclosures shall be treated as mounted in clean conditions as specified in BS 2618 clause 3. Where enclosures, as described above cannot be adopted, ventilation of enclosures, naturally or forced air, shall be considered. Equipment mounted in such enclosures shall be treated as mounted in dirty conditions as specified in BS 2618 clause 3, except that

enclosure pressure ventilated with filtered air shall be designated as clean areas.

(b) In the case of machines, the machine frame forms the enclosure. Machines shall be regarded as inside mounted and shall comply with this Clause.

20.10.6. Underframe Enclosures

(a) Clipped covers shall be used where regular access to equipment is necessary, and bolted covers elsewhere on the underframe. Covers shall be light weight, shall be fully compliant with PS 21.10, shall be designed to prevent distortion and damage, and shall be fitted with lifting handles and safety chains. Clipped covers shall be provided with location guides to facilitate location and correct fitting by one man. Particular care shall be exercised in ensuring a good seal against the ingress of dust and water, for the life of the equipment. Furthermore, water shall be prevented from accumulating on seals and gaskets.

(b) Covers which are substantially flat may be light weight metal pressings otherwise meeting the above requirements.

20.10.7. Enclosures Inside the Car

(a) In the case of body mounted equipment other than in the passenger area, suitably stiffened lift off hinged doors may be used. Doors hung on "piano" hinges shall be used in passenger areas. Doors shall be secured by approved locks in cabs or passenger compartments according to the levels of security requirements (refer to PS 32).

(b) Bolts shall only be used to secure doors or covers where access is infrequent. Where bolts are used for hinged doors or covers they shall be captive to the door or panel.

(c) No enclosures will be allowed in or opening into passenger areas, which contain apparatus whose voltage exceeds 300 V to earth.

(d) Enclosures in which heat or arcs may be generated shall be lined with barriers of insulating material. These materials shall also be used for vents, where

required. The design of such vents in the case of heavy duty equipment shall be such that the arc has a clear path to the outside of the enclosure and such that the vents do not tend to impede the emerging gas.

20.10.8. Access to Equipment

(a) Equipment with moving parts shall be so arranged that the moving parts are easily accessible for inspection and maintenance. The location of any item requiring adjustment shall be for approval.

(b) In the case of contactors, relays and cam operated switch groups it shall be possible, without breaking any pipe joints, or any electrical connections except those to the item concerned and without disturbing any other equipment, to change the following:

(i) All contact tips and flexible copper braids.

(i i) All arc chutes and arcing horns.

(i i i) All contactors and relays.

(i v) All magnet valves.

(v) All auxiliary contact enclosures complete.

(v i) All plug in cards.

This requirement may, at the Engineer's discretion, be extended to other apparatus.

20.10.9. Openings

In the case of air inlets, outlets or vents accessible from the platforms or areas to which passengers have access, it shall not be possible to touch, or to insert any object into any moving or electrically energised equipment, including blower or fan rotors. Any such inlet, outlet or vent which is mounted other than in such an area shall be covered with a mesh or grille so that it is impossible to insert a hand or finger to a dangerous extent.

20.10.10. Roof Mounted Equipment

Roof mounted equipment may be mounted externally in a recessed area of the roof, or inside the roof cavity. Outside mounted equipment shall follow the

roof profile as closely as possible. Such equipment shall be water tested before assembly, and, if repair is required, it shall be completely removed from the car. The design shall ensure that penetration of water cannot occur, either at sealing surfaces or at fixing points.

20.10.11. Outside Mounted Equipment

Where outside mounted equipment on the underframe is mounted within 750 mm of the structure gauge and includes bare conductors energised at high voltage, an earthed screen (solid or mesh) shall be provided to prevent accidental contact with staff walking beside the car.

20.10.12. Underframe Mounted Battery Box

(a) The battery shall be mounted, half in each of two battery boxes, one on either side of a car.

(b) These battery boxes shall be suspended from the underframe.

(c) Inside the battery box, the battery set shall be mounted in a detachable battery tray with a suitable sliding pull out arrangement to facilitate easy access for battery maintenance.

(d) The battery box location shall be arranged to provide easy access for maintenance inspection and topping up of water.

(e) Vents shall be provided in the top, ends and back of box.

(f) The battery box floor shall be shaped to support and locate the battery and to assist drainage. A lip shall be provided at the front to prevent spillage from running down the front of the box. Ample drainage outlets shall be provided, which shall discharge clear of all equipment, and otherwise as low down as practicable.

(g) The battery boxes shall be made of steel lightweight construction suitably protected with two coats of epoxy paint or unpainted stainless steel.

(h) A lid, with top mounted lift off hinges shall be provided with safety straps.

(i) With the lids removed, the whole front of the box shall be clear. Vents shall be provided in the top, ends and back of box.

(j) The lid, in the closed position, shall be secured by spring clips.

(k) The battery tray shall incorporate a secure quick release safety locking mechanism to keep the battery set in position, of which the locking and releasing position shall be easily identifiable.

(l) Activation of the locking mechanism shall separate the battery tray from the battery box.

(m) This battery tray shall be mounted on angles and, arranged so that a fork lift truck can lift the half battery out in its box as a unit once the cables and box fixings are released.

20.11 Electrical And Electronic Design Requirements

20.11.1. Safety Requirements

(a) Workmanship and Material

(b) Good workmanship shall be used in the construction and installation of the equipment installation.

(c) All equipment and wiring shall be out of sight of passengers when installed within the car body, except where the equipment is specifically intended for their use.

(d) All materials chosen and used in equipment installation shall be purposely designed for the intended application and shall not cause undue fire risk or electrical hazard.

20.11.2. Protection

(a) Electrical equipment shall be mechanically and electrically protected so as to prevent danger from shock, burn, or other injury to persons or damage to property or from fire of an electrical origin.

(b) Mechanical protection shall include the provision of protective covers, guards and means of identification, the display of warning notices and the placing of equipment out of reach. The design of safety signs shall be complied with BS 5378:Part 1:1980 (if not applicable, replacement by BS 5499-5-2002 is acceptable).

(c) Electrical protection shall include the provision of isolation, protective devices and earthing facilities as well as equipotential bonding of all the exposed conductive parts and extraneous conductive parts. Design of the protective provisions shall comply with EN 50153:1997.

(d) For the purpose of maintenance, it is important to ensure the safety of persons approaching the equipment to work on it or attend to it. It shall be noted that equipment shall not only be so constructed and protected as to be suitable for the conditions under which they are required to operate, but shall also be installed to be capable of being maintained, inspected and tested with due regard to safety.

20.11.3. Circuit Arrangement

20.11.4. Division of Circuits

(a) The equipment shall be divided into circuits where necessary or practicable and each circuit shall be separately protected and controlled.

(b) Each circuit shall be protected by an overcurrent protective device with its operating current value closely related to the current demand of the current-

using equipment connected or intended to be connected to it and to the current carrying capacity of the conductor connected.

(c) A fault on one circuit shall not result in the shutting down of any unrelated parts of the installation as far as reasonably practicable.

20.11.5. General Requirements

(a) Each circuit shall be provided with means of interrupting the supply on load and isolation for electrical servicing and testing purpose without affecting other circuits.

(b) Unless otherwise specified, all hardwired control circuit shall be supplied by the DC output of the auxiliary converter (refer to PS 17.4).

(c) Safety related circuits (refer to PS 9.9) shall be electrically separated from one another and from other circuits.

(d) For the safety related circuits, a dedicated pairs of wire shall be provided for both poles of DC supply and means of circuit isolation (e.g. circuit breakers, relay contacts or contactor contacts) shall also be provided at both poles of supply to facilitate a "double cut" circuit isolation of the safety related circuit.

(e) Single phase loads in an installation with three phase supply shall be evenly and reasonably distributed among the phases.

21.11.6. Current Demand

(a) The current rating of a circuit shall not be less than the current demand of the circuit.

(b) The current demand of a circuit shall be the same as the rating of the overcurrent protective device of the circuit.

(c) The nominal current or current setting of the devices shall not be less than the design current of the circuit.

(d) The nominal current or current setting of the devices shall not exceed the lowest of the current-carrying capacities of any of the conductors in the circuit.

(e) The current causing effective operation of the devices shall not exceed 1.45 times the lowest of the current-carrying capacities of any of the conductors of the circuit.

(f) Sufficient safety margin shall also be provided on determining the current rating of a circuit.

(g) For a circuit having non-simultaneous or cyclic loads such that only one of these loads can be in use at any one time, the greatest of these loads shall be used in calculating the current demand of the circuit.

21.11.7. Isolation and Switching

(a) An equipment shall be provided with a main switch or circuit breaker and a means of isolation to cut off all voltages. These two functions may be incorporated in a single device.

(b) The main switch or circuit breaker shall interrupt all live conductors and be capable of cutting off the full load current of the equipment from supply.

(c) Every circuit or group of circuits shall be provided with:

(i) a means of isolation; and

(i i) a means of interrupting the supply on load.

20.12 Specific Electronic and Electrical Requirements

20.12.1. Selection Criteria for Electronic and Electrical Components

The Contractor shall ensure that:

(a) Components selected have ratings and characteristics appropriate to their applications and are able to withstand the electrical, mechanical and environmental stresses to which they will be subjected during manufacture, storage and use, when incorporated in the equipment.

(b) Components are defined by a specification reflecting the requirements of Clause 12.1.1.

(c) Components are selected to minimise the range to be stocked by the AUTHORITY as spares.

(d) Components are selected to maintain continuity of supply for the life of the equipment.

(e) Procedures and controls governing selection and use of components to meet the policy set out in the configuration control program shall be defined in the Contractor's and Subcontractor's work instructions and these are traceable by the Contractor's quality management system (refer to PS 27).

20.13 Sources of Supply

20.13.1. Components selected shall be obtained from manufacturers or distributors able to supply them with evidence of conformity to the relevant specification.

(a) The Contractor shall ensure traceability of components.

(b) The Contractor shall ensure that all components shall not be obsolete or reached its end-of-life for at least 5 years as measured from the time of delivery to AUTHORITY. Otherwise, the Contractor shall ensure that replacement of the obsolete or end-of-life component is readily available of which the replacement component shall be directly replaceable and forward compatible with the replaced one. In the event that any obsolete or end-of-life component is informed by the supplier, the Contractor shall report to the Engineer immediately and provide detailed specification of the replacement component for approval.

20.13.2 Grounding Concepts

(a) Objective

(i) Since proper grounding is fundamental for reliable electrical and electronic circuits, the design of electrical grounding shall adhere to a proven set of requirements and design approaches to produce safe and trouble-free electrical and electronic circuits.

(ii) The grounding practice used in the design and assembly of electrical and electronic systems shall protect personnel and circuits from hazardous currents and damaging fault conditions.

(b) System Grounding Requirements and Design Approaches

(i) The design of electrical and electronic systems shall comply with the following as a minimum:

(1) A ground reference plane shall be established that will hold the grounds for all systems, subsystems, equipment metallic components, surfaces, and electrical and electronic parts at the potential of the base structure;

(2) Within equipment, power shall have dedicated returns;

(3) Except for a single-point reference, all electrical signal and power grounds

shall be electrically isolated from each other, and each separately derived electrical system shall be electrically connected to structure at only one point;

(4) A dedicated power return shall be used except where necessary to support system requirements.

(ii) The following design approaches shall be considered for the design of these systems:

(1) Within equipment, conditioned electrical power shall be DC-isolated from chassis and structure except at a single point;

(2) Within equipment, the single-point reference shall be routed external to the equipment for termination to ground, or routed directly to the chassis for termination;

(3) The control power bus return shall be independent of the primary electrical power return and shall be referenced to the return system at a single point;

(4) Secondary and tertiary electrical power shall be single-point grounded and shall be returned to that single reference ground point;

(5) When all single-point grounds are not terminated to chassis or structure, secondary and tertiary electrical power shall be DC isolated by a minimum of 1 megohm;

(6) Power conversion performed to supply conditioned power to several devices or functions shall reestablish a single-point ground reference for the serviced equipment or functions;

(7) Equipment shall not depend on other equipment for reference or grounding, either signal or power, unless it is also dependent upon the other equipment for its power;

(8) Signal circuits with frequencies below 2 MHz, with interfaces external to equipment, shall be balanced and isolated from chassis;

(9) All returns and references shall be brought out of equipment on individual connector pins;

(1 0) Shield connections shall be made to connector shells or to connector pins that are, or will be, grounded when mated;

(1 1) Single-ended circuits with the lowest frequency component equal to or above 2 MHz shall be coupled by coaxial or screened twist pair cable with the shield or screen terminated 360 degrees at each end;

(1 2) External to an equipment, single-ended electrical signals shall be prohibited for signal frequencies below 2 MHz except where electrical isolation is maintained.

(iii) Electric Shock Prevention

(1) Proper grounding shall be provided to protect personnel from accidental contact with metallic elements that may have hazardous voltage potentials due

to system faults or accidental contact between energized elements and equipment chassis, frame or cabinet structure.

(2) Case voltage rise shall be limited to reduce currents to levels that do not produce adverse reactions and possible secondary effects. Typically, case voltage rise shall be limited to prevent hazardous currents. Table 20-1 summarizes the alternating and direct currents and their shock effects.

(3) In order to evaluate the performance of shock prevention, the measuring method of touch-current specified in IEC 60990:1999 shall be applied.

(iv) Bonding

(1) The integrity of interconnected conductive elements shall be ensured by electrical bonding, a process in which components or modules shall be electrically connected to provide a low-impedance conductor.

(2) Positive mechanical locking means, such as, clamps, bolt and screw attachments, washers and materials, shall be used to ensure consistent bonding of equipment under various temperatures and corrosion environments.

(3) The use of jumper cables will not be accepted except across movable vibration or thermal isolation joints.

(4) Surface preparation for bonded joints shall begin by removing all anodic film, grease, paint, lacquer, or other high-resistance properties from the flaying surfaces.

(5) Correct use of scrapers, abrasives or chemical cleaning methods to provide a clean, smooth bonding surface shall be adopted according to the type of joint (i.e., metal-to-metal, metal-to-nonmetal or nonmetal-to-nonmetal).

(6) Example bonding impedances for selected bonding classes are shown in Table 20-2.

(v) Cabling/Connector Grounding

(1) Since cabling extending outside grounded enclosures is vulnerable to radiated emissions if cable lengths are a significant portion of the wavelength of the system's highest operating frequencies, adequate shielding and grounding shall be provided to ensure proper system operation.

(2) Shield terminations at connectors shall be gripped by the connector back shell to provide a low impedance 360 degree connection.

(3) Soldered connections shall not be used due to the difficulty in repair and wiring changes.

(vi) Detailed requirements and practices of circuit earthing shall refer to Clause 20.19.

20.14 Equipment Construction

20.14.1 In order to facilitate efficient trouble shooting or equipment replacement, the various parts of the electrical and electronic equipment supplied shall be ~~grou~~ped into small sections, such as in the form of equipment panel, module and box.

20.14.2 As far as possible, plugs and sockets compatible with MIL-C-26482 ~~and connectors conforming to BS 9522 F0017 shall be used for connecting each~~ section of equipment ~~group. In addition, the coupling shall be indicated by an audible click and the alignment shall be provided with 3 red dots on the receptacle and plug. For those connectors that are used for communication~~ equipment, MIL-C-24308 and IEC 60 807 complied ~~connector shall be used.~~

As far as possible, plugs and sockets conforming to MIL-C-26482 or MIL-C-5015, and connectors conforming to BS 9522 F0017 shall be used for connecting each section of equipment group. For interior applications it is acceptable to use AMP circular plastic connectors where space is limited. In addition, the coupling shall be indicated by an audible click and the alignment shall be provided with dots on the receptacle and plug. For those connectors that are used for communication equipment, MIL-C-24308 and IEC 60 807 complied connector shall be used.

20.14.3 The use of modular design particularly with the DIN rail mounting arrangements conforming to BS 5825:1980 shall be encouraged, so that the individual equipment can be removed for maintenance with minimum disturbance to the other equipment.

20.14.4 To configure the individual electrical and electronic equipment section, the Contractor shall arrange all of the equipment according to the principles of ease to access in which it can be maintained. In providing satisfactory space for the maintainer to carry out his tasks, the Contractor shall take account of

the basic human data considerations of body size, strength and stamina. Detailed requirements on maintainability shall refer to PS 26.

20.14.5 Electrical Creepage and Clearance

(a) Electrical creepage and clearance shall be as specified in BS2618 and comply with Table 20-3.

Alternating Current at 60Hz (mA)	Direct Current (mA)	Reaction
0.5-1	0-4	Perception
1-3	4-15	Surprise
3-21	15-80	Reflex action
21-40	80-160	Muscular inhibition
40-100	160-300	Respiratory block
> 100	> 300	Usually fatal

Table 20-1 Summary Effects of Electrical Shock

Bonding Class	Impedance
A (Antenna installation)	DC resistance < 2.5 milliohms
H (Shock hazard)	DC resistance < 100 milliohms
R (RF potentials)	DC resistance < 2.5 milliohms Impedance < 100 milliohms up to 1 MHz
S (Static charge)	≤ 1 ohm (conductive structure) ≤ 1000 ohms (composites) ≤ 1000 ohms (conductive subassemblies)

Table 20- 2 Example Bonding Impedances and Bonding Class

Nominal line voltage	Minimum surface creepage values			Minimum electrical clearance values	
	Clean Conditions	Dirty Conditions	Roof Mounted	Inside Mounted	Outside Mounted
volts	mm	mm	mm	mm	mm
250 to 600	12	30	60	12	25
750	20	50	65	12	35
1200	30	60	80	15	45
1500	40	70	90	20	50
2400	60	90	115	25	65
3000	75	100	140	30	75

TABLE 20-3 Surface Creepage and Electrical Clearance Values for Equipment In Circuits Operating At Voltages Exceeding 250 V and Not Exceeding 3000 V

Notes: The following meanings have been assigned to the terms used in the headings of Table 20-3:

(a) Clean conditions. Applies to equipment mounted in vehicle compartments, switch-group (control-group) cases, cupboards and all enclosed apparatus.

(b) Dirty conditions. Applies in particular to resistors mounted in a resistor compartment, beneath the underframe or on the roof of the vehicle.

(c) Roof mounted. Applies in particular to ceramic insulators for high tension circuits and for bare conductors.

(d) Inside mounted. Applies to equipment mounted either in an enclosure which is dust-proof or in a chamber where clean conditions apply.

(e) Outside mounted. Applies to equipment which does not fulfil the conditions for inside mounting.

(f) Electrical clearance. The values given in the table do not apply to situations influenced by electrical arcs.

20.15 Cable

All conductor shall have a current-carrying capacity not less than the maximum current demand it normally carries, be capable of withstanding the prospective fault current, and suitable for operation in the environment and at the design voltage of the insulation.

The minimum quantity of inflammable material shall be used in the construction of all cables which shall, as far as is practicable, minimise the production of smoke and toxic fumes in the event of fire or short circuit.

20.15.1 Cable Joints and Connections

(a) All connection at a cable termination or joint shall:

(i) Be mechanically and electrically sound;

(i i) Be protected against moisture, mechanical damage and any vibration liable to

occur;

(iii) Not impose any appreciable mechanical strain on the fixings of the connection;

(iv) Not cause any harmful damage to the cable conductor;

(v) Be appropriate to the size and type of conductors with which they are to be used; and

(v i) Be suitably insulated for the voltage of the circuits in which they are situated.

(vii) No strand of a stranded conductor in a cable core shall be cut away in making a cable joint or termination.

(b) Unless otherwise approved, all cable terminations shall be of the crimped type and soldered connections shall not be used.

(c) All mechanical clamps and compression-type sockets shall securely retain all the wires of the conductor.

(d) For the purposes of approval, samples of types of crimped lugs, or other terminations shall be submitted with the following information:

(i) Maker, Maker's Mark and Type Number. 2

(i i) Cable size and stranding for which the cable lug is suitable.

20.15.3 The Engineer may require tests before approval and will require to be satisfied that the quality of crimping will be maintained by the carrying out of regular tests on all equipment under the supervision of his representative.

20.15.4 High voltage cables, of conductor sizes up to 6 mm shall be crimped with a lug which grips the insulation as well as the conductor, or other arrangements made to prevent excessive flexing of the core where it emerges from the lug.

20.15.5 The insulation need not be crimped where the conductor size exceeds 6 mm2 irrespective of the insulation grade, however if the cable is in a position where movement occurs, such as earth brush, then suitable crimping or strain relief shall be provided to prevent stress of the conductor at the point of connection to the crimp.

20.15.6 Lugs shall be closed end type unless otherwise approved.

20.15.7 Terminals shall be of the steel screwed post type securely moulded into an

insulating base. All power terminations on one stud shall be assembled together without intervening, such as nuts and washers. Studs or bolts shall not be used to carry current.

20.15.8 Alternative forms of terminals will be considered where appropriate but post terminals are mandatory for safety circuits.

20.15.9 Terminal posts or the equivalent shall be mounted horizontally or vertically downwards. Vertical posts shall only be used if the posts are completely shielded from the possibility of being bridged by a conducting object dropped onto or lying across the terminals. Horizontal posts shall be so arranged that there is little possibility of an object lying across two posts. Failure of a fixed terminal shall not result in scrapping of a complete piece of equipment.

20.15.10 Cables terminating in plugs or sockets may be secured by soldering where the plug is too small for crimping to be practicable and a suitable cable clamp provided.

20.15.11 Terminals and terminal boxes shall be so arranged that water collecting in ducts and conduits cannot reach live parts.

20.15.12 Terminals for circuits of different voltages shall be kept in separate groups. Negative and neutral terminals shall be grouped separately.

20.15.13 Cable glands shall securely retain without damaging the outer sheath of the cables.

20.15.14 Electrical connections shall not be used as the sole means of mechanical support for components other than those mounted on printed circuit boards. Contactors and other equipment which are specifically designed to be mounted via its electrical connections is exempt from this requirement provided that the appropriate manufacturers data sheets are submitted for information to the Engineer.

20.16.Cable Enclosure

20.16 Cable enclosures as protective conductors

20.16.1 Types of protective conductors, such as circuit protective conductors, earthing conductors, of which shall be formed by rigid steel conduits, trunking or ducting.

20.16.2 Metallic enclosures where used as protective conductors shall:

(a) Have a cross-sectional area according to BS 7671;

(b) Have an electrical continuity achieved and maintained to afford protection against mechanical, chemical or electrochemical deterioration; and

(c) Permit the connection of other protective conductors at every predetermined tap-off point.

20.16.3 All cable enclosures shall be properly supported and of a type suitable for any risk of mechanical damage to which they may be liable in normal conditions of service or adequately protected against such damage.

20.16.4 Where cable enclosures pass through fire barriers, the opening made shall be sealed according to the appropriate degree of fire resistance.

20.16.5 Where cable enclosures are not used as protective conductors, the non-metallic enclosures can be used provided that the material used shall comply with the specified fire requirements.

20.17.Conduit - Trunking and Ducting

20.17 Conduit

20.17.1 Conduit shall be of an approved non-metallic grade except where high mechanical strength or electrical continuity is a requirement.

20.17.2 Metallic conduit where approved shall be of solid drawn seamless zinc coated steel or aluminium EMT.

20.17.3 The conduit and fittings shall comply with BS4568 Screwed type, Class 4 or equivalent.

20.17.4 The nominal minimum outside diameter of any rigid conduit to be used shall be 16mm with a minimum wall thickness of 1.4mm.

20.17.5 The outlets of all metallic conduits shall be protected by suitable bushes. All steel conduits, conduit fittings and the associated metallic boxes for the enclosure of electrical accessories shall be protected against corrosion on both the inside and outside surfaces.

20.17.6 An adequate number of suitably sized adaptable boxes shall be provided in conduit installation to enable cables to be drawn in easily and without damage.

20.17.7 Conduits in exposed locations shall be provided with an effective means of sealing the cable entry to prevent the ingress of water and condensed moisture.

20.17.8 The use of flexible conduits which have been service proven, shall be used across movable vibration or thermal isolation joints.

20.17.9 Flexible conduits shall be PMA-type or flexible steel. If flexible steel conduits are used, flexible steel conduits shall comply with BS 731 Part 1 (if not applicable, replacement by BS EN 61386-1:2004 is acceptable) or equivalent. In addition, the flexible steel conduits shall be of the metallic water tight pattern with oversheath.

20.17.10 Workmanship

(a) Conduits shall not be bent in such a manner which appreciably distorts their original cross-sectional shape or causes damage to the conduits.

(b) Burrs, sharp edges and projections shall be removed from the internal surfaces and ends of conduits, ducting or other enclosures when installed.

(c) Where the protective coating on a metallic enclosure has been damaged after installation, such surface shall be effectively restored by paint or other suitable coating to prevent corrosion.

20.18 Trunking

20.18.1 Trunking and fittings shall comply with the requirements specified in BS 4678 part 1 or equivalent.

20.18.2 Trunking installations shall be constructed using manufacturer's standard fittings such as tee or angle pieces, throughout as far as practicable.

20.18.3 All steel trunking and fittings shall be protected against corrosion.

20.18.4 The steel trunking installation shall be made mechanically and electrically continuous throughout,and be effectively earthed.

20.18.5 Electrical continuity shall be achieved by means of connecting a protective conductor of adequate size across the two adjacent ends of the trunking.

20.18.6 Every entry to the trunking installation shall be provided with smooth bore bushes or grommets and the return edge of the lid of the trunking shall be left intact in order to prevent and/or to be protected against the ingress of water.

20.19 Ducting

20.19.1 Ducts shall be sealed all round, including any removable lids or covers, against ingress of moisture and dirt.

20.19.2 Lids shall be provided to enable the cables to be introduced easily into the duct.

20.19.3 The cables and cable loom shall be cleated or otherwise secured into the duct sufficiently frequently to prevent movement.

20.19.4 Ducting with top access lids shall be avoided whenever possible and will not be accepted for under floor mounting.

20.19.5 Duct lids shall not be used for cable support.

20.20 Space Factor

Space factor of at least 45% shall be provided for all cable conduits, trunkings and ductings.

20.21 Cable Runs

20.21.1 All cables shall be run in a vertical or horizontal direction, where practicable and shall be secured flat or in a bundle, such as on the surface of body panels, columns, partitions or ceilings, throughout the entire route.

20.21.2 Where cables run as a span, such as between beams, trusses, rigid support throughout their entire length shall be used.

20.21.3 Cables crossing an expansion joint shall be formed into a loop such that any movement in the joint shall not stress the cables.

20.21.4 Where a wiring system passes through elements of car construction such as floors, walls and roofs, the opening remaining after passage of the wiring system shall be sealed according to the specified degree of fire resistance.

20.21.5 The internal bending radii of all cables shall not exceed the limit provided by the associated cable manufacturers.

20.21.6 All exterior cables external to equipment cases or ducts that are smaller than 6 AWG must be protected by conduits, trunking or ducts. Interior cables shall be appropriately supported in conduits, trunking, trays, ducts or free-air.

20.21.7 Heavy Current Connections

(a) Heavy current connections may be by cable or bare strip.

(b) Heavy current cables run in ducts or unprotected shall be adequately cleated or secured against chafing or movement. Unprotected power cables, suitably sheathed, shall be cleated at not more than 400 mm centres. For the smaller cable size cleat distances less than this may be necessary. Such cables may be run bundled together as necessary to give additional support.

(c) Cable runs shall not cross a horizontal floor or surface except where unavoidable, and then a clearance of at least 25 mm shall be left beneath the cables, and where the likelihood exists of the cables being damaged they shall

be protected by a removable tread plate.

(d) Bare copper strip may be used within enclosures, with the following provisions:

(i) The conductor shall be of adequate stiffness, and shall be adequately supported and clamped against movement, resonance or vibrations.

(ii) Adjacent conductors may be separated by an insulator to ensure correct spacing and to give increased stiffness.

(iii) The arrangements shall be such that no stress is placed on the terminations by the conductors.

(iv) All bends radii shall be appropriate to the hardness of the copper strip used.

(e) Where cables pass through holes in the traction motor frame, oil resistant resilient bushes suitably clamped shall be provided to prevent chafing of cables and to seal against the ingress of oil and water.

20.21.8 Light Current Connections

(a) Light current connections outside enclosures shall be by cables protected by conduits or ducts, or unprotected where so approved.

(b) Cables inside enclosures may be run unprotected, and, where more than one cable, made up into cable looms.

(c) Cable looms shall be made up by fastening them together to form a neat bundle. The individual cables shall be laid parallel and pulled straight and shall have a neat appearance. Particular care to obtain parallel lays shall be taken where looms go round corners.

(d) The looms shall be fastened at not more than 150 mm intervals. Fastenings shall also be applied at the start and finish of any bend, and at the point at which one or more cables leave the loom so as to secure the leaving cables. The term fastening includes the application of flame retardant lacing cord or of approved, non metallic, proprietary fasteners to secure the bundle. The use of self adhesive tape or lacing cord will not be accepted. Care shall be taken that the fastenings are not tightened excessively. Fastenings shall only be applied using the manufacturers recommended tool to obtain the tightening force appropriate to the cable.

(e) As far as practicable cables shall leave looms at right angles, to give a neat appearance. Sufficient slack shall be allowed to prevent a constraint being placed on cable terminations.

(f) The use of proprietary cable ducting and support systems inside enclosures as an alternative to the foregoing requirements shall be submitted for approval.

(g) High and low voltage cables shall be kept separate. Where cables of greater than 208 V between conductors are approved as being carried in the same jumper as other cables they may be run together as far as the adjacent junction box. AC cables shall not be run so as to result in eddy current heating of conduits.

(h) Light current cables or cable looms shall be adequately secured to supports. Cables or cable looms shall be supported sufficiently frequently to prevent movement chafing or vibration in service.

20.21.9 Location of Cables and Looms

(a) Cables and looms shall be run in such positions that they are clear of apparatus and do not impede access for maintenance. They shall be clear of high temperature and electric arc areas. Arc or heat barriers to protect the cable runs shall be provided where it is not possible to avoid such areas, in such a way as to allow circulation of air around the cables.

(b) Sharp edges over or near which cables or looms may run shall be protected. The possibility of displacement in service shall be duly considered. Where cables pass through metallic partitions polychloroprene grommets or equivalent protection shall be provided.

20.21.10 Cable Identification

(a) All wires shall be indelibly marked for proper circuit idenfication. Where the wires are confined within a particular component, colour coding may be used.

(b) Each wire #10 AWG and similar shall be permanently and legibly marked along its entire length by means of hot stamping or equivalent. Each designation shall be no more than 3-inches from the last designation on the last 24-inches of wire nearest the termination, and 36-inches apart on the rest of the wire run. The circuit designation shall reflect what is shown on the electrical schematics.

(c) Wires larger than #10 AWG, multi-conductor cables, and other wires not capable of being continuously stamped, shall be identified by white or yellow heat shrinkable wire sleeves, attached to each end of the wire. The sleeve shall be printed with the circuit designation, and installed on the end of the wire as close to the termination as practical.

(d) Wire sleeves shall be of a type that does not come loose, age nor deteriorate due to UV light, dirt, grease or contact with other contaminants which may be encountered in a railway environment. Neoprene rubber markers will not be accepted. Markers requiring dilating fluid will not be accepted. Samples shall be submitted to the Engineer for approval.

20.21.11 Conduit Runs

Conduit shall be adequately secured and supported by clips or otherwise. Welding of conduit will not be accepted. Metallic conduit shall be used on trucks, in exposed positions on the underframe, and to protect the cables

between the Collector Shoe and protective devices for the traction and auxiliary supplies. Non metallic conduit shall be used elsewhere except as approved.

20.22 Safety Circuits

20.22.1 Insofar as is practicable safety circuits shall be run direct to apparatus and not to terminal bars. Where it is essential that intermediate terminals be used, (for example, circuits which pass through intercar jumpers) the terminals shall be covered and separated from others terminals. All safety circuit cables shall be coloured yellow.

20.22.2 The Engineer will direct which circuits or sub-circuits shall be designated safety circuits within the meaning of this Clause.

20.23 Inter-car Connections

20.23.1 Inter-car connection shall be by an approved form of multicore cable taken to contact boxes integral with the couplers.

20.23.2 600V connections shall be by bolted cables.

20.23.3 Care shall be taken that the cables run in easy bends without undue flexing.

20.24 Train Wires

All multicore train wires shall be run from coupler to coupler, irrespective of whether required by the circuit, except where the circuits demand otherwise.

20.25 Spare Wires

20.25.1 Spare wires shall be provided and terminated in the same way as other wires.

20.25.2 The spare wires shall be shown on the wiring diagram and labelled with cable markers in the same way as all other wires.

20.25.3 As a minimum requirement, the following spare control hardwires shall be provided for future uses:

(a) Between the electrical connection boxes of the auto-couplers: all remaining electrical connections shall be provided with spare wires.

(b) Between underframe connection boxes at car ends: 6 nos. of spare wires shall be provided.

(c) Between underframe connection boxes and equipment cases: 4 nos. of spare wires shall be provided.

(d) Connection boxes between underframe and saloon: 6 nos. of spare wires shall be provided.

(e) Between saloon connection boxes and equipment inside the saloon: 4 nos. of spare wires shall be provided.

20.25.4 All spare wires shall be properly secured and insulated by appropriate end cap or capsulate.

20.26. Insulators and Insulating Panels and Boards

20.26.1 All insulating material used for the train shall be non-hygroscopic, anit-tracking and substantially non-ignitable. Phenolic resin bonded paper to BS 5102 (if not applicable, replacement by BS EN 60893-2-2004 is acceptable) or phenolic resin bonded fabric to BS 2966 Type 2A, shall be used for panels or for small insulators of simple shape.

20.26.2 All surfaces of insulators or insulating panels shall be smooth, hard, free from air bubbles, cracks, scratches, inclusions or similar surface imperfections.

20.26.3 Moulded resin insulators for areas where arcs are present, including brush gear support insulators, shall be moulded of a suitable grade of silica filled epoxy resin, or similar approved material so formulated that, in the event of a flashover, the insulator can be cleaned and fit for further service by wiping or, in severe cases by minimal cleaning with aluminium oxide paper.

20.26.4 The insulators shall have a smooth finish without special surface coating.

20.26.5 Brush gear support insulators shall be fitted with a PTFE replaceable sleeve.

20.26.6 Ceramic insulators shall only be used where approved, and approval will only be granted where alternative materials cannot be used.

20.26.7 Moulded mica tubes or components of similar materials shall not be used.

20.27.Circuits and Earthing

20.27 General

20.27.1 This Clause covers all car electrical circuits.

20.27.2 Simplicity is required in circuit design. The number of different types of component shall be minimised.

20.27.3 Unless specifically approved by the Engineer, DC and single phase AC circuits shall be such that one pole of each device shall be connected directly to the negative or neutral line, without switches, fuses or contacts on the negative side.

20.27.4 The practice of de energising devices by short circuiting the operating coil will not be permitted. The use of economy resistors or of separate pull in and hold coils for contactors, solenoids or similar devices will not be accepted.

20.28 600V Traction Circuits

20.28.1 600V traction circuits shall be protected by overload and/or current balance relays operating approved fault rupturing devices. Fuses will not be accepted. A high speed fault limiting device shall be provided. The device shall meet the requirements of IEC 60077. Collector Shoes, lightning arrestors (if provided), and lead in cables may be regarded as protected by the sub station system.

20.28.2 600V Auxiliary Circuits

600V auxiliary circuits shall be protected by fuses. In all cases, the fault discriminating characteristics of the system shall be submitted for approval.

20.28.3 Low Voltage Circuits

(a) DC power sources shall be protected on the input side where practicable. In the case of a battery, it shall be protected by fuses in both the positive and negative lines installed in close proximity to the respective battery terminals. The unprotected positive and negative battery cables and terminals shall be physically segregated.

(b) Battery switches shall be provided.

(c) AC power sources shall have a fuse or miniature circuit breakers (MCB) in each phase and the neutral shall be earthed.

(d) Fuses, except as mentioned above, shall only be used where approved.

(e) Protection and isolation of low voltage circuits other than the above shall be by MCB. Note that in all cases, these will be backed up by the power source fuses.

(f) Where regular switching is anticipated, separate switches shall be provided in addition to the MCBs.

20.29 Cable Ratings

Rating of cables of 4.0 mm2 or larger shall not be less than 90% of the rating of the protecting fuse or MCB. 2.5 mm cable may be protected by an MCB of

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up to 30 A rating and 1 mm cable may be protected by an MCB of up to 20 A rating.

20.30 Earthing

20.30.1 Separate insulated earthing bars shall be provided for the 600VDC, 37.5VDC and 360VAC circuits.

20.30.2 Earthing bars for 600V circuits shall be connected to at least two earthing brush boxes on different trucks by separate cables.

20.30.3 Car bodies shall be earthed to at least two other earthing brush boxes also on different trucks.

20.30.4 Traction motor frames shall be connected to the adjacent earthing brush box in all cases. The same earthing brush boxes shall not be used for the 600V circuit and for the car body earths.

20.30.5 Earthing brush boxes shall be insulated from their mountings for 750V and arranged so that build up of dirt cannot short circuit the insulation. Care shall be taken that earth paths in parallel to the earth brushes via bearings are prevented.

20.30.6 The Collector Shoe lead conduit construction and earthing shall provide a low impedance path to any likely fault current. The conduit(s) shall be of heavy gauge weather proof construction and be adequately earthed to the underframe by an earthing bar used solely for this purpose. Proper sealing shall be provided to protect the conduit entry against the ingress of water.

20.30.7 Low voltage earthing bars shall be connected directly to the car body by a bolted link.

20.30.8 The negative or neutral of each separate AC or DC circuit including power sources shall be connected separately to the earthing bar of the car in which is the appropriate power source. For the purposes of this Clause, the negative of each circuit supplied by a separate MCB shall be considered a separate circuit.

20.30.9 In the case of train line negative the connection shall be in the operative cab made by a suitable contactor.

20.30.10 Resiliently mounted equipment shall be provided with earth links.

20.30.11 Such as all equipment cases and resistor frames, mountings on the underframe must be properly earthed by an earthing cable connected to a earthing pad on the underframe.

20.30.12 Where equipment with secondary or tertiary insulation systems are used, all live and floating conductors shall be protected by an earthed cover.

20.30.13 The negative or neutral of each separate AC or DC circuit including power sources shall be connected separately to the corresponding earthing bar of the car in which the power source originates. For the purposes of this Clause, a separate circuit shall be considered to be that circuit that is supplied by an individual MCB.

20.30.14 In the case of the train line negative the connection shall only be made at one point. This shall be achieved in the car of the active driving cab via the use of a suitably rated contactor.

20.30.15 All metallic boxes, cases and enclosures containing electrical equipment, including cable ducts, which are not intended to be part of the live circuit shall be properly earthed with an insulated flexible earth bond to the relevant earth bar.

20.30.16 Earthing by means of a flexible earth bond shall be required on each equipment case irrespective of whether the equipment case is directly mounted to the car body.

20.30.17 For auxiliary voltage circuits designed with earth returns within the metallic equipment case these shall be connected to a common, insulated earthing terminal bar which shall be connected to the appropriate earthing bar by a flexible earth bond.

Item 20.30.17: (No specifications text modifications required.)

20.30.18 Where the metallic equipment case is constructed of a ferrous metal the earth terminal shall be welded to the casing.

20.30.19 Non-ferrous metallic equipment cases shall also require a permanently fixed

earthing terminal mounted in a way to ensure that any electrolytic action is prevented.

20.30.20 Both earthing terminals and the flexible earth bonds shall be suitably sized to accommodate the prospective fault current, also taking into account the relevant fault detection/isolation system.

20.30.21 The physical length of the flexible earth bond shall be as small as practically possible and its purpose shall be clearly distinguishable.

20.30.22 Detachment of either end of the flexible bond shall be such that it does not fall into any moving parts or on to any electrical item that may be live.

20.30.23 The position of the earth terminal/stud assemblies and the associated earthing cables shall enable the termination to be easily connected without the requirement to remove any equipment or apparatus.

20.30.24 All earth terminations shall be clearly visible.

20.30.25 An associated group of electrical components, from a common power source, not within an equipment casing shall be suitably earthed at one common point.

20.30.26 Loop earthing between items of equipment is not acceptable.

20.30.27 Where equipment with secondary or tertiary insulation systems are used, all live and floating conductors shall be protected by an earthed cover.

20.30.28 In the event of non-metallic boxes, cases and enclosures being used there shall be no metallic fastenings passing from the inside to the outside which can be inadvertently energised electrically by a fault occurring inside the box, case or enclosure.

20.30.29 The cross sectional area of the earthing cable shall not be less than that of the incoming supply to the case or frame.

20.30.30 Any earth fault or insulation breakdown shall not cause any object accessible to maintenance or operating staff to become live.

20.30.31 The removal of any earthed equipment or item shall not interrupt the earthing arrangement of any other remaining earthed electrical equipment.

20.30.32 Special earthing arrangements for electronic equipment where required, shall be submitted for approval, and shall be compatible with the above.

20.30.33 Screens shall be provided on circuits to meet the requirements of the equipment or system concerned.

20.30.34 The screen shall be continuous through all intermediate connections/components on a car.

20.30.35 Screen earths and low auxiliary earths shall not be terminated on the same terminal.

20. 30.36 The screen shall not form a path for circulating currents.

20.31 Circuit Diagrams

Circuit diagrams shall be clear and easy to interpret and shall comply with IEEE Std 315.

20.32.Auxiliary Contacts

20.32.1 Auxiliary contacts shall be of the silver butt type. They shall be contained in a separate dust proof contact enclosure under an approved type of cover. In the case of small relays and the like the whole relay may be contained in the enclosure. The contact enclosure is required irrespective of the type of enclosure of the main equipment. The cover shall be transparent plastic and all fixings shall be captive. Acrylic resin will not be accepted.

20.32.2 The Engineer shall be satisfied that condensation of moisture inside the contact enclosure will be prevented. Contacts shall be adequately protected against corrosion.

20.32.3 The above requirements also apply to the contact section of master controllers, but the enclosure may be formed by the controller case and need not be of transparent plastic.

20.32.4 The connections shall be made outside the contact enclosure. It shall be possible, as far as practicable, to remove a contact enclosure complete and substitute another of the same type without removing the contact cover.

20.32.5 Notwithstanding the above, the use of an approved type of small contactor for several applications, either as a relay or as a contactor, shall be considered, even if it does not fully comply with the foregoing, to economise on equipment types.

20.33. Power Contacts

20.33.1 All power contacts shall be fitted with contact tips, securely fixed to their support and arranged for easy removal without further dismantling. Contact screws of size M8 or larger shall not be provided with screwdriver slots. Current shall be taken from moving contacts by flexible copper braids, amply proportioned and having end connections secured by crimping only, with flared ends to avoid abrasion of the shunt. Braids shall be supported and restrained so as to prevent damage due to excessive movement or vibration. Passage of current through springs or bearings shall be positively prevented.

20.33.2 Fixings of all blowout coils and connections shall be submitted for approval.

Blowout coils shall be connected on the positive side of the contacts. Permanent magnet blowouts shall be submitted for approval.

20.33.3 Arc horns which are removed with the arc chute are not permitted. Where used, the associated flexible lead shall be sleeved.

20.33.4 The Contractor shall satisfy the Engineer that all arc chute components have adequate resistance to erosion and burning from the arcs to which they may be subjected.

20.33.5 Arc chutes shall be of a manageable size. Arc chutes that weigh more than 5 kg shall include an inner replaceable arc box to avoid changing the whole assembly when cheek wear occurs.

20.34 Rotating Electrical Machines

20.34.1 The design of all rotating electrical machines used for the train shall be complied with IEC 60349.

20.34.2 All rotating electrical machines, particularly those are underfloor mounted, shall be fitted with resilient mountings to eliminate transmission of mechanical vibrations to the carbody.

20.34.3 Rotating parts shall also be adequately guarded and protected against ejection under failure conditions. Suitable protection shall be put in place to guard against the ejection of rotating parts under failure conditions.

20.34.4 The rotating electrical machines shall be of the self ventilated type, with simple means provided for exclusion of dust and water. Alternatively, fully enclosed proven air cooled type motor will be considered.

20.35 Coils and Windings

20.35.1 This Clause shall apply to all coils and windings, including relay and contactor coils, inductances and transformers, but excluding coils and windings for machines or for oil immersed equipment.

20.35.2 All coils shall be fully impregnated, or encapsulated by a system rated class H, and shall be continuously rated at the maximum working voltage and/or current, except where approved.

20.35.3 Connections to coils shall be to terminals securely fixed to the coil body, to which the ends of the winding can be brought, and which can carry a suitable fixing for the incoming lead.

20.35.4 Coils with leads which are brought out from the coil shall be submitted for approval. The leads shall be of suitably insulated multistrand wire and taken to an adjacent terminal block or connector. The joint between the winding and the lead shall be taped or otherwise fixed into the coil body.

20.35.5 All coils shall be securely fixed to their cores, or otherwise arranged to prevent movement in service.

20.36 Plugs and Plug in Components

All multipin plugs, plug in relays, component boards, electronic cards or racks, or the like shall comply with the following:

20.36.1 The plug or device shall be adequately and positively secured against working loose.

20.36.2 The plug contacts shall be adequate and proof against failure to make good contact.

20.36.3 Incorrect insertion of the plug or device and consequent damage to the contact shall be positively prevented by the use of a guide, shield, or otherwise.

20.36.4 The cable shall be attached to the plug or socket by an approved method. Where the cable size is 1.0 mm^2 or larger crimped connection shall be used except where otherwise approved.

20.36.5 All the plugs and sockets shall be labelled.

20.36.6 The caps shall be provided to cover equipment sockets when removed from the car.

20.37 Control Relays and Contactors

20.37.1 Unless electrical isolation is required for safety reason or otherwise specified, control relay shall not be used and microprocessor or software based equipment shall be used whereas applicable (refer to PS 20.50).

20.37.2 Calibrated relays shall have the adjusting mechanism securely locked after setting. Calibration marking on the relays will not be required.

20.37.3 Where the use of time delay relays is accepted they shall not use liquid damping to obtain the time delay unless the damper is of the fully sealed type.

20.37.4 Microswitches of the fully sealed type will be considered subject to satisfactory performance on an endurance test, as part of a contactor or otherwise.

20.38 Low Voltage Components

20.38.1 Low voltage components such as all low voltage switches, rotary switches and push buttons indicator lamps shall be submitted for approval.

20.38.2 The size, colour and brightness of fault indicator and similar lights shall be submitted for approval. If filament lamps are used the lamp bulbs shall be

underrun by energising them at less than 90% of their rated voltage. If required, filament lamps shall use dim/bright indication.

20.38.3 Low Voltage toggle switches shall have a quick action mechanism. Switch contacts shall be of the wiper or wiping butt type. Alternatively the use of switches or push buttons with the whole contact part mounted in a sealed box, will be considered. Toggle switches shall have the "Off" position upwards (2 position type) or in the mid position (3 position type) except where otherwise approved.

20.38.4 Rotary switches shall have a quick action mechanism and shall be capable of continuous rotation in either direction. They shall have a steel shaft not less than 9 mm at the least section. Except where otherwise specified they shall have the position for normal service with the operating handle vertical.

20.38.5 Push buttons, except where otherwise specified, shall be shrouded.

20.39 Protection Devices

20.39.1 Miniature circuit breakers (MCBs) shall be of the magnetically tripped type in accordance with IEC 60934. The OFF and Tripped position shall be the same, with toggle downwards. Alternative circuit breaker type shall be submitted for approval.

20.39.2 The toggle shall be arranged to include means to attach securely, a label or a seal, but tripping of the device shall not be inhibited by such a seal. Operation of the tripping mechanism shall return the toggle to the OFF position. MCBs having alternative arrangements shall not be offered.

20.39.3 The MCB's offered shall be available in the combinations set out in IEC 60934, incorporating trip for coils remote operation, auxiliary contacts rated at not less than 0.5 A, 37.5 VDC., alternative breaker current/time tripping characteristics and with minimum trip currents between 101 % and 125 % of the rated current. The load rating calculations for each MCB shall be submitted for approval. The calculation shall be revised based on loads measured on the cars, and MCB ratings amended as necessary.

20.39.4 Particular care shall be taken to ensure adequate creepage distances to earth and between terminals of adjacent MCBs are maintained with the units grouped as closely as possible.

20.39.5 MCBs shall be mounted in such a way that shrinkage of insulating panels does not cause loosening of the electrical connections.

20.39.6 Access shall be provided to the rear of the insulating panel, which may be hinged for this purpose where so approved. Where mounted on a switch board in a cab or similar positions a front sheet metal cover shall be provided, so

arranged that any one MCB can be removed from the front without disturbing the rest, after removal of an escutcheon plate or otherwise.

20.39.7 Irrespective of the toggle position, the upper connection to all MCBs shall be the line (AC circuits) or the positive (DC circuits).

20.40 Fuses

All fuses shall comply with IEC 60269-1. Fuse carriers shall be back inserted, provision being made to remove the complete fuse panel.

20.41 High current Resistors

20.41.1 Heavy current resistance elements shall comply with IEC 60322 and shall be of the edgewound corrosion resistant, unbreakable "non sag" type. Such resistors shall have a negligible temperature coefficient.

20.41.2 High voltage heavy current resistor elements shall be mounted on, and insulated from (primary insulation) a steel sub frame and the sub frame itself shall be mounted on and insulated from (secondary insulation) the main resistance frame. All insulation shall be suitable for the system voltage. Care shall be taken that adequate strength and insulation is provided at the support for the sub frame. Mica tubes, as part of insulator assembles, will not be accepted.

20.41.3 All power resistor frames must be safety-earthed.

20.42 Light Current Resistors

20.42.1 Light current resistors shall be of the wire or strip wound type, with the conductor set in vitreous enamel. Where the wire size exceeds l mm the use of vitreous enamel is not mandatory but in all cases the coating, if any, shall not tend to peel off or disintegrate.

20.42.2 The sliders of pre set resistors shall be adequately locked in position. If adjustment is required between overhauls then the use of rotary preset

resistors is a requirement. Such resistors shall have a means of preventing casual adjustment of the setting.

20.42.3 Resistors shall have a resistance within ±5% of the nominal value, unless otherwise specified or approved. The value, rating and tolerance shall be marked on the resistor.

20.42.4 Carbon rod, or carbon track resistors will not be accepted. Silicon carbide resistors will not be permitted unless the Engineer is satisfied that they are adequately rated.

20.42.5 High voltage protective resistances shall have a rating to match the characteristic of the protective fuse or other device and shall be subject to approval.

20.43 Capacitors

20.43.1 The type of capacitor used for each application shall be submitted for approval. The service life of electrolytic capacitors shall be at least 10 years.

20.43.2 Fuses and discharge resistors where required, shall not be integrated with the capacitors.

20.44 Instruments

20.44.1 This Clause covers electrical and pneumatic instruments. Detailed design requirements regarding the operability of instruments shall refer to PS 21.5.

20.44.2 All electrical instruments and their accessories shall be of an approved type, to IEC 51, with a true zero, with movements suitably damped for rail traction service and shall comply with the following requirements as appropriate.

20.44.3 Instruments shall be suitable for mounting in or on a panel vertically, or at an angle to the vertical of 30 or less. The panel may be of ferrous or other material.

20.44.4 Zero adjustment shall be provided on all instruments. Adjustors shall be accessible only from the rear of the instrument, and without opening the core.

20.44.5 All screws shall be effectively locked. Use of a locking compound will be considered.

20.44.6 Electrical instruments shall be suitable for a circuit working voltage of 660 V

to earth and a minimum high potential test of no less than 3000 V to earth.

20.45 Driver's Desk Instruments

20.45.1 The term "Driver's Desk Instruments" includes such as speedometers, ammeters and pneumatic pressure gauges.

20.45.2 Instrument cases shall be weather proof, and of rugged construction. Small openings for ventilation in the rear of the case may be provided subject to approval.

20.45.3 All instrument dials shall have at least 100 mm diameter dial and 240 scale (both dimensions approx.) marked with black figures on a white or opaque dial as appropriate. The instrument glass shield shall be positively secured.

20.45.4 All instruments shall incorporate dials and/or pointers with luminous elements with an approved half life, emitting no detectable radiation and containing no radioactive material.

20.45.5 The scale markings and pointer shall be clearly legible from full daylight through to complete darkness. No significant light shall escape into the cab from the scale and none at all from elsewhere.

20.45.6 The method of illumination should minimise dazzle in the tunnel environment and maximise visibility in bright sunlight. Glass covers should be of toughened and diffused type.

20.46 Other Instruments

These shall be at least 75 mm dia approx. surface or flush mounted, to an approved drawing and shall have a 100° (approx.) scale. Battery charging ammeters, if provided, shall have a centre zero ±50° scale. Illumination will not be required.

20.47 Accuracy

20.47.1 The accuracy of instrument systems (i.e. overall accuracy including accessories) from 10% to 90% f.s.d. of the instrument shall be as under:

(a) Desk mounted instrument systems which include speedometer generators, AC or DC current transformers or the like: ±3%

(b) Other desk mounted instrument system: ±2%

(c) Instrument systems other than (a) or (b) above: ±5%

20.47.2 All accessories shall be interchangeable. Accessories having means of adjustment will be considered, but, once set, it shall, for systems as set out in

(b) above, be possible to fit any instrument and still obtain the above specified accuracy grade without adjustment, and the instrument resistance shall be selected accordingly.

20.48 Electronic Equipment

20.48.1 Electronic equipment shall comply with EN 50155.

20.48.2 All electronic equipment shall be subject to the following provisions:

(a) Electronic equipment shall normally be mounted in "clean" enclosures, such as sealed against ingress of dirt and moisture. Large components or those that dissipate considerable heat such as transformers and resistors may be mounted

outside the enclosures. Heat sinks and cooling fins may penetrate the enclosure so that the dissipating element is outside and the component in a clean area.

(b) Groups of less than 10 kg weight may be arranged at self contained, easily removable and replaceable units, with external connections brought to a plug and socket.

(c) Any software used in the electronic equipment shall comply with PS 29.

(d) If microprocessor control equipment is used, software documentation shall be provided in accordance with PS 29. In addition, any special test equipment or facilities for testing and checking of the microprocessor based PCBS shall be declared. Any software used to carry out the automatic tests shall be provided together with associated document and test procedures by the Contractor at no additional cost to the AUTHORITY.

(e) Adjustable or pre-set resistors shall not be used.

(f) The LEDs used shall have the following conventions:

Red	-	indicate fault condition (normally off)
Green	-	indicate normal operation condition (normally on).
Yellow	-	indicate status of system (normally can be on or off)

20.48.3 Circuit boards in safety control system, such as the braking system, which, if

the train is operated with card removed, could cause damage, directly or indirectly, shall be connected through a safety circuit to disable the train if a circuit board is removed.

20.49 Printed Circuit Board (PCB)

20.49.1 Material

(a) The material for the PCB shall be:

(i) high impact resisting,

(i i) non-absorbent,

(i i i) anti-corrosive,

(i v) flame retardant,

(v) ozone and Ultra-violet resisting, and

(v i) produce low smoke and nil toxic fume such as carbon monoxide in the event of fire or short circuit.

(b) The copper laminate shall be firmly attached to the board and shall be resistant to blistering and peeling when heated with a soldering iron.

(c) The minimum thickness of PCB shall be at least 1.6mm.

20.49.2 The laminate used shall be epoxy-glass based to BS 4584 part 3 or CEM equivalent type (if not applicable, replacement by BS EN 60249-2-5-1994 is acceptable).

20.49.3 The board which is designed for free of maintenance, shall be potted by Epoxy. The potting material shall be of UL94V-0 rated.

20.49.4 Track Layout and Artwork

(a) Track to track, track to pad, and pad to pad spacing shall in general be as wide as the electrical clearance can allow.

(b) The cross-section of each circuit track shall be adequate to prevent fusing or delamination of the track under fault conditions before the protecting device, such as, fuse, has been able to interrupt the fault current.

20.49.5 Component Layout and Fixing

(a) Component parts shall be located, secured and disposed with respect to each other and the structure members so that they can be inspected, removed and replaced without damage to or causing an undue disturbance of other parts or wiring.

(b) All components shall be mounted such that they do not become damaged or disconnected when the equipment is subjected to any type and routine tests.

(c) All components shall be mounted on one side only.

(d) Physical separation and protection of the terminals and wiring shall be provided by means of insulation separators.

20.49.6 Protective Coatings

(a) All PCB assemblies shall be protected on both sides with a flame retardant protective transparent coating, in order to prevent deterioration or corrosion due to moisture and atmospheric contaminants. The coating shall not have any adverse reaction with any other materials or components used. The coating shall be solvent removable with cleaner for PCB repairing purpose.

(b) The type of coating and cleaner shall be submitted for approval.

20.49.7 Components

All components shall comply with BS 9000.

20.49.8 Sourcing

(a) Components with complete physical and functional compatibility according to the manufacturers' published data together with a reliable source shall be used.

(b) All integrated circuits and semi-conductor device shall be standard devices available from at least two different manufacturers.

20.49.9 Choke and Transformer

The chokes and transformers listed in the component list are the special purpose devices which shall be supplied by the Contractor. Windings shall be vacuum impregnated or encapsulated and shall terminate on a terminal board mounted on the item. Secondary windings shall be isolated from the primary winding. The Contractor shall state the insulating material used, submit information and demonstrate operational compatibility.

20.49.10 Component Cooling

(a) All power electronic switches and heat dissipated components shall be of natural cooling type.

(b) Cooling fans shall not be used within electronic equipment unless a positive indication of fan failure is provided for maintenance purpose and subject to Appoval.

20.49.11 Push Button Switches

(a) Push button switches shall suit the standard 32.5 mm diameter panel hole fixing.

(b) The contacts shall be rated for a life of not less that 10 years and shall be capable of operating under emergency conditions of multiple unit operation.

(c) Terminals shall accept ring tongue crimps. The push button design shall be capable of assembly with at least 3 normally open plus one normally closed contacts.

(d) The contract rating shall not be less than 2 A inductive with a time constant of 15ms at 37.5 VDC.

20.49.12 Connectors

(a) All PCBs shall be connected to the internal case or rack wiring as appropriate

by means of approved multipin connectors. Connectors complied with DIN 41612 and IEC 60603-2 shall be used.

(b) Connectors between PCBs or electronic modules and the train wiring and/or other racks or cases shall be by means of multipole connectors.

(c) Unless otherwise approved, the use of PCB edge connectors will not be permitted.

(d) The contact area of each connector shall be plated with to a minimum thickness of 1.25µm of gold over a minimum of 0.75µm of low stress nickel.

(e) Mechanical polarisation to prevent insertion into the wrong socket shall be provided to all PCBs.

20.49.13 Locking

Each PCB or module shall be positively retained in the rack or case by a fastener or spring loaded locking pin.

20.49.14 Limitation of failure

In any electronic rack system, the failure of any one module or individual circuit board shall neither cause loss of the electronics power supply within the rack, nor cause subsequent failure of circuits on other PCBs or modules.

20.49.15 Status monitoring

Each PCB or module shall incorporate indicator and/or test socket mounted on the front panel which shall show:

(a) power supply on;

(b) status of digital inputs/outputs; and

(c) status of analogue inputs/outputs.

20.49.16 Test points

(a) Test points shall be provided in an appropriate locations on modules and PCBs. A negative return test point shall be provided.

(b) The test points shall accept a standard 2mm diameter plug and shall be sited with sufficient clearance to permit a standard oscilloscope probe to be attached to the plug.

(c) As an alternative, these test points may be wired through a connector to a

portable test and monitor box.

(d) Whichever method is used, each test point shall be clearly identified on both the equipment and on any related drawings.

20.50 Use of Microprocessor or Software Based Equipment

20.50.1 Single microprocessors shall not be used in circumstances where a single fault condition could result in any unsafe conditions. Where microprocessor based equipment is used in a safety application, a minimum of three independent processor shall be used, with any output recurring a minimum 2 out of 3 vote before being activated.

20.50.2 Where microprocessor system incorporate technology such as surface mounted component, multilayer circuit boards or flexible PCBs, the Contractor shall provide evidence demonstrating that satisfactory operational experience has been gained on the successful use of these technologies in a similar railway environment.

20.50.3 It is preferred that Integrated Circuits (ICs) are soldered directly into the circuit board. This includes all forms of memory IC and microprocessors. The use of sockets in specific instances will be considered at the discretion of the Engineer and will generally be limited to the installation of preprogrammed devices containing the operating software for the system. Where IC sockets are employed, the devices contained therein shall be positive retained once installed.

20.50.4 Microprocessor based system shall have watchdog circuits to ensure correct software operation. The watchdog circuit should not be reset except when the main control program, including all subroutines and allied programs, is running correctly. When the watchdog circuit detects a fault, it shall trigger hardware forcing all system outputs into a safe state before resetting the system and then the system shall enter into a self-test mode. Normal operation shall only be resumed if all self-test checks are satisfactory.

20.50.5 Power supply rails shall be closely monitored. Any transient or dip likely to cause data corruption, or partial loss of correct hardware initialisation states,

shall be detected and outputs forced into a safe state. When the power supply recovers , all ICs shall be reset and the system re-initialised.

20.50.6 Microprocessor systems shall incorporate self-test and diagnostic facilities to locate and indicate faults within the system. It is preferred that the system has sufficient inbuilt diagnostic capabilities to automatically identify all system faults. However, any additional in-built test hardware or software shall not lead to reduced system reliability or safety. It shall also be possible to use

such diagnostic facilitates whilst the equipment is in normal operation in order that real-time events may be monitored whilst the train is in motion.

20.50.7 Design consideration shall be given to the diagnostic facilitates to record system behaviour and parameters for a period before and after a trigger signal initiated from the diagnostics terminal for maintenance purpose.

20.50.8 Where microprocessor systems require additional test or diagnostic equipment, this shall be portable for use on the train. It shall wherever possible derive its power supply from that of the system under test. Where the test/diagnostic equipment employs portable computers, the Contractor shall provide means of powering such equipment from the low voltage power supply of the train.

20.50.9 Test equipment shall be robust and easy to use with the minimum of specialist training.

20.50.10 Light Emitting Diodes (LEDs) shall be used to indicate faulty modules to allow rapid fault diagnosis and maintenance.

20.50.11 Faults occurring during system operation shall be logged with information stored in non-volatile memory. The data stored shall be accessed by a portable hand-held terminal for maintenance purposes, shall be concise and allow the nature of the fault to be clearly identified. The hand-held terminal shall also be used to access or control any in-built system maintenance functions such as signal state monitoring and control of output signals for test purposes.

20.50.12 For those software functions that are operational related, the software shall be designed in such a manner that it shall be possible to access and adjust within safe limits the operating parameters of the equipment for test and development purpose without modifying the source code. Choices for “save” or “remove” the change shall be provided at the end of the adjustment process of the operating parameters. Any alternations without “saving” the change shall be lost whenever the equipment is re-initialised. When a “saved” change is made, automatic update of the software parameter version shall be provided when the equipment is re-initialised. Security measure shall be provided in the

above adjustment process to prevent unauthorized alternation.

20.50.13 Microprocessor bus signals shall be properly terminated to prevent cross-talk or corruption of signals. Bus signals shall be well separated and ground planes used on PCBs to reduce susceptibility to electro-magnetic interference.

20.50.14 Additional requirements of the microprocessor based system on the application of TIMS shall refer to PS 10.

20.51 Health and Safety Requirements for Construction Works

20.51.1 The Contractor and his Subcontractors shall comply with the specified health and safety requirements and the relevant statutory regulations , especially the National Electrical Safety Code (NESC®) and their subsidiary legislations of the Canadian Government.

20.51.2 The Contractor and his Subcontractors will be required to stop work whenever any of the above requirements is found breached and will not be allowed to resume work until the satisfactory rectification of the unsafe condition.

20.52 Paint Performance

20.52.1 All painted surfaces shall have a service life mutually established between the Paint Supplier, the Contactor and the AUTHORITY.

20.52.2 The paint coating shall resist mechanical damage in accordance with the following requirements for its specified life:

(a) Scratch resistance in accordance with BS 3900 : Part E2 : 1992 when using when using a 2.5 kg load.

(b) Impact resistance in accordance with BS 3900 : Part E7 : 1992.

(c) Clip resistance in accordance with BS AU 148 : Part 15 : 1990. The degree of damage shall not exceed Grade 2.

(d) Abrasion resistance equivalent to ASTM D4060 - 84, shall be such that the weight loss shall not exceed 30 mg after 500 cycles, using CS10 wheels detailed in the Taber Abrader Test.

20.52.3 Paint adhesion in accordance with BS 3900 : Part E6 : 1974 shall meet level 1 with 1 mm spacing between cross cuts.

20.52.4 Paint elasticity for metal substrate, in accordance with the following parts of BS 3900, shall

(a) not exceed 25 mm when using the conical mandril defined in Part E11 : 1985.

(b) be greater than 3.5 mm under slow deformation, as defined in Part E4 : 1995.

20.52.5 The paint coating shall be capable of withstanding all contaminants encountered in normal service as well as the cleaning routines detailed in the PS.

20.52.6 The gloss level of the painted surface shall not fade by more than 10% throughout its service life in accordance with BS 3900 : Part D5 : 1997.

20.52.7 The painted surface shall not exhibit any mottling, cracking, blistering or other forms of deterioration throughout its service life.

20.52.8 All painted surfaces shall match and display a uniformity of colour throughout their service life.

Table 20-4-1 - Minimum Weld Quality Levels for Arc Welds in Steel

Defect	Critical Welds	Non-Critical Welds
Cracking	Not permitted	Not permitted
Lack of fusion	Not permitted (note 1)	Not permitted
Lack of root penetration	Not permitted (note 1)	Not permitted
Individual slag inclusions (internal)	For t ≤ 18mm: l < t/2 or l < 6mm, whichever is the smaller, w < 1.5mm. For t > 18mm: l < t/2 or l <	(note 2)
Linear groups of inclusions (internal)	Individual length < 8% of the length of the group, which in turn is not to exceed 12t in length. (note 1)	(note 2)
Internal porosity	Individual pores < 1.5 mm. Localized < 2% by area	(note 2)
Surface inclusions/gas pores	Not permitted (note 3)	Not permitted (note 3)
Undercut (note 5)	max. depth = 0.5mm. max. length of continuous defect = 20mm. max. cumulative length of	max. depth = 0.5mm. max. length of continuous defect = 40mm. max. cumulative length of
Spatter	Not permitted (note 5)	Not permitted (note 5)

For Butt Welds Only:-

Excess weld metal (note 4)	< 20% of the thickness of the thinnest member comprising	< 20% of the thickness of the thinnest member comprising

Excess penetration bead (note 4)	the joint, subject to a maximum of 2mm	the joint, subject to a maximum of 3mm
Linear misalignment		

t = parent metal thickness, l = length of defect, w = width of defect

Notes for Table 20-4-1

1. Maximum internal planar defect size determined ultrasonically = 9 sq.mm. Minimum separation from adjacent defect = 20mm. Surface braking defects are not allowed.

2. Internal defects are not normally monitored; where special examinations are performed and reveal internal defects, the criteria for critical welds shall be applied.

3. This does not mean that the whole joint is rejectable, merely that attention be given to the particular area affected for example, local grinding or repair.

4. Final weld surface finish shall be consistent with the requirements of BS 5400:Part 10 for the class of weld required.

5. All weld spatter, where accessible, shall be removed after welding, prior to final inspection and/or painting (whichever is applicable).

Table 20-4-2 -Minimum Weld Quality Levels for Arc Welds in Aluminium and its Alloys

Defect	Critical Welds	Non-Critical Welds
Cracking	Not permitted (note 1)	Not permitted (note 2)
Lack of fusion	Not permitted (note 1)	Not permitted (note 2)
Lack of root penetration	Not permitted (note 1 & 3)	Not permitted (note 3)
Individual inclusions (internal)	t < 18mm: l < 0.3t < 6mm, w < 1.5mm t > 18 mm	(note 2) (note 2)
Linear groups of inclusions (internal)	Individual length < 8% of the length of the group which shall not exceed 12t in length (note 1)	(note 2)

Internal porosity	Individual pores d < 0.3t. max d = 3mm	(note 2)

		localized < 2% by area	
Copper/Tungsten inclusions		Not permitted	Not permitted
Surface inclusions/gas pores/porosity (note 4)		Not permitted (note 5)	d < 0.2t max d = 3.0mm
Undercut (note 5), (note 6)	a) Inter-mittent	Not permitted	Not permitted
	b) Continuous	max. depth = 0.5mm.max. length of continuous defect = 10mm. max. cumulative length of defects within 300mm =	max. depth = 0.5mm (note 7)
	c) Isolated	as for intermittent above	max depth = 1.0 mm max length = 10 mm on a non repetitive basis (note 8)
Spatter(note 9)		Not permitted	Not permitted
Incomplete weld fill		Not permitted	Intermittent depth < 0.1t max depth = 1mm max length = 20mm
For Butt Welds Only:			
Excess weld metal (note 6)		max height (h) = 1.5mm + 0.15b subject to a max of 3mm	max height (h) = 1.5mm + 0.15b or h < 0.5t whichever is the smaller
Excess penetration bead (note 6)		h < 0.5t subject to 3mm max	h < 0.5t subject to 3mm max
Linear misalignment		0.2t of the thickness of the thinnest member comprising the joint subject to a max of 2mm	0.2t of the thickness of the thinnest member comprising the joint subject to a max of 2mm
Fit-up (note 10)		Gap for butt joints as per welding procedure specification	Gaps for butt joints as per welding procedure specification
Root concavity	a) Continuous	Not permitted	Not permitted
	b) Intermittent	Not permitted	depth < 0.2t, max depth = 1mm max length = 20mm in 300mm of weld
For Fillet Welds Only:			

Fit-up (note 10)	0.25t of the thickness of the

subject to a max of

0.25t of the thickness of the thinnest member comprising the joint subject to a max of

	1.5mm	1.5mm
Fillet weld size measurements	Leg length as per welding procedure/drawing	Leg length as per welding procedure/drawing
Fillet weld profile (note 11)	Throat thickness = 0.7 - 0.9 of the specified leg length	Throat thickness = 0.7 - 0.9 of the specified leg length

d = depth of defect, l = length of defect, w = width of defect, b = weld width,

t = parent metal thickness, LL = Specified Leg length, TT = Throat Thickness,

LT = Measured leg length, g = fit up root gap

Notes for Table 20-4-2

1. Maximum size of point reflectors determined ultrasonically = 9 sq.mm.

   Minimum separation from adjacent defect = 20mm. Surface breaking defects are not allowed.

2. Internal defects are not normally monitored; where special examinations are performed and reveal internal defects, the criteria for Quality Category 1 shall be applied.

3. Permitted in inaccessible areas if proven acceptable under the prevalent service loading conditions. Single V, U, J, Bevel and Square Edged Butt welds made from one side shall have sealing runs deposited on the reverse side where access permits.

4 . Porosity on a cluster basis shall be considered on a fitness for purpose basis.

5 . This does not mean that the whole joint is rejectable, merely that attention be given to the particular area affected for example, local grinding or repair.

6. Final weld surface finish shall be consistent with the requirements of BS 8118 the class of weld required.

7. The total cumulative intermittent undercut shall not exceed 30% of the total length of a continuous weld.

8. Isolated undercut shall not be acceptable where it occurs in a systematic or repetitive manner i.e. where a deficiency in operator skill or the welding procedure is exposed.

9. All weld spatter, where accessible, shall be removed after welding, prior to final inspection and/or painting (whichever is applicable).

10. Unless dictated by extrusion tolerances.

11. Where uneven fillet weld leg lengths exist, the smaller leg length shall conform to the minimum specified leg length and the larger leg length shall not exceed the smaller leg length by more than 25%.

SECTION 21 DESIGN REQUIREMENTS 2

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Section 21 Design Requirements

21.1 Purpose

21.1.1. The policies and procedures presented in this Section establish a common frame of reference for developing the System Engineering Management System (SEMS).

21.1.2. 21.1.2. The SEMS shall be an integral part of the Quality Management System (refer to PS 27) and shall also meet the requirement for Quality Assurance or Management in design in accordance with the ISO 9000: 2005. The general guidelines specified in the IEEE Std 1220-2005 "IEEE Standard for Application and Management of the Systems Engineering Process" shall be followed as far as applicable.

21.1.3. These policies and procedures establish the basis for integrating the technical efforts of the entire design team of the Contractor to meet program, cost, schedule and performance objectives with an optimal design solution that encompasses the system and its associated manufacturing, test and support processes.

21.1.4. The Contractor shall establish and maintain the SEMS in accordance with the policies and procedures.

21.2 Policies

21.2.1. This Section of PS covers requirements of policies and procedures for the SEMS which shall be observed as the minimum requirements which are acceptable to the Engineer.

21.2.2. The Contractor may offer alternative standards which are equivalent to or better than those herein, and which the Contractor shall justify to the satisfaction of the Engineer.

21.2.3. The Contractor shall nominate a System Engineering Management (SEM) representative with overall responsibility for the SEMS. The SEMS shall be initiated by a series of design plans (refer to PS 21.2.6(b)) which shall identify and establish the required documents detailing policy, organizations, engineering tasks, processes and the necessary documentation to be prepared.

21.2.4. The SEM shall be applied throughout the design life cycle as a comprehensive, iterative technical management process to:

(a) Translate the operational needs into configured systems through a systematic, concurrent approach to integrated design of the systems and the related manufacturing, test and support processes;

(b) Integrate the technical inputs of the entire design team and all technical disciplines (including the concurrent engineering of manufacturing, logistics and test) into a coordinated effort that meets established program cost, schedule and performance objectives;

(c) Ensure the compatibility of all functional and physical interfaces (internal and external) and ensure that system definition and design reflect the requirements for all system elements: hardware, software, facilities, people and data;

(d) Characterize technical risks, develop risk abatement approaches and reduce technical risk through early test and demonstration of system elements. The result of the above risk assessment shall be documented in the System Assurance Plan (refer to PS 21.4).

21.2.5. The SEM as a process shall place equal emphasis on system capability, manufacturing processes, test processes and support processes in the context of Specialty Engineering.

21.2.6. Specialty Engineering

(a) The objective of the Specialty Engineering shall be of twofold:

(i) to integrate specific system attributes and disciplines into the acquisition process; and

(ii) to assess and confirm the following system attributes of Specialty Engineering:

(1) System Assurance (refer to PS 21.4);

(2) Operability Engineering (refer to PS 21.5);

(3) Weight Management (refer to PS 21.6);

(4) Electromagnetic Compatibility (refer to PS 21.7);

(5) Noise Engineering (refer to PS 21.8);

(6) Software Management (refer to PS 21.9);

(7) Fire Engineering (refer to PS 21.10).

(b) The following design plans shall be documented and used in SEMS as Specialty Engineering tools or agents to ensure achievement of the required performances:

(i) System Engineering Management Plan (refer to PS 21.3);

(i i) System Assurance Plan (refer to PS 21.4);

(i i i) Operability Plan (refer to PS 21.5);

(i v) Weight Management Plan (refer to PS 21.6);

(v) Electromagnetic Compatibility Plan (refer to PS 21.7);

(v i) Noise Plan (refer to PS 21.8);

(v i i) Software Management Plan (refer to PS 21.9);

(v i i i) Fire Engineering Plan (refer to PS 21.10).

(c) The Contractor shall perform Specialty Engineering analyses in order to define requirements and design features and/or describe characteristics of the design and related operations in support of the associated analyses, including the Trade-Off Studies (refer to PS 21.11) and Synthesis Analysis (refer to PS 21.12). These analyses shall b performed throughout the project's lifecycle. Analysis results shall be submitted for approval by each stages of SEMP (refer to PS 21.3.2).

21.2.7. Total system approach shall be used on the SEM in order to optimize total system performance and minimize the cost of ownership. The total system consists the prime rolling stock equipment, the people who operate and maintain the system, the systems security procedures and practices, the operation of the system in its intended operational environment and the way the system responds to any effects unique to that environment; the compatibility, interoperability and integration of the system with other systems; the operational and support infrastructure (including Control, Communications); training and training devices; any data required by the system in order for it to operate; and the system's potential impact on the environment and environmental compliance.

21.2.8. The Configuration Management (refer to PS 21.13) shall be used as a supporting function to the SEM throughout the design life cycle. The Configuration Control Program (refer to PS 21.14) as a tool of Configuration Management shall be used to provide the means for formal control of the technical aspects of a project and anchors the operational and technical requirements in documentation that is standard for both the Engineer and Contractor.

21.2.9. In order to ensure the above SEM requirements are met, a representative from the Subcontractor, manufacturer, supplier or vendor shall be nominated for each major system/equipment (refer to Appendix D) to lead the design management of the associated major system/equipment and to assist the SEM representative (refer to PS 21.2.3) to perform the required SEM tasks.

21.3 System Engineering Management Plan (SEMP)

21.3.1. The System Engineering Management Plan (SEMP) shall establish the plan

for the SEM required to define the system performance parameters and preferred system configuration to satisfy the technical requirements as stipulated in the PS, the planning and control of technical program tasks, integration of the engineering specialities and the management of a totally integrated effort of design engineering, computer software engineering, specialty engineering, test engineering, logistics engineering, quality

evaluation and production engineering to meet cost, technical performance, quality and schedule objectives for a specific project or program.

21.3.2. Five stages of SEMP

The Contractor shall identify five stages of the SEMP in accordance with the following definitions:

SEMP 1: System Definition;

SEMP 2: Sub-System Definition - Preliminary Design;

SEMP 3: Sub-System Definition - Detailed Design;

SEMP 4: Sub-System Definition - Fabrication, Assembly, Integration & Test;

SEMP 5: System Pilot Fabrication, Testing & Training.

21.3.3. Detailed Criteria for the SEMP Stages

(a) According to the definition of SEMP, the Design Data in a form of Design Document (refer to PS 21.3.5) shall be grouped into 5 corresponding design packages, and the submission program of these 5 packages of Design Data shall be carefully organised, so that the at each stages of SEMP, sufficient design information are provided to demonstrate the required level of design development are achieved.

(b) Based on the above 5 design packages of Design Data, the proposed level of design information to be submitted at each stage of SEMP shall be provided in the Design Data Submission Plan (refer to PS 21.3.4).

(c) Consideration shall be given on the preparation of the Design Data Submission Plan, in order to ensure that the required submission dates of

interface Design Data are met.

(d) Criteria for the Completion of each SEMP Stages

SEMP Stages		**Design Documents to be Submitted**		**Status of completion***
SEMP 1:	System Definition;	Level 1:	System Requirements Document (SRD)	100% Completion
SEMP 2:	Sub-System Definition - Preliminary Design;	Level 2: Level 3:	System Specification Document (SSD) System Technical Design	> 90% Completion > 70% Completion

SEMP Stages		Design Documents to be Submitted		Status of completion*
SEMP 3:	Sub-System Definition - Detailed Design;	Level 2:	System Specification Document (SSD)	100% Completion
		Level 3:	System Technical Design Document (STDD)	> 90% Completion > 70% Completion
SEMP 4:	Sub-System Definition - Fabrication, Assembly, Integration & Test	Level 3:	System Technical Design Document (STDD)	100% Completion
		Level 4:	Design Information (DI)	
SEMP 5:	System Pilot Fabrication, Testing &	Level 4:	Design Information (DI)	100% Completion

*: The proportion of the total numbers of Design Data to be submitted of which at least an "Approved in Principle" status was received on the related submission(s).

21.3.4. Design Data Submission Plan (DDSP)

(a) The SEMP shall include a Design Data Submission Plan (DDSP) which shall be submitted to the Engineer by the date stated in the PS (refer to Appendix G). The DDSP shall show in detail the timing and sequence of each design document (refer to PS 21.3.7) in accordance with the SEMP. The DDSP shall contain but not be limited to the following information:

(i) Design approval Request (DAR) Number

(i i) Title of the DAR

(ii) Contractor's reference

(i v) Contractor's document reference or drawing number

(v) Relevant Clause(s) in the PS

(v i) Expected submission date of each DAR

(vii Actual submission date of each DAR

(viii) Status

(b) The DDSP shall be reviewed in the Technical Review Meeting (refer to PS 21.3.9). If required by the Engineer, the DDSP shall be revised in order to meet the design requirements.

21.3.5. Design Documents

(a) Based on the design plans (refer to PS 21.2.6(b)) that serve as the design input to the System Engineering Management System (refer to PS 21.1), the following four level of design documents shall be produced and submitted as the design output to this System Engineering Management System:

Level 1: System Requirements Document (SRD)

Level 2: System Specification Document (SSD)

Level 3: System Technical Design Document (STDD)

Level 4: Design Information (DI)

(b) Level 1 - System Requirements Document (SRD)

(i) The SRD is the top level design document which explains how the requirements of the PS are to be achieved at the train level. Proposal of system classifications shall also be provided in the SRD.

(ii) Design review of SEMP stage 1 shall be conducted when the SRD has been established.

(c) Level 2 - System Specification Document (SSD)

The SSD is the second level design document which defines how the requirements of the SRD shall be fulfilled by the individual systems (such as, car body and traction system). This document shall demonstrate the Contractor's understanding of the system's functional requirements and of interface requirements between systems including the Contractor’s own systems and those of other interfacing contractors.

(d) Level 3 - System Technical Design Document (STDD)

(i) The STDD defines how each system as defined in the SSD shall be achieved. The purpose of this STDD is to evaluate the optimization, correlation, completeness, and risks associated with the allocated technical requirements of a system. Due considerations shall be given to ensure all issues as stipulated in the design plans are fully addressed. Also a summary of the

related design submission lists shall be included for each system STDD.

(ii) Basic manufacturing and/or procurement considerations shall also be reviewed and planning for production engineering in subsequent phases shall be addressed.

(iii) Design review on the SSD and STDD shall be timely conducted particularly when the manufacturing and/or procurement works have been proceeded.

(iv) For those systems which involves the electronic and software based drive and/or control functions, the following additional information shall be provided:

(1) Refer to section 29.16 for software documents requirements.

(2) Context Block Diagram (CBD)

As part of the STDD, the CBD shall show how the control software and electronic hardware interconnect to achieve the overall control function. Detailed design information shall not be shown here but provided in the individual design submissions.

(v) Level 4 - Design Information (DI)

The DI shall provide the detailed design information of:

(1) Detailed design proposal of system, assembly and component. Supplementary information, such as drawing, diagram, datasheet, calculations and product catalogue, shall also be provided, as appropriate;

(2) Test and inspection specification (refer to PS 22);

(3) Test and inspection result (refer to PS 22);

(4) Operation and Maintenance Manual (refer to PS 30);

(5) Training proposal (refer to PS 23); and

(6) Deliverables of software (refer to PS 29).

21.3.6. SEMP Presentation

(a) At the end of each stage of the SEMP, a SEMP presentation shall be conducted and a SEMP report shall be submitted which shall cover each section of the plans as specified in PS 21.2.6(b).

(b) Unless otherwise specified, the SEMP presentation shall be conducted at the Engineer's premises.

(c) The SEMP report shall present an integrated approach between the sections of the plan demonstrating that the Contractor is addressing the requirements of each section concurrently.

21.3.7. Each SEMP stage, ends in a milestone, to be identified in the Schedule of Milestones (refer to Appendix G).

21.3.8. Monthly SEMS Reports

(a) The Contractor shall prepare Monthly SEMS Reports, which shall be submitted to the Engineer by the first week of the month.

(b) The SEMS Report shall focus on the technical issues, progress of the SEMP and its associated design plans and summary of the design submission status.

21.3.9. Technical Review Meeting

(a) During the execution of the Contract, the Engineer will call technical review meetings as he deems necessary to discuss the progress of the design works in accordance with the above SEMP.

(b) The SEM representative (refer to PS 21.2.3) or his written delegate who shall be responsible for all technical matters, shall attend the technical review meetings.

(c) If required by the Engineer or the SEM representative (PS21.2.3), the responsible Subcontractor, manufacturer, supplier or vendor as nominated for each major system/equipment (refer to PS 21.2.9) shall attend the technical review meetings. In addition, the responsible engineers or designers of the Contractor shall be presented in such meetings if it is deemed necessary by the Engineer.

(d) In general meetings will be held bi-monthly, but can take place more frequently if required.

(e) Unless otherwise specified, the technical review meeting shall be conducted at the Contractor's premises, the actions should be agreed upon during the meeting and minutes of these meetings will be issued by the Engineer.

21.3.10. Engineering Audit

(a) Periodically during the life of the Contract the AUTHORITY will conduct compliance audits of the SEMS to ensure the design, procurement, manufacturing and testing works conform to the PS requirements. Not less than 4 weeks notice will be given by the Engineer. The Contractor shall provide suitably qualified staff to accompany the audit team.

(b) The Contractor shall be responsible for ensuring that Subcontractors, vendors and suppliers participate in the engineering audits, as appropriate.

(c) Unless otherwise specified, the engineering audits shall be conducted at the Contractor's facility or at a designated Subcontractor facility. The Contractor

shall provide the necessary resources and material to perform the engineering audit effectively.

(d) The Contractor shall:

(i) Ensure that each engineering audit schedule is compatible with the availability of the necessary information and contract documents, for example, system engineering data, trade study results, producibility analysis results, risk analysis results, specifications, manuals, drawings, reports, hardware, software, or mock-ups.

(ii) Ensure that all Subcontractors, vendors and suppliers personnel or those chosen to make presentations of design proposals shall be prepared to discuss in technical detail any of the presented material within the scope of the review.

(iii) Follow up and resolve all action items in the minutes which will be prepared and distributed by the Engineer and identify whether Subcontractors, vendors and/or suppliers actions are required for its resolution.

21.4 System Assurance Plan

21.4.1. It is an essential requirement of the train design that at every stage of SEMP, the requirements of safety, reliability, availability and maintainability are adequately considered and any modifications resulting from these considerations be included in the design. Therefore, the Contractor shall provide a System Assurance Plan which shall detail the Contractor's intended methodology for controlling the system assurance process within his own organisation and cover his Subcontractors, vendors and suppliers with an aim to meet the system assurance requirements specified in PS 25.

21.4.2. The detailed requirements of the System Assurance Plan shall be referred to PS 25.2.1.

21.5 Operability Plan

21.5.1. Goals and Objectives of Operability Plan

(a) In order to facilitate the operability design development, an Operability Plan shall be provided according to the requirements specified below.

(b) The Operability Plan shall be submitted at each stage of SEMP to ensure the potential design solutions is able to meet the specified train service, operational, maintenance and training needs.

(c) The goals of Operability Plan is to ensure a thorough understanding of the functional relationships between the operational safety and efficiency of operation and control system and the characteristics of the operator as a

person, tasks, environments, and technologies; hence to apply the above understanding to:

(i) Enhance system safety by integrating human performance characteristics and technological functions to anticipate (and minimize) the probability and adverse consequences of human or system errors;

(ii) Optimize the efficiency of the operation and control system by explicitly assessing and accounting for the capabilities and limitations of the human component.

(d) The objectives of Operability Plan are:

(i) To develop increased knowledge and predictive models of human performance relative to the characteristics of the tasks, environments and technologies in the train operation and control system;

(i i) To develop human factor engineering design criteria based on the above knowledge and models.

Note: The human factor engineering design criteria shall be the summation of available knowledge that defines the nature and limits of human capabilities as they relate to the operation, maintenance or control of systems or equipment, and which may be applied during engineering design to achieve optimum compatibility between equipment and human performance.

(e) As an integral part of the SEMP, the Contractor shall submit an Operability Plan which shall include a study of the man-machine interface in order to ensure the user friendliness of the train system. Both quantitative and qualitative measures shall be used to determine the user friendliness. The Contractor shall carry out human factors engineering which shall be the systematic application of knowledge about human sensory, physical, intellectual, and motivational attributes to the design of equipment, software, tasks, documentation, and the environment of the work place to better suit people. The ultimate objective of human factors engineering is to achieve maximum human efficiency in system development, operation, and

maintenance.

21.5.2. The process of ensuring operability is continuous and consists of the verification of operability by operators and formal determinations of operability whenever a verification or other indication shall be called into question of the system's or component's ability to perform its specified function.

21.5.3. This Section of the PS presents descriptive detail, technical data and diagrams

relating to some of the important issues concerned with the human factors concept in operability and the operators' requirements for train operation, maintenance and training tasks. This Section of the PS also embodies procedures, techniques, practices and tools which when followed or used correctly will reduce, but not necessarily eliminate the probability that the use of equipment may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and in no way absolves either the Contractor, Subcontractor or the supplier from statutory and all other legal obligations relating to health and safety at any stage of the Contract or use.

21.5.4. Particular attention is drawn to the following hazard(s), although the list is not necessarily exhaustive and the inclusion of such a list does not absolve the Contractor from the obligations referred to in this Clause:

(a) Upper limb pains and discomfort.

(b) Eye and eyesight effects.

(c) Fatigue and stress.

(d) Epilepsy.

(e) Facial dermatitis.

(f) Electro magnetic radiation.

(g) Implications of user error.

21.5.5. The details contained within this Standard do not replace or take precedence over any act or ordinance related to health and safety. The requirements of this Standard and of any Health and Safety Regulations are to be seen as complementary.

21.5.6. Objectives

(a) All systems, equipment and facilities supplied under the scope of work of the Contract shall provide work environments which foster effective procedures, work patterns, and personnel safety and health, and which minimize factors that degrade human performance or increase error.

(b) Design shall be such that operator workload, accuracy, time constraint, mental

processing and communication requirements do not exceed operator capabilities. Design shall also minimize personnel and training requirements within the limits of time, cost, and performance trade offs.

(c) In order to ensure the human requirements are satisfied, the design principles stipulated in the ISO 6285: 2004 and ISO 10075-2: 1996 shall be applied. In addition, the operating and safety principles specified in the IEC 73: 1996 and IEC 447: 1993 shall be followed in the design of man-machine interfaces. Wherever the above standards duplicate requirements for a particular criterion, the more stringent standard shall apply and any conflict in requirements shall be brought to the attention of the Engineer. Any variation from these standards

may be proposed, the Contractor shall state the area and the reasons for approval.

(d) In view of the fact that operability and qualification are closely related concepts. Therefore, operation training shall be provided by the Contractor in a manner that training is designed for qualification purpose. Such that at the end of the operations training, the Commission's operators are fully qualified and able to perform the specified train operation and the associated system functions if called upon. The detailed requirements of the training requirements shall be referred to PS 23.

21.5.7. Standardization

(a) Controls, displays, marking, coding, labelling, and arrangement schemes (equipment and panel layout) shall be uniform for common functions of all equipment.

(b) Criterion for selecting off the shelf commercial equipment shall be the degree to which the equipment conforms to this Standard. Where off the shelf equipment requires modification in order to interface with other equipment, the modification shall be designed to comply with the criteria herein.

21.5.8. Function Allocation

Design shall reflect allocation of functions to personnel, equipment and personnel equipment combinations to achieve:

(a) Required sensitivity, precision, time, and safety.

(b) Required reliability of system performance.

(c) Minimum number and level of skills of personnel required to operate and maintain the system.

(d) Required performance in a cost effective manner.

21.5.9. Human Engineering Design

The design of train systems, equipment and facilities shall reflect human engineering factors that affect human performance, including, when applicable:

(a) Satisfactory atmospheric conditions including composition, pressure, temperature and humidity, including safeguards against uncontrolled variability beyond acceptable limits.

(b) Range of acoustic noise, vibration, acceleration, shock, blast, and impact forces and safeguards against uncontrolled variability beyond safe limits.

(c) Protection from thermal, mechanical, electrical, electromagnetic, visual, and other hazards.

(d) Adequate space for personnel, their equipment, and free volume for the movements and activities they are required to perform during operation and maintenance tasks under both normal and emergency conditions.

(e) Efficient arrangement of operation and maintenance workplace, equipment, controls, and displays.

(f) Adequate natural or artificial illumination for the performance of operation and control.

(g) Safe and adequate passageways, ladders, platforms, detrainment ramp, and other provisions for ingress, egress, and passage under normal and emergency conditions.

(h) Provisions for minimizing psycho/physiological stress effects of mission duration and fatigue.

(i) Design features to assure rapidity, safety, ease and economy of operation and maintenance in normal and emergency maintenance environments.

21.5.10. Fail Safe Design

A fail safe design shall be provided in those areas where failure can cause catastrophe through damage to equipment, injury to personnel or inadvertent operation of critical equipment.

21.5.11. Simplicity of Design

The equipment shall represent the simplest design consistent with functional requirements and expected service conditions. It shall be capable of being operated, maintained, and repaired in its operational environment by personnel with a minimum of training.

21.5.12. Interaction

The design of the system shall reflect the interaction requirements of the TIMS (refer to PS 10).

21.5.13. Safety

Design shall reflect applicable system and personnel safety factors, including minimization of potential human error in the operation and maintenance of the system, particularly under emergency or non routine conditions.

21.5.14. Human computer Interface (HCI)

(a) Computer programs and equipment interfaces shall provide a functional interface between the system for which they are designed and users (operators/maintainers) of that system.

(b) This interface shall optimize compatibility with personnel and shall minimize conditions which can degrade human performance or contribute to human error.

(c) The purpose of this part is also to influence the operational effectiveness of manned systems in a positive way by ensuring that the design of human computer interfaces support effective human computer interaction.

(d) This part is intended to reduce the risk of computer based systems being put into service in which the performance of capability of the system's users results in the system failing to satisfy operability requirements.

(e) Operability requirements addressed include the overall standards of system effectiveness, the levels of user training, support and effort required to achieve those standards, and considerations of system availability, reliability and user acceptance.

21.5.15. Operability Engineering Design Life Cycle

(a) The operability requirements shall be established through a logical breakdown of operation and maintenance functions to the extent feasible during early system design, these operability requirements shall be applied to all stages of the SEMP throughout the operability design life cycle.

(b) SEMP Stage 1

(i) The Contractor shall submit a conceptual design of operability proposal to demonstrate the correct understanding and specification of the user requirements in the context of: the nature of the users, their goals and tasks, and the environment in which the train will be used.

(i i) In addition, this conceptual design shall include an explicit construction of the ideas or concepts that an operator needs to learn about what a train is, what it can perform, and how it is intended to be used. It may also address what a train is not, what it cannot perform, and how it is not intended to be used. Conceptual design shall done from the user's point of view.

(iii) In order to facilitate design verification in the SEMP stage 3, a series of qualitative and quantitative targets of operability requirements shall be established at this stage of SEMP.

(b) SEMP Stage 2

(i) The qualitative and quantitative targets provided during SEMP stage 1 shall be allocated to various elements of the system to the extent necessary for design guidance purpose with emphasis on the human element of the system.

(ii) The allocation results shall constitute specific parameters to which the system shall be designed.

(iii) The context of SEMP stage 2 operability plan shall enable the design team of the Contractor to focus on exactly who is expected to be using the system, for what purpose, and under what circumstances.

(i v) Based on the conceptual design, an engineering design proposal shall be produced. In addition, the engineering design proposal shall specify the functional and structural details of how the required operability is implemented.

(v) As a matter of preference, a non-developed product which is a proven design and readily available from the commercial market, shall be used to fulfil the user interface requirements.

(v i) The Contractor shall carry out an assessment to identify the risks to the system's overall operational objectives which might arise through the operability design, particularly the human computer interface design.

(v i i) All feasible engineering design proposal shall be evaluated as part of the iterative system analysis process on the basis of technical performances and man-machine interfaces.

(viii) In arriving at a specific recommended approach, the human hierarchy shall be incorporated to determine the actual personal quantities and skill-level requirements for each engineering design proposal.

(ix) As a result of engineering design proposal review, any change from the initial allocation of man-machine requirements shall be implemented through the Configuration Control Program.

(c) SEMP Stage 3

(i) As the design progresses and data is available, the system analysis shall be re-applied in the form of an ongoing design evaluation process. An error analysis shall also be performed to identify critical activities where operator-induced system failures are likely to occur.

(ii) The objective of system analysis at this stage shall be such that the proposed design configuration shall be reviewed from the standpoint of the human being in the system. Any problem areas identified shall initiate design configuration change as required and record according to the requirements of Configuration Control Program.

(iii) Towards the end of the SEMP stage 3, prototype equipment shall be developed and tested for the purpose of verifying or demonstrating various system characteristics. All selected hardware and software components of the system shall be verified by actually performing certain operator and maintenance tasks in order to ensure complete human-equipment compatibility.

(iv) A feasibility study shall also be carried out by the Contractor to verify the engineering proposals in the context of a comprehensive user study, which shall include:

(1) Scenario based elicitation of user requirements; and

(2) Operability assessments confirmation and refinement of the operability target.

(v) In addition, the Contractor shall produce mock-up and/or prototype of the plausible solutions to validate the design proposal by:

(1) Evaluating the solutions against user requirements;

(2) Implementation of ergonomic principles and standards; and

(3) Measure whether operability targets have been achieved.

(vi) The above verification of human performance shall be accomplished through a formal personnel test and evaluation program of the Engineer's

representatives.

(vii) Based on the results of the mock-up, personnel test and evaluation program, a user evaluation report shall be produced by the Contractor to confirm the user-friendliness of the system.

(viii) An operability acceptance questionnaire shall be drafted by the Contractor and submitted for approval. It shall document all the assessment/acceptance activities including demonstrations, prototypes and development rigs for both informal and controlled trials.

(ix) The trials may use experts and representative personnel from the user or maintainer of the Engineer. The results of the assessments derived from the use of the questionnaire shall cover the functionally, equipment operability and the performance of the users during agreed scenarios. It may also cover the interoperability between equipments used in close proximity or in relationship to one another.

(d) SEMP Stage 4

(i) The Contractor shall identify and plan the production and installation processes which directly affect quality of the operability performance. As an integral part of the quality system (refer to PS 27), the Contractor shall ensure that the above processes are carried out under controlled conditions.

(ii) In order to ensure an effective control of manufacturing quality, the Engineer shall be afforded the right to verify at the Contractor's, Subcontractor's and/or supplier's premises that all related products conform to the operability requirements.

(iii) The Contractor shall produce a testing plan (refer to PS 22) to ensure that the operability targets can be achieved in the production process

(iv) During the later phase of SEMP stage 4, the ongoing system analysis shall constitute manufacturing data collection, updated human-equipment analysis and corrective action as required.

(e) SEMP Stage 5

(i) The Contractor shall produce a test report with complete evidence of conformance of the finished product to the operability targets.

(i i) The Contractor shall provide a training plan to ensure the operability targets can be maintained by the user.

21.6 Weight Management Plan

21.6.1. As an integral part of the SEMP, the Contractor shall submit a weight management plan which shall define the way in which the requirements for overall vehicle weight and weight distribution shall be achieved.

21.6.2. The weight management plan shall include, but not be limited to, the following items:

(a) Appointment of a person with the responsibility of developing the overall vehicle weights and weight distribution from the individual component weights.

(b) Allocation of maximum weights for Subcontractor's equipment during the purchasing phase so that the maximum weight for the equipment can form a part of the contract for that equipment.

(c) Review of weight with a view to weight saving as an integral part of the design review process.

(d) Publication of a weight report which shall form part of the monthly SEMS report, to update the emerging weight. Any variations from the previous report shall be explained and justified.

(e) Verification of the weights of individual components during the manufacturing phase.

21.7 Electromagnetic Compatibility Plan

21.7.1. General Requirements

(a) As an integral part of the SEMP, the Contractor shall submit an Electromagnetic Compatibility (EMC) Plan which shall define the overall approach and methodology in achieving the electromagnetic compatibility requirements.

(b) It is essential that the Contractor and all Subcontractor(s) shall conform to the EMC requirements as defined by the EMC Plan.

(c) The cars shall be electromagnetically compatible within themselves, with other cars provided by the Contractor, with all other rail vehicles and trains in operation at the AUTHORITY, with the AUTHORITY's signal system which includes both single-rail and double-rail track circuits.

(d) The Contractor shall conduct a program which achieves and documents electromagnetic compatibility (EMC) of the Cars. The Contractor shall apply the EMC program requirements to all sub-contractor(s). The Contractor shall ensure that all equipment, when operating individually or concurrently with other subsystems, complies with the EMC requirements. The Contractor shall ensure that each train configuration complies with the EMC requirements, in all possible operation modes, including all allowed modes of degraded

performance and failure modes.

21.7.2. EMC Standards

The supplied equipment shall meet internationally recognized standards, where applicable, on EMC requirements. The EMC plan shall list the applicable standard to be adhered to in the areas of:

(a) Susceptibility to Radiated Electromagnetic Energy

(b) Electrical Fast Transient/Burst

(c) Electrostatic Discharge

(e) Radiated, Radio-Frequency, Electromagnetic Field Immunity

(f) Surge Immunity

(h) Conducted Disturbances Immunity

(i) Power Frequency Magnetic Field Immunity

21.7.3. Interference Considerations

The Contractor shall take into account the following interference mechanisms in his design and take all necessary measures to eliminate their impact on the supplied equipment:

(a) Radiated interference - at a distance greater than approximately one sixth of a wavelength away from a radiating antenna or interfering source the radiation field dominates and is the mechanism to be considered;

(b) Induced interference - can be due to direct magnetic induction from power electronics and cables. The induction field produced by rate of change of current not equal to zero is the most significant component at distances less than one sixth of a wavelength away from the disturbing source;

(c) Conducted interference - can take several forms:

(i) Interference present on the power supply to equipment

(i i) Equipment that shares a common earth return can be subjected to

interference from other equipment due to voltage drops across the return path

(i i i) Signalling equipment that uses the running rails as conductors to transmit or receive signals is subject to interference coupled into the running rails as a result of traction return current in the running rails

(iv) Equipment with external interface can be subjected to interference present on interface cables and wires

(d) Electrostatic discharge - occurs under dry atmospheric conditions in which electrostatic discharge from the human body (can become charged to several thousand volts) can result in loss of data or may physically damage equipment containing sensitive components.

(e) General Electromagnetic Interference

The Contractor shall ensure that there is sufficient protection to prevent Electromagnetic Interference (EMI) from any components and systems of the supplied trainborne equipment, including traction motors and auxiliary converters, from affecting the on-board systems and systems within and adjacent to the Existing Lines.

21.7.4. Rolling Stock Radiated and Conducted Emissions

As a minimum requirement, the maximum levels of radiated EMI and conducted emission of trainborne equipment shall not exceed the levels specified in the Standard EN 50081-2.

21.7.5. Rolling Stock Equipment Immunity Levels

(a) All trainborne electrical and electronic equipment shall be immune from any radiated electromagnetic interference produced by other pieces of trainborne equipment and external sources.

(b) Any equipment which contains sensitive electronic components to electrostatic discharge and is likely to be handled or touched by personnel or customers shall be protected against electrostatic discharge.

(c) All trainborne electrical and electronic equipment shall be immune to the conducted interference levels as defined in the Standard EN 50082-2 in the frequency range 150 kHz to 80 MHz.

21.7.6. Communication Equipment Compatibility

(a) The communication equipment of the Existing Lines shall operate reliably in terms of performance and functionality in the electromagnetic environment produced by the trains.

(b) The Contractor shall liaise and co-operate with the Interfacing Contractors and Named Suppliers in the exchange of EMC data and related equipment performance characteristics to produce a compatible system.

(c) The Contractor shall limit levels of chopper/inverter harmonic currents/inrush current into trainborne filters and provide sufficient train input impedance to limit 600 Hz and 1200 Hz supply ripple currents.

(d) All trainborne communication equipment supplied by the Communication contractor will be immune to any magnetic fields generated by trains, third rail / power return rails, power cables and traction motors.

(e) In addition to the EMC requirements for all trainborne equipment, the Contractor shall ensure that under normal supply conditions the static magnetic fields due to cables and traction motors and inductors in the power circuits and static magnetic fields due to currents in the third rail and return rails, shall not cause noticeable effect on any saloon passenger information display boards, TIMS display terminals or VSS trainborne video displays.

21.7.7. Signalling Equipment Compatibility

(a) The existing signalling equipment including the SCS shall operate reliably in terms of performance and functionality in the electromagnetic environment produced by the trains.

(b) The Contractor shall liaise and co-operate with the SCS contractor in the exchange of EMC data and related equipment performance characteristics to produce a compatible system.

21.7.8. Public Systems Compatibility

The Contractor shall ensure that any static or alternating magnetic fields generated by the trains shall not interfere with the correct operation of customer goods or any magnetic media. The flux density between the floor level and 2 m above floor level shall not exceed 1 mT. These limits shall apply under all normal modes of operation.

21.7.9. Supply Filter

A Radio Frequency Interference (RFI) filter shall be fitted to the trains if required for the train to be compatible with the intended operating environment, and reach the RFI levels of the T1 cars.

21.7.10. Testing Requirements

In order to ensure and demonstrate EMC compliance, a comprehensive programme of testing is required to be performed by the Contractor. The tests

shall include, as a minimum, Vehicle and Equipment Level tests, as defined within the EMC Plan, and as approved by the Engineer.

(b) Specific requirements for equipment level:

(i) Equipment Performance Criteria for Immunity Tests

All equipment supplied shall not become dangerous or unsafe, or be damaged as a result of the application of the immunity tests. One of the following performance criteria shall apply according to the tests performed:

(1) Performance Criterion A:

The equipment under test shall maintain normal performance within the specified limits throughout the course of the tests. No software codes or data shall be affected in any way by the tests.

(2) Performance Criterion B:

The equipment under test may suffer from a temporary degradation or loss of function or performance during the tests. The equipment under tests must be self-recoverable without any operator intervention or system reset upon withdrawal of the test waveforms/signals. No software codes or data shall be affected in any way by the tests.

(ii) Interference Test

(1) Radiated Frequency Emission

All equipment supplied shall be designed and tested to EN55011 Group 1 Class A emission levels for radiated frequency emission.

(2) Conducted Emission

All equipment supplied shall be designed and tested to EN55011 Group 1 Class A emission levels for conducted emission.

(c) Immunity Test

Note: For those test requirements that IEC 1000 series are not applicable, the corresponding replacement of IEC 61000 series is acceptable.

(1) Radiated Frequency Immunity

All equipment supplied shall be designed and tested to IEC 1000-4-3 Class 3 immunity levels for radiated frequency immunity. The performance criterion A shall apply.

(2) Electrostatic Discharge Immunity

All equipment supplied shall be designed and tested to IEC 1000-4-2 Class 3 immunity levels for electrostatic discharge immunity. The performance criterion B shall apply.

(3) Fast Electrical Transient Immunity

All equipment supplied shall be designed and tested to IEC 1000-4-4 Class 3 immunity levels for fast electrical transient immunity. The performance criterion B shall apply.

(4) Surge Immunity

All equipment supplied shall be designed and tested to IEC 1000-4-5 Level 3 immunity levels for surge immunity. The performance criterion B shall apply.

(5) Conducted Disturbances Immunity

All equipment supplied shall be designed and tested to IEC 1000-4-6 Level 2 immunity levels for conducted disturbances immunity. The performance criterion A shall apply.

(6) Power Frequency Magnetic Field Immunity

All equipment supplied shall be designed and tested to IEC 1000-4-8 for power frequency magnetic field immunity. The severity level shall be submitted for approval. The performance criterion A shall apply.

These tests are not meant to be exhaustive in demonstrating EMC compliance. The Contractor shall propose additional tests as appropriate in order to demonstrate full EMC compliance.

21.7.11. EMC Management Life Cycle

(a) SEMP Stage 1

The Contractor shall prepare and submit an EMC plan for approval during SEMP Stage 1. The EMC plan shall include the following:

(i) The name and title of a person acting as single point of contact on EMC matters. Any subsequent change of nominated person shall be subject to

approval.

(ii) The roles and responsibilities of staff involved in EMC on the Contract, their job titles, previous experience and qualifications on EMC matters.

(iii) An organization chart highlighting persons involved in EMC on the Contract.

(iv) The overall methodology and steps to be taken on EMC throughout the Contract with expected dates of actions including documentation submission dates.

(v) An initial list of design documentation, test specifications and test reports with a single paragraph description of each document to indicate compliance with the Standard.

(b) SEMP Stage 2

Based on the EMC Plan, the Contractor shall prepare and submit an EMC philosophy document for approval during SEMP Stage 2 which shall at least include the following:

(i) Detailed methodology and steps to be taken on EMC

(i i) Design practices to be adopted throughout the design process to ensure EMC is ultimately achieved

(iii) Identification of emissive and susceptible equipment to which the design practices will be applied

(i v) Identification of interface(s) between systems that are sensitive to EMI and methods to achieve EMC

(v) A signalling compatibility specification that include:

(1) A listing of interference sources and mechanisms applicable to each sub-system with quantitative analysis to define the worst case values of interference signals

(2) A review of the system design with quantitative analysis to determine whether the worst case levels of interference signals will disrupt normal operation of the system

(3) A description of proposed remedial measures to correct any identified problems

(vi) A communication compatibility specification that include:

(1) Identification of interference sources

(2) Design practices to be adopted to achieve EMC on communication equipment

(c) SEMP Stage 3

Based on the EMC philosophy document, the Contractor shall prepare and submit an EMC design review document during SEMP Stage 3 for approval which shall at least include the following:

(i) Radiated EMI Requirements

Documentation shall be provided to demonstrate by design how the emission of radiated EMI has been minimized and also to demonstrate the steps which have been taken to achieve the required immunity of equipment to radiated EMI from all other sources.

(ii) Magnetic Field Requirements

Documentation of all calculations to show that the magnetic field requirements have been satisfied.

(iii) Inductive Interference Requirements

Documentation of all calculations to show that the psophometrically weighted current taken by the train does not exceed that specified in the Specification.

(iv) Conducted Interference Requirements

Documentation of all calculations to show the conducted interference requirements have been satisfied.

(v) Signalling Compatibility Study

Documentation of steps taken to avoid interference with the Signalling systems. The areas to be covered shall include:

(1) List of specific EMC requirements for each signalling equipment type

(2) Description of the traction and auxiliary equipment including circuit diagrams

(3) Fault tree analysis

(4) Failure modes effects and criticality analysis (FMECA)

(5) Normal and fault supply ripple current calculations for traction and auxiliary converter

(6) Supply filter resonant frequency design

(7) RFI shielding methods

(8) Analysis of the control system regarding potential EMI mechanisms

(vi) Communication Compatibility Study

Documentation of steps taken to avoid radiated EMI from trains affecting communication equipment.

(vii) Test Schedule

A schedule of tests to be conducted which define the specifications to be used for each test, the location where the test will be carried out, the facilities

required and other parties involved. The minimum number of tests as specified above shall be included in the schedule.

(viii) Test Specification

Specifications for each test specified in the test schedule shall be produced in detail.

(d) SEMP Stage 4

(i) The Contractor shall submit a report demonstrating that all EMC measures

(such as installation of EMC shielding and ground plate) as identified and approved in the EMC philosophy document and EMC design review document have been fully implemented to the required standards. Manufacturing and installation plan/procedures and inspection report highlighting the EMC related measures shall be included.

(ii) The Contractor shall conduct the specified testings during SEMP Stage 4. These shall be grouped into the vehicle and equipment level.

(e) SEMP Stage 5

The Contractor shall consolidate all the testing results, calculations, theoretical analysis and design studies into a single document and submit the document to demonstrate the full EMC compliance with the Standard.

21.8 Noise Plan

21.8.1. The Contractor shall submit a detailed Noise Plan and programme to illustrate

the manner in which the required exterior and interior noise levels will be achieved and the necessary interfaces between the Contractor and the noise specialist.

21.8.2. General Requirements

(a) The Contractor shall make every effort to reduce the internal and external noise in the train.

(b) The motors, compressors, fans and any other auxiliary equipment shall be incorporated with those elements that offer improved acoustical performance over standard design.

(c) Equipment and components shall be mounted to minimize the generation and propagation of airborne and structure borne noise. Similarly, the interior of the cars - i.e. floors, outer and inner walls, doors, ceiling and windows - shall be designed to minimize transmission of airborne and structure borne noise. Such

noise reducing measures which are needed to comply with the stated requirements shall be established by the Contractor.

(d) Irritating, audible pure tones, rattling and clattering shall not occur.

(e) Where the term passenger positions are used in connection with measurement and checking of noise and vibrations, it shall be taken to cover positions of both seated and standing persons.

(f) The requirements shall be met by all car types in a train consisting of 6 cars.

(g) Unless otherwise specified, all measurements shall be made in accordance with ISO 3381: 2005 and ISO 3095: 2005.

(h) The specified levels are given as two values as follows:

Target/Acceptance e.g. 80/83 dB

The target levels shall be used in design/modelling predictions. The acceptance levels are mandatory and shall be achieved in practice. They include all measurement uncertainties and shall not be exceeded.

(i) Train speed measurements shall be made with an independently calibrated measurement system.

(j) Unless otherwise specified, all noise measurements with cars running shall be performed over the Existing Subway Lines.

(k) The Contractor shall carry out prototype testing on his own test track. The track and wheels on the test vehicle shall meet the following requirements:

Wheels: Surface roughness of no greater than 10 µm Ra,

cut-off length = 2.5 mm

Track/wheel requirements are with reference to: ISO 4287: 1997, ISO 3095:2005 where applicable.

(l) Effects of Tonal Noise

If clearly audible tones occur, 5 dB will be added to the measurement value before comparison with the specified requirement. The criteria for occurrence of clearly audible tones are given in Clause 5 of this Standard.

(m) Effects of Impulsive Noise

If impulsive noise occurs then 5 dB will be added to the measurement value before comparison with the specified requirement. The approach proposed in ISO 3381: 2005 shall be used to characterize noise with impulsive character.

(n) Noise Control Measures

The following noise control measures shall be evaluated during the design stage to improve sound insulation and reduce noise emission as needed to comply with the specification requirements:

- Floating floor construction for weight reduction, improving sound insulation and avoiding an excessive passenger loaded deflection.
- Application of the silencer into the Traction Motor for reducing its noise emission.
- Application of the silencer in front of supply air duct of the HVAC. Consideration shall be given to ensure sufficient airflow quantities with adequate air velocities given rise from pressure drop before and after silencer.
- If tread brake unit is used, the brake block shall be able to compensate for wheel wear automatically and self-align with the wheel centre in order to reduce braking noise as generated by the excessive vibration between the brake block and wheel tread.

21.8.3. Noise Levels

(a) Exterior Noise Levels

(i) Train Stationary

(1) With a train stationary on a straight, level track and all auxiliary systems operating simultaneously under the loading conditions which generate the maximum noise, the noise level measured at a position 7.5 m horizontally from the track centre line and 1 500 mm above the head of the rail, shall not exceed 70/72 dB at any point along the length of the train on either side.

(2) Noise level resulting from simultaneous operation of all saloon doors on one

side measured at any position 7.5 m horizontal from the track centre line and 1 500 mm above the head of the rail, shall not exceed 70/75 dB.

(b) Train Moving on Surface Section

With a train moving at all speeds up to 80 km/h on a straight, level track, and operating in any mode of acceleration, including starting from standstill, deceleration, including friction braking, or coasting, with all auxiliary systems operating simultaneously in maximum condition, the noise level measured on either side, at 25 m from track centre line and 1 500 mm above the head of the rail, shall not exceed 75/78 dB.

(c) Train Moving at Curves

The noise level generated by the new wheels for a tare (W1) train running over a depot curved track of radius 140 m at constant speed of 20 km/h under a dry weather, measured at a fixed position on the inner side of the curve of 7.5 m horizontally from the track centre line and 1 500 mm above the head of the rail, shall not exceed 70/73 dB.

21.8.4. Interior Noise Levels

(a) Train Stationary

(i) In an empty car with all auxiliary equipment operating simultaneously at maximum capacity, the noise level in the car saloon and driver's cab shall not exceed 65/68 dB in accordance with the requirements of ISO 3381:2005.

(i i) In an empty car the noise produced by simultaneous operation of all saloon doors on one side of the car, without operation of any other auxiliary equipment shall not exceed 72/77 dB, at all points in the car 1 000 mm from the doors and 1 500 mm above the floor.

(b) Train Moving on Surface Section

(i) When an empty train operates at all speeds of up to 80 km/h with all auxiliary systems operating simultaneously at maximum conditions and with the car operating in any mode of acceleration, including starting from standstill, deceleration including friction braking, or coasting, the noise level in the car interior shall not exceed the following values when measured in accordance with ISO 3381:2005:

Train Operator's Cab –

Compartments –

71 dB

70/73 dB 6

8/

Truck area ┼ 70/73 dB

Intercar ┘

(ii) The areas of the vehicle referred to in (i) above shall be as follows:

Train operator's	The cab area forward of the cab rear bulkhead
Compartments	Saloon areas not covered by the areas referred to below
Vestibule	Door areas between adjacent draught screens
Truck area	An area immediately above the trucks equal in length to the overall length of the truck

Intercar	The area between saloon bulkheads on adjacent vehicles located in the intercar connection at a height of 1500 mm above floor

(c) Train Moving in Underground or Tunnel Sections

For a train moving at all speeds up to 80 km/h in any tunnel, with all auxiliary systems operating simultaneously and with the car operating in any mode of acceleration, deceleration or coasting, the noise levels, excluding noise generated by pressure pulses when entering tunnels and noise generated by passing vehicles, in the car interior and the train operator's cab shall not exceed the values as given by more than 9 dB.

(d) Train Operator's Exposure to Noise

In the train operators's cab, the train operator's noise exposure level LAeq8h shall not exceed an 8 hour Leq of 80 dB, excluding all audible warnings and messages, for a typical shift which shall be assumed to comprise 4 hours of continuous duty, 45 minutes break, and a further 3 hours of continuous duty. Details of journeys, speed profiles and track conditions are given in Appendix I Annex 1. A test to confirm compliance with this requirement shall be performed and the results shall be submitted for approval.

21.8.5. Method for Determining Audible Tones in Noise

The method to determine the presence of pure tones shall be the tonality limits provided in Annex C of ISO/DIS 1996-2 Annex D. As an alternative, the Zwicker method can be used. This method is described in the following sections. As a minimum, the Zwicker method shall be provided for information.

(a) The method is based on the psycho-acoustic concept of critical bands and the objective of the method is to give the same judgement of the prominence of any tones as an average listener.

(b) The method is based on the Zwicker Critical Bands, and is in most details equivalent to ANSI S12.10:1985 (or ANSI S12.10:2002). It consists of three steps:

(i) Frequency analysis.

(i i) Determination of the sound pressure level of the tone(s) and the sound pressure level of the masking noise within a critical band centered at the tone frequency.

(iii) The difference between the levels (ΔLtn) is compared to a criterion curve, and it is decided whether the tone is "Prominent".

(c) Frequency Analysis

(i) Any kind of narrow band frequency analyzer may be used, but the effective analysis bandwidth (equivalent to the noise bandwidth) shall be less than the values shown in the table below:

Tone Frequency, Hz		20-63	63-200	200-630	630-2k	2k-6.3k	6.3-20k
Effective analysis	Abs.	20 Hz	20 Hz	20 Hz	22 Hz	57 Hz	126 Hz
	Rel.	32%	10%	3.5%	2.8%	2%	1.6%

(For an FFT analysis, this condition is fulfilled if the actual tones are placed on the upper 2/3 of the frequency range).

(ii) If the tone as well as the noise is stationary, the analysis time should be at least 2 minutes, 200-500 spectra should be averaged. For non-stationary conditions see Clause 5.8.

(iii) In the case of a tone complex with closely spaced tone components, an even finer resolution may be needed to determine the level of the masking noise correctly.

(d) Determination of Sound Pressure Levels

(i) The bandwidth of the critical bands are:

Center Frequency (f_c), Hz	20-500	Above 500
Bandwidth	100 Hz	20% of f_c

(ii) The critical band is positioned with centre frequency coincident with the tone

frequency. If more closely spaced tones are present, the critical band is placed so that it includes the largest possible number of the most prominent tones. The lowest critical band is 20 Hz - 120 Hz.

(e) Sound Pressure Level of Tone, Lpt

The sound pressure level of the tone Lpt is read from the analysis. It may be necessary to correct for the picket-fence effect of digital narrow band analyzers. If more tones are present in the same critical band, their levels are added on energy basis to give the total Lpt.

(f) Sound Pressure Level of the Masking Noise within a Critical Band, Lpn

(i) The sound pressure level of the noise is determined from the same analysis as if the tones were not present. All peaks resulting from the tones and their possible sidebands are disregarded.

(ii) The total noise level within a critical band, Lpn may be found as the average level within the critical band, Lpn,avg, and corrected to the bandwidth of the critical band:

$$L_{pn} = L_{pn,avg} + 10 \log_{10} \frac{\text{Critical Bandwidth}}{\text{Effective Analysis Bandwidth}}$$

(iii) Lpn,avg can be determined by visually averaging of the spectrum apart from the tones.

(iv) Alternatively, the level may be found by energy summing of all analysis bands within the critical band not due to tones. In this a correction must be made for the effective analysis bandwidth being generally wider than the frequency reduction. With the commonly applied Hanning weighting function, the analysis bandwidth is 1.5 times the resolution.

$$\Delta L_{tn,crit} = 4.5 - \log_{10} \left[1 + \left(\frac{f}{502} \right)^{2.5} \right]$$

(g) Evaluation

The difference between the tone level and the noise level, ΔLtn = Lpt - Lpn, is compared to a criterion curve. If ΔLtn is below the lower curve, the tone is masked and cannot be detected by average listeners. If ΔLtn is above the upper criterion curve, the level of the tone is 6.5 dB above the threshold and is described as "Prominent" by average listeners. For rating of noise a +5 dB penalty is then applied. The equation of the criterion curve is:

(h) Non-Stationary Conditions

(i) If the level of the frequency of the tone is varying, the highest level of the tone is found from a frequency analysis using time weighting F. A minimum of 5 analyses shall be carried out and the average computed from the average of the highest 5 levels. The level of the masking noise is found by averaging over at least 2 minutes.

(ii) It is difficult to approximate time weighting constant F by use of an FFT analyzer. The following method is recommended, being validated for ordinary 400-lines FFT analyzers:

(1) With a full scale frequency of 1 kHz, a single spectrum approximates time weighting F.

(2) With a full scale frequency of 2 kHz or higher, the exponential average of two spectra approximates to time weighting F. In this connection it must be made sure that the "real time" frequency of the analyzer is not exceeded.

(i) More Tones in Separate Critical Bands

If there are several tones (or groups of tones) in different critical bands, each critical band is evaluated separately. The critical band giving cause for the largest ΔLtn contains the most dominant tone(s).

21.8.6. Noise Engineering Design Life Cycle

(a) SEMP Stage 1

The Contractor shall prepare and submit a noise plan for approval during SEMP Stage 1. The noise plan shall include:-

(i) The name and credentials of the Contractors proposed noise specialist for approval prior to commencement of work in this area.

(i i) Details of the validated computer model which shall be used to evaluate airborne and structure borne noise levels of the entire cars and key noise sources.

(i i i) Design review with identification of noise sources and airborne and structure borne noise transmission paths.

(i v) Determination of airborne and structure borne noise source strength for all relevant noise sources, which shall include, but not be limited to:-

(1) Wheelsets (wheel-rail contact noise)

(2) Motors

(3) Gears

(4) Compressors

(5) Pneumatic equipment

(6) Air conditioners

(7) Doors

(8) Traction and auxiliary control equipment

(v) Evaluation of airborne and structure borne noise reducing measures for the car body including, but not be limited to, floor, sidewall, roof, doors, windows, ventilation openings, air conditioner ducting, interconnection gangways.

(v i) Formulation of relevant noise specifications for Subcontractors in order to achieve final noise specifications

(vii) Predictions for the exterior and interior noise levels for the train travelling at full speed based on the computer model as octave band pressure levels and the A-weighted sound level.

(viii) A description of the prediction method and how the predictions were carried out, including and assumptions made.

(ix) Provision for revised noise predictions as further information becomes available during SEMP Stages 2, 3, 4 and 5.

(b) SEMP Stage 2

The Contractor shall submit updated noise predictions based on detailed noise specifications developed for all major items of equipment and accepted by the suppliers of the equipment. The report shall include:-

(i) Detailed noise specifications for all the equipment.

(i i) Preliminary designs for the vehicle showing any special measures necessary to

achieve the noise levels such as floor arrangement, air conditioning ducting.

(c) SEMP Stage 3

The Contractor shall submit a revised noise prediction based on the noise levels contracted with the manufacturers of equipment. The predictions shall include the following:-

(i) Details of any changes from the previous predictions with detailed explanations.

(ii) Noise specifications contracted by the manufacturers of equipment with details of any deviations form the original specifications.

(iii) Evaluation of any areas of risk with proposed contingency measures for these areas

(iv) Details of any areas of development required to achieve the specifications, together with development plans for these areas. This shall also include details of any testing programmes for sub systems, for example the floor, air conditioning units and motors, and finite-element modelling, for example with gearboxes.

(d) SEMP Stage 4

The Contractor shall submit a revised noise prediction based on the noise

levels achieved during testing of the individual items of equipment. The predictions shall include information on:-

(i) Noise levels for the equipment, together with test reports which confirm that the levels will be achieved.

(i i) Explanation of any deviations form the specified levels for the equipment.

(i i i) Details of any remedial measures which are necessary, together with plans for implementation of these measures.

(e) SEMP Stage 5

The Contractor shall carry out testing on completed vehicles and trains to demonstrate that the overall noise requirements have been achieved and shall submit detailed final test reports for approval.

21.9 Software Project Management Plan

21.9.1. As an integral part of the SEMP, the Contractor shall submit a Software Project Management Plan (SPMP) consisting of the Software Quality Plan, Software Development Programme, Software Verification and Validation Plan and Software Configuration Management Plan which shall define the planning, design, development, verification, validation, maintenance and configuration management of all software supplied for the Contract. The primary objective of the SPMP is to ensure the quality of all software supplied which form part of the integrated systems to meet the Contract requirements.

21.9.2. It is essential that all software suppliers (the Contractor and all Subcontractor(s)) shall conform to the software requirements as defined by the Software Project Management Plan.

21.9.3. The detailed requirements of the Software Project Management Plan shall be referred to PS 29. The events defined by the Software Quality Plan and Software Verification and Validation Plan shall be integrated with the stages of the SEMP.

21.10 Fire Engineering Plan

21.10.1. Introduction

(a) Fire performance requirements are specified in the two usual areas of (materials) reaction to fire and (items / structures) fire resistance. The reaction to fire performance includes reference to both smoke and toxic fume emission in addition to flame retardancy. The materials required are therefore of a Limited Fire Hazard (LFH) type in the widest sense of the phrase. For all materials and cable, requirements according to Clause 8 of NFPA 130 or the other international standards of this section, shall be met. Refer also to PS 20.3.2 for particular requirements on determination of power output on flash over fires.

(b) The flammability, smoke and toxic fume reports, if performed before NTP,

must have been performed a maximum of 5 years before the NTP. The report shall be supplied with a letter confirming the material tested is identical, in composition and manufacturing process, to the material supplied for this contract.

(c) For reports performed after the NTP, the report shall include a photo showing the sample installation in the test arrangement. The reports will be supplied in an electronic format on a CD-ROM.

21.10.2. Standards/Reference

(a) International Standards

BS 476:Pt 4:1989 Non-combustibility test for materials

BS 476:Pt 6:1989 Method of test for fire propagation for products

BS 476:Pt 7:1997 Method for classification of the surface spread of flame of products

BS 476:Pt 20:1987 Method for determination of the fire resistance of elements of construction (general principles)

BS 476:Pt 22:1987 Methods for determination of the fire resistance of non-loadbearing elements of construction

BS 2782:Pt1:M141:1986 Method 141A to 141D Oxygen index of combustion

BS 6853:1999 Fire precautions in the design and construction of railway passenger rolling stock

NF X 70-100 : 1986 Fire Behaviour Tests - Analysis of Pyrolysis and Combustion Gases - Pipe Still Method (if not applicable, replacement of NF X 70-100-1 and NF X 70-100-2 is acceptable)

NFPA 130 : 2003 Fixed Guideway Transit and Passenger Rail Systems

(b) International Standards for Cables

BS 4066:Part 1:1980 Method of test on a single vertical insulated wire or cable (if not applicable, replacement by BS EN 60332-1-1-2004 and BS EN 60332-2-1-2004 is acceptable)

BS 4066:Part 2:1989 Method of test on a single small vertical insulated wire or cable (if not applicable, replacement by BS EN 60332-1-1-2004 and BS EN 60332-2-1-2004 is acceptable)

BS 4066-Part 3:1986 Method for classification of flame propagation characteristics of bunched cables (if not applicable, replacement by BS EN 50266-1, BS EN 50266-2-1, BS EN 50266-2-2, BS EN 50266-2-3, BS EN 50266-2-4, BS EN 50266-2-5 is acceptable)

BS 5308:1986 Instrumentation cables

BS 5425:1986 Coaxial cable for wideband distribution systems

BS 6360:1991 Conductors in insulated cables and cords (if not applicable, replacement by BS EN 60228:2005 is acceptable)

BS 6387:1994 Performance Requirements for Cables Required to Maintain Circuit Integrity under Fire Conditions

BS 6469:1990 Insulation and sheaths of electric cables

BS 6500:1990 Insulated flexible cords and cables

BS 6853:1999 Fire precautions in the design and construction of railway passenger rolling stock

IEC 811:1985 Common test methods for insulating and sheathing materials of electric cables

IEC 60331:1970 Fire-Resisting Characteristics of Electric Cables

NF X 70-100:1986 Fire Behaviour Tests - Analysis of Pyrolysis and Combustion Gases - Pipe Still Method (if not applicable, replacement of NF X 70-100-1 and NF X 70-100-2 is acceptable)

NF C 32-021 Test Methods for Cables Used under Special Conditions

NF C 93-522 Electrical Wires for Wrapped Connections

21.10.3. Definitions / Abbreviations

Ext Exterior

FTI Flammability Temperature Index

HP Horizontal Prone

HS Horizontal Supine

Int Interior

LFH Limited Fire Hazard

LOI Limiting Oxygen Index

V Vertical

21.10.4. General Requirements

(a) This Section of PS specifies categories of material, tests and requirements of fire resistance and reaction to fire.

(b) The requirements for the reaction to fire performance of the main material surfaces vary depending on the location and orientation of the material. The

locations are split into interior and exterior. The orientation is described as one of three types.

Horizontal Supine (HS) - orientation as a floor

Vertical (V) - orientation as a wall

Horizontal Prone (HP) - orientation as a ceiling.

Some testing is item specific and is referenced and described as such.

(c) The requirements apply to all materials. Where materials are contained in a box, e.g. an equipment case, and the box is sealed and constructed from a material which has fire resistance (by inspection or from certification) commensurate with the fire load within the box, then subject to approval, the enclosed materials need not comply.

(d) A category of materials is defined as being minor; i.e. of minor usage. These categories are intended to be used for materials, the amount of which in any particular area, is insufficient to justify its consideration as a surface. As an indication the limiting surface may be taken as 0.01m^2.

(i) For interior use, items up to 500g may be considered in this category. For exterior use, items up to 2kg may be considered to be in this category.

(ii) For interior use items below 100g do not require testing. For exterior use items below 400g do not require testing.

(e) The right is reserved to require testing and compliance for items below the testing threshold weights if inspection, say, of a materials schedule, indicates that the grouping or density of such items may lead to a hazardous situation developing.

21.10.5. Fire Resistance Requirements

(a) Floor

(i) The floor shall achieve 30 minutes endurance rating when tested according to the ASTM E 119 procedure in NFPA 130.

(ii) The floor sample shall be of a sufficient size to accommodate examples of any floor penetrations used on the vehicle. These shall also achieve the required fire resistance.

(b) Equipment Cubicle Interface with Saloon or Cab

(i) The saloon or cab face of the interface shall achieve 20 minutes integrity to BS 476 : Parts 20 and 22.

(ii) In carrying out the test consideration shall be given to avoiding spurious effects caused as a result of the metallic circumference of the wall/floor of the train expanding within a "fixed" ceramic structure, a situation which will not occur in practice.

(c) Cavities

(i) Any cavity formed in the wall which is not filled to both faces with a non-combustible (classified by a standard called in NFPA 130 or BS 476 : Part 4) insulating material shall be prevented from "communicating" with any ceiling cavity by the inclusion of a barrier at the wall cavity/ceiling interface. The function of the barrier is to prevent ready movement of air up towards any ceiling void promoting a "chimney" or "stack" effect.

(i i) <u>If warranted by the Fire Hazard Analysis in 25.5.5.c ,</u> Any cavity formed in the ceiling which is not filled to both faces with a non-combustible (classified by a standard called in NFPA 130 or BS 476 : Part 4) insulating material shall be compartmented across its width at distances not exceeding 5m by the inclusion of a barrier. The function of the barrier is to prevent ready movement of air through the void which would promote conditions of high heat transfer efficiency.

(iii) The barrier shall be prepared from a material which is either by inspection (proven on previous contract), or from certification, capable of achieving 30 minutes integrity to BS 476 : Parts 20 and 22. No fire resistance test of the full structure is required.

(i v) The interface between the barrier and the interior faces of the cavity shall be protected or bonded in such a way that ready movement of fire products between the barrier and either of the faces is prevented when exposed to fire. Intumescent protection should be considered.

(v) The design and materials shall be submitted for approval.

(d) Seat Shell (Back & Base)

(i) It is required that the material used to form the seat shell (back and base) protects the seat trim from the effects of fire occurring under or around the seat.

(ii) The material shall, therefore, either by inspection (proven on previous contract), or from certification be capable of achieving 10 minutes integrity to BS 476: Parts 20 and 22. No fire resistance test of the full seat is required.

21.10.6. Reaction to Fire Methods

(a) Surfaces

(i) Flame Retardancy

As an option to the NFPA 130 standards, the methods to be used are BS 476 : Parts 6 and 7. Both shall be used in standard form and the requirements are given in standard form with the exception that certain surfaces are required to be Nil spread for the BS 476 : Part 7 test. This is not a formal categorisation under the standard but the information is available in the full report of the tests.

(ii) Smoke Emission

As an option to the NFPA 130 standards, the methods used are BS 6853 Appendix B5.2, (vertical and horizontal prone) and Appendix B5.4 (horizontal supine). The requirements are given in the standard form using the standard units.

(iii) Toxic Fume Emission

(1) The method to be used is NF X 70 100 (if not applicable, replacement of NF X 70-100-1 and NF X 70-100-2 is acceptable) or an alternate standard approved by the Engineer. The methodology is as standard but there is a requirement to measure and consider an additional species, nitrogen dioxide (in the form of nitric oxide and nitrogen dioxide combined, quoted as nitrogen dioxide).

(2) The NF X 70-100 standard normally generates toxic fume emission in units of milligrams of species per gram of material combusted. For surfaces this value needs to be converted to a notional value on an area basis using information specific to the application; e.g. the weight per unit area of the material. (If this leads to unrealistically high values for thick materials, this will be considered, in the event of a contravention of the requirements occurring, on a case by case basis where an effective depth of surface will be defined by the Engineer).

(3) For the NF X 70-100 method, the results for all the gases measured, with the addition of nitrogen dioxide, should be expressed as grams of toxin per m2 of surface. The value generated for each toxin is weighted for relative effect by dividing by the reference values also in gm 2.

(4) The resulting ratios shall be summed to give the weighted summation ratio, "R". This ratio is allowed to vary reflecting changes in location and amount of material destroyed.

(b) Cables

(i) General Requirements

(1) Minimum quantity of inflammable material shall be used in the construction of all cables which shall minimise the production of smoke and toxic fumes in the event of fire or short circuit.

(2) All cables shall have high resistance to fire propagation. Hazardous conditions arising from the overheating or ignition of cables shall be avoided.

(3) Demonstrations shall be included to certify that the generation of toxic gases in the burning cable materials does not exceed the requirements of commonly acceptable toxicity standard.

(4) The cable sheath shall be able to withstand at least 150ºC of hot air for 10 minutes with no deterioration to its property and without exhibiting surface cracks or punctures.

(5) The primary wires and cables shall not suffer any damage or punctures after a prolonged exposure to mineral oil.

(6) Single core and multi-core power cables shall be suitable for use with voltages of 500V or 1500V either DC or AC up to frequency of 1000 Hz.

(7) Control cables shall be suitable for use with voltage up to 250VDC or AC up to frequency of 1000 Hz.

(8) Communication cable shall be suitable for use with voltage up to 16 Vpeak-to-peak for arcnet, 20 Vpeak-to-peak for serial data link (such as RS 485), 2 Vpeak-to-peak with highest frequency of 10M bits/s for ethernet.

(9) The cable shall meet the following quality assurances:

- Maximum differences of the cable wall thickness (including cable insulation and sheath);
- Consistency of cable and conductor diameters;

- No wrinkles/permanent damages to the cable insulation shall be caused by bending.

(ii) Operation Condition

(1) All insulation and sheath shall be moisture and heat resistant.

(2) The maximum continuous conductor temperature appropriate to the application conditions and the maximum conductor short circuit temperature shall not be lower than 90ºC and 250ºC respectively.

(3) The cables to be used for the following circuits shall meet all requirements according to the BS 6387 : 1994 and IEC 60331 : 1970:

- Safety related controls (refer to PS 9.9);
- Train and passenger information management (refer to PS 9.10);
- Emergency operations (refer to PS 9.11);
- Special controls (refer to PS 9.12).

(iii) Insulation and Sheathing

(1) Material

- All cables shall have an insulating sheath and shall exhibit low flame propagation when exposed to fire. Hazardous conditions arising from the overheating or ignition of cables shall be avoided.
- Natural rubber and thermoplastic materials shall not be used.
- Insulation and sheathing material shall be of extruded material or tape lapping.
- Insulating materials which are made by tape lapping shall have their overlapping surfaces bonded together and the tape overlapping shall exceed 66.7%.
- Lapped sheaths shall be made of a single tape with an overlapping exceeding 50%.
- It shall be possible to strip the outer sheath of multi-core or pair cables from the core without damage to any component in the core and it shall also be possible to strip all primary insulation cleanly from the conductor.

(2) Appearance

- The insulation and sheath shall be smooth and free from defects which would affect performance or use. There shall be no surface irregularities such as rippling, bubbling and bulging, and no excretion, pleats or visible deformation.
- Cable sheathing for all safety circuits shall be coloured yellow. The colour of other cables and the cores shall be agreed between the Engineer and the Contractor.
- The colour of the sheath and the printing shall be permanent and remain legible for the service life of the cables.

- Cable identification marking on the outer sheath surface shall at least contain the following minimum requirements :
- the type of insulating material;
- the nominal cross-sectional area of the conductor;
- the rated voltage in Volts;
- the type of wire or cable and the composition;
- the reference of wire and cable specification;
- the manufacturer's logo and year of manufacturing.
- the markings shall be printed no more than 1 m apart.

Details of the marking are to be agreed between the Engineer and the Contractor.

(3) Geometrical Characteristics. The Contractor shall submit the dimensions for all the cables, including the maximum, nominal and minimum values of diameters and thicknesses of the insulating covers, the outer sheaths and the screening, for approval. These shall be measured in accordance with BS 6469 or IEC 811.

(4) Mechanical Characteristics

- The tensile strength shall exceed 7 MPa and the elongation at break shall exceed 100%. The stress at 50% elongation shall be recorded for reference.
- The measurements shall be carried out in accordance with BS 6469 or IEC 811.

(5) Physical and Chemical Performance. All insulation and sheathing shall have excellent resistance against moisture, heat, mineral oil, acids, alkalis, all conventional impregnating varnishes and potting resins, ozone, ultraviolet light and sunlight radiation.

(iv) Conductors

- All conductors shall be stranded and tinned and shall be in accordance with all relevant aspects of BS 6360 (if not applicable, replacement by BS EN 60228:2005 is acceptable) or ASTM-B33 for tinned annealed copper.
- The core of the wires shall be stranded or twisted, singly or together, and must conform to Insulated Cable Engineers Association “ICEA S-19-81 / NEMA WC3 Rubber-Insulated Wire & Cable” and American Association of Railroads “AAR RP-585”.
- To enhance circuitry reliability, all cables shall be designed such that if one conductor in a bunch is subjected to the maximum possible fault current within the tripping time of the protective device, other adjacent cables are not affected.

(v) Ratings

- All cables shall be rated with sufficient capacity for their intended duty and sized appropriately in relation to the design load current, circuit protection setting, ambient temperature of 40ºC and the installation condition.
- All cables shall be required to operate in conditions where a

combination of installation conditions and current flow may result in conductor temperature not exceed 85ºC.

- The size of the cable conductor shall be such that the drop in voltage from the origin of the installation to any point of that installation does not exceed 2.5% of the nominal supply voltage when the conductors are carrying the full load current, but disregarding starting conditions.
- The cross sectional area of the earthing cable shall not be less than that of the incoming supply to the case or frame.

(vi) Characteristics of Wires and Cables

(1) Geometrical Assembled Characteristics

- The cores and cables shall be cylindrical.
- The difference between two values of the diameter recorded in any two directions shall not exceed 15% of the upper limit of diameter.
- Diameter measurements shall be carried out in accordance with BS 6469 or IEC 811.
- For multicore cables, the length of lay of the cores of a layer shall not exceed twenty times of the actual diameter of that layer.

(2) Mechanical Characteristics

- All cables shall have the properties of easy processability (such as removal of insulation).
- The individual cores of multicore cables shall have sufficient cohesion to form a closely bonded assembly but without adhesion presenting any difficulties in separating the cores.
- All cables shall have good resistance against cutting, abrasion and notch propagation.

(3) Conductor Temperature. The maximum continuous conductor temperature appropriate to the application conditions and the maximum conductor short circuit temperature shall in no case be lower than 90ºC and 250ºC respectively.

(vii) Fire Specification

(1) The reaction of cables to fire is specified in respect of flame retardancy, smoke emission and toxic fume emission.

(2) Qualification

- Qualification of a single cable size and type may be achieved by meeting the requirements given above.
- Qualification of a cable type for diameters from d to 2d (max) may be achieved by cables of diameter d and 2d meeting the requirements.

- Subject to approval, qualification of a range wider than that given by d to 2d may be possible depending on the extent of the passes achieved.

(viii) Additional Information

The Contractor shall submit the following data of all cables for approval:

(1) Maximum conductor short circuit current carrying capacity for one second duration

(2) Relative permittivity of the insulation

(3) Maximum dielectric loss angle of the insulation

(4) Thermal resistivity of the insulation

(5) Fire loading of the cable (MJ/kg)

(6) Weight per unit length

(ix) Screened Cables

(1) For single core screened cable, the screening braid shall be made of 0.1 mm diameter tinned copper strand.

(2) For two cores screened cable, the screening braid shall be made of 0.12 mm diameter tinned copper strand. The cable shall consist of a group of twisted primary wires.

(3) The filling factor shall not be less than 0.6, as defined in BS 6500. In the case of multi-pair cable, the screens shall be electrically isolated from each other.

(4) The oversheath material of the screen cable shall have an insignificantly low surface leakage property to prevent the flow of leakage current between the screen braid and the outer sheath.

(x) Special Cables

(1) As deemed necessary, the Contractor may recommend to the Engineer the use of cables of special construction, for example of reduced wall insulation, which do not fully comply with all the above requirements. These cables may include those used in electronic equipment and inside enclosures.

(2) The Contractor shall submit all the relevant information of these cables for approval.

(xi) Radio Frequency (RF) Cables for Telecommunication Systems

(1) Dielectric. The cable dielectric shall be solid high density polyethylene.

(2) Double Screening (if required). Screening shall be achieved by the use of copper braid or aluminium tube with an overlap so that full 100 % coverage of the dielectric is afforded (Note: spray on types of construction are not acceptable).

(3) The screening effectiveness shall comply with BS 5425 : Part 1.

(4) Feeder Coaxial Cable for Radio

Electrical Requirements:

Capacitance	101 pF/m max.
Characteristic impedance	50 ± 3 Ω
Relative propagation velocity	at least 66 %
Longitudinal loss at 100 m	150 MHz < 7.2 dB
	400 MHz < 13.8 dB
	900 MHz < 23.0 dB

(5) VSS Cable

Electrical Requirements:

Capacitance	68 pF/m max.
Characteristic impedance	75 ± 3 Ω
Relative propagation velocity	at least 66 %
Longitudinal loss at 100 m	10 MHz < 2.0 dB
	100 MHz < 6.2 dB
	500 MHz < 11.0 dB
	1000 MHz < 22.0 dB

(xii) Communication and Data Transmission Cables

(1) Screening

- Screening shall be achieved by the use of laminated tape, consisting of an aluminium foil bonded to a polyester film for strength, applied to the cable with an overlap so that full 100 % coverage of the conductors is afforded (Note : spray on types of construction are not acceptable).
- A drain wire or continuity conductor, laid under and in contact with the

aluminium foil shall be provided and shall be in accordance with BS 5308 clauses 7 and 10 as appropriate.

- The tinned annealed copper conductor, which may be of solid or stranded construction, in keeping with current manufacturing techniques, shall have a minimum cross-sectional area of 0.5 mm2.
- The maximum resistance of the drain wire or continuity conductor provided shall meet with the requirements of BS 6360(if not applicable, replacement by BS EN 60228:2005 is acceptable).
- Individual shield of twisted pairs coverage shall be greater than 90%.

(2) The twisting arrangement shall be no less than 12 twists per meter.

(3) Electrical Requirements:

Impedance characteristic	120 Ω±10%
Attenuation	< 15 dB/km
Distributed capacitance	46 pF/m
Capacitive unbalance to shield	< 1.5 pF/m at 1.0 BR
Crosstalk rejection	> 55 dB (if 2 pairs in the same cable)

(c) Upholstered Seat Faces

(i) Flame Retardancy

(1) The surfaces of both the upholstered seat cushion (base) and seat squab (back) shall be treated as for general surfaces within the car. Where the surfaces are very similar or identical it is not required to perform two tests.

(2) The selected test methods are limited to certain thicknesses of sample. The test piece shall consist of the surface of the seat to the greatest depth conveniently tolerated by the test method and shall be closely representative of the real seat.

(ii) Smoke Emission

This is item specific. The test method used shall be BS 6853 Appendix B5.3. The test shall be carried out on the fully upholstered seat. As an alternative, testing of the material to the NFPA 130 standard is acceptable.

(iii) Toxic Fume Emission

Data shall be supplied on the loose covers (in isolation) and on the foam core, using the normal NF X 70 100 test protocol (if not applicable, replacement of NF X 70-100-1 and NF X 70-100-2 is acceptable) or alternative method approved by the Engineer but with the data being augmented by measuring nitrogen dioxide. For the NF X 70 100 method, the data shall be converted to a gm 2 basis and the contribution from the various layers summed. In the event of a contravention of the requirements occurring, any unrealistically high values will be reviewed by the Engineer who may allow an adjustment made based on an effective depth of surface available. Any adjustment will be made

on the basis of the results of observations made, particularly in the smoke emission test and on the nature of the design.

(iv) Seat Shell Back & Seat Base

(1) Flame Retardancy. These surfaces shall be treated exactly as for the equivalently orientated surfaces.

(2) Smoke Emission. These surfaces shall be treated exactly as for the equivalently orientated surfaces.

(3) Toxic Fume Emission. These surfaces shall be treated exactly as for the equivalently orientated surfaces.

(v) Minor Materials

(1) Flame Retardancy. These materials shall be subjected to testing by BS 6853 Method A, thereby determining the Flammability Temperature Index (FTI). If the material is unsuitable for testing by this method; e.g. a thermo-plastic which is mobile at temperature, then recourse shall be made to the Limiting Oxygen Index (LOI) method BS 2782 : Part 1 : Method 141. As an alternative, testing of the material to the NFPA 130 standard is acceptable.

(2) Smoke Emission. The materials shall be tested to BS 6853 Appendix B5.1 using an open fine wire mesh support. If the material or item is unsuitable for testing with this support; e.g. a thermo-plastic which is mobile at temperature, then recourse shall be made to a copper foil tray support. As an alternative, testing of the material to the NFPA 130 standard is acceptable.

(3) Toxic Fume Emission. The method used shall be NF X 70 100 (if not applicable, replacement of NF X 70-100-1 and NF X 70-100-2 is acceptable) augmented by the inclusion of nitrogen oxides expressed as nitrogen dioxide. A weighted summation shall be carried out. An alternative method approved by the Engineer may also be used.

21.10.7. Testing Requirements (when using alternative to NFPA 130)

(a) Surfaces

Property	Location Int/Ext	Orientation HS/V/HP	Method	Requirement
Flammability	Int	HS	BS 476 Pt7	Class 2
		V	BS 476 Pt6 BS 476 Pt7	i_1<6, I<12 Class 1
		HP	BS 476 Pt6 BS 476 Pt7	i_1<6, I<12 Class 1 Nil spread
	Ext	HS	BS 476 Pt7	Class 2
		V & HP	BS 476 Pt6 BS 476 Pt7	i_1<6, I<12 Class 1

Smoke	Int	HS	BS 6853 B5.4	Ao<300
		V & HP	BS 6853 B5.2	Ao(ON)<2.4 Ao(OFF)<3.6
	Ext	HS	BS 6853 B5.4	Ao<600
		V & HP	BS 6853 B5.2	Ao(ON)<4.8 Ao(OFF)<7.2
Toxic Fume	Int	HS	NF X 70-100*	R<5

		V & HP	NF X 70-100*	R<1
	Ext	HS	NF X 70-100*	R<10
		V & HP	NF X 70-100*	R<2

* If not applicable, replacement of NF X 70-100-1 and NF X 70-100-2 is acceptable.

The reference levels for calculating the weighted summation ratio are given below.

Reference Levels (gm -2)	
CO_2	22000
CO	420
HCl	36
HBr	41
HCN	13
HF	4
SO_2	62
NO_2	48

(b) Cables

(i) As a minimum requirement, the Contractor shall carry out relevant tests as specified below on all cables to demonstrate their compliance with the requirements stipulated in this Section of PS or as stated in American Association of Railroads "AAR RP-585 – Wiring and Cabling Specification Recommended Practice".

(ii) Physical and Chemical Performance

- The Contractor shall carry out all the relevant tests as listed in BS 6469 and IEC 811, such as, the resistance to heat, resistance to mineral oil and resistance to ozone, for all types of cable sheaths and insulations to be used to demonstrate the physical and chemical properties.
- Resistance to Acids and Alkalis. The cable sample shall be immersed

in accordance with NF C 32-021 in acid and alkali baths for 168 ± 1 hours at 23 ± 2 oC, after which the mechanical characteristics shall be determined. Tubular samples shall be immersed with their ends protruding. The acid and alkali baths shall be the normal solution of hydrochloric acid and sodium hydroxide respectively. After immersion, measurement of the mechanical characteristics shall be repeated and the variation in stress at 50% elongation from the unaged samples shall not exceed 25%.

(iii) Conductor. All the tests as specified in BS 6360 (if not applicable,

replacement by BS EN 60228:2005 is acceptable), including elongation test and electrical resistance test, shall be carried out.

(vi) Mechanical Characteristics

The Contractor shall carry out appropriate tests for all types of cables to be used to demonstrate the compliance with the associated mechanical properties. As a minimum requirement, the cables shall be successfully tested to the following tests for mechanical characteristics:

(1) Adherence of Cores of Multicore Cables. The individual cores of multicore cables shall have sufficient cohesion to form a closely bonded assembly, but with adhesion presenting any difficulties in separating the cores in use. This shall be checked by taking a length of cable approximately half the length of twist of the outer core layer, and removing the sheath and any separators. This assembly shall be allowed to fall from a height of 500mm onto a horizontal rigid surface, when the cores and any fillers shall separate on impact.

(2) Resistance to Cutting. This test shall be carried out on finished cable samples of 500mm length in accordance with NF C 93-522, however the increase in load shall be obtained by moving the knife at 5 ± 1 mm/min, and shall be carried out at tow temperatures, 20 ± 5ºC and 90 ± 5ºC. The value of the load required to produce electrical continuity between the knife and the conductor shall exceed the following values:

For conductor sections up to 35mm	120N at 20 C	20N at 90 C
For conductor sections over 35mm	500N at 20 C	100N at 90 C

(3) Resistance to Abrasion

- For the test of abrasion resistance of insulation and sheath, the abrasion blade (refer to testing blade A as shown on the figure below) shall be applied with a force of 10N for cables of cross sections of 1.5 to 35mm2. The abrasion blade shall be applied with a force of 20N for cables of cross sections in excess of 35mm2.
- A testing weight of at least 200g shall be provided to the steel wire abrasion blade (refer to testing blade B as shown the figure below) for the test of abrasion resistance of marking.

Test arrangement for abrasion resistance of insulation and sheath and indelibility of marking

- For test of abrasion resistance of insulation and sheath, an electrical circuit with 50VDC and 0.05ADC supply shall be provided. Such that when the abrasion blade has penetrated the insulation or sheath of the cable sample and contacted with the cable conductor, the test equipment including the stroke counter shall be switched off automatically.
- A hardened tungsten carbide blade shall be mounted perpendicularly to the axis of the cable sample as shown on the figure above. This testing blade shall be rubbed over the cable sample with an amplitude of oscillation of 10 to 20 mm with a frequency of 50 ± 5 cycles per minute.
- The sample shall be securely clamped and shall undergo four tests at each of two temperatures of 20 and 90ºC.
- After each test, the sample shall be moved 100mm and rotated through 90º. Each test is complete when the abrasion blade has contacted the conductor of the cable sample.
- The test requirement is the arithmetic mean of the four tests and the number of cycles to failure shall be greater than the following:
- Abrasion resistance of marking. Test method which is similar to the test of abrasion resistance of insulation and sheath, shall be provided for test of abrasion resistance of marking, except that only three tests shall be made and the test result shall be after the three tests, no continuous strip shall be visible on the marking for at least 150 double-strokes.

- Notch Propagation. The cable shall be notched to a depth of a third of the sheath thickness around its circumference. It shall be coiled round and

secured to a mandrel of diameter six times the external diameter of the sample, such that two coils are on each side of the notch. This assembly shall be subjected to the following temperatures for four hours each:

- 25 +0/-5 ºC
- 20 ± 5ºC
- 90 ± 5ºC
- At the end of the test, the assembly shall be removed from the oven, and allowed to attain ambient temperature before being subjected to the voltage strength at a voltage of three times the rated voltage plus 500V or 8kV, whichever is the greater, for a period of 1 minute. No breakdown shall occur in this test.

(v) Electrical Characteristics

(1) Transverse Dielectric Strength

- A sample shall be fully immersed, except for the ends which shall protrude by about 150 mm, in water at 20 ± 5ºC for 24 hours. With the sample still immersed, a sinusoidal alternating voltage with frequency between 49 and 61 Hz of the specified value shall be applied to the cable for 5 minutes.
- The test voltages are :
- 1500 V rms for 250 V rated control cables;
- 2500 V rms for 500 V rated single core cables;
- 6000 V rms for 1500 V rated single core cables;
- 5000 V rms between conductors for 500 V rated multicore cables.
- The cable under test shall withstand the test voltage without breakdown or perforation.

(2) Transverse Disruptive Voltage

With the test set up, the applied voltage is increased in 2 kV steps every minute until breakdown occurs. Breakdown shall occur above the following values :

- 5000 V rms for 250 V rated control cables;

- 6000 V rms for 500 V rated single core cables;
- 15000 V rms for 1500 V rated single core cables;
- 12000 V rms for 500 V rated multicore cables.

(3) Longitudinal Dielectric Strength

- A 320 mm sample shall have two annular electrodes attached. These shall consist of copper wire which shall wrapped around the centre part of the sample with their internal windings about 50 mm from each other. The resultant assembly shall be immersed in water at 20±5ºC for four hours with a length of 50 mm at each end being left out of the water. Then, the

assembly shall be removed from the water, and the surface dried with lint free filter paper. The assembly shall then be subjected to an A.C. voltage as specified below with a frequency of 49 to 61 Hz applied between the electrodes. The leakage current between the two electrodes shall be measured after 10 seconds loading, and shall be less than 1 mA.

- The voltage shall then be raised uniformly at a maximum rate of 100 V per second until flashover occurs. The flashover voltage shall not be less than the values specified below.

	Test voltage	**Flashover voltage**
Control cables	1500 V	5 kV
Power cables	2000 V	10 kV

(4) Stability of Insulation

A five metre sample shall be dipped into an solution of sodium chloride at about 10 g/l, maintained at 60 ± 2ºC for 150 ± 1 hours, with a length of about 250 mm at each end being left out of the solution. Throughout the duration of the test, a direct current supply is connected to the cable. The test voltage shall be:

- 750 V for 250 V rated control cables;
- 1000 V for 500 V rated cables;
- 2500 V for 1500 V rated cables.

The cable shall withstand the test voltage with breakdown.

(5) Insulation Resistance

$$K = \frac{R}{\log D}$$

Immediately following the voltage strength test, the insulation resistance at ambient temperature shall be measured. The test shall also be carried out at high temperature, for which a five metre sample shall be immersed for two hours in water at 60 ± 2ºC, with the exception of the ends which shall protrude by about 100 mm. The value of insulation resistance in MΩ/km shall be used to calculate the coefficient K, from the following formula :

where R is the measured insulation resistance

D is the mean outer diameter of cable

d is the mean diameter of conductor

The minimum values of K shall be :

Small Scale Qualification	Requirements
BS 6853 App A - Flammability Temperature Index (FTI)	The cable sheath tested in isolation shall achieve an FTI greater than 280ºC when tested at the thickness used on the cable.

	20°C	60°C
Control cables	5000	50
Power cables	500	10

(6) Test for Dimensional Change

A 320 mm sample shall be placed in an oven for 16 hours at 125 ± 2ºC. The sample shall then be removed and allowed to cool to ambient temperature. After cooling, measurements shall be taken of any extension or retraction of the covering. The maximum retraction shall be 3 mm and the maximum extension shall be 6 mm.

(7) Fire Specification (as alternative to NFPA 130)

- In respect of flame retardancy, cables shall be qualified by suitable performance in three small scale tests. These are, a flammability test on the sheath, a flammability test on the cable and a parameter (related to rate of reaction to fire) derived from the smoke emission test. In the event of failure in any of these tests qualification may be attempted by resort to a larger scale test.
- In respect of smoke emission, cables shall be qualified by resort to a test on the complete cable.
- In respect of toxic fume emission cables shall be qualified by resort to a test on the sheath.
- Flammability:

BS 4066 Pt 1/Pt 2 (or BS EN 60332-1-1-2004 and BS EN 60332-2-1-2004)	When tested to the appropriate part the cable shall pass the requirements.
BS 6853 B5.5	In this test (carried out for smoke emission purposes) the gradient in units of (abs) m² "burn length"-1 min-1 of the smoke emission vs time curve (Ao vs t) shall not exceed, over any one minute interval in the flame (ON) period, the greater of 0.05Ao(ON) {as specified} or
Large Scale Qualification	

BS 4066 Pt3 (or BS EN 50266-1, BS EN 50266-2-1, BS EN 50266-2-2, BS EN 50266-2-3, BS EN 50266-2-4, BS EN 50266-2-5)	With approval this test may be resorted to if, in the event of a failure in any of the above tests, qualification is still sought. The equipment and pass/fail criteria of the above method retained by the test piece array is varied. "Bundles" of cables shall be prepared as described for the smoke emission testing (see below) and tested as a single layer with alternate "bundles" missing; i.e. with spaces between the "bundles" equal to the "bundle" diameter. The width of the test array shall exceed 250 mm.

- Smoke Emission (refer to BS 6853 Clause B5.5):
  - The chamber and fire source shall be as defined in the above

standard. The cable array used in the test shall be prepared by combining "bundles" of cable "strands" in a flat array. The number of "strands" within a "bundle" shall be calculated from the specified cable diameter ("d" mm) as given below. If no diameter is specified the value used shall be the actual diameter of the cable. (In some cases the "bundle" will consist of only 1 "strand").

- The number of "strands" in a "bundle" is given by $3a^2+3a+1$ where "a" is the integer part of (d+9)/2d. The "strands" in a "bundle" shall be arranged in a close packed hexagonal array which must be precise for 19 "strands" and below but may be notional from 37 "strands" and above. The "bundle" shall be formed by twisting the "strands" such that the lay length of the "bundle" (i.e. the length of the helix repeat unit) shall be between 12 and 18 times the nominal "bundle" diameter. The nominal bundle diameter is d(a+1). The central "strand" of any "bundle" shall not be twisted; i.e. single "strands" shall be straight.
- The cable array used in the test shall consist of the minimum number of "bundles" (N) required to give a test array width in excess of 45 mm based on the nominal "bundle" diameter. Thus Nd(a+1) shall exceed 45 mm.
- The maximum allowable values for Ao(ON) and Ao(OFF) are given by the following expressions where the "angle" calculated is given in degrees. (The expressions are a numerical convenience only and nothing more fundamental should be inferred from their form.)
- Ao(ON) = (tan-1(d/45))/45 - (tan-1(d))/2025
- Ao(OFF) = 1.5Ao(ON)

• Toxic Fume Emission (refer to NF X 70-100 (if not applicable, replacement of NF X 70-100-1 and NF X 70-100-2 is acceptable) or alternate method, such as, Boeing BSS 7239 toxicity standard, as approved by the Engineer):

- This shall be carried out on the sheathing material and in addition to the species normally quantified in the test, a value for the emission of nitrogen oxides (expressed as nitrogen dioxide) shall be determined. The emissions shall be determined in the usual units of mg of species per g of material. The values thus determined shall be weighted using the reference values given below. The summation of these weighted ratios shall be less than 1.

Reference Values (mgg 1)	
CO2	22000
CO	420
HCl	36

HBr	41
HCN	13
HF	4

SO2	62
NO2	48

- The specific test conditions and acceptance criteria of the above tests shall be submitted for approval and the test results shall be submitted to certify the compliance with these requirements.

(c) Seats (alternative test methods to NFPA 130 and Boeing BSS 7239 toxicity standard)

Property	Part Shell/Trim	Orientation Back/Base	Method	Requirement
Flammability	Shell/Trim	Back	BS 476 Pt6 BS 476 Pt7	i_1<6, I<12 Class 1
	Shell	Base	BS 476 Pt6 BS 476 Pt7	i_1<6, I<12 Class 1
	Trim	Base	BS 476 Pt7	Class 2
Smoke	Trim	Full Seat	BS 6853 B5.3	Ao<10
	Shell	Back/Base	BS 6853 B5.2	Ao(ON)<4.8 Ao(OFF)<7.2
Toxic Fume	Trim	Back	NF X 70-100*	R<3
		Base	NF X 70-100*	R<5
	Shell	Back/Base	NF X 70-100*	R<2

* If not applicable, replacement of NF X 70-100-1 and NF X 70-100-2 is acceptable.

It should be recalled that the toxic fume weighted summation ratio for the seat trim (back and base) shall be made on the basis of adding the contributions from the various layers.

(iv) Minor Materials (alternative test methods to NFPA 130 and Boeing BSS 7239 toxicity standard)

Property	Location Int/Ext	Method	Requirement
Flammability	Int/Ext	BS 6853 A	FTI>350
		else	else

Smoke	Int	BS 6853 B5.1	Ao<0.025
	Ext	BS 6853 B5.1	Ao<0.05
Toxic Fume	Int	NF X 70-100*	R<1
	Ext	NF X 70-100*	R<2

* If not applicable, replacement of NF X 70-100-1 and NF X 70-100-2 is acceptable.

-1

The reference levels for calculating the weighted summation ratio are given below.

Reference Levels (mgg)	
CO_2	22000
CO	420
HCl	36
HBr	41
HCN	13
HF	4

21.10.8. Fire Engineering Life Cycle

(a) SEMP Stage 1

The Contractor shall prepare and submit a Fire Engineering Plan as part of SEMS (refer to PS 21.2.3 and PS 21.10) for approval. The plan shall include, but not be limited to, the following:

(1) The name and credentials of the Contractor's fire specialist.

(2) Detail statement of the role and responsibility of fire specialist.

(3) Methodology to be adopted for prediction the power output from fire flash over.

(4) Development of a schedule of non-metallic materials used in the construction of the train to identify the following, but not be limited to:

- type and description of material
- quantity

- location and orientation
- test to be required
- certification
- fire load

(5) Development of a fire load schedule for the train.

(6) Preliminary identification of potential fire hazard area.

(7) Formulation of relevant fire specifications for Subcontractors in order to achieve final fire performance requirements.

(8) Preliminary predictions for power output with description of the prediction method and how the predictions were carried out, including all assumptions made.

(9) Preliminary calculations of the fire load schedule for the train together with the fire load density.

(1 0) Provision for revised predictions and fire load schedule as further information becomes available during subsequent SEMP stages.

(1 1) The Contractor shall submit a conceptual cable schedule to demonstrate the correct understanding and specification of the requirements specified in this Section of PS.

(b) SEMP Stage 2

(1) The Contractor shall submit detailed predictions on fire power output and calculations of the fire load schedule hence the fire load density based on the chosen materials.

(2) The Contractor shall evaluate the fire load reduction measures subsequent to exceeding of permitted fire load as specified in PS 20.

(3) The Contractor shall submit all certification of readily tested materials for approval.

(4) Upon the completion of the design development of the individual sub-system, the Contractor shall submit a detailed cable schedule to demonstrate the correct applications of cables for each sub-system.

(c) SEMP Stage 3

(1) The Contractor shall carry out all necessary fire test using representative production material to verify and validate the design.

(2) The Contractor shall submit a revised fire prediction based on the test results. The predictions shall include details of :

- Details of any changes from the previous predictions with detailed explanations.
- Fire specifications contracted by the manufacturers of material with details of any deviations form the original specifications.
- Evaluation of any areas of risk with proposed contingency measures for these areas

- Details of any areas of development required to achieve the specifications, together with development plans for these areas.

(3) The Contractor shall submit all certification of tested materials for approval.

(4) According to the results of design verification and validation of the individual sub-system, the Contractor shall revise cable schedule, if necessary, to update the final selections of cables for each sub-system.

(d) SEMP Stage 4

(1) The Contractor shall submit revised predictions on fire power output and calculations of the fire load schedule hence the fire load density subsequent to development of engineering, manufacture, production and installation.

(2) The Contractor shall provide detail explanation/justification of any deviations form the previous predictions or calculations.

(3) The Contractor shall propose details of any remedial measures which are necessary, together with plans for implementation of these measures.

(4) A test plan shall be submitted to detail the testing methodology and programme of each cable testing activities. The Contractor shall carry out all the tests as listed in the approved test plan accordingly.

(e) SEMP Stage 5

(1) The Contractor shall perform and submit final assessment/ calculations to confirm the predicted fire power output, fire load schedule and fire load density of the completed vehicles and trains.

(2) The Contractor shall submit all test and inspection reports for approval.

21.11 Trade-Off Studies

21.11.1. The Contractor shall conduct trade-off studies at each stage of SEMP when

deviating from the baseline to select the configuration that best satisfies the project requirements, such as performance, life cycle cost considerations, schedule, safety, reliability and maintainability.

21.11.2. The Contractor shall develop a Value System and a Sensivity Analysis to aid him in the selection of the best options for the project.

21.11.3. The Contractor shall establish a value system upon which the selection of the configuration that best satisfies project requirements, can be made. These selection criteria shall include:

(a) Mandatory requirements to be met before it can be given further consideration;

(b) Attributes which are not mission limits; and

(c) System attributes shall be weighed and the weights agreed upon with the Engineer.

21.11.4. Sensitivity Analysis

Where necessary or agreed with the Engineer, the Contractor shall conduct a sensitivity analysis to determine the sensitivity of a decision to the change in the value of attributes or system parameters and/or value system.

21.11.5. Trade-off Study Reports

(a) The Contractor shall document all trade-off studies as part of the monthly SEMS reports (refer to PS 21.3.11) that:

(i) Describe alternative candidates; and

(i i) Provide justification for the selection.

(b) These reports shall be traceable under the Configuration Control Program (refer to PS 21.3.14) to the:

(i) Requirement from which they originate; and

(i i) The new requirement imposed on the system, resulting from the trade-off study.

21.12 System Synthesis

Once the Level 1 Design Document i.e. the SRD (refer to PS 21.3.8) is prepared, the Synthesis process shall be initiated to define system elements and to refine and integrate these elements into a physical architecture.

21.12.1. As part of the Synthesis process, the functional architecture is provided to clarify and bound the system.

21.12.2. The Contractor shall document, in a suitable form agreed upon with the Engineer, a set of schematic diagrams, physical and mathematical models, computer simulations, layouts, detailed drawings and similar engineering graphics, the performance, configuration and arrangement of the chosen system and its elements and the technique for their test, support and operation.

21.12.3. These documents shall illustrate intra- and inter-system and item interfaces, permit traceability between the elements at various levels of the system detail, and provide means for complete and comprehensive change control. The documentation shall also include the following items:

(a) The Configuration Identification List (PS 21.13);

(b) Interface Management Control Plan (refer to PS 21.2.6);

(c) Dependent elements in the DDSP (refer to PS 21.3.7).

21.12.4. The system schematic block diagram and envelope drawings shall be given engineering drawing numbers and shall be maintained by the Contractor throughout the life of the project. These drawings shall form part of the baseline configuration and shall be placed under Configuration Control Program (refer to PS 21.13).

21.12.5. Interface Management

(a) The objective of the Interface Management is to achieve functional and physical compatibility between all interrelated system elements, the Contractor shall carry out interface management to ensure that the various internal system pieces are coordinated as well as integrated with external systems. As the total system is decomposed via iterative interaction of Functional Analysis, Requirements Management, and Synthesis, physical and functional interfaces are identified and managed.

(b) For the purpose of the Interface Management, considering the train as a system, an interface shall be defined as any boundary between one system and another. It may be external, internal, functional, or physical. Interfaces occur within the system (internal) as well as between the instant system and another system (external) and may be functional or physical (e.g., mechanical, electrical) in nature. The Contractor shall identify all internal and external interface requirements and document them as part of the Level 2 Design Document i.e. SSD (refer to PS 21.3.8). By SEMP 5, the Contractor shall submit a Interface Control Document (ICD) or a set of drawings which shall be a controlled document that describes the detailed as-built implementation of the interface requirements.

(c) The Contractor shall submit an Interface Management Control Plan which shall form part of the SEMP (refer to PS 21.3) to describe the management process. This plan provides the means to identify and resolve interface incompatibilities and to determine the impact of interface design changes.

21.13 Configuration Management

21.13.1. Policies

(a) The Contractor shall use the initial contracted baseline as the point of departure for configuration and change management.

(b) The Configuration Management shall establish and maintain consistency of a product's performance, functional, and physical attributes with its requirements, design, and operational information throughout its life.

(c) The Configuration Management shall be an orderly identification, documentation, and maintenance of a product's functional performance and physical attributes. The tasks are focused on consistency of requirements, design, and operational information throughout the product’s life.

(d) The Configuration Management shall be able to:

(i) Define material both functionally and physically by drawings, specifications and related documentation identifying the configuration to the lowest level required to assure repeatable performance.

(i i) Perform the technical and administrative functions of identifying, recording, controlling and reporting the functional and physical characteristics of material during its life cycle.

(iii) Allow the maximum degree of design and development latitude, yet to introduce at the appropriate time the degree and depth of configuration control necessary for production, interoperability and logistic support.

(i v) Ensure that the configuration of Configuration Items (refer to PS 21.13.2) is known and the pertinent functional and physical interfaces between systems, equipments and software are established, controlled and recorded throughout their life cycle.

(v) To ensure that specifications, engineering drawings, software documentation and the related technical data are adequate to facilitate the Configuration Control Program (refer to PS 21.14).

(e) Once baselined design is generated, changes are systematically proposed for approval and managed to ensure that traceability/accountability is maintained throughout myriad levels of documentation. The scope of this process element begins with planning the Configuration Management Control Program (refer to PS 21.14) for the context and environment in which it is to be performed.

(f) Throughout the whole project life cycle, a status check on the entire

Configuration Management shall be provided to deliver accurate and timely information concerning the product and its associated design data. This status report shall form part of the monthly SEMS report (refer to PS 21.3.11).

(g) Support tasks within Configuration Management shall include developing training plans, defining performance-based management measurements, and assessing methods and trends to effect process improvements.

21.13.2. Configuration Items

(a) The Configuration Items shall be an aggregation of the approved hardware, firmware, software, or any of its discrete portions, which satisfies an end use function and is designated for configuration management.

(b) Configuration Items may vary widely in complexity, size and type, from a system, assembly or component to a test meter.

(c) During development and manufacture of the initial production configuration, Configuration Items are those items whose performance parameters and physical characteristics must be separately specified and controlled to provide the management insight needed to achieve the overall end use function and performance.

(d) For the microprocessor based system, the Configuration Items shall include, but not limit to, (a) software version of the source code and (b) software parameter version of the operating parameter (refer to PS 32.3.12). It is a requirement that any change in the software of the microprocessor based equipment, both software version and software parameter version shall be automatically updated by the affected microprocessor and displayed on the TIMS under Maintenance Mode (refer to PS 10.2.1(b)(v)) and the associated special tool (refer to PS 24.3.2) whenever the equipment is re-initialised.

21.13.3. As an integral part of the SEMP, the Contractor shall submit a pertinent issue of Configuration Identification List which is the summary of all approved Configuration Items at the end of each stage of SEMP. The Configuration Identification List shall also form part of the SEMS Report (refer to PS 21.3.7).

21.13.4. The Contractor shall ensure that the current approved Configuration Documentation is available when needed.

21.14 Configuration Control Program

21.14.1. Policies

(a) Throughout the entire project lifecycle, the Contractor shall initiate Configuration Control Program to:

(i) Attain maximum efficiency in the management of engineering changes by ensuring that Engineering Change Proposals are justified, processed and evaluated promptly and, when approved, are implemented using approved procedures.

(ii) Ensure that total performance, cost effect and the effect of Engineering Change Proposals, concessions and production permits on the project are known at the time of their approval.

(b) As part of the SEMP, the Contractor shall submit a Configuration Control Program for preparing and submitting Engineering Change Proposals and related information.

(c) The proposed engineering changes require a complete analysis of the impact of the proposed engineering change.

(d) This Section of the PS delineates configuration control requirements and provides instructions for preparing and submitting proposed engineering changes (which is an alteration in the approved Configuration Identification List of a Configuration Item under development, delivered or to be delivered) and related information. Such changes require a complete analysis of the impact if the engineering change described by an Engineering Change Proposal (which is a proposed engineering change and the documentation by which the change is described, justified, and submitted for approval) were implemented.

(e) The data package submitted with an Engineering Change Proposal shall contain a description of all known interface effects and information concerning changes required in the approved Configuration Identification List.

(f) The configuration control requirements as stipulated in this Section of PS shall be imposed on both the contractor and Subcontractors.

(g) This Section of PS covers requirements for submission of the above Engineering Change Proposal and Specification Change Notice. The Specification Change Notice is a document used to propose, transmit and record changes to a specification. In proposed form prior to approval, the Specification Change Notice supplies proposed changes in the text of each page affected. In final approved form, the Specification Change Notice summarizes the approved changes to the text of each page affected.

21.14.2. Scope. This Section of the PS establishes the requirements, formats, and procedures to be utilized in the preparation of configuration control documentations. Included are requirements for:

(a) maintaining configuration control of Configuration Items, both hardware and software;

(b) preparing and submitting Engineering Change Proposal and Specification Change Notice.

21.14.3. Intended Use. This Section of the PS shall be used by the Contractor and the Engineer activities to:

(a) Establish and maintain effective configuration control of the approved Configuration Identification List;

(b) Propose engineering change to the approved Configuration Items, both hardware and software which are designed, developed or modified for meeting the Contract requirements;

(c) Prepare Specification Change Notice; and

(d) Control the form, fit and function of in-house developed items used in Configuration Items, including proprietary and non developmental items. Non developmental items are existing developed and available hardware or software that are capable of fulfilling the specified performance requirements, thereby minimizing or eliminating the need for costly research and development programs. A Non Developmental Item is usually an off the shelf or commercial type product, but may also include hardware or software already developed by or for the rolling stock applications.

21.14.4. Engineering Change Proposal

(a) Application

Configuration control requirements established by this Section of the PS apply only to the Configuration Identification List which has been approved.

(b) Classification

An engineering change shall be classified as Class I or Class II by the originator in accordance with the following definitions:

(i) Class I Engineering Change

A proposed engineering change to a Configuration Item shall be determined to be Class I by examining whether the required performance would be impacted as a result of implementing the change.

(ii) Class II Engineering Change

A Class II engineering change identifies a minor change to a Configuration Item or its documentation that can be affected entirely by the Contractor within the scope of the Contract effort without changing the approved Configuration Identification List. Class II changes are also applicable during production and are normally identified and processed to correct documentation errors or to enhance Contractor productivity without detriment to the Engineer.

Class 1 Engineering Change Proposals shall be submitted for approval. Class II changes shall be submitted for information.

(c) Procedures

The steps for preparing and processing an engineering change consist of the following:

(i) determination of a need for the change;

(i i) establishment by the originator of a classification of the engineering change as Class I or Class II as agreed by the Engineer;

(i i i) preparation of an Engineering Change Proposal;

(i v) submission to the Engineer;

(v) review;

(v i) approval by the Engineer;

(v i i) incorporation of approved Engineering Change in the Configuration Item and in the Configuration Identification List;

(viii) status accounting;

(ix) verification of change accomplishment; and

(x) distribution of documentation change.

(d) Preparation of Engineering Change Proposal

Although the Engineering Change Proposal originator can be either the Engineer or the Contractor, all formal Engineering Change Proposal shall be prepared by the Contractor.

(e) Supporting Data

All Engineering Change Proposal shall be supported by drawings and other data if required to justify and describe the change and to determine its total impact including assessments of changes to system operational characteristics. Any testing done by the Contractor to validate concepts or new technology to be employed in the proposed engineering change should be presented if such test data is vital to the decision regarding acceptance of the change.

(f) Submission of Engineering Change Proposal

To facilitate preparation and submission of Engineering Change Proposal, the Contractor may use automated processing techniques provided all essential and applicable data elements are addressed sequentially. Where facilities exist, electronic transfer should be considered to expedite processing. The Contractor shall not implement any class of proposed engineering change until it is approved.

(g) Revisions of Engineering Change Proposal

With an agreement of the Engineer, an Engineering Change Proposal shall be revised when major alterations or changes to the initial Engineering Change Proposal are necessary in order to describe the proposed change.

(h) Amendments to Engineering Change Proposal

With an agreement of the Engineer, an amendment shall be provided to clarify, correct, add to, delete from or make other minor changes to a submitted or previously amended Engineering Change Proposal. Amendments to an Engineering Change Proposal shall explicitly state the change to the previous document.

21.14.5. Specification Change Notice

(a) Application

A Specification Change Notice shall be prepared to propose a change to a specification that is affected by an Engineering Change Proposal and the specification is one that is maintained by the Engineering Change Proposal originator. Or when authorized, a Specification Change Notice shall be used to update a specification, unrelated to an Engineering Change Proposal or design change. Errors of a minor nature (such as typographical errors and punctuation.) normally shall not be corrected, except as an incidental part of the next technically required Engineering Change Proposal and accompanying proposed Specification Change Notice.

(b) Purpose

The Specification Change Notice is a document used to propose, transmit, and record changes to a specification. The Specification Change Notice is used as a cover sheet and may serve as a letter of transmittal; the page changes associated with that Specification Change Notice shall be attached and shall constitute an integral part of the Specification Change Notice.

(c) Proposed Specification Change Notice

(i) A proposed Specification Change Notice shall be used to propose to the specification approving activity the exact change in specification paragraphs, figures or other content that will be distributed to users if the Engineering Change Proposal is approved. The proposed modification in content submitted with the proposed Specification Change Notice may be in the form of specification change pages or as an enclosure on which the proposed changes in sentences, paragraphs, figures and tables, are described.

(ii) The Contractor shall not implement any change in the specification until the proposed Specification Change Notice is Approved.

(d) Approved Specification Change Notice

With an agreement of the Engineer, an approved Specification Change Notice shall be issued to all parties concerned to implement and record the required specification change. It shall also provide a summary listing of pages affected by all previously approved changes. Specification Change Notice is not cumulative insofar as transmittal of change pages from previous change is concerned, and changes distributed with previous Specification Change Notice remain in effect unless changed or cancelled by an Specification Change Notice of later issue. However, the summary of current changes is a cumulative summary as of the date of approval of the latest Specification Change Notice.

(e) Changed pages

Updated and reissued pages shall be complete reprints of pages suitable for incorporation by removal of old pages and insertion of new pages. All portions affected by the change shall be indicated by a symbol in the right hand margin adjacent to the change and encompassing all changed portions. When changed pages are issued for specifications with pages printed on both sides of a sheet, and only the page on one side of a sheet is affected by the change, both sides of the sheet shall be reissued. The unchanged side shall be reprinted without change and shall not carry the date of the change or be included in the change summary as being affected by the change.

(f) Supersession

When a proposed Specification Change Notice must be revised and resubmitted, the resubmitted Specification Change Notice shall retain the same basic Specification Change Notice number but must be re identified as a revision to avoid confusion with the original submission.

SECTION 22 TESTING REQUIREMENTS 2

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Section 22 Testing Requirements

22.1 General Requirements

22.1.1. The fitness for purpose of all Works and items of equipment shall be demonstrated by a combination of tests/inspections including Pre-delivery Tests a.k.a. Works Tests (refer to PS 22.9), Post-delivery Tests which include: Commissioning Tests in CITY (refer to PS 22.10), Tests on Completion (refer to PS 22.11) and Integrated Testing (refer to PS 22.12) during the SEMP stage 5 (refer to PS 21.3.4). These tests/inspections shall be performed at the Contractor's works, or other agreed venue, or as considered relevant. Detailed requirements of the above tests/inspections shall comply with the Tables App-B-1 to App-B-4 in Appendix B.

22.1.2. A Preliminary Testing Plan shall be provided and submitted for approval by the end of SEMP stage 2. The Preliminary Testing Plan shall include the following items:

(a) Identify the testing requirements for all stages of tests specified in PS 22.1.1.

(b) Identify the Contractor's representative who will be the overall in charge of the testing and commissioning phases.

(c) Provide a preliminary testing programme which shall include staff resources. This programme shall be able to demonstrate that all tests shall be achievable taking into account of time-scales, man-power constrains with regards to the proposed testing work patterns.

(d) Identify any testing instructions and specifications that may be required.

(e) Take into account of any training needs.

(f) Define the limits of the testing, particularly the responsibilities and interfaces.

(g) Highlight the site transport and accommodation requirements for both system/equipment under test and testing staff.

(h) Ensure that occupational safety considerations are adequately addressed.

(i) Define the style and length of tests, commissioning and possessions of the Commission's track.

(j) Identify the required test and communication equipment, such as test instruments, special tools and portable radios.

22.1.3. A Testing Plan shall be provided and submitted for approval by the end of SEMP stage 3 and the Preliminary Testing Plan specified in PS 22.1.2 shall be used as the baseline of the Testing Plan. The Testing Plan shall include the following items:

(a) Confirm all items specified in the Preliminary Testing Plan are fully covered.

(b) Give a full description of the work and the associated testing.

(c) Establish a firm testing programme, including the proposed commissioning dates.

(d) Define the limits of capabilities and responsibilities for each sections of system, sub-systems and components under test.

(e) Define the interfaces with other systems and disciplines.

(f) Specify the staff resources and competency requirements.

(g) Confirm training requirements.

(h) Identify occupational safety requirements.

(i) List all documentation to be used, including testing instructions, codes of practice and testing specification. The submission dates of these documentations shall also be specified in the testing programme for approval.

(j) Specify the train movements, if applicable.

22.1.4. Logical and practical divisions of test/inspection items shall be included in the Testing Plan. It shall also allow sections of the system or sub-systems to be tested individually and separately if necessary. Any overlap between these sections shall be clearly identified and there shall be no gaps.

22.1.5. Tests/inspections shall be planned in such a manner that all sections of the system or sub-systems shall be successfully tested and proved meeting the PS requirements before installing onto the train. In addition, once a sub-system or its component parts have been taken through a series of tests, they shall not be dismantled to facilitate subsequent tests in order to avoid negating the original tests.

22.1.6. Contingency arrangements shall be included in the Testing Plan to facilitate a planned response to foreseeable problems in order to avoid affecting the manufacturing, assembling, testing and commissioning programmes. Procedures such as design change control shall be incorporated.

22.1.7. Testing Plans shall be updated and refined in response to changes in the

objectives of the scheme, or to clarify the objectives of each test and its relationship with other tests.

22.1.8. The Commissioning Plan shall be developed from the above Testing Plan and submit for approval. It shall cover all critical testing activity particularly the interfaces with other systems specified in Appendix I. Any liaison with engineers of other disciplines required from the Commission or other contracts during the test and commissioning phase shall be specified in the Plan. The Commissioning Plan shall include the following items:

(a) Define items from the testing plan in details.

(b) Define interface limits.

(c) Describe the commissioning team and allocate clearly the roles and responsibilities of each team member.

(d) List the sections of system, sub-systems or equipment to be commissioned.

(e) State the documentation control procedures to be used for the commissioning phase.

22.1.9. The tests/inspections shall be carried out to approved national or international standards or as dictated elsewhere in the Specification, and in accordance with the Approved Inspection and Testing Plan. The Inspection and testing plans shall be submitted to the Engineer for approval at least four (4) weeks prior to commencement of the related works. The Contractor shall maintain a list of all proposed inspection and testing plans for every activity requiring inspection. Inspection and testing plans shall include and identify at least the following :-

(a) the sequence of inspection/testing activities;

(b) the inspection/testing requirements of either activities or materials;

(c) the acceptance criteria or relevant specification;

(d) the level of inspection required including the provision for witnessing by the Engineer or its representative;

(e) any certification requirements or records to be kept; and

(f) records of any non-conformance identified during inspection or testing.

22.1.10. All major components and assemblies shall be subject to a First Article Inspection (FAI) (refer to PS 22.6) at the place of manufacture by the Engineer or its appointed representative prior to be installed onto the train.

22.1.11. Where an item of equipment has been used previously in a similar application then the Type Test (refer to PS 22.6) results may be submitted for approval in place of conducting a type test for that item of equipment. approval will be given only where sufficient evidence is provided to show that the equipment successfully passed all type tests required by the PS, or more arduous tests,

and that the item is the same as that to be provided under the Contract.

22.1.12. For the micro-processor based systems, sub-systems or equipment shall require strict adherence to the requirements of software and change control specified in PS 21.

22.1.13. In association with the change of software version during module replacement or modification, the micro-processor based systems, sub-systems and equipment shall be provided with the built-in version control and can be accessed by the diagnostic/testing facilities specified in PS 24.3.11. Proper procedure shall be provided in the above plans to state the software version change control and records shall be provided to the satisfactory of the Engineer that this control measures are being adequately performed during test and commissioning phases.

22.1.14. Where an item of equipment fails to meet the requirements of any particular test or inspection stage then it shall be the responsibility of the Contractor to take corrective action to make good any defect thus found across all items of that type at its cost.

22.1.15. Between the testing and commissioning phases and handover of the trains, a maintenance regime shall be provided to ensure that all systems, sub-system and equipment remain in the design intended condition. The scope and responsibility for this shall be clearly defined in the testing and commissioning plans. Any spares, where appropriate, shall be specified and provided.

22.1.16. Any equipment or component used for the purposes of test including mock up or prototype installation shall be maintained, repaired and made good any defect found or replaced at the Contractor's cost prior to deliver to the Commission.

22.1.17. In the event that any test is failed, the Contractor shall, at its own expense, take whatever action is deemed necessary, such as, rectification, readjustment or design changes (including software modifications) to the satisfaction of the Engineer, in order to meet the testing requirement.

22.1.18. A full report of all failures occurring during testing shall be submitted to the Engineer, who may require that a modification be carried out to rectify any defects thus encountered.

22.1.19. Before any proposed change is implemented, it shall be subject to a preliminary safety and RAM assessment according to PS 25 in order to proof that no adverse effect to the safety and RAMS performance will be caused by the proposed change.

22.1.20. All changes and modifications shall be subject to the normal design and

approval processes according to the Configuration Control Program (refer to PS 21). The Engineer may, at its discretion, request the undertaking of a further tests to validate the design changes undertaken at the Contractor's cost.

22.1.21. Modifications required to make equipment pass tests shall be applied to all similar equipment. Modification instructions, test instructions and modification programme shall be submitted for approval according to the Configuration Control Program. approval will not be granted unless the Engineer is provided with sufficient information to demonstrate that the results of type tests will not be invalidated by the modification.

22.2 Format of Specifications

22.2.1. Separate specifications shall be submitted for each individual Works Tests, Commissioning Tests, Tests on Completion and Integrated Tests. The specifications shall be applied on both inspections and tests and it shall include the following items:

(a) Detailed testing procedures, the test instrumentation and circuitry to be employed, the exact parameters to be measured and the acceptance criteria to be applied to each measurement.

(b) Test records which shall serve the purpose of certification of the successful completion of a test.

(c) Check-lists to assist the recording process of tests and commissioning.

(d) Annotation to specify the following information:

(i) precise method of confirming the successful completion of a test, for example, a tick.

(i i) clear identification of who carried out the test, for example, printed name and position.

(iii) method of adding reminder notes and comments.

(iv) precise methods of confirming completed sections, for example, individual sheets, series of tests, stage-works.

(v) method of identifying errors and invoking corrective action in the event of failed tests.

(vi) maintenance of test logs showing the tests failed and the remedial action taken.

22.2.2. Should the Engineer consider that the tests/inspections proposed to be inadequate to verify fitness for purpose, the Engineer shall have the right to

call for additional tests/inspections stages at no cost to the Commission.

22.2.3. Should any measurements made be subject to a tolerance then this tolerance must be stated in the testing or inspection specification.

22.3 Approval Process

22.3.1. Not less than 60 days before the commencement of any test the detailed Test or Inspection Specification shall be submitted for approval which shall form part of the level 4 design information as defined in the PS 21.

22.3.2. No less than ninety (90) Days before the first test is due to be carried out, the Contractor shall submit to the Engineer for approval a schedule of tests as required by the PS giving full details of and the procedure for all tests to be carried out under the Contract and the standards or limits to be achieved. This Schedule shall be based on the Inspection and Testing Plan and shall indicate the approximate date of the test and the venue of the test.

22.3.3. No tests shall be carried out until:

(a) the full design information has been submitted for approval and reached an Approved in Principle status; and

(b) both the Test Specification and the Schedule of Tests have been Approved

22.3.4. At the Engineer's discretion, note that any tests carried out before approval shall be repeated at no extra cost to the Commission and following reasonable notice.

22.4 Testing Facilities

22.4.1. The Contractor shall bear the cost of all testing facilities, including all

materials, samples, test pieces, items of equipment, labour, fuel, duly certified instrumentation and measuring equipment.

22.4.2. The Contractor shall provide all facilities at its premises for conducting these tests unless a more appropriate venue is chosen. If this is the case then the Contractor shall advise the new venue for approval and bear the costs associated with testing at the alternative site.

22.5 Notification of Testing/Inspection

22.5.1. At the discretion of the Engineer, all testing/inspection is subject to the requirement for witnessing by the Engineer or its appointed representative, and as such, notice is required of the commencement of all tests and inspection stages identified in the Inspection and Testing Plan, be they Works

Tests, Commissioning Tests, Tests on Completion and Integrated Testing.

22.5.2. A minimum of twenty one (21) days notice in writing shall be given prior to the commencement of any tests or inspection stages (including First Article) according to the Approved Schedule of Tests (refer to PS 22.3.2). This notice shall state the venue, the starting date and time/duration of the tests.

22.6 Nature of Tests/Inspections

22.6.1. Testing shall be divided into two distinct categories, namely Type Testing and Routine Testing. Type Testing is required to verify that the piece of equipment or system operates in accordance with the Approved Design Data. Routine Testing is required to verify that the equipment or system has been built in such a way that it satisfies the requirements of the Approved Design Data (refer to PS 21) as verified by the Type Test.

22.6.2. Inspection shall also be divided in a similar manner, namely First Article Inspection and Routine Inspection. The First Article Inspection verifies that the Approved Design criteria have been met and the Routine Inspections ensure that the standard, Approved at First Article Inspection, is being maintained.

22.6.3. To demonstrate consistent production quality these Type and Routine Tests/Inspections shall also be completed in full or in part to the satisfaction of the Engineer at production cycle intervals agreed with the Engineer.

22.7 Tests/Inspections Process

22.7.1. The Contractor shall perform the test/inspection according to the Approved Test and Inspection Specification.

22.7.2. The Engineer shall has the right to witness any of these test/inspection at any stage of test/inspection progress.

22.7.3. Where a test/inspection stage requires that a measurement be made, then the result of this measurement together with the serial number of the measuring instrument shall be recorded on a suitable results sheet, embodied in the test/inspection specification according to PS 22.2.1 above.

22.8 Acceptance Procedure

22.8.1. Unless otherwise specified, the results of all Type and Routine Inspections/Test shall be submitted for approval in the form of a report which shall form part of the level 4 design information as defined in the PS 21, no later than ten (10) working days following the successful completion of each Type or Routine Inspections/Tests. approval will only be granted where it is

demonstrated to the satisfaction of the Engineer that the passing criteria defined in the approved test specifications are successfully achieved. Request for extension of time for submission of Type Test report shall be applied in written by the Contractor for approval.

22.8.2. Any subsequent testing which takes place before this approval is given may result in retesting being required, this retesting being to the cost of the Contractor.

22.8.3. Inspection records from the First Article Inspection shall be submitted for approval. approval will only be granted where it is demonstrated to the satisfaction of the Engineer that any areas of non-compliance identified during the FAI have been corrected, and any resultant design changes re-submitted.

22.8.4. Any defects recorded at the First Article Inspection shall be rectified and incorporated in the design and/or manufacturing process at the earliest possible opportunity and shall be fitted retrospectively in an approved manner to all items not thus modified.

22.8.5. Records from Routine Inspection shall be held by the Contractor and made available timely for the Engineer's inspection.

22.8.6. Copies of the Approved routine test results shall be submitted together with the associated train log book (refer to PS 22.8.7).

22.8.7. Train Log Book

In addition to the Configuration Control Program, for each unit of train a Log Book (as known as, the Car History Book) shall be provided which shall include the following items at the point of handover of the associated unit of train to the Commission after the completion of the Tests on Completion (refer to PS 22.11.4):

(a) Records of the equipment configurations and serial numbers of all equipment

fitted to the train. Contractor's attention is drawn to the requirements of serial configuration package according to Appendix J.

(b) Maintain an up-to-date list of outstanding tests, modifications and defects.

(c) Records of all successfully completed vehicle level routine tests.

22.8.8. The acceptance of tests shall be the successful completion of tests, approval of the test results and receipt of the associated train Log Book.

22.8.9. Additional copies of records of all tests/inspections results shall also be held at the Contractor's (or Subcontractor's) works to be made available to the Engineer on demand.

22.9 Works Tests

22.9.1. The Works Tests specified in Appendix B shall constitute the Testing before Delivery of the trains.

22.9.2. No Works Tests shall be carried out on the micro-processor based systems, sub-systems or equipment until they are successfully completed all required software tests specified in PS 29.

22.9.3. In addition to the Works Tests specified in Appendix B, the Contractor shall carry out the following installation tests on a routine basis for each train:

(a) Quality Control Tests which shall include the following test items:

(i) Wire count. A wire count shall be a check of every termination point to ensure that the correct number of wires is terminated. The correct number of wires can be zero, so terminations where no wires are expected are also checked. This check shall be applied on all safety related circuits (refer to PS 9) and the ATC interface circuits (refer to Appendix I Annex 3).

(ii) Continuity test. This test shall be carried out to ensure the continuity and correspondence of each individual wire with its wiring diagram.

(iii) Insulation and earth tests. These tests shall be carried out to check both every core of a cable and every other core, and between every core and earth for correct insulation values. For those wires that are impracticable to test between every wire, test on all rack wires to earth shall be applied.

(b) The above Quality Control Tests shall be repeated for any wiring change.

22.10 Commissioning (Tests in CITY)

22.10.1. The Commissioning Tests specified in PS 22.10 shall constitute the Tests on Completion (refer to PS 22.11) of the trains.

22.10.2. The Commissioning Tests identified in Appendix B of the PS, the Contractor shall meet the test requirements specified below.

22.10.3. Type Commissioning Tests

(a) On the first train or trains (as convenient) delivered, the Contractor shall undertake at its cost in a comprehensive programme of Type Tests to adequately demonstrate that the requirements of the Specification have been satisfied.

(b) The Contractor shall also participate in system wide integration testing to ensure that the train and its systems do not introduce any adverse effects into the railway and its environment.

(c) This testing shall demonstrate compatibility between the train and the interfacing systems specified in the Appendix I.

(d) Compatibility with the existing train systems shall be satisfactorily tested (refer to PS 9.11.1).

(e) The Contractor shall be responsible for correcting any interfacing defects thus identified in any equipment or systems included in its scope of supply.

22.10.4. Routine Commissioning Tests

(a) Following delivery of the trains to the Site each train shall be commissioned by the Contractor and at an appropriate time the Engineer will witness certain of these tests to satisfy himself that the trains are acceptable for running in passenger service.

(b) These tests will be a subset of those tests performed at Type Test, to demonstrate that the principal features of the train are compliant with the PS.

(c) This shall include but not be limited to a test of all safety systems.

(d) The Contractor shall provide the Engineer with a full record of the modification status and software versions fitted to a train at the time that the routine commissioning test is conducted.

22.11 Tests on Completion

22.11.1. The Tests on Completion specified in PS 22.11 shall constitute the Tests on Completion of the trains.

22.11.2. The Tests on Completion are identified in Appendix B. The Contractor shall demonstrate to the satisfaction of the Engineer in the Tests on Completion that the performance requirements of the train are met and suitable for passenger service in the existing Lines systems.

22.12 Integrated Testing

22.12.1. The Integrated Tests shall demonstrate to the satisfaction of the Engineer the operation of all aspects of the various Work and systems forming all interfaces, and the functioning of all the Works as an integrated whole. If any such tests show that the Works or the relevant section are in any respect not in accordance with the Contract, the tests shall be repeated as soon as practicable

thereafter and for so many times as is required to pass the test. The Contractor shall make adjustments and modifications to the Works before repetition of any such test, which shall be at the cost of the Contractor and shall be carried out with all reasonable speed.

22.12.2. The Contractor shall agree with all Subcontractors who have responsibility for the provision of plant which interface with Plant and system provided by the Contractor, a schedule of Integrated Tests. The schedule shall be submitted by the Contractor to the Engineer for approval not less than ninety (90) Days before the first Test on Completion is due to commence. The schedule shall include an indicative programme showing when Integrated Tests would be conducted.

22.12.3. Damage, including damage to plant supplied by the Subcontractors, resulting from failure during Integrated Tests due to incorrect manufacture, installation or Tests on Completion by the Contractor shall be made good, by the Subcontractor supplying the damaged plant, at the expense of the Contractor.

22.12.4. The Contractor shall demonstrate to the satisfaction of the Engineer in the Integrated Tests that the compatibility requirements between the train and the existing Lines systems are met.

22.13 Final Acceptance Certificates

22.13.1. Upon the following requirements are met, it will lead to the issuance of the Final Acceptance Certificate according to GC 28 Completion and Acceptance on a train basis in order that the particular consist of train will be put into passenger service by the Commission:

(a) All tests of Tests on Completion (refer to PS 22.11.4) and integrated tests (refer to PS 22.12.5) are successfully completed and the associated test reports are granted with at least the status of Approved in Principle;

(b) The train Log Book is documented to the satisfaction of the Engineer and delivered to the Engineer;

(c) The following requirements shall be met before handing over of the first train:

(i) All Approved Type Test results have been delivered to the Engineer;

(i i) All required quantities of Approved spares for running maintenance (refer to PS 24.2.1) have been delivered to the Engineer;

(i i i) All required training are satisfactorily implemented; and

(i v) The batch 1 and 2 O&M Manuals are granted with at least the status of Approved in Principle.

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Section 23 Training Requirements

23.1 Scope of Training

23.1.1 The Contractor shall provide a comprehensive training program for the Commission's maintenance and operations employees. The program shall ensure that these employees have the competence to operate, maintain, and repair the subway cars to be supplied as part of this contract.

23.1.2 The maintenance training program shall be comprised of a series of instructor-led and computer-based training (CBT) modules whose content shall include but not necessarily be limited to all major vehicle systems and requisite procedures for operation, inspection, vehicle recovery, overhaul, and use of test equipment for each of these systems. For each module, the Contractor shall provide both instructor-led pilot and train-the-trainer sessions as well as training documentation.

23.1.3 The training documentation shall be sufficient to allow future on-going sustainable instruction by the Commission for its employees (refer to documentation requirements in Sections 23.2.1 and 23.3 below.)

23.1.4 ~~For the maintenance training program, once the Contractor has delivered the~~ pilot and train-the-trainer ~~sessions and adequately assessed the trainees' skill~~ and knowledge, the Commission will be responsible ~~for the delivery of all subsequent training to Commission employees using the CBT modules.~~ For the maintenance training and vehicle operation training programs, once the Contractor has delivered the pilot and train-the-trainer sessions and adequately assessed the trainees' skill and knowledge, the Commission will be responsible for the delivery of all subsequent training to Commission employees using the CBT modules subway simulator provided by the Contractor (refer to Section 23.1.6 below)

23.1.5 The Commission will provide a learning management system (LMS) as a platform (refer to Attachment B for detailed specifications) for delivering the

CBT modules. The Contractor shall provide all requisite computer software and hardware in accordance with detailed specifications according to Attachment B.

23.1.6 The Commission will be responsible for delivering vehicle operation training on the basis of an instructor's guide, a training manual and the subway simulator provided by the Contractor.

23.1.7 The Contractor will be responsible for delivering pilot and train-the-trainer

vehicle operation training on the basis of an instructor's guide, a training manual and the subway simulator or trainset. (Item 23.1.7 is a new item added)

23.2 General Requirements

23.2.1 Training Documentation

(a) For each maintenance module, the Contractor shall provide the following documentation: an instructor's guide, a training manual, assessment instruments, and a computer-based training (CBT) package.

(b) In instances where a sub-contractor is used to provide a module, the Contractor shall be fully responsible for the provision of the training documentation.

(c) Training documentation shall be designed in such a way as to allow the Commission to deliver the training effectively once the Contractor has delivered the pilot and train-the-trainer sessions.

(d) The Commission shall be granted with the right to use, reproduce, and modify any training documentation as it deems necessary for further instruction of Commission personnel.

(e) All training documentation shall conform to the various vehicle configurations and be updated to the end of the contract.

(f) All training documentation shall conform to the following production standards:

- All documentation shall incorporate North American standards for paper size.
- All training manuals shall be develop using a software application acceptable

to and approved by the Commission.

- All illustrations, diagrams, etc. shall be created in vector, CMYK colour and .EPS or .AI format.
- All photographs shall be in TIFF, CMYK colour and 300 DPI format.
- Line drawings shall be used instead of photographs wherever possible.

23.2.2 Scheduling of the Pilot and Train-the-Trainer Sessions

(a) Training shall commence only after all of the following are complete:

- All operating and maintenance manuals have been reviewed and accepted by the Commission, and
- All training documentation has been accepted and approved by the Commission (refer to PS 23.4.8 for details regarding pilot sessions for the CBT packages).

(b) The Commission and the Contractor shall jointly develop a training schedule for the pilot and train-the-trainer training sessions that takes into account maintenance and operational requirements and suits the various work locations and work shifts of the Commission's personnel.

(c) The maximum duration of each pilot and train-the-trainer day including lunch and breaks shall not exceed eight hours.

(d) Maximum class size shall be mutually agreed upon by the Commission and the Contractor.

23.2.3 Instructors

(a) The Contractor shall be solely responsible for ensuring sufficient qualified personnel are provided to adequately instruct the pilot and train-the-trainer sessions.

(b) Instructors must be competent and completely familiar with the content being taught and with the special tooling, test equipment, manuals and procedures to be employed by the Commission.

(c) The Contractor shall make arrangements satisfactory to the Commission and be solely responsible for ensuring that instructors supplied by all sub-contractors are sufficiently qualified.

23.2.4 Revisions

(a) The Contractor shall make all revisions to training documentation deemed necessary by the Commission subsequent to both the final subway car configuration period, scheduled reviews of submittals (See Section 23.3), and

the pilot and train-the-trainer sessions of each module.

(b) The Contractor shall provide the final versions of all training documentation prepared from the corrected draft.

23.2.5 Other Resources

(a) All training is to be carried out at the Commission's facilities.

(b) The Contractor shall provide all computer software and hardware necessary for the delivery of the computer-based training modules which shall be compatible with the Commission's existing LMS.

(c) The Commission will make available to the Contractor, at no cost, any Commission computer projectors and projection screens. The Contractor shall provide the Commission with a list, prior to the pilot course, noting which of this equipment shall be required.

(d) The Contractor shall provide functional mock-ups and equipment component simulators required for the delivery of specific modules as identified in the training development plan. Such mock-ups and simulators shall be required for equipment requiring theoretical discussion. All mock-ups and simulators shall become property of the Commission.

(e) The Commission will provide a Curriculum Development Specialist to review training documentation and a Training Coordinator to be responsible for administration for the duration of the training program.

23.2.6 Penalties for Late Submission

Liquidated Damages according to GC39 shall be applied to late submissions of training documentation or late delivery of pilot and train-the-trainer sessions which constitutes the cause of delay of the issuance of the Final Acceptance Certificate (refer to PS 22.13(c)).

23.3 Submittals

23.3.1 The Training Development Plan

(a) The Contractor shall provide a detailed training development plan that shall include the following:

- An overview of the training program,

- A detailed description of training documentation, both print-based and computer-based,
- A description of each module,
- A proposed schedule for the delivery of the pilot and train-the-trainer (phase I) sessions,
- A proposed schedule for the submission, review and approval of all training documentation,
- A target audience matrix indicating which modules each group of employees shall take,

- A list of qualifications for each individual to be involved in the development of both print-based and computer-based training materials, and
- A list of qualifications for each instructor.

(b) Each module description shall include:

- Any required prerequisites,
- Module objectives,
- A detailed content description,
- The module duration,
- A list of any instructional aids or functional mock-ups required in addition to training documentation,
- An indication of any special facility or equipment requirements, and
- The proposed assessment instruments.

(c) The qualifications listed for each individual to be involved in the development of both print-based and computer-based training materials shall include:

- The position in the Contractor’s or sub-contractor's organization,
- The length of time employed by the Contractor or sub-contractor,
- Relevant experience in instructional development and technical writing,
- Education, and
- Other reasons for selection of the individual.

(d) The qualifications listed for each instructor shall include:

- The position in the Contractor’s or sub-contractor's organization,
- The length of time employed by the Contractor or sub-contractor,
- Relevant training experience,
- Relevant technical experience and demonstrated knowledge of the equipment being taught,

- Education, and
- Other reasons for selection of the individual.

(e) The submittal date for the training development plan shall be no later than three months after the award of the contract. The Commission will review and provide comments within four weeks of receipt. The Contractor shall revise, finalize, and resubmit the training development plan not later than four weeks after receiving comments from the Commission.

23.3.2 Instructor's Guide

(a) The Contractor shall provide an instructor's guide for each of the maintenance training programs. It shall contain all the material the instructor shall need to deliver the program with the exception of the training manual and the computer-based package.

(b) The instructor's guide shall include the following components:

- A cover,
- A table of contents,
- An instructor introduction to establish the program overview, rules and expectations for trainees, guidelines for delivering the program, etc., and
- Detailed instructions covering the set-up and use of the CBT packages, any required functional mock-ups or simulators and any on-the-job components.

(c) The submittal date for the instructor's guide shall be staggered and in accordance with the documentation submittal schedule agreed upon in the approved training development plan.

(d) The Commission will review and provide comments on the instructor's guide within four weeks of receipt. The Contractor shall revise, finalize, and resubmit the instructor's guide not later than four weeks after receiving comments from the Commission.

23.3.3 Training Manuals

(a) The Contractor shall provide a training manual for each maintenance module as well as for vehicle operation training.

(b) The content of each manual shall adequately cover all content listed in the training plan. It shall be limited exclusively to information required by the identified target audience in the performance of their jobs. It shall exclude unnecessary technical detail and be written at a technical level appropriate to the target audience identified for the module.

(c) All manuals shall conform to the Commission's standard on readability and other standards on language and page layout and design as described in the Training Department's Information Standards document (refer to Attachment A.).

(d) All training manuals shall use the same numbering system and formatting.

The prose treatment shall be fully developed and not limited to outline format.

(e) The components of each training manual shall include the following:

- A cover,
- A table of contents,
- A list of figures,
- An introduction to explain the course overview and the use and structure of the manual,
- A list of module objectives,
- Module content consisting of information and procedures,

- Adequate use of high quality line drawings, diagrams, and charts to support content,
- References,
- A list of acronyms,
- A glossary, and
- An index.

(f) The submittal date for the first training manual shall be concurrent with the submittal of the corresponding Instructor's guide. Submittal dates for remaining training manuals shall be staggered and in accordance with the documentation submittal schedule agreed upon in the approved training development plan.

(g) The Commission will review and provide comments on each training manual within four weeks of receipt. The Contractor shall revise, finalize, and resubmit the training manual not later than four weeks after receiving comments from the Commission.

23.3.4 Assessment Materials

(a) The Contractor shall provide assessment instruments to determine that trainees have successfully mastered the content of the maintenance modules. These assessment instruments shall be in the form of written tests and sign-off sheets.

(b) A written test shall be administered in each module to assess trainees' knowledge of module content. A sign-off sheet shall be administered in each procedures-based module to document that the trainee has demonstrated the procedures or tasks taught in the module.

(c) Each written test will:

- Be constructed so as to sample critical course content explicitly from the training manual for the module,
- Contain a minimum of 25 questions,
- Be composed only of multiple choice questions developed in adherence with

the Training Department's Item-Writing Guidelines (refer to Attachment C),

- Include a hard copy of a trainee version, a reference version with the correct answers bolded and the exact content source indicated for each question,
- Be made available in both print-based and computer-based formats, and
- Include an alternate version for retesting.

(d) The written test shall be considered a controlled document and the Contractor shall take all necessary measures to guard the security of the test.

(e) Each sign-off sheet will:

- List critical tasks to be demonstrated by the trainee independently and without the assistance of the instructor,
- Include only tasks that are dealt with explicitly in the training manual for the module, and
- Be designed so as to require the signature of both the instructor and the trainee for each task.

(f) The submittal date for the first assessment materials shall be concurrent with the submittal of the corresponding Instructor's guide. Submittal dates for remaining assessment materials shall be staggered and in accordance with the documentation submittal schedule agreed upon in the approved training development plan.

(g) The Commission will review and provide comments on each submittal of assessment materials within four weeks of receipt. The Contractor shall revise, finalize, and resubmit these materials not later than four weeks after receiving comments from the Commission.

23.4 Computer-Based Training Packages

23.4.1 The Contractor shall provide a stand-alone computer-based training (CBT) package suitable for delivery on the Commission's LMS.

23.4.2 The content of the CBT package shall adequately cover all content listed in the training plan. It shall be limited exclusively to information required by the identified target audience in the performance of their jobs. It shall exclude unnecessary technical detail and be written at a technical level appropriate to the target audience identified for the module.

23.4.3 The content of the CBT package shall be the same as the comparable training manual for the same module but the language of the manual shall be suitably adapted to the requirements of the computer-based medium.

23.4.4 The CBT package shall be designed with maximum flexibility to allow it to be used effectively for:

- Both independent self-directed learning and instructor-led classroom instruction, and
- Both initial training and refresher/review training.

23.4.5 The CBT package shall incorporate the following features and functionality.

(a) User Interface:

- PC-based,

- Log-on screen using AUTHORITY employee number,
- Interactive information display,
- Open navigation with familiar and easy to operate controls suitable for users with minimum computer skills,
- Consistent layout and navigation throughout the CBT.

- Self-paced by the user,
- Exit button and access to main menu available at all times,
- Feedback for the user whenever computer processing is required,
- Clean and uncluttered screen environment, and
- Branded for the AUTHORITY.

(b) Presentation of Content:

- The CBT will permit access to individual sections as desired,
- Appropriate levels of interactivity to encourage user participation (i.e. interactive exercises, case studies, quizzes, etc.),
- Bookmarking functionality,
- Optional introduction to course navigation, screen layout, icons, etc.
- Content that is sufficiently detailed to ensure information flow and provide internal support,
- Accurate, consistently formatted and grammatically correct on-screen text,
- Content is organized in an appropriate sequence (simple to complex, concrete to abstract, etc.),
- Content and practice are directly linked back to learning objectives,
- Different learning styles are addressed in the course design,
- Content is free of negative stereotyping and adheres to the Commission's Workplace Harassment and Workplace Violence policies,
- High quality digital images, compressed video, animation and cut-away diagrams used as required,
- Professional voice-over, or optionally high quality text to speech if approved by the Engineer, and

- Links and cross references for background and/or supporting information, such as:
  - Related procedures
  - Material and parts list
  - Required tools
  - Check sheet/inspection records
  - Safety warnings and precautions derived from Commission-approved hazard analyses.

(c) Content Review and User Evaluation:

- Content reviews/quizzes at the end of each section,
- Activities and exercises positioned appropriately throughout the modules, •

  User feedback for correct and incorrect responses, including:

- o Congratulations and encouragement
- o Correct information provided after two incorrect responses.

- Written assessment instruments are included at the end of each package (refer to Section 23.3.4).

23.4.6 The CBT packages shall be developed in a software application acceptable to the Commission and have the necessary authoring tools and instructions for updating as required. The CBT package shall fully comply with:

- Sharable Courseware Object Reference Model (SCORM) 1.3 Guidelines (a.k.a. SCORM 2004) released by the Advanced Distributed Learning (ADL) Initiative; and
- AICC standard AGR-006 (File-based CMI Systems).

It is a requirement that both SCORM and AICC standards current at the time of NTP plus two years, shall be complied with.

23.4.7 In addition to the above requirements, the CBT package shall conform to:

(a) The Commission's standard for readability and other standards on language described in the Training Department's Information Standards document (refer to Attachment A),

(b) The Commission's standard for CBT development described in the Training Department's Information Standards document (refer to Attachment A),

(c) The Commission's technical requirements and network environment (refer to Attachment B).

23.4.8 The CBT package shall be developed using the following design stages:

(a) Prototype:

- The prototype shall use the same technology as the final product.
- The prototype shall be tested in the Commission's computer environment, and •

The prototype shall include the following representative content:

- Splash screen and login
- Sample content pages
- Sample assessment and feedback screens
- Navigation and flow.

(b) Storyboards:

- The storyboards shall provide the following information for each screen of the CBT package:
  - Title hierarchy and numbering system
  - On screen text
  - Description of digital assets used

- o Content flow
- o Applicable links
- o User feedback
- o Assessment exercises
- o Branching and other programming directions.

- The storyboards shall be presented in their native environment using a mock-up of the CBT user interface.

(c) Beta version:

- The Contractor shall provide a beta version of each completed CBT section for testing and review by the Commission.
- Each completed CBT section shall be piloted with a user's group made up of the appropriate Commission personnel.
- User feedback from the pilot sessions shall be included, where appropriate in the Commission's comments to the Contractor.

(d) Final version:

- The Contractor shall deliver a final version of each CBT section incorporating the Commission's comments and revisions (refer to Section 23.4.10 below).

23.4.9 The submittal date for the first beta CBT section shall be no later than 3 months after approval of the instructor's guide by the Commision. Submittal dates for remaining CBT sections shall be staggered and in accordance with the documentation submittal schedule agreed upon in the approved training development plan.

23.4.10 The Commission will review and provide comments on each CBT section within four weeks of receipt. The Contractor shall revise and resubmit the CBT section no later than four weeks after having received comments from the Commission.

23.4.11 All CBT content including: text, digital assets, executable files, source code, etc. used for the development of the CBT shall be the property of the Commission and may be used, reproduced or modified in any form necessary for further instruction of Commission personnel.

23.5 Training Program Design

23.5.1 Content Overview and Module Structure

The CBT will be developed as an integrated package using a “top-down” approach. Training will begin by providing a vehicular overview followed by

a general introduction to the physical, functional, and interactive characteristics of each of the Train/ vehicle/ car primary systems. Subsequently detailed primary system training will be developed and presented in modular format. Generally, system training will be presented using up to six (6) modules as described in PS 23.5.1(c) below.

(a) As a minimum, the maintenance training program shall cover the content indicated below.

(b) Content shall be organized on the basis of the following 18 systems:

1. Carbody—Interior/Exterior
2. Propulsion
3. Braking
4. Auxiliary Power—Battery/Auxiliary Supply
5. Train Information Management System
6. Electrical Auxiliary System/Circuits
7. HVAC
8. Pneumatic Distribution and Supply
9. Trucks
10. Gearbox
11. Wheels and Axles
12. Suspension
13. Couplers—Mechanical/Electrical
14. Speed Control System
15. Passenger Doors
16. Lighting—Interior/Exterior
17. Communications Equipment
18. Special Tools, Portable and Bench Test Equipment

(c) For each system, up to six modules shall be developed. However, training content (module definition as well as the number of modules required) will be determined by both parties on a case by case basis:

1. Introduction

- Overview of the system, including the location and function of constituent components, and
- Comparison to similar systems on existing Commission vehicles.

2. Theory

- Detailed, technical description of the operation of the system and system interfacing.
- Use of electrical/pneumatic drawings and schematics.

3. Inspection

- Detailed, technical description of the maintenance of the system based on safety, standard, and visual inspection procedures,

- Description of access to the system and constituent components for maintenance, and
- Procedures for functional testing of the system and removal and replacement of components and line replaceable units.

4. Vehicle Recovery/Disablements

- Detailed, technical description of the recovery of the system, and
- Description of all electrical and pneumatic isolation switches, valves, by- passes, and cut-outs relevant to the system.

5. Overhaul

- Detailed, technical description of the overhaul of the system down to the component level, and
- Procedures for removal and replacement as well as disassembly and reassembly of components.

6. Test Equipment

- Descriptions of and procedures for using any test equipment required for inspecting, recovering, or overhauling the system or one of its constituent components.

(d) The resulting sections shall be assigned to suit the individual training needs of each user. Each individual program shall depend on the trainee's reference trade and responsibility level. Only the Introduction and Theory modules may be considered prerequisites for other sections.

23.5.2 For vehicle operation training, the training manual shall include the following content:

(a) A description of the car and the equipment,

(b) Normal vehicle operations, and

(c) Vehicle recovery procedures for disablements and equipment failures.

23.6 Maintenance Training Delivery Strategy

23.6.1 Overview of Delivery Strategy

(a) Training shall be delivered to Commission employees in two phases.

(b) In phase I, the Contractor's instructors shall deliver train-the-trainer sessions to two groups of Commission employees: Training Department Instructors and Rail Cars & Shops Department supervisory and technical staff.

(c) In phase II, all additional Commission employees requiring training on the new subway cars shall be trained using the computer-based modules identified for their respective positions.

23.6.2 Phase I Training

(a) The Contractor's instructors shall deliver phase I training. This training shall be comprised of an instructor-led train-the-trainer session for each module. It shall be based on the instructor guides, training manuals provided by the Contractor for each module. It shall be conducted both in the classroom and on-the-job.

(b) The target audience of phase I training is Training Department Instructors and Rail Cars & Shops supervisory and technical staff.

(c) The Contractor shall ensure that phase I training provides the target audience with all the technical skills and knowledge requisite for supporting subsequent training in phase II. This phase shall be deemed complete only when the Commission's training team is fully trained and capable of providing all remaining support.

(d) Phase I training shall commence with the delivery of the first six subway cars.

23.6.3 Phase II Training

(a) The Commission will deliver all phase II training using the training documentation provided by the Contractor (refer to Section 23.3). This training shall be computer-based but have an on-the-job component. The trainee shall receive a training manual for each module and additional support from Commission personnel qualified in phase I. On-site Contractor personnel shall be available as additional technical resources as required.

(b) The target audience of phase II training is all maintenance employees who shall be required to maintain and repair the new subway cars. The target audience matrix provided by the Contractor as part of the training development plan shall establish which modules each group of employees shall take.

(c) The Commission in conjunction with the Contractor will establish a timetable for the delivery of this training that takes into account the prior approval of CBT sections, by the Commission, the delivery of the new subway cars and the termination of warranties.

23.7 Trainee Assessment

23.7.1 The Contractor shall develop all necessary written tests and sign-off sheets as part of the training documentation (refer to Section 23.3.4).

23.7.2 The Commission will administer all written tests and sign-off sheets to trainees and maintain all assessment records.

23.8 Administration

23.8.1 For phase I maintenance training, the Contractor shall ensure that its instructors adhere to the requirements of the agreed upon schedule. The Contractor shall also ensure that its instructors take attendance and submit attendance records and certificates of completion to the Commission's Training Department during phase I.

23.8.2 For phase II maintenance training and vehicle operation training, the Commission will be responsible for all administrative processes including scheduling, registration, and record keeping.

23.9 Evaluation of Maintenance Training

23.9.1 Instructor-Led and CBT Pilot and Post-Pilot Revisions

(a) The Contractor shall conduct a pilot of each module demonstrating the instructor's guide, the training manual and CBT package, as appropriate. Each pilot shall be attended by a number of the Commission's personnel who shall evaluate the module and recommend changes as required.

(b) On the basis of course evaluation results, changes shall be mutually agreed upon by the Commission and the Contractor. The Contractor shall take corrective action in terms of training documentation, including CBT packages as appropriate. These revisions shall be carried out at no additional cost to the Commission.

(c) Should a major change be recommended, the Commission may require the pilot module to be repeated.

23.9.2 Evaluation of Phase I Training

(a) The Contractor shall ensure that its instructors collect a course evaluation form from each trainee in each module in phase I. The evaluation shall be conducted in accordance with the Training Department's standard operating procedure TR-024 Administration of Level One Training Evaluations (refer to Attachment D.).

(b) On the basis of course evaluation results, the Contractor may be required to take additional corrective action in terms of training documentation. These revisions shall be carried out at no additional cost to the Commission.

Attachment A: Training Department Information Standards

Attachment A for PS 23_Addendum No 2 in Acrobat.pdf (please open this file with Acrobat Reader V6.0 or later.)

Attachment B: AUTHORITY Desktop Configuration

The following describes the current desktop configuration.

Current Hardware

The current standard Desktop Hardware configuration installed at the Commission consists of an Intel based processor with Windows XP as the standard operating system.

Current Software

Information Technology Services, Desktop Services provides a standard set of software on all workstations (desktops/laptops). Microsoft Office 2002 is the standard for productivity tools. All workstations have virus protection software installed and enabled.

User Access

Users do not have permission to log in to any workstation and server locally. All access to the servers is done through client/server applications, web based applications, or Citrix clients.

System applications should allow 3rd parties access into AUTHORITY network to be able to access the application on the server using Industry Best Security Practices, like:

- Secure Shell (SSH) for Remote Access Control,
- Challenge response techniques allowing use of One Time Password for user authentication
- Password Aging
- Account blocking for use of wrong password, and,
- Password locked screen saver.

If communication is over the internet – The HTTPS protocol should be used for accessing the system. A small number of designated users might use other protocols via VPN or SSL VPN connections.

Servers

AUTHORITY system hardware utilizes Intel based servers.

The operating system is MS Windows 2003 Server OS at current patch levels as required.

MS IIS is used as a Web server.

Applications and Databases are usually installed on different servers in the production environment. i.e. The Application is installed on one Server in the Production environment. The production database is located on a different server.

AUTHORITY Database servers run on an HP-UX platform.

MS Active Directory service provides user authentication and authorization.

Rational ClearCase is used as a version control system.

Application/System

The AUTHORITY's current Learning Management System consists of:

- Application & Version: PATHLORE LMS Enterprise Edition 6.5 •

Application/Web Server: IIS 5.0

- Reporting Tools: Crystal Reports Professional 9.0

The CBT modules must fully comply with SCORM 1.2 Guidelines and be AICC compliant with AGR-006 (File-based CMI Systems)

Dates must be in YYYYMMDD format.

AUTHORITY Network Environment

The AUTHORITY LAN environment is a switched/routed 10/100/1000 Mbps Ethernet Network delivered over the AUTHORITY's own fibre backbone and carrier provided links. The carrier environment is composed of a variety of links at 3/10/100Mbps. AUTHORITY is connected to the Internet over a 10Mbps link to the service provider. The AUTHORITY's internal network connects to the Internet via firewall environment.

AUTHORITY Data Environment

AUTHORITY Data environment is supplied by Oracle servers.

The standard database software is Oracle.

The database is stored in Storage Area Network (SAN).

Attachment C: Training Department Item Writing Guidelines

Item-Writing Guidelines for Multiple Choice Questions

Content

1 . Remember the guideline from SOP TR-001 Development of Written Tests: The content domain of written tests will normally contain only knowledge sections of the job analysis, performance sections that would be impractical to test on a performance test, and safety critical information.

2 . Use a content domain matrix to select content for questions.

3 . Focus the question on a single idea or task derived from a validated resource book or job analysis where available.

4 . Keep the question job-related and linked to a practical job competency possibly through creating a real-life scenario or situation in the stem of the question.

5 . Keep items independent. It should not be necessary to know the answer to one item to answer another; one item should not provide a clue to another.

Level of Difficulty

6. Eliminate irrelevant difficulty by:

- Using simple, familiar language
- Using the positive rather than the negative in the stem
- Using technical language or jargon only if it is the target of the question
- Keeping the reading level of the item at least two grade levels below the formal education level of the test taker
- Avoiding irrelevant or obscure knowledge or skill areas

7 . Avoid clues inadvertently built into the stem or response choices.

8 . Use response choices that are close in meaning to make the question more difficult and choices that are very different to make it less difficult.

The Question Stem

9 . Keep the stem brief but include sufficient information for the test taker to know what is being asked before reading the response choices.

1 0 . Try using a short sentence at the beginning of the stem to set up a scenario or situation, e.g., You are operating your streetcar on the 510 E line and have entered the tunnel to E Station. You see…

11. Try to write the question in the second person, e.g., You are approaching a flashing amber signal…, rather than the third person, e.g., The Operator is approaching a flashing amber signal…

Response Choices

12. Provide four response choices for each question.

13. Do not repeat information in each response choice that could be included in the stem.

14. The response choices should serve either as completions to a statement stem or as short replies to a question stem.

15. Be sure all response choices are parallel in structure.

12. Arrange responses, if possible, in a logical order, e.g., quantitative choices in ascending order.

The Key Answer

17. Write the key answer, i.e., the correct answer from the response choices, so that it provides a logical and grammatical completion of a statement stem or a logical and concise answer to a question.

18. Keep the key similar in length, detail, and grammatical construction to the distractors.

19. Make the response choices, A, B, C and D, the key answer an approximately equal number of times in a test.

20. Be sure the sequence of key answers is random.

Distractors

21. Keep distractors plausible and able to attract respondents who are not fully

knowledgeable or skilled.

22. Use “none of the above” as a distractor only in items where there is one absolutely correct answer.

23. Never use “all of the above” since it allows a respondent who knows only that two of the choices are correct to choose it.

Sensitivity

24. Avoid stereotypes and if you cannot avoid gender referents, alternate male and female.

Attachment D: Training Department Standard Operating Procedure: Administration of Level One Evaluations

1.0 PURPOSE

The purpose of this procedure is to ensure that level 1 training evaluations are administered, reviewed, and tracked in a consistent manner.

2.0 SCOPE

Level 1 evaluation refers to the questionnaire survey administered to trainees in order to measure their reaction to a training course. The procedure is applicable to all courses delivered by the Training Department.

3.0 RESPONSIBILITY

3.1 The Manager - Training Department is responsible for ensuring that this procedure is applied to all Training Department programs.

3.2 The Training Superintendent is responsible for ensuring Instructors distribute the level 1 evaluation form and follow this procedure for all courses delivered in their respective areas.

3.3 Instructors are responsible for conducting level 1 evaluations in accordance with this procedure for all courses they deliver.

3.4 The Training Clerk will set up and maintain the data on the level 1 evaluation results.

4.0 PROCEDURE

ADMINISTER EVALUATIONS

4.1 The standard level 1 evaluation (see attached) form will be used for all Training Department courses.

4.2 At the start of the course, the Instructor will provide all participants with an evaluation form and introduce the use of the form.

4.3 At the end of the course, the Instructor will provide detailed instructions for filling out and submitting the form.

4.4 The Instructor will emphasize the need for frank and honest responses and will guarantee anonymity for all trainees in their evaluation of the course.

4.5 The Instructor will ask for a volunteer to collect the evaluations anonymously by having trainees place them in an envelope which the volunteer will then seal. The Instructor will provide the volunteer with the envelope.

4.6 The Instructor will leave the room or training area while the trainees are filling out the form in order to ensure anonymity and encourage independent responses.

4.7 The Instructor will collect the sealed envelope from the volunteer and deliver it sealed to the relevant Training Superintendent.

REVIEW RESULTS

4.8 The Training Superintendent will review the completed training evaluation forms for the course.

4.9 The Training Superintendent will discuss the results of the evaluation with the Instructor as necessary.

TRACK RESULTS

4.10 The Training Superintendent will provide the Training Clerk with the completed evaluation forms on a weekly basis.

4.11 The Training Clerk will input the results into a database.

4.12 The Training Clerk will produce and distribute quarterly reports detailing evaluation results by program to the Manager - Training Department, the Training Superintendents and the Superintendent - Planning & Program Development.

PREPARED BY: SUPERINTENDENT - PLANNING AND PROGRAM DEVELOPMENT **DATE:**
APPROVED BY: MANAGER - TRAINING DEPARTMENT **DATE:** **SIGNATURE:**

SECTION 24 SPARE PARTS, SPECIAL TOOLS AND TESTING EQUIPMENT2

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Section 24 Spare Parts, Special Tools And Testing Equipment

24.1 General Requirements

24.1.1. The Contractor shall provide all spares for running maintenance (refer to PS 24.2.1), special tools and test equipment (refer to PS 24.3) to facilitate the Commission to maintain, repair and overhaul the trains effectively and efficiently while ensuring the trains maintain a high standard of safety and reliability. The Contractor shall ensure continuous supply source of spares throughout the design life of the trains.

24.1.2. All spare parts shall be identical to the equivalent installed items. All items shall be complete and ready for installation except for wire or cable for external connections.

24.1.3. All spare parts, special tools and test equipment shall be delivered to a location in CITY as directed by the Engineer suitably packed for protection against weather, rough handling during transportation and subsequent warehouse storage and clearly marked with a unique identification.

24.1.4. The Contractor shall minimize the number of different types of special tools and test equipment required to meet maintenance requirements.

24.1.5. All test equipment shall have the same design life as that of the equipment or system it tests.

24.1.6. Not later than 15 weeks after the date of the Notification of Award, the Contractor shall submit for approval the lists of spare parts, special tools and test equipment to be supplied. The lists shall be an amplification and confirmation of the lists supplied with the Proposal and shall be subsequently modified and amended as necessary with changes in design according to the requirements of PS 21.14 - Configuration Control Program.

24.1.7. In the event that modifications are introduced in any part of the cars under the terms of the Contract, the Contractor shall at no cost to the Commission, modify or replace any spare parts, special tools and testing equipment, whether delivered or otherwise.

24.1.8. The Contractor shall confirm and update as necessary the lists of spare parts, special tools and test equipment to align with the latest approved design. Copy of each of the updated lists shall be submitted to the Engineer according to the requirements specified in PS 21.14.

24.1.9. Based on the recommended lists of spare parts, special tools and test

equipment, the Engineer will determine those essential parts or items that are required for delivery prior to the commissioning of the first train at a time as specified by the Engineer and those that can be delivered at a later stage.

24.1.10. Each item of spare parts, sub-assemblies and assemblies shall be clearly and precisely labelled/tagged showing appropriate part numbers and parts descriptions and component/assembly identification codes for unique identification purpose.

24.1.11. The information supplied in respect of each spare part shall include, but not be limited to, the following :-

(a) Detailed part description

(b) Unique component/assembly identification code (for easy identification of assembly/module/unit/system it belongs to)

(c) Name and address of the manufacturer and the address of its Canadian agent (if any)

(d) Manufacturer's part number

(e) Contractor's part number

(f) Manufacturer/Contractor drawing number

(g) Unit price

(h) Number off per train with special remark on interchangeability of the parts

(j) Estimated service life/annual consumption rate

(k) Shelf life (if any)

(l) Recommended quantity

(m) Minimum order quantity for subsequent orders

(n) Lead time for delivery of additional quantities

(o) Overall dimensions including packing (if any)

(p) Special storage requirements (if any)

24.1.12. The information supplied in respect of each special tool and test equipment shall include, but not be limited to, the following :-

(a) Full description of the tool/test equipment

(b) Application

(c) Name and address of manufacturer and tool/equipment model number

(d) Delivery period

(e) Recommended quantity

(f) Minimum order quantity for subsequent orders

(g) Power rating (if applicable)

(h) Dimensions, with/without packing

(i) Special storage requirements (if any)

(j) Weight

(k) Unit price

(l) Lead time for delivery of additional quantities

24.1.13. Where a spare part, special tool or test equipment is to be produced by the

Commission, the Contractor shall provide detailed technical specifications and drawings for the manufacture of the tools.

24.1.14. When a spare part, special tool or test equipment, or any part thereof including any software, is no longer available from the original supplier, the Contractor shall provide the Commission with an equivalent substitute which shall fulfil all the functions of the original item to not worse than the original performance standards.

24.2 Spares Recommendation

24.2.1. Spares for Running Maintenance

The final list shall be submitted for approval 3 months before delivery of the first train.

24.2.2. Other Maintenance Spares

(a) The list shall also include those major items, such as, traction motors and trucks, which must be held as a float for unit exchange purpose.

(b) The final recommendation shall be submitted for approval within 2 months following delivery of the first train.

24.2.3. Commissioning/Warranty Spares

(a) The final recommendations shall be submitted for the Engineer's approval at least 6 months prior to the delivery of the first train and shall be delivered together with the first train.

(b) The Contractor shall provide and maintain this spares holding throughout the Defect Liability Period.

24.2.4. Special Spares

A special spare list for those spare parts/components which require delivery lead time longer than 6 months, such as, wheelset, or any specifically made parts/component, shall be submitted for approval at least 6 months prior to the delivery of the first train.

24.2.5. Strategic Spare

A list of strategic spare parts likely to be required for contingency or replacement after major incidents, such as, collision and derailment, shall be submitted for approval at least 6 months prior to the delivery of the first train.

24.3 Special Tools and Test Equipment

24.3.1. Special tools and test equipment shall be:

(a) those that are not easily acquired from the commercial markets;

(b) those that cannot be found in the reputable tools supplier's catalogues (such as. MacRAE'S Blue Book, RS Components International and McMaster - Carr Supply Company);

(c) those that are not commonly used in industrial application; or

(d) those that are not included in yard (refer to Appendix I Annex 5).

24.3.2. Special tools and test equipment shall be provided to enable the maintenance personnel of the Engineer to carry out in-house testing and repair of the train and its associated equipment/component. In addition, all special equipment or facilities that are used to adjust, test, fault diagnosis and repair the microprocessor based PCBs/equipment shall also be supplied.

24.3.3. The special tools and test equipment provided shall ensure that all levels of routine maintenance can be carried out to the approved maintenance schedule with the yard facilities provided.

24.3.4. The special tools and test equipment shall ensure that the maintainability targets specified in PS 25.9 can be achieved.

24.3.5. Where appropriate special tools and test equipment, such as, wheel skates, shall also be provided for the use of a rescue team during major incidents to achieve fast recovery.

24.3.6. The special tools and test equipment shall be sufficient in number to allow the

trains to be maintained and overhauled to the approved maintenance schedule.

24.3.7. Any additional equipment that are required for the special tools and test equipment to carry out their intended function shall be kept to minimum. Any equipment that uses microprocessor control to analyses the performance of the train system, or its component parts, shall be configured to allow a data download of these test results. This information must provide the date and time of test, the tester's name, type of equipment tested, its modification status and serial number and any test results.

24.3.8. For free standing equipment the Contractor shall advise the storing and fixing arrangements of the special tools and test equipment.

24.3.9. Special tools and test equipment shall cover, but not be limited to, the following functions

(a) Special keys and tools for access covers and doors

(b) Operation tools for special equipment and fasteners

(c) Inspection and measuring gauges for preventive and corrective maintenance, including equipment overhauls

(d) Special tools and test equipment required in the installation, removal, repair, adjustment and commissioning of equipment

(e) Test equipment for checking the functions and performance of equipment in-situ on the train

(f) Test equipment for interfacing with the Train Management System and any other microprocessor based equipment on the train to facilitate maintenance for identification of the faulty part down to the LRU level (refer to PS 26.2.5). Such equipment shall provide functions such as downloading fault logs, interrogation and adjustment of parameters.

(g) Test equipment which shall provide simulated inputs to the equipment for accessing its performance in-situ on the train

(h) Test equipment and simulators for checking and verifying the functions and performance of equipment at the workshop in repairs and overhauls

(i) Equipment for programming microprocessor based equipment

(j) Special tools for rerailment and for handling a locked axle

(k) Tools and equipment for supporting any condition-based maintenance schemes

24.3.10. Test equipment and simulators described in (f), (g) and (h) above for electronic equipment shall be so designed that the success rate of fault finding and rectification operations shall not be worse than 95%.

24.3.11. If a portable notebook or palmtop computer (PC) is used for the application of test equipment and simulators described in PS 24.3.10, the Contractor shall ensure that only one single PC shall be required for interfacing with all microprocessor controlled equipment on the train, including the TIMS, Event Recorder and the control system of other equipment (such as traction converter and doors). All software used for the above test and simulation purpose shall comply with PS 29.

24.3.12. For Contract purpose, total six (6) nos. of test equipment and simulators and/or PC shall be provided.

24.3.13. All relevant operation and maintenance information (for example, manuals, drawings, circuit diagrams and etc) for the special tools and test equipment shall be provided and submitted for approval.

24.3.14. The final list shall be submitted for approval 6 months before delivery of the first train.

24.3.15. The special tools and test equipment together with the associated operation and maintenance information shall be delivered not later 3 months after the delivery of the first train.

24.3.16. Training of all special tools and equipment shall be provided by the Contractor according to the training requirements (refer to PS 23.8).

24.3.17. An additional list of special tools and test equipment which are used in production and are surplus to requirements upon Completion and which the Contractor would be willing to sell to the Commission, shall be provided for the Engineer's review and acceptance at least 6 months prior to the delivery of the first train.

24.4 Submission and Delivery Schedules

Item	Descriptions	Schedules
1.	Submit the detailed lists of spares, special tools and test equipment	Not later than 15 weeks after the date of the Notification of Award
2.	Update and submit a revised lists of spare parts, special tools and test equipment together with an amplification and confirmation of the lists supplied with the Proposal and shall be subsequently modified and amended as necessary with changes in design	SEMP stage 3
3.	Update and submit a revised lists of spare parts, special tools and test equipment	SEMP stage 4
4.	Training of all special tools and equipment	SEMP stage 5
5.	Submit the final list of commissioning/warranty spares	6 months prior to the delivery of the first .
6.	Submit the final list of special and strategic spare	6 months prior to the delivery of the first .
7.	Submit the final list of special tools and test equipment	6 months prior to the delivery of the first .
8.	Submit all relevant operation and maintenance information (for example, manuals, drawings, circuit diagrams and etc) for the special tools and test equipment	6 months prior to the delivery of the first .
9.	Submit an additional list of special tools and test equipment which are used in production and are surplus to requirements upon Completion and which the Contractor would be willing to sell to the Commission	6 months prior to the delivery of the first .

10.	Submit the final list of spare parts for running maintenance	3 months prior to the

Item	Descriptions	Schedules
		delivery of the first
11.	Submit the final list of other maintenance spares	2 months prior to the delivery of the first
12.	Delivery of spare parts for running maintenance and commissioning/warranty spares	Together with the first
13.	Deliver the special tools and test equipment together with the operation and maintenance information	Not later 3 months after the delivery of the

SECTION 25 SYSTEM ASSURANCE 2

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Section 25 System Assurance

25.1 Introduction

25.1.1. This Section defines the requirements and techniques for system assurance.

The general requirements and specific tasks for the System Assurance Plan (SAP) (refer to PS 25.2.1) during the design development, production, and initial operation of the train are also provided.

25.1.2. The Contractor shall ensure that all system assurance requirements are met

for each System Engineering Management Plan (SEMP) stage. The required tasks and deliverables are summarised against each SEMP stages in Table 25-1 at the end of this Section.

25.2 Key Deliverables

25.2.1. System Assurance Plan (SAP)

(a) As an integral part of the SEMP, the Contractor shall provide a SAP

which shall detail the Contractor's intended methodology to plan, manage and control the system assurance process. The SAP shall either be integrated as a single document or presented as separated Reliability Program Plan, Availability and Maintainability Program Plan and Safety Program Plan.

(b) The objectives of the SAP are:

(i) to ensure that the requirements of reliability, availability,

maintainability and safety (RAMS) are fulfilled

(ii) to ensure that hazards and RAMS problems shall be

identified early in the project

(iii) to ensure that any improvements found necessary during the system assurance process be included in the design in a timely manner.

(c) The contents of the SAP shall consist of, but not be limited to, the following elements:

(i) Organisation and key personnel of the Contractor/ Subcontractors that will carry responsibility for the implementation of the SAP

(i i) Roles and responsibilities

(i i i) Monitoring and control of the system assurance activities of the Contractor/ Subcontractors

(i v) Integration of system assurance activities within the overall design / construction processes

(v) Performance targets to be met

(v i) Programme of system assurance tasks (refer to PS 25.3.1)

(v i i) Outline of System Assurance Demonstration Plan (refer to PS 25.2.3)

(v i i i) Internal audit program. If applicable, it shall form part of the Quality Plan (refer to PS 27.1.2(h)(i).

(d) The Contractor shall submit the SAP as part of the SEMP presentation (refer to PS 21.3.5) and update as required.

25.2.2. System Assurance Progress Report

(a) The Contractor shall submit a System Assurance Progress Report for monitoring and control of the system assurance process as part of the SEMP presentation and SEMP Report for each stage.

(b) The System Assurance Progress Report shall contain the following as a minimum:

(i) Progress and status of system assurance tasks against the

(ii) Updated summaries of theoretical system assurance analyses (refer to PS 25.3.2), Hazard Log (refer to PS 25.3.3) and Register of Train Failures (refer to PS 25.3.4)

(iii) Progress and status of corrective actions (refer to PS 25.5.14)

(iv) A softcopy of Contractor's hazard database (refer to PS 25.4.5)

(c) Upon the request of the Engineer, the full records and results of each task performed in system assurance tasks shall be submitted.

25.2.3. System Assurance Demonstration Plan

(a) The Contractor shall provide a System Assurance Demonstration Plan to cover testing and demonstrations associated with the safety, reliability, availability and maintainability of the trains and its subsystems. The System Assurance Demonstration Plan shall address any pre-production and production tests, and demonstrations on the achievement of Reliability, Availability and Maintainability targets after the commencement of the Defects Liability Period. The System Assurance Demonstration Plan shall either be integrated as a single document or presented as separated Reliability Demonstration Plan, Availability & Maintainability Demonstration Plan.

(b) The contents of the System Assurance Demonstration Plan shall include, as a minimum, the following:

(i) Organisation and key personnel

(ii) Roles and responsibilities

(iii) System assurance targets to be met by demonstration

(iv) Items to which demonstration shall be carried out

(v) Suggested testing methods

(vi) Techniques and methods to be employed

(vii) Unequivocal definition of pass and fail criteria

(viii) System assurance demonstration activity programme, including test period

25.2.4. Reliability, Maintainability and Availability Demonstration Reports

(a) The Contractor shall submit separate reports on reliability, availability and maintainability demonstrations within 1 month after the completion of the respective demonstrations. The report shall provide evidence that the respective RAM targets have been achieved and shall include any supporting information and calculations.

(b) The Contractor shall submit interim reports to monitor RAM

performance, and to determine the effectiveness of corrective actions, if any, on a regular basis. The frequency of submission of the interim reports shall be agreed in the System Assurance Demonstration Plan.

25.3 General System Assurance Requirements

25.3.1. System Assurance Tasks

(a) The Contractor shall carry out system assurance tasks at different stages of the SEMP and during the Defects Liability Period in order

to ensure that all system assurance requirements, in particular, those issues related to software and interface design, shall be satisfied.

(b) System assurance tasks shall be integrated into the design, development, manufacturing and installation activities as a systematic approach. Outputs of such tasks shall be fed back to the respective activities and corrective actions shall be developed and implemented where necessary.

(c) The Program of system assurance tasks shall include, but not be limited to, the following:

(i) SSP (refer to PS 25.5.1)

(i i) Theoretical system assurance analyses, which shall include, as a minimum:

- Preliminary Hazard Analysis (refer to PS 25.5.2) identifying the need for further Safety Analyses such as:
- Interface Hazard Analysis (refer to PS 25.5.3)
- Operating & Support Hazard Analysis (refer to PS 25.5.5)
- Failure Modes, Effects and Criticality Analysis (refer to PS 25.5.9)
- Fault Tree Analysis (refer to PS 25.5.10)
- Derivation and Apportionment of RAM targets (refer to PS 25.5.11)
- RAM Modelling and Predictions (refer to PS 25.5.12)

The Contractor may propose for approval alternative techniques to the ones specified provided that they shall achieve the same objectives.

(i i) Safety Verification (refer to PS 25.5.13)

(i i i) Reliability Testing/ Commissioning (refer to PS 25.5.14) (iv) RAM Performance Demonstrations (refer to PS 25.5.15)

(v) Failure Reporting, Analysis and Corrective Action System (FRACAS) (refer to PS 25.5.16)

(v i) Operational Safety Report Process (refer to PS 25.5.17) (vii) Certification Process (refer to PS 25.5.18)

(d) The outputs of system assurance tasks shall be submitted as Design Documents (refer to PS 21.3.8).

25.3.2. Theoretical System Assurance Analyses

(a) The Contractor shall carry out theoretical analyses to assess the RAMS performance of the train, its systems and subsystems. The causes, probability and consequences of individual hazard shall be established and evaluated.

(b) Information such as failure modes and probabilities employed in the theoretical analyses shall be based on life experience or approved references such as MIL-HDBK-217F, RAC NPRD-95 or RAC FMD-97.

(c) Theoretical system assurance analyses shall be updated to account for any changes in the design of the trains up to SEMP stage 5.

(d) The results of the theoretical system assurance analyses, including updated versions of the Hazard Registration System (refer to PS 25.3.3) and Register of Train Failures (refer to 25.3.4), shall be submitted and presented as part of the System Assurance Progress Report at each SEMP stage.

(e) The results of the theoretical safety analyses shall be consolidated into the hazard database (refer to PS 25.4.5).

(f) The following assumptions shall be adopted in all theoretical RAMS analyses:

Running distance per car per year: 113,000 km (70,000 miles)
Distance between station stops: 1 km (0.62 miles)

Train operating time per day: 20 hours

25.3.3. Hazard Registration System

(a) The Contractor shall establish a Hazard Registration System to register hazards identified in the various safety analyses. The output of the Hazard Registration System shall be presented in a form of Hazard Log with an approved format and shall be updated at each SEMP stage and shall be submitted as part of the System Assurance Progress Report (refer to PS 25.2.2(b)) and System Assurance Engineering Report (refer to PS 25.2.4(b)).

(b) The format of the Hazard Registration System report shall be agreed with the Engineer.

(c) The Hazard Registration System shall be submitted in electronic copies. The electronic copy shall be prepared in Microsoft® Access or Excel Version 2002 compatible, stored in a compact disk.

25.3.4. Register of Train Failures

(a) In addition to the Hazard Registration System, the Contractor shall also set up and maintain a Register of Train Failures to document all scenarios which will result in a train failure (refer to PS 25.7.4). The causes, consequential effects and impact on train service shall be recorded for each entry in the Register. As a minimum, all those criteria that constituted a train failure (refer to PS 25.7.4), shall be adopted and form part of the above Register.

(b) The Register of Train Failures shall be submitted in both printed and electronic copies. The electronic copy shall be prepared in Microsoft® Access or Excel Version 2002 compatible, stored in a compact disk.

25.3.5. Performance Targets

(a) For the purpose of train service commitment, it is deemed necessary that the train shall achieve performances targets for the following aspects:

(i) Safety (refer to PS 25.6)

(i i) Reliability (refer to PS 25.7)

(i i i) Availability (refer to PS 25.8)

(i v) Maintainability (refer to PS 25.9)

(b) The ab~~ove performance targets shall be achieved under the condition~~ that maintenance is performed by the Commission as follows:

(i) Maintenance work is carried out by skilled and suitably qualified personnel appropriate to the work

(i i) The maintenance team is constituted according to the approved Operation and Maintenance Manual

(i i i) The work is carried out according to maintenance procedures in the approved Operation and Maintenance Manual

(i v) Tools and spare parts required by the work are readily available

(v) The work is carried out using the Commission's maintenance facilities as described in Appendix I Annex 6.

(v) The work is carried out using the Commission's maintenance facilities as described in Appendix I Annex 5.

(c) Failure to achieve the reliability performance target defined in PS 25.7 shall be deemed to be a defect under GC29 – Warranty. Failure to achieve the reliability performance target defined in PS 25.7 shall be deemed to be a defect under GC39.

25.4 Contractor's Hazard Registration System

25.4.1. In order to ensure that the hazards which have been identified by either the AUTHORITY or Contractor, will be given adequate attention early in the design stage and in such a way that changes shall be made in a cost effective manner, the Contractor shall initiate a Hazard Registration System to carry out a thorough review of the following information:

(a) Rolling stock hazards as identified by either the AUTHORITY or Contractor; (b) Analyses from similar works undertaken before.

25.4.2. All Contractor’s Hazard Registration System's records will be provided in electronic format of Microsoft® Access or Excel Version 2002 compatible, stored in a compact disk, and the Contractor shall incorporate a Hazard Identification Number into the Hazard Registration System as the basis for normalization, update, expansion and further study.

25.4.3. The Contractor shall comply with the severity, probability and risk acceptance classification system defined in MIL-STD-882E when completing the various safety hazard analyses. The Contractor shall be required to submit proposals for mitigation of all risks, other than those classified as "Acceptable" or outside the Contractor's scope or control.

25.4.4. Apart from the newly identified hazards, the Contractor shall document hazards from the above information that are deemed applicable to the trains into the relevant hazard analyses. Where practicable, the design shall incorporate the same safeguards for these hazards. The Contractor shall clearly identify the new hazards in the hazard analyses and shall make every effort to avoid duplication of hazards.

25.4.5. The Contractor shall formulate a hazard database "Hazard Registration System" to record all the hazards identified in the

various hazard analyses. A softcopy of the hazard database shall be submitted to the Engineer.

25.4.6. The hazard database shall be constructed in the in electronic format of Microsoft® Access or Excel Version 2002 compatible, stored in a compact disk, with memo text fields as specified in Figure 25-1.

25.4.7. The Contractor shall appoint a Hazard Controller shall be responsible for management, control and monitoring of the above Hazard Registration System. The Hazard Controller shall conduct a regular hazard review meeting with the responsible engineers of the Contractor / Sub-Contractors / Suppliers, and work closely with the SEM representative (refer to PS 21.2.3) in order to ensure all identified hazards are addressed timely as part of the SEMS process. The Hazard Controller shall be the safety engineer as specified in PS 25.5.1(a).

25.4.8. The following areas shall be highlighted in the summary of the respective hazard analysis for the Engineer's attention:

(a) All new hazards identified by the Contractor as a result of the new system design, interfaces, usage or operational environment shall be highlighted with new Hazard Identification Numbers;

(b) Any potential increase in risk level of existing hazards to an Unacceptable or Undesirable Level due to change in hazard frequency or severity;

(c) Any uncontrolled risks that are outside the Contractor's responsibility and require the Engineer or other contractor's actions.

25.5 Specific System Assurance Tasks

25.5.1. System Safety Program (SSP)

(a) The Contractor shall initiate and maintain a SSP according to MIL-STD-882E as a guideline. All safety related program; safety assessment, verification and validation shall be under the control, of a suitably qualified independent safety engineer nominated by the Contractor as his representative.

(b) The Contractor shall initiate and maintain a System Safety Program Plan (SSPP) to define how the SSP will be implemented in order to ensure that all the safety requirements, particularly those that are specified in PS 25.6, are met.

(c) The SSP shall be application of management and engineering principles, criteria and techniques to optimize all aspects of safety within the constraints of operational effectiveness, time, and cost throughout all phases of system life cycle.

(d) The SSP shall ensure that the design incorporates, within the specified project restraints, the highest attainable level of inherent safety. It shall eliminate or reduce the probability of events that shall cause injury or death to personnel, or damage to or loss of equipment or property. The objective of SSP shall be taking the most effective actions to control potential hazards in the SEM process as early as possible.

(e) In the event that hazards cannot be controlled by design measures, including safety and warning devices, special operating procedures shall be developed and documented. The safety program shall provide support to the SEMS and shall ensure that the applicable requirements of MIL-STD-882E, SSP Requirements, are met.

(f) The SSP shall define and address the safety analyses that shall be performed during SEMP 1. By the end of SEMP 1, an analysis that identifies conditions that may cause injury or death to personnel and damage or loss to equipment and property shall be performed. During SEMP 2 and SEMP 3, the Contractor shall perform other systems safety analyses to determine adherence of the design to all required safety standards and criteria, and to ensure avoidance or reduction of identified hazards. Operating and maintenance procedures shall also be reviewed for compliance with all required safety standards and criteria.

(g) By the end of SEMP 4, the SSP shall include follow-up / corrective procedures to ensure that safety hazards identified by the systems safety analyses are eliminated or reduced to acceptable levels of risk, and that actions taken are documented.

(h) The Contractor shall prepare specific safety program documentation which shall form part of the System Assurance Progress Report (refer to PS 25.2.2). This documentation shall include, but not be

limited to, safety analysis reports and the final systems safety report.

25.5.2. Preliminary Hazard Analysis

(a) Preliminary Hazard Analysis shall provide an early, top level assessment of the design for possible hazards and to initiate appropriate actions to mitigate/eliminate hazards.

(b) The Preliminary Hazard Analysis shall be reported using the form in Figure 25-2 or an equivalent approved by the Engineer.

(c) Preliminary Hazard Analysis shall give an initial indication of any Safety problems which may arise.

(d) The Contractor shall also carry out a preliminary assessment of the likely levels of Safety to be achieved.

25.5.3. Interface Hazard Analysis

(a) The Interface Hazard Analysis identifies and assesses existing or potential hazards between subsystems and/or systems and their effect on overall system safety and operations. The emphasis is on interfaces. The Interface Hazard Analysis shall be conducted on the critical interrelationships of each subsystem and system to determine the cause and effect of possible independent, dependent and simultaneous failures that could present a hazardous condition, including failures of safety devices. When the Interface Hazard Analysis indicates a potential problem, it should be made known to the Engineer immediately.

(b) The Interface Hazard Analysis shall be reported using the form in Figure 25-2 or an equivalent approved by the Engineer.

25.5.4. Operating & Support Hazard Analysis

(a) The Operating & Support Hazard Analysis shall be conducted according to MIL-STD-882E as a guideline on all tasks and human actions, including acts of omission and commission, by persons interacting with the system, subsystems and assemblies at any level, and including the public. All human factors and ergonomic aspects of the design and its operation shall be considered. When the Operating & Support Hazard Analysis indicates a potential safety

hazard, it shall be made known to the Engineer immediately.

(b) The Operating & Support Hazard Analysis shall be reported using the form in Figure 25-2 or an equivalent approved by the Engineer.

25.5.5. Safety Requirements / Criteria Analysis

(a) The Safety Requirements / Criteria Analysis shall be conducted based on MIL-STD-882E as a guideline to develop design requirements to eliminate or reduce the risk of the identified hazards to an acceptable level.

(b) A Blast Analysis shall be carried out. It is a requirement that due design consideration shall be given to improve a vehicle's ability to reduce the damage that results from an on-board or nearby explosion, as a minimum, the vehicle shall be able to:

(i) maintain structural integrity and prevent catastrophic collapse of the vehicle body;

(ii) maintain at least basic operating capacity in order to evacuate the area being attacked and protect the passengers on board;

(iii) ensure the body components will not fragment in an explosion, and shall shield occupants from flying debris;

(iv) ensure the selection of structural materials shall increase strength and melting temperature.

Constructability guidance on blast resistant structures design according to the “Structures to Resist the Effects of Accidental Explosions”, Army Technical Manual 5-1300/Navy Publication NAVFAC P-397/Air Force Manual (AFM) 88-22 (TM 5-1300) (Department of the Air Force, 1990), shall be followed where applicable.

(c) The Fire Hazard Analysis which shall be part of the Vehicle Fire Hazard Analysis, shall be carried out. Due design consideration shall be given to improve survivability of the passengers under the worse case design fire scenarios according to NFPA 130. For example, subject to the outcome of the fire hazard analysis, a light weight non-fibrous types of fire curtain shall be provided and automatically deployed during fire at the gangway area as a solution to provide 1 hour integrity according to the requirements of BS 476, part 22. Guidance on fire hazard analysis according to Annex E of NFPA 130 shall be followed where applicable.

(d) A Crashworthiness Analysis shall be carried out. Due design consideration shall be given to ensure the safety of occupants i.e. both train operators and passengers, on the following areas:

- Impact Avoidance. Preventing accidents from happening.

- Primary Crashworthiness. Ensuring occupants are prevented from experiencing excessive decelerations.

- Secondary Crashworthiness. Ensuring that any injuries caused by: (i) loss of survival space when the vehicle structure collapses,

  and

  (ii) impact with interior furniture and fittings, are prevented / minimised.

- Minimising Post-Crash Hazards. Preventing and minimising hazards such as fire and exposure to chemicals.

- The analysis shall include, but not limited to:

(i) Identification of the vehicle structure collapse mechanism;
(ii) Improving the energy absorption capability of the rail vehicle structure; and
(iii) Study of the seat configurations or restraint system to enhance reductions in occupant injury levels. The Contractor shall substantiate the above analysis by using well accepted computer modelling techniques, such as LS-DYNA®, to assess occupant injuries during rail impacts and to demonstrate that the above safety requirements are met.

(e) Arc Flash Hazards

The Arc Flash Hazard Analysis shall be carried out as part of the vehicle arc flash hazard analysis. Due consideration shall be given o minimize employee and passenger exposure to arc flash hazards. All arc flash hazards shall be categorised according to the NFPA 70E criteria.

25.5.6. Failure Modes, Effects and Criticality Analysis

(a) The Failure Modes, Effects and Criticality Analysis shall be undertaken on all components in systems or equipment which are found to have failure modes whose failure consequences are classified as "Critical" or worse in accordance with the Hazard Severity Categories defined in MIL-STD-882E, or cause train delay of or greater than five minutes.

(b) The effects of different modes of component failure shall be propagated to the next level of the system or equipment and this process shall be continued until the overall effect on system function shall be determined. The effect of any equipment redundancy shall be incorporated into the results.

(c) An estimation of the effects of the failure on passengers and staff shall also be made, including the delay to the service, and an estimation of time taken to restore the system to normal operation will also be required.

(d) The report of the Failure Modes, Effects and Criticality Analysis shall conform to the example shown in Figure 25-3 or an equivalent approved by the Engineer.

25.5.7. Fault Tree Analysis

(a) Fault Tree Analysis shall involve the preparation of a logic diagram, which traces the events or combinations of contributing events which have led to an undesirable occurrence (referred to as the "top event"). Each of the contributing event(s) shall be also considered in turn, together with the subsidiary events involved in those failures.

(b) The process shall be continued with each event being scrutinised for its causes until it is not practical to proceed to a lower level or the process need not be continued because the probability of the occurrence of the event is demonstrably negligible. To the most extent, Quantitative Fault Tree Analysis shall be prepared. Qualitative Fault Tree Analysis may also be used when evaluation of probability is based on estimation, especially in the case of human actions.

(c) Fault Tree Analysis shall be performed on those events whose failure consequences are classified as "Critical" or worse in accordance with the Hazard Severity Categories, and whose residual risk level is "Unacceptable" or "Undesirable" according to MIL-STD-882E.

25.5.8. Derivation and Apportionment of RAM Targets

The Contractor shall decide, with agreement of the Engineer, to what extent the overall targets for RAMS of their Works shall be decomposed to sub-system/component level. The Contractor shall then apportion the overall targets among the sub-system / components. Those aspects of design which are contributing disproportionately high levels of risk to the non-achievement of RAMS targets shall be identified.

25.5.9. RAM Modelling and Predictions

(a) The purpose of RAM modelling is to develop a model of the functional interdependencies of the system/subsystem on the train. It

shall provide an analytical framework for apportioning the system level RAM targets into lower level estimates to generate design goals.

(b) Reliability, Availability and Maintainability prediction is a bottom up analytical process which provides quantitative estimates on overall system RAM performance based on estimates of lower level subsystems.

(c) RAM prediction shall identify weak links in the system, provide quantitative assessment of a design with respect to achievement of

the RAM targets and highlight areas having the largest potential for improvement.

(d) Documents shall be provided to show how the configuration of the system contributes to its overall RAMS performance, and the trade-off between relevant parameters.

25.5.10. Safety Verification

The Safety Verification shall be conducted based on MIL-STD-882E as a guideline to demonstrate that safety functions / features which are an integral part of the design shall work as intended. The process shall be either covered by analysis, test, , or inspection on items of equipment critical to safety.

25.5.11. Reliability Testing/Commissioning

(a) During specific SEMP stages as defined in Table 25-1, individual components and sub-assemblies shall be tested to precipitate design or quality failures. Any deficiency of problem found during the test shall be analyzed and validated corrective action / modification implemented on the production units, as required.

(b) As a minimum requirement, simulated endurance tests shall be carried out, during SEMP stages 3 and 4, on each of the top 5 items of equipment which are expected to contribute to the greatest number of train delays in accordance with the theoretical analyses.

(c) Each item to be tested shall be operated under simulated operation conditions for at least 1.2 times of the number of duty cycles or operating time that it shall experience in actual service between overhauls or replacements. A report containing details of the test and the results shall be submitted as part of the System Assurance Progress Report.

(d) Details of the tests shall be submitted for the Engineer's approval in the System Assurance Demonstration Plan as defined in PS 25.2.3.

25.5.12. Reliability, Availability and Maintainability Performance Demonstrations

(a) RAM performance demonstrations shall be carried out as defined in the respective RAM requirements. The information collected shall enable comparison to be made with the theoretical work undertaken during the design through to testing & commissioning stages, with

an aim to ensure that the required level of RAM is achieved in service.

(b) The Contractor shall propose for approval accept / reject criteria in the formulation of the System Assurance Demonstration Plan (refer to PS 25.2.3), which shall take into account the following factors:

(i) RAM targets specified in the PS;

(i i) Quantity of equipment in operation under scope of supply of the Contract;

(iii) Accumulative operational time or distance travelled;

(c) If the required RAM targets cannot be demonstrated during the Defects Liability Period, then the Contractor shall present an alternative demonstration proposal in the System Assurance Demonstration Plan.

25.5.13. Failure Reporting, Analysis and Corrective Action System

(a) The Contractor shall establish a Failure Reporting, Analysis and Corrective Action System throughout the defined SEMP stages to provide a documented history of any problems and failures and their associated corrective actions as well as detailing how and why each problem arose, or failure occurred.

(b) The Failure Reporting, Analysis and Corrective Action System shall monitor the Reliability performance of the equipment, from the design (where changes may result from conclusions of the predictive analysis), through testing and commissioning and into operation. The system shall be used to monitor the performance of components and to identify pattern failures so that corrective action shall be taken to improve both current and future systems.

(c) The progress and corrective actions of key items shall be

summarised in the System Assurance Progress Report.

25.5.14. Operational Safety Report Process

(a) The Operational Safety Report Process shall include an Operational Readiness Review (ORR) and preparation of an Operational Safety Report (OSR).

(b) By SEMP 5, the Contractor shall conduct an ORR of the complete system. The ORR shall include, but not limit to, the following activities in order to verify:

(i) Applicable operations, maintenance, and emergency rules, procedures, and plans have been properly developed, reviewed, and implemented

(i i) Manuals, showing how to operate and maintain systems equipment and facilities, have been properly developed, reviewed, approved, and accepted by the Engineer

(i i i) Safety-related training for both operator and maintainer has been properly developed, performed, and successfully completed

(i v) Emergency training has been properly developed, performed, and successfully completed

(v) Emergency drills and training have been conducted with the satisfaction of the Engineer:

(1) To familiarize and train response of both operator and maintainer in emergency procedures

(2) To evaluate response procedures

(3) To identify improvements to response procedures before a real emergency occurs

(4) To maintain an adequate level of preparation for a possible emergency

(b) Upon the completion of the ORR, the Contractor shall submit an OSR which shall be a record of:

(i) Verification and validation of all safety issues as identified by the hazard analysis are closed out and all corrective actions are properly implemented to the satisfaction of the Engineer.

(i i) Verification and validation of all related procedures and plans are tested for effectiveness under simulated operating

conditions for normal, abnormal, and emergency situations

(iii) Verification and validation of all related operating and maintenance procedures and plans are judged as meeting the verification requirements or are recommended for modification.

25.5.15. Certification Process

(a) In order for AUTHORITY to complete its Safety Certification process to allow

a revenue service train operation, the Contractor shall provide certificates of compliance. These certificates shall cover the train as

a system operating in the existing Lines. The Certification Process shall demonstrate the compliance of the certifiable elements with regard to the safety requirements of the Specification. The basis for the Certification Process shall follow the guidelines according to the "Handbook for Transit Safety and Security Certification" (doc ref: DOT-FTA-MA-90-5006-02-01, issued at: November 2002, issued by: Federal Transit Administration (FTA)) whereas applicable.

(b) By SEMP 1, the Contractor shall provide a Certification Plan to define how the process is implemented. Guidelines according to the Section of "Safety and Security Certification Plan" of the "Handbook for Transit Safety and Security Certification" (doc ref: DOT-FTA-MA-90-5006-02-01, issued at: November 2002, issued by: Federal Transit Administration (FTA)), shall be followed.

(c) As part of the Certification Process, the Contractor shall identify the elements that need to be certified for the project. Certifiable elements shall include all project elements that shall affect the safety of passengers, operators, maintainers or contractors.

(d) During SEMP 1 to 3, the Contractor shall identify safety design criteria for each certifiable element. The safety design criteria shall provide guidance to the definition of systems, sub-systems and components, the development of performance requirements, and the final specification of the train. Whenever possible, reference to their identification and documentation should be included in the associated Design Documents (refer to PS 21.3.8).

(e) By SEMP 3, the Contractor shall provide a Design Criteria Conformance Checklist for each certifiable element to record requirements generated from safety design criteria. These checklists shall provide a format to verify compliance with identified safety requirements. In the certification process, contract specifications, design criteria, applicable codes, and industry standards shall constitute this verification. Once the checklist format is completed, verified checklists shall be submitted for approval. Documentation supporting verification of the safety requirement should be available for review by the Engineer.

(f) By SEMP 4, the Contractor shall provide a Construction

Specification Conformance Checklist to verify that the as-built systems incorporate the safety requirements as identified in the Specifications and other Contract Documents, including approved changes since the final design. Once the checklist format is completed, verified checklists shall be submitted for approval. Documentation supporting verification of the safety requirement should be available for review by the Engineer.

(g) As an integral part of the Testing Plans (refer to PS 22.1), the Contractor shall ensure that all testing requirements should be reviewed for safety considerations. All tests as specified in PS 22 are subject to certification, and certification of the above test shall be verified in the Construction Specification Conformance Checklist, or combined with the associated testing specifications.

(h) By SEMP 5, a Certificate of Compliance shall be issued for each identified element. As a minimum requirement, the following Identify Certifiable Elements shall be included:

Sampled Certificate	Certifiable Elements
0701	Design Requirements & Disciplines
0702	Testing and Commissioning
0703	Training
0704	Maintenance Disciplines, Standby Parts & Spare Parts
0705	Manuals & Drawings
0706	Noise, Vibration and Electromagnetic Interference
0707	Quality Assurance
0708	Software Planning, Development, Verification & Validation

(h) Prior to issuing Certificates of Compliance, the Contractor shall ensure that:

(i) All certification documentations are reviewed to confirm no outstanding items remain. In the event that any remaining work-around is deemed necessary and affecting a certifiable element, the Contractor shall submit for approval a hazard management plan which shall analyze the hazard and control the risk to an acceptable level for a defined period of time.

(ii) Approval of certifiable elements occurs only when work has been completed in conformance with criteria and hazards have been reduced to an acceptable level.

(i) Upon completion of all Certificates of Compliance issued by the

Contractor, the Commission will proceed with the System Safety Certification.

25.6 Safety Requirements

25.6.1. Safety is defined as freedom from those conditions that shall cause death, injury, occupational illness, or damage to or loss of equipment or property, or damage to the environment.

25.6.2. Safety performance shall be assessed by the Risk Index of individual hazards identified during the System Assurance process.

25.6.3. The Risk Index of a hazard shall be identified from the Risk Assessment Matrix defined by MIL-STD-882E in accordance with the following parameters associated with the hazard:

(a) The hazard probability ranking shall be calculated for the entire fleet under the assumptions defined in PS 25.3.2(f); and

(b) The hazard severity category shall be based on an average passenger load per train.

25.6.4. The Contractor shall ensure that the Risk Index of all hazards on the train shall not be worse than the "Acceptable" category i.e. either "Acceptable" or "Acceptable with Review" as defined in the Risk Assessment Matrix defined by MIL-STD-882E

25.6.5. The Contractor shall adopt the mishap severity categories according to Table A-II of MIL-STD-882E, a table of suggested mishap probability levels based on the 'Fleet or Inventory' column of Table A-III of MIL-STD-882E, and a Risk Assessment Matrix based on these two tables, and with the Suggested Criteria of Figure 1 in Appendix A-IV of MIL-STD-882E.

25.7 Reliability Requirements

25.7.1. Definition of Reliability

The reliability of the trains shall be measured based on the number of train service disruption incidents, hereafter referred to as Train Delays, which are caused by train failures during operation.

where:

Train Delay: A Train Delay is an event caused by one or more Relevant Failures either requiring passengers detrainment and Immediate Train Removal from service or causing a delay of or over 5 minutes at terminal arrival. If a train does not need immediate removal but is removed at the next convenient location or opportunity without detrainment, this shall not be counted as a train delay.

Relevant Failure: An improper condition of Items (Part, Component, Assembly, Subsystem, System) which requires a corrective

maintenance action (replacement, repair, reset, adjustment, software re-load) to restore the affected item to its normal operating condition. A Relevant Failure of an item is an independent failure plus any dependent failure caused thereby which results in loss of function of that item caused by any of the following:

- A fault in the item while operating within its design and environmental specification limits.
- Improper operation, maintenance, or testing of the item as a result of Builder-supplied documentation or other Builder failure to meet its contractual obligations.
- Premature item degradation.
- Failures or failure indications which require operator/maintenance technician corrective action prior to return of that item to a functioning state.
- Consumable items requiring replacement for reasons other than normal fleet wear/aging.
- Software failures which manifest themselves in an equipment failure or in an indication of failure, resulting in loss of function of an item in accordance with the Specification.
- Repetitive loss of function of any Item which shall not be duplicated when investigated and, therefore, shall not be corrected by a specific maintenance action ("no trouble found"). This excludes temporary loss of function due to built-in self-reset feature.

Non-Relevant Failure: Any failure or condition of an item which meets one or more of the following criteria:

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A failure caused by malfunctions of other equipment (secondary failure).

A failure caused by human error, except as noted for Relevant Failures.

A failure caused by accidents not associated with the normal operation of the item, such as collision or striking a foreign object on the right-of-way.

A failure caused by operating the item outside of design or environmental specified limits.

A failure caused by malfunction of Components not furnished, designed, manufactured, modified, or installed by the Builder, Subcontractor, or Manufacturer under the provisions of these Specifications, or which is shown by Builder's analysis and Failure Review Board concurrence to be out of Builder's scope of responsibilities under these Specifications.

A failure caused by abusive or incorrect action by the AUTHORITY

- operators or maintenance personnel or incorrect maintenance procedures or practices by the AUTHORITY.
- Consumable items requiring replacement during specified preventive maintenance or which should have been replaced during a previously scheduled maintenance interval and were not.
- Reported failures for which, upon final review, insufficient or inadequate documentation is obtained to determine failure relevancy, subject to agreement of all FRB members.

Item: A non-specific term used to denote any portion of a Car, including software.

Reliability: The probability of performing a specified function without failure and within design parameters, for at least the operating distance specified, under actual operating conditions. Measured reliability is defined to be in terms of the total operating distance divided by the total number of relevant failures.

AUTHORITY shall have the final word on the relevancy of Train Delay events.

25.7.2. Measurement of Reliability

The reliability of the trains shall be assessed using a “Mean Distance Between Train Delays” measure.

The Mean Distance Between Train Delays (MDBTD) shall be the ratio of the accumulated mileage of each car in the fleet during a given period over the total number of Train Delays Failures during the same period. The MDBTD shall be demonstrated during the Reliability Demonstration using moving windows covering 12 consecutive months (12-month moving windows). The demonstration shall be based on the following formula.

$$\text{MDBTD} = \frac{\text{Accumulated Mileage of all cars of the fleet (in car - miles)}}{\text{Number of Train Delays}}$$

A Failure Review Board (FRB) shall be	established and composed of members of the Contractor and of AUTHORITY. The FRB shall meet on a weekly basis and has the mandate to review all Train Delays and assess the relevancy and attribution based on the criteria defined above.

25.7.3. Reliability Targets

The trains shall achieve a reliability target not less than 772,485 car kilometres (480,000 car miles) for MDBTD criteria by the end of the reliability demonstration period:

25.7.4. Conditions for Train Delays

A list of Train Delays criteria shall be defined as part of the Reliability Program Plan and logged in the Register of Train Failures. This Train Delays criteria list shall be used to determine the relevancy of train delays accounted for the Reliability Demonstration.

25.7.5. Recovery from Train Failures

To minimise service disruption incidents caused by train failures, the trains shall be designed to meet the following requirements:

(a) Failures that may potentially lead to Train Delay as detailed in the Register of Train Failures shall be recoverable by either automatic reset features or manual intervention from the Operator (fault isolation, cut-out, etc.).

(b) In the event that the failure is not recovered within five minutes and/or the train is required to be immediately withdrawn from service, the train operator shall be able to carry out failure isolation and start the return journey at fully laden load (refer to PS 4.4.11) under the train's own power, to the nearest yard or refuge siding.

(c) In the event that no tractive power is available from the defective train and an assistance train is required, the train operator shall, within five minutes, be able to prepare the train for emergency push out or pull out operation (refer to PS 4.4.3).

25.7.6. Demonstration of Reliability Performance

(a) The Reliability Demonstration Period shall begin from the beginning

of the fifth month following the date of the issue of the Final Acceptance Certificate for the last Six Car Subway Train Set of the first Group. The period shall last for at least 12 months and shall end when the reliability target is achieved.

(b) During the Reliability Demonstration Period, the Engineer shall maintain records for all train delays and details of train failures. Such records shall be made available to the Contractor.

(c) During the Reliability Demonstration Period, the Engineer shall review train failure records and decide whether additional scenarios are to be incorporated into the Register of Train Failures. The

Contractor shall then update the Register for the Engineer's approval within 30 days of the Engineer's notice for updating.

(d) The failure records of the trains shall be assessed at the end of each month starting from the 12th month of the reliability demonstration period. The value of the reliability measure defined in Clause 25.7.2 shall be calculated from the records for the preceding 12 months and compared to the reliability targets.

(e) In the event that the reliability target is not achieved, the determination of reliability achievement shall be continued at monthly intervals until the reliability target is achieved in the same 12-month period.

(f) In the event that the reliability target is not achieved, the Contractor shall, at his own expense, take whatever action is deemed necessary to meet the reliability requirement.

25.8 Availability Requirements

25.8.1. Measurement of Availability

(a) Availability shall be assessed by the following measure:

$$\text{Availability} = \frac{1 - DT(RE)/3 + DT(OPM) + DT(CM)}{\text{Total Time}}$$

where:

(i) Total Time is the time in hours in the assessment period multiplied by the number of cars supplied under the Contract.

(i i) DT(RE), or Down Time due to service checks, is the total down time in hours due to service checks (refer to PS 26.3.2), summed over all cars supplied under the Contract during the assessment period.

(i i i) DT(OPM), or Down Time due to Other Preventive

Maintenance, is the total down time in hours due to Preventive Maintenance (refer to PS 26.3) other than service checks (refer to PS 26.3.2), summed over all sessions carried out on the cars supplied under the Contract during the assessment period.

(iv) DT(CM), or Down Time due to Corrective Maintenance, is the total down time in hours due to corrective maintenance

(refer to PS 26.4), summed over all sessions carried out on the cars supplied under the Contract during the assessment period. Time spent on train integrity inspections after train reformations arising from corrective maintenance work shall be included.

(b) The above down times shall be counted starting from the moment when work is physically started on a car or train and shall end when the car or train is restored to service condition (PS 2.5.1). The time shall cover the full content of the maintenance work concerned, including safety precautions, inspections, servicing, replacement of equipment, defect detection and rectification, testing and restoration to service condition.

25.8.2. Availability Target

The trains supplied shall achieve a minimum availability of 96.5%.

25.8.3. Demonstration of Availability Performance

(a) The average availability of the trains shall be assessed either by analytical/theoretical methods or, through measurement at the end of the fifteenth month after the issue of the Certificate of Completion of the Works. The total maintenance down times for all trains shall be collected by the Engineer and made available to the Contractor and the average availability during the preceding 6 months, shall be worked out from the above formula.

(b) In the event that the availability target is not achieved, the determination of availability achievement in the preceding 6-month period shall be continued at monthly intervals until the target is achieved.

(c) In the event that the availability target is not achieved, the Contractor shall, at his own expense, take whatever action is deemed necessary to meet the availability requirement.

25.9 Maintainability Requirements

25.9.1. Maintainability Targets

The maintainability of a given maintenance operation shall be measured by the arithmetic mean of the times required to complete a sample of the same operation. After the maintenance operation the train involved shall be restored to service condition.

The trains shall meet the following maintainability targets:

(a) A Service Check (15 days) - not more than 2 hours per car with a team size of not more than 2 persons

(b) B Service Check (45 days) - not more than 36 person-hours per car

(d) General Overhauls - not more than 56 hours (7 working days) per train

(e) Scheduled Equipment Replacements - not more than 6 hours per session, 90% of the time.

(f) Corrective Maintenance Operations shall result in a Mean Time to Repair (MTTR) of no greater than 1.5 hours. This shall be the weighted average of the MTTR of the key system of the vehicle. MTTR shall include fault isolation, removal and replacement of failed item and checkout. It excludes logistic time (time to bring the train in the shop, time to get the part(s), preparation of required tools, etc).

Corrective Maintenance Operations shall result in a Maximum maintenance time to repair (Mmax) of 4 hours for at least 90% of all actions.

In addition to the above maintainability targets, the trains shall also satisfy maintenance requirements specified in PS 26. Any replacement of good LRUs due to inaccurate diagnosis shall be included in the maintenance time.

25.9.2. Demonstration of Maintainability Performance

(a) As part RAM performance demonstration, the Contractor shall carry out tests to show that all maintainability targets are met.

(b) The tests shall cover all preventive maintenance sessions (refer to PS 26.3) and a representative sample of actual or simulated corrective maintenance (refer to PS 26.4) operations. Reference shall be made to MIL-HDBK-470 in the formulation of the maintainability tests.

(c) All maintainability tests shall be completed within 6 months after the delivery of the first train.

(d) The analyses and demonstration of maintainability performance shall include the following steps:

(i) Removal of the failed part

(i i) Replacement of the failed part

(iii) Checkout, testing

Notes: The following activities are excluded from the breakdown and calculations:

- Logistics (time to bring the train to the shop, time to get the parts, time to get the proper tools, etc.)
- Fault Isolation (troubleshooting)

(e) In the event that any maintainability target is not achieved, the Contractor shall demonstrate that the actual maintainability concept is the most adequate and has been maximized for maintenance operations and accessibility of equipment.

Preliminary ID:	To be arbitrarily defined by the Contractor for exclusive use in his report.
System:	Operating System, activity or equipment of which the hazard is originated.
Subsystem:	Element of the system from which hazard may arise due to failure, malfunction or mal-operation.
System Operating Mode:	The operating condition of the system during which the hazard may arise.
Evaluation Team:	Name of the company/person and/or team members who identified the hazard.
Owner:	Hazard Controller of the hazard. (Reserved for
Susceptible Location:	The most likely location where the hazard may arise.
Susceptible Time:	The most likely time when the hazard may arise.
Description:	The general description of the hazard.
Potential Cause:	The act or abnormal event which could cause the hazard.
Effect/Consequences:	Most likely effect or consequence of the hazard.
Frequency:	Estimated frequency of occurrence per year. This is referred to the most likely consequence but not the
Severity:	The degree of severity of the consequence.
Risk Index:	The ranking of the hazard according to the risk assessment matrix.
Proposed safeguard:	The control measures to prevent the occurrence of the hazard or mitigate its consequence.
Remark:	Reserved for AUTHORITY Use.

Figure 25-1 (Sheet 1 of 3) Example of Hazard Registration Database Structure

Field	Field Name (Field Description)	Type	Width	Dec
1	PREID	Character	8	(Preliminary Hazard ID)
* 2	REGDATE	Date	8	(Registration Date)
3	SYSTEM	Character	40	(System)
4	OSYSTEM	Character	20	(other system not prescribed below)
5	SUBSYSTEM	Character	40	(Subsystem)
6	OSUBSYSTEM	Character	40	(other subsystem not prescribed below)
7	OPER_MODE	Character	25	(Operation Mode)
8	OOPER_MODE	Character	40	(other operation mode not prescribed below)
9	EVAL_TEAM	Memo	10	(Evaluation Team)
* 10	OWNER	Character	40	(Hazard Controller)
11	DESC	Memo	10	(Description)
12	LOCATION	Memo	10	(Location)
13	TIME	Character	20	(Time)
14	OTIME	Character	40	(Other time)
15	CAUSE	Memo	10	(Cause)
16	FRE_DESC	Character	28	(Frequency Description)
+17	EFF_CONSQ	Memo	10	(Effect and Consequence, passenger and/or staff)
18	FREQUENCY	Numeric	10	(Frequency in value [midpoint of that frequency class])
19	SEVERITY	Character	20	(Severity)
20	RISK_INDEX	Character	2	(Risk Index)
21	EX_SF_MIT	Memo	10	(Proposed Safeguard)
* 22	REMARK	Memo	10	(Remark)

* Reserved for AUTHORITY Use

+ The header of this field should follow one of the formats given below:

a) Hazard with consequences affecting passenger only:

[Passenger]

xxxxx

xxxxx

b) Hazard with consequences affecting staff only:

[Staff]

xxxxx

xxxxx

c) Hazard with consequences affecting both passengers and staff:

i) Parent record for passenger consequences

[Passenger+]

xxxxx

xxxxx

ii) The associated record for staff consequences. In addition, the 'Description' Field should be entered as "Hazard description refers to Ref. xxxxx".

[Staff+]

xxxxx

xxxxx

Figure 25-1 (Sheet 2 of 3) Example of Hazard Database Structure

System operating mode

ABNORMAL, ABNORMAL OR EMERGENCY, NORMAL, NORMAL OR ABNORMAL, NORMAL OR EMERGENCY, EMERGENCY, ALL, OTHER

Susceptible time

ANY TIME, TRAFFIC HOUR, NON TRAFFIC HOUR, MORNING PEAK, EVENING PEAK, OFF PEAK, OTHER

System

ROLLING STOCK

Subsystem

SYSTEM	SUBSYSTEM
ROLLING STOCK	AIR CONDITIONING
ROLLING STOCK	AUXILIARY SUPPLY
ROLLING STOCK	BATTERY
ROLLING STOCK	TRUCK & SUSPENSION
ROLLING STOCK	BRAKING & PNEUMATIC
ROLLING STOCK	COUPLER
ROLLING STOCK	DOOR
ROLLING STOCK	ELECTRIC MULTIPLE UNIT
ROLLING STOCK	INTERFIT
ROLLING STOCK	MOTOR & DRIVE
ROLLING STOCK	TRACTION SUPPLY & COLLECTOR SHOE

Severity

CATASTROPHIC, CRITICAL, MARGINAL, NEGLIGIBLE

Frequency

Risk index

UNACCEPTABLE, UNDESIRABLE, ACCEPTABLE WITH MANAGEMENT TECHNICAL REVIEW, ACCEPTABLE

Figure 25-1 (Sheet 3 of 3) Example of Hazard Database Structure

+ System Mode (Normal, Abnormal, Emergency)

* The most severe outcome from a hazard, should be classified

Figure 25-2 Example of Hazard Analysis Form

FMECA Table

System *1. Traction & Braking*
Subsystem *2. Traction Motor*

Ref	Item	Failure Rate for Item (per hour) (A)	Failure Mode	Cause	Mode of Failure	Failure Effect			Existing Design	Car Redundant Relevant (Xi out of Yi)	No. of Items per Car Yi
						Sub-	System	Service			
TB.TM.1	Traction Motor	9.52E-06	Fails to provide motive force for power	Electrical fault	Single Failure	Fails to provide motive	One traction motor not available to provide tractive effort	No effect - Condition on operational policy	Multiple motors fitted	-	4
					Multiple Failures	*Fails to provide motive force*	*Loss of tractive effort for over 4 axles*	*Section Unavailable - stalled train*	*Multiple motors fitted*	*3 out of 4*	*4*

Note 1 Single Failure: (A x Ys) Multiple Failures: Use Redundancy Formula

Note 2 Include all time causing delay e.g. ti

Figure 25-3 Example of Failure Modes Effects and Criticality Analysis Form

System Assurance Requirements	PS Ref	Completion of SEMP Stages					
		SEMP 1: Concept Exploration	SEMP 2: Design Development and Review	SEMP 3: Design Verification and Validation	SEMP 4: Engineering and Manufacturing	SEMP 5: Inspection, Testing, Commissioning,	Defects Liability Period
Key System Assurance Deliverables							
System Assurance Plan	25.2.1	D	D	D	D	D	
System Assurance Progress Report	25.2.2	D	D	D	D	D	D
System Assurance Demonstration Plan	25.2.3		D	D	D	D	D
Reliability, Availability and	25.2.4						D
System Assurance Tasks							
Preliminary Hazard Analysis	25.5.2	D	D				
Interface Hazard Analysis	25.5.3		D	D	D	D	
Operating & Support Hazard Analysis	25.5.5		D	D	D	D	
Safety Requirements/Criteria Analysis	25.5.7		D	D	D	D	
Failure Modes, Effects and Criticality	25.5.9		D	D	D	D	
Fault Tree Analysis	25.5.10		D	D	D	D	
Derivation and Apportionment of RAMS	25.5.11	D	D				
RAMS Modelling and Predictions	25.5.12		D	D	D	D	
Hazard Log	25.3.3		D	D	D	D	
Register of Train Failure	25.3.4		D	D	D	D	
Safety Verification	25.5.13					A	
Reliability Testing/ Commissioning	25.5.14			A	A	A	
RAM Performance Demonstration	25.5.15					A	A
Failure Reporting, Analysis And	25.5.16		A	A	A	A	A
Operational Safety Report Process	25.5.17					A	
Certification Process	25.5.18	A	A	A	A	A	A

Legend: A Activity

D Deliverable (a.k.a. submittals)

Table 25-1 Summary of System Assurance Tasks and Deliverables by SEMP Stage

SECTION 26 MAINTENANCE REQUIREMENTS 2

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26.8 ..... As-built Drawings 20

Section 26 Maintenance Requirements

26.1 General

26.1.1. Maintenance Programme

(a) The Contractor shall establish and provide documentation for a comprehensive maintenance programme for upholding the service condition (refer to PS 2.1.7) of the trains. The objective of the maintenance programme shall be to ensure that the trains will satisfy the following requirements throughout their design life:

(i) Operational safety requirements as defined in PS 25.6

(i i) Reliability requirements as defined in PS 25.7

(i i i) Availability requirements as defined in PS 25.8

(i v) Maintainability requirements as defined in PS 25.9

(v) Quality of comfort, including cleanliness and appearance, experienced by passengers

(v i) Minimum life cycle cost

(b) The maintenance programme shall cover preventive maintenance, corrective maintenance, cleaning, condition-based maintenance and any other activities necessary to maintain the trains in a condition that can fulfil the above requirements. Within the context of this Specification and unless otherwise specified, the term 'maintenance' shall include all activities covered by the maintenance programme.

26.1.2. Maintenance Policy

(a) The maintenance programme shall be based on a planned preventive maintenance approach. Each train will undergo a series of regular maintenance sessions, the contents of which will be increased progressively in accordance with the amount of service and in line with the maintenance requirements of individual equipment. Where appropriate, condition-based maintenance techniques shall also be adopted to minimize the amount of maintenance work, downtimes and the associated costs.

(b) Service checks and cleaning work shall be so organized that they can be completed within the time limits specified under maintainability requirements.

(c) All corrective maintenance work shall be completed within the time limits specified under maintainability requirement.

(d) The Contractor shall satisfy with himself on the various access restrictions as specified in PS 25.8.1(f) that the performance of the Works will not be

affected. The Contractor shall make his best maintenance design to minimise downtime and maximise the availability of the trains.

26.1.3. Submission

Information pertaining to maintenance requirements shall constitute part of the design documents to be submitted for approval.

26.2 Design for Maintenance

The Contractor shall ensure that maintenance considerations are duly incorporated into the design of the train. Features that can minimize or facilitate maintenance shall be built into the design as integral elements. As a minimum, the following requirements shall be satisfied:

26.2.1. Health and Safety

(a) The design of the trains shall be such that all maintenance activities can be carried out safely.

(b) The Contractor shall identify all potential hazards to personnel or equipment that may arise during all maintenance activities in Operating and Support Hazard Analyses (refer to PS 25.5.5) or similar studies. For example, the design of the carhouse receptacle together with the isolating and test switch (refer to Appendix Annex 5 Clause 6.2) shall ensure that no single point failure will cause any unsafe hazard to the maintainer.

(c) The Contractor shall establish and specify, for each potential hazard, corresponding preventive, mitigative or protective measures to reduce the risk to an acceptable level as defined in the Risk Assessment Matrix in PS 25.

(d) The Contractor shall ensure that all maintenance activities shall comply with relevant legislation in Canada regarding health and safety. For example, the Occupational Health and Safety Act, safety regulation 658/79.

(e) Testing procedures shall be built into all maintenance work to ensure that the

trains shall be restored to a safe operation condition upon completion of the maintenance work.

26.2.2. Human Factors

(a) Ergonomic principles shall be adopted in the design of the train so that maintenance and cleaning activities are tailored to suit the capability and limitations of the maintenance staff. In general, guidelines in ISO 6385 and Def Stan 00-25 Parts 15-21 and Part 25 shall be adhered to. Anthropometric dimensions for the Canadian population shall be adopted.

(b) The design of maintenance work shall be such that skills and training requirements are minimized. This shall be achieved primarily with the aid of the TIMS (refer to PS 10) and YMSS (PS 18.6) plus other special tools and equipment supplied under the Contract as the workshop level maintenance aid.

(a)

26.2.3. Accessibility

(b) Lockable door which shall only be opened by the maintenance key (refer to PS 32 and Contract Drawing No. NST-009), shall be provided for those equipment that are designed for maintenance access inside the saloon and cab. Access to equipment shall require minimum effort and shall not impose undue strain to maintenance and cleaning personnel.

(c) Equipment shall be configured in such a way that ease of access corresponds with the frequency of access for both preventive and corrective maintenance, with the most frequently accessed part having the easiest access. Unless it is approved by the Engineer, all control equipment shall be accessible within the saloon area.

(d)

(e) The layout and mounting of equipment shall facilitate inspections, testing and replacement during fault finding. Adequate access shall be provided to the extent possible so that when replacing one particular LRU it will not be necessary to remove other components having a lower replacement frequency, which may block the access.

(f) Access covers and doors of equipment cases and cabinets shall be provided with quick release fasteners to reduce the time and effort for removal and restoration. Access covers and doors accessible by passengers shall be designed against tampering.

The design of access to underframe mounted equipment shall take account of the fact that personnel working on the underframe will wear bump caps. Lockable door for all underframe mounted equipment, shall be equipped with flush-mounted, foldable T-shaped handle with adjustable compression latches features, such that no hand tool or key shall be required to open or lock the door.

The design of the vehicle components shall use modular components approach which allows for the quick removal and replacement of modules and reduces

repair and maintenance costs. Detailed modularization requirements shall refer to PS 26.2.5 and 26.2.6.

(a) Lockable door which shall only be opened by the maintenance key (refer to PS 32 and Contract Drawing No. 20099 for Square SRT Key), shall be provided for those equipment that are designed for maintenance access inside the saloon and cab. Access to equipment shall require minimum effort and shall not impose undue strain to maintenance and cleaning personnel.

(b) Equipment shall be configured in such a way that ease of access corresponds with the frequency of access for both preventive and corrective maintenance, with the most frequently accessed part having the easiest access. Unless it is approved by the Engineer, all control equipment shall be accessible within the saloon area.

(c) The layout and mounting of equipment shall facilitate inspections, testing and replacement during fault finding. Adequate access shall be provided to the extent possible so that when replacing one particular LRU it will not be necessary to remove other components having a lower replacement frequency, which may block the access.

~~(d) Access covers and doors of equipment cases and cabinets shall be provided with quick release fasteners to reduce the time and effort for removal and restoration. Access covers and doors accessible by passengers shall be designed against tampering.~~

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(f) The design of the vehicle components shall use modular components approach which allows for the quick removal and replacement of modules and reduces repair and maintenance costs. Detailed modularization requirements shall refer to PS 26.2.5 and 26.2.6."

26.2.4. Interface with AUTHORITY's Maintenance Facilities

The trains will be maintained by the AUTHORITY and stabled at the AUTHORITY's maintenance facilities as described in Appendix I Annex 5. The Contractor shall ensure that:

(a) The trains and the maintenance programme are designed to interface safely,

effectively and efficiently with the maintenance facilities in all aspects

(b) All maintenance activities are so organized that they can be completed to the required standards under the technical and operational constraints imposed by the maintenance facilities

26.2.5. Line Replaceable Units (LRUs)

(a) Equipment shall be constructed in such a way that when a failure occurs, the train can be restored to service condition by replacing the defective equipment items that give rise to the failure. Such defective equipment items are referred to as Line Replaceable Units, or LRUs.

(b) LRUs shall be designed for quick and easy replacement so that maintainability targets for corrective maintenance defined in PS 25.9 can be achieved.

(c) In order to avoid replacing unnecessary complete higher level assemblies which will increase the costs in replacement, handling, reconditioning and spares holding, LRUs shall generally be the lowest level items in the equipment system which satisfy one of the following conditions:

(i) Replacement or repair of lower level components in the item will require extensive stripping down and it is not practicable to design the item otherwise

(ii) Replacement or repair of any defective part within the item can only be achieved with proper equipment in a workshop environment and it is not practicable to design the item otherwise

(d) To give some examples, the following items shall be designed for replacement as LRUs:

(i) Roof Mounted HVAC

(i i) Contacts of specific contactors

(i i i) Electronic printed circuit boards

(i v) Electrical relays

(v) Brake actuators

(v i) Air compressors

(v i i) Autocouplers

(v i i i) Trucks

(i x) Window glazing

It is a requirement that the drop table shall be designated for the use of truck

removal / replacement only (refer to PS 25.8.1(c)).

(e) As far as practicable, quick release connections such as plugs and adapters shall be provided between a LRU and the train to facilitate replacement. Relay connections shall be of the plug-in type such that no wire disconnection and reconnection are required during replacement. All quick release connections shall have a robust design which shall be able to accommodate LRU replacements throughout their design life.

(f) LRUs mounted on the underframe, except for trucks, items on the traction drives and the suspension, shall be designed so that they can be replaced at the Running Maintenance Area of the AUTHORITY's yards (refer to Clause 2 and 3.5 of Appendix I Annex 5).

26.2.6. Workshop Replaceable Units (WRUs)

(a) Equipment which are functionally closely related shall be grouped into manageable physical modules, hereafter referred to as Workshop Replaceable Units (WRUs), to minimize the time and effort required by their replacement during car overhauls (refer to PS 26.3.3) and scheduled equipment replacement (refer to PS 26.3.4) sessions.

(b) Examples of WRUs are:

(i) A pneumatic block to hold components in the compressed air system

(i i) A brake equipment module containing valves in the air brake system

(i i i) Complete equipment cases containing contactors and relays in the traction inverter or auxiliary converter

(c) WRUs shall be designed in such a way that the time for recommissioning tests on the train is shortened by relocating most of the testing upstream at the overhaul workshop.

(d) Connections, other than mechanical mountings, between a WRU and the train shall be achieved through quick release fittings such as multi-way jumper plugs. Such quick release fittings shall have a robust design which shall be able to accommodate WRU replacements throughout their design life.

(e) As far as practicable, WRUs mounted on the underframe shall be designed to allow replacement to be carried out with the train standing at a track at the Running Maintenance Area. Only when this is not feasible, for example trucks, shall replacement be performed at a Lifting / Heavy Maintenance Area described in Appendix I Annex 5.

(f) Notwithstanding the above requirements, the design of WRUs shall allow any LRU which forms part of the WRU to be replaced, in-situ without replacing the entire WRU, within the time limit specified under relevant maintainability targets (refer to PS 25.9).

26.2.7. Lifting and Towing

(a) Proper handles shall be provided on heavy equipment designed for manual lifting.

(b) Equipment or components weighing over 20 kg (44 lbs) shall be designed for handling with overhead cranes and forklift trucks. Where necessary, they shall be provided with integral lifting lugs or eyes, or attachment points for similar fittings.

with dolly or forklift truck. Where necessary, they shall be provided with integral lifting lugs or eyes, or attachment points for similar fittings.

(c) Towing points shall be provided on each car to allow towing as specified in Appendix I Annex 5.

26.2.8. Running Hour Counter

(a) In order to facilitate maintenance scheduling, a running hour counter function shall be provided for each major equipment such as traction motor, air compressor, refrigerant compressor and doors for recording the running hours (or cycles in the case of doors and similar equipment) accumulated on the equipment.

(b) The running hours shall be recorded in the TIMS (refer to PS 10). Such information will then be downloaded for further processing.

(c) The running hour counter shall be reset when the equipment on the train is replaced by a new item.

26.2.9. Submission

(a) Interface with AUTHORITY's Maintenance Facilities

(i) At SEMP stage 3, the Contractor shall submit for approval any modification necessary to the AUTHORITY's maintenance facilities specified in Appendix I Annex 5 in order that the trains can interface with such facilities.

(ii) At SEMP stage 4, the Contractor shall submit for approval a schedule of tests to demonstrate that the trains shall be compatible with each of the AUTHORITY's maintenance facilities in accordance with PS 26.2.4.

(iii) The Contractor shall carry out tests to demonstrate that the trains can interface with each of the AUTHORITY's maintenance facilities as specified under PS 26.2.4. (b) WRUs and LRUs

(i) At each of SEMP stages 3 and 4, the Contractor shall submit an updated list of LRUs and WRUs for approval.

The list shall identify all LRUs and WRUs on the train as defined in PS 26.2.5 and 26.2.6 respectively. For simplicity, LRUs may be enumerated in generic terms in conjunction with a statement of any exceptions.

Any equipment items that are not able to meet the full requirements specified in PS 26.2.5 and 26.2.6 shall be reported to the Engineer.

(ii) At each of SEMP stages 4 and 5, the Contractor shall, upon the request of the Engineer, demonstrate by physical exercises that the design of specific WRUs or LRUs is able to meet relevant maintainability requirements.

(c) Running Hour Counter

At SEMP stage 2, the Contractor shall submit a list of equipment to be covered by the running hour counter for approval.

(d) Additional Submissions Related to Design for Maintenance

At the request of the Engineer, the Contractor shall submit additional details regarding Design for Maintenance as defined in PS 26.2 above for approval, and to demonstrate physically that relevant requirements are satisfied.

26.3 Preventive Maintenance

26.3.1. Organization of Preventive Maintenance Work

The Contractor shall establish and provide documentation for a preventive maintenance programme for the trains in accordance with the following requirements:

(a) Maintenance Action

Maintenance action is defined as the smallest sub-division of maintenance work to be carried out in-situ on the trains, such as bearing lubrication, filter change and relay operation check.

(b) Maintenance Tasks

(i) Preventive maintenance actions to be carried out in-situ on the trains shall be grouped into logical blocks referred to as maintenance tasks.

(i i) The maintenance actions in a maintenance task shall be carried out together as a complete module. They shall either be done on the same equipment / equipment system, such as the collector shoe; or at the same location, such as saloon or driving cab.

(i i i) Maintenance tasks shall form the basic building blocks of all maintenance sessions other than equipment overhauls. Low level tasks such as basic safety inspections shall be repeated in all preventive maintenance sessions while high level tasks such as truck replacement shall only be carried out at specific car overhauls.

(iv) Separate tasks shall be provided to cover maintenance actions to be carried out at different stages of a maintenance session.

(c) Maintenance Sessions

(i) Preventive maintenance work to be carried out in-situ on the trains shall be grouped into Maintenance Sessions during which a train will not be available for service. Maintenance sessions shall be designed to maximize availability and reliability while minimizing costs at the same time.

(i i) Each maintenance session shall be divided into a number of logical work stages such as preparation, servicing and inspections, and recommissioning, as defined in PS 30. Each stage shall consist of individual maintenance tasks.

(iii) The following types of maintenance sessions shall be provided to cover the maintenance requirements of trains at different service ages:

- Service Checks
- Car Overhauls
- Scheduled Equipment Replacements

(iv) The minimum requirements for each type of maintenance session are specified in PS 26.3.2 to 26.3.4 below. The Contractor may propose alternatives to such arrangements for approval.

(d) Equipment Overhauls

Equipment overhauls refers to the following:

(i) scheduled overhauls of individual equipment

(i i) repair of defective equipment removed from the trains during corrective maintenance

Such work shall be carried out outside the trains at the workshop with the required tools and equipment for the work.

26.3.2. Service Checks

(a) General Requirements

(i) To the most extent possible and in order to reduce train movements in the shops, Schedule maintenance tasks and activities shall be organized with a minimum interval of 45 days (B-Service checks).

(ii) Service checks include all regular safety checks, inspections and servicing necessary for maintaining the trains in service condition (excluding pre-departure daily inspections and tests).

(iii) The interval of B Service Checks shall be integral multiples of that for A Service Checks.

(iv) Service checks shall be designed to be carried out on complete trains so that each train will only be required to visit the yard once within the lowest service check interval. However the design of the trains and the service check contents shall also allow the service checks be carried out separately on individual units at different times.

(b) A Service Check

Interval: 5,000 km (approx. 15 Days) minimum

Downtime:Not more than 2 hours (including work arising) per car

Location: Running Maintenance Area (refer to Appendix I Annex 5)
Work Content: 'A type tasks' - Checks on safety and reliability critical equipment, general visual inspections, and replenishment of items such as lubricants and water.

(c) B Service Check

~~Interval: 15,000 km (~~Approx. 45 Days) minimum

~~Downtime:Not more than 36 person-hours (including work arising) per car~~
~~Location: Running Maintenance~~ Area

Work Contents: 'A type tasks' plus items at multiples of 15,000 km intervals ('B type tasks', regular scheduled maintenance)

26.3.3. Car Overhauls

(a) General Requirements

(i) Car overhauls are high level service checks which require the train or cars to be down for more than one Day.

(i) Car overhauls are high level service checks which require the train or cars to

be down for more than one working Day.

(ii) The contents of car overhauls shall be designed to meet the maintenance requirements of individual equipment while making the best use of their service lives between overhauls or replacements.

(iii) To minimize downtime, major equipment shall be replaced on an item-for-item exchange basis. Repair or overhaul of the used equipment shall be carried out independent of the car overhauls.

(iv) The car body shall require minimal attention at overhauls. Pipework and electrical cables shall last for the life of the car.

(v) Car overhauls shall normally be carried out on complete trains. However the design of the trains and the service check contents shall also allow the overhauls be carried out separately on individual units at different times.

(b) General Overhauls

Interval: 420,000km (Approx. 42 months) minimum
Downtime:Not more than 10 Days (including work arising) per train
Downtime:Not more than 7 working days (including work arising) per train

Location	Lifting / Heavy Maintenance Area (refer to Appendix I Annex 5)
Work Contents	'A & B type tasks' plus inspections, equipment replacements and repairs that require extensive stripping down.

(c) Mid-life Refurbishment

Interval (min):	2.1 million km (approx. 17.5 years)
Location:	Lifting / Heavy Maintenance Area
Work Contents:	As that of general overhauls plus complete refurbishment and replacements or repairs that require further stripping down

After mid-life refurbishment, the cars shall be returned to a condition which will enable them to run until the expiry of their design lives without major attention.

26.3.4. Scheduled Equipment Replacements

(a) Normally equipment shall be replaced during car overhauls to minimize downtime and overhead. Equipment that are not able to accommodate the 420,000 km car overhaul interval will be replaced according to a separate programme independent of the overhauls. Where possible, such replacements shall be carried out during service checks.

(b) The number of scheduled equipment replacements outside service checks shall not exceed 1per unit per year, or 3 per train per year.

26.3.5. Submission

(a) General

(i) The Contractor shall submit a Master Maintenance Schedule (refer to PS 30) in progressive amount of details for approval at various stages of design development.

(ii) The Master Maintenance Schedule shall contain information for every type of service checks, car overhauls and scheduled equipment replacements, as specified in PS 30.

(iii) Such information shall be documented systematically in the form of database or spreadsheet files in Microsoft® Access or Excel Version 2002 compatible. To facilitate the Engineer's work on maintenance planning, the electronic files for the Master Maintenance Schedule shall also be submitted at each stage in CD-ROM.

(b) SEMP Stage 2 - Basic Outline

An outline of each of the preventive maintenance sessions (refer to PS 26.3.1(c)) shall be submitted for approval at SEMP stage 2. Each outline shall contain the following information:

(i) Name of maintenance session

(i i) Brief description of work content

(i i i) Maintenance interval

(i v) Estimated downtime

(v) Estimated manpower and skills requirement

(c) SEMP Stage 3 - Detailed Outline

Preliminary versions of the following documents, as defined in PS 30, shall be submitted for approval:

(i) Master Maintenance Schedule

(i i) Maintenance Tasks Matrix

(i i i) Maintenance Checklists

(d) SEMP Stage 4 - Full Details

Complete versions of the following documents, as defined in PS 30, shall be submitted for approval:

(i) Master Maintenance Schedule

(i i) Maintenance Tasks Matrix

(i i i) Maintenance Checklists

26.4 Corrective Maintenance

26.4.1. Corrective maintenance refers to the following works:

(a) Identification and rectification of defects or alleged failures on the trains in order to restore them to service condition

(b) Rectification of defects found during preventive maintenance sessions

(c) Repair of defective equipment at the workshop

26.4.2. The design of equipment on the trains shall facilitate fault finding so that defects can be identified and repaired within the time limits specified under maintainability requirements.

26.4.3. As a basic requirement, to the extent possible, fault indicators shall be provided to indicate any failures affecting passenger service to both the train operator during service and the maintenance personnel during service checks.

26.4.4. To the most extent possible, the TIMS on the train shall provide aids for identifying the source of the failure down to the LRU in which the defect is located.

26.4.5. Major equipment systems on the train shall be equipped with self-diagnostics and fault logging systems which can capture relevant information at the time of equipment failure. Such information shall be made readily available to maintenance personnel for fault finding purposes.

26.4.6. The Contractor shall provide special test equipment which can furnish in-situ assessments of the function and performance of equipment on the train.

26.4.7. The above provisions, together with diagnostics aids in the TIMS, shall form an integrated system for supporting all corrective maintenance activities on the trains.

26.5 Cleaning

The external and interior of the trains will be cleaned regularly to maintain the trains at a high standard of cleanliness. The Contractor shall develop and specify a comprehensive cleaning programme for the up-keeping of the

cleanliness standard. The cleaning programme shall consist of detailed cleaning methods, cleaning procedures, materials, cleaning intervals, train downtimes and the manpower required to carry out the work.

No cleaning work will be carried out when the trains are in passenger service.

26.5.1. External Cleaning

(a) Water / Detergent Washing

(i) The external body of the trains will be cleaned regularly by an automatic water / detergent wash plant described in Appendix I Annex 5.

(ii) The trains shall be designed such that no damage shall be done to any part of the train by the washing process. No water shall be allowed to enter the saloon, the driving cab or any other unintended enclosures on the train.

(iii) The Contractor shall specify the frequency of water / detergent washing, which shall not be more than once per 2 service Days.

(iv) The Contractor shall specify the chemicals and the concentration required for the wash process.

(b) Acid Washing

(i) The Contractor shall specify whether acid washing is necessary to maintain the car body at the required standard of cleanliness.

(ii) Acid wash, where required, will be carried out at an automated acid wash plant described in Appendix I Annex 5. The Contractor shall specify details of the acid wash process, which shall include, but not be limited to, the following:

- frequency of washing, which shall not be more than once per 30 Days

- chemicals, concentration, soaking period and number of passes

(iii) Where acid washing is required, the train shall be designed such that it is not adversely affected by the acid washing process.

(c) Window Cleaning

(i) The window glass of the trains will be kept free from water stains at all times. Where this cannot be achieved by the automatic external washing defined in PS 26.5.1(a) and (b) above, the Contractor shall develop and specify a cleaning process to remove the stains.

(ii) Where regular cleaning is required, the Contractor shall ensure that parts of the train that will be affected by the process, for example car body finishes, window seals and fittings, will not be adversely affected by the process.

(iii) The cleaning process shall only be carried out during internal heavy cleaning sessions and shall meet the following requirements:

Interval:	not less than 60 Days
Manpower:	not more than 2 manhours per car

26.5.2. Internal Cleaning

The Contractor shall ensure that material finishes in the saloon and driving cab are designed to minimize the downtime and manpower for internal cleaning.

Internal fittings which require cleaning, such as air conditioning air grills and light diffusers, shall be readily accessible to the cleaning personnel and shall be easily cleaned by simple tools.

The material finishes in the saloon and driving cab shall be designed to withstand the action of common cleaning agents and water used during all internal cleaning activities.

(a) Internal Light Cleaning

(i) Internal light cleaning will take place daily in the stabling sidings at night during non-traffic hours. No services will be provided in the siding, hence power assisted cleaning will be limited to that which can be provided from the on board power sockets.

(i i) Such cleaning will be limited to mopping of the floor, cleaning the seats and wiping down internal surfaces. The Contractor shall specify detailed requirements for such cleaning.

(i i i) Internal light cleaning shall be completed with not more than 5 manhours per

train.

(b) Internal Heavy Cleaning

(i) Internal heavy cleaning will take place in dedicated heavy cleaning tracks

(refer to Appendix I Annex 5), which will be equipped with full length, car floor level platforms, with provision for electrical power and water.

(i i) Such cleaning shall be carried out at intervals of not less than 30 Days.

(i i i) The Contractor shall specify detailed requirements for such cleaning.

(i v) Internal heavy cleaning shall be completed with not more than 6 manhours per car.

26.5.3. Submission

(a) SEMP Stage 2 - Outline

The following information shall be submitted for approval for each type of cleaning described in PS 26.5.1 and 26.5.2:

(i) Brief description of work contents

(i i) Cleaning intervals

(i i i) Estimated downtime

(i v) Estimated manpower requirement

(b) SEMP stage 4 - Details

Information shall be submitted for approval for each type of cleaning described in PS 26.5.1 and 26.5.2. Such information shall include, but not be limited to, the following:

(i) For external cleaning:

- Specification of chemicals to be used at automated washing plants and for window cleaning (where necessary)
- Cleaning intervals
- Compatibility with existing chemicals for cleaning and the cleaning processes

(ii) For internal cleaning:

- Cleaning methods and procedures
- Specifications for cleaning tools and materials
- Cleaning intervals
- Manpower and skills requirements
- Downtime

26.6 Equipment Identification Labels

26.6.1. General Requirements

(a) The Contractor shall provide equipment identification labels on all items of equipment that are subject to workshop overhauls and repairs, ranging from

complete equipment assemblies or WRUs such as trucks and inverter assemblies, down to the lowest component that is to be overhauled or repaired as a single entity, such as brake actuators and electronic printed circuit boards.

(b) Equipment identification labels shall be positioned so that when the equipment is mounted on the train, the markings can be readily read by both maintenance personnel or a hand-held bar code reader during maintenance inspections, without the need for extensive stripping down.

(c) Equipment identification labels shall be designed to last for the life of the equipment on which they are attached. The markings shall withstand the operation and maintenance environment experienced by the equipment and shall be capable of being updated subsequent to equipment modifications.

(d) Each equipment identification label shall be marked with the part number, serial number, and the version number of any modifications in both alphanumeric characters and bar codes. The part numbers shall be consistent with those given in the Illustrated Parts Catalogue described in PS 30 and Appendix J. Each item of equipment shall have a serial number that is unique to any other items of the same model.

(e) The Contractor shall provide detailed specifications on equipment for producing the equipment identification labels and identify sources where the equipment can be obtained by the Commission.

26.6.2. Submission

The Contractor shall submit the following for approval:

(a) at SEMP stage 3, a list of equipment on the train to be provided with identification labels.

(b) at SEMP stage 4:

(i) Design of equipment identification labels

(i i) Specification of the bar code system

(i i i) Specification and sources for the equipment for producing the equipment identification labels

26.7 Operation and Maintenance (O&M) Manual

TM

26.7.1. Deliverables

(a) The Contractor shall provide a comprehensive set of printed and electronic copies of O&M Manual for the trains in accordance with the requirements in PS 30.

(b) The final deliverables shall include the following:

(i) Twenty complete sets of the approved printed O&M Manual in hard copy

(i i) Two copies of the approved text and databases for the printed O&M Manual in electronic format on CD-ROM

(iii) Two copies of all approved illustrations in electronic format in AutoCAD release 13, on CD-ROM.

(iv) A desk-top PC containing all the necessary software and hardware which allow it to act as a central server for the purpose of desktop publishing of the O&M Manual (refer to PS 30). The Contractor shall be responsible for

obtaining all required licences for the softwares. Licences for network applications shall cover at least 20 users.

(c) The printed O&M Manual shall be processed in 3 separate batches:

(i) Batch 1 shall consist of the following volumes:

- Volume I, Technical Descriptions Manual
- Volume II, Train Operator's Manual

(ii) Batch 2 shall consist of the following volumes, excluding parts on car overhauls and equipment overhauls:

- Volume III, Equipment Maintenance Manual
- Volume IV, Fault Diagnostics Manual
- Volume V, Illustrated Parts Catalogue
- Volume VII, Special Tools and Test Equipment

(iii) Batch 3 shall consist of the following:

- Volume VI, Software Manual
- Volume VIII, Vendor Documentation
- Remaining parts of Volumes III, IV, V and VII excluded in Batch 2.

26.7.2. Submission

(a) SEMP Stage 3

The Contractor shall submit the following for approval at SEMP stage 3:

(i) Outline of the structure and contents of individual volumes of the printed O&M Manual. This shall include:

- the titles of all chapters, sections and subsections for each volume
- breakdown of each item in the equipment hierarchy into 2 lower levels of details

(ii) Sample formats and layouts for all parts of the manuals, including items such as text, illustrations, maintenance schedules, work instructions, checklists and illustrated parts catalogues.

(b) SEMP Stage 4

The Contractor shall submit the draft versions of all volumes of the printed O&M Manual at SEMP stage 4. Such submissions shall be provided in the batches defined in PS 26.7.1(g) above. Three copies of the draft documents shall be provided in each submission.

(i) The first draft for Batch 1 of the printed O&M Manual shall be submitted immediately upon commencement of the O&M Manual Programme specified in the Engineer's Programme in Appendix F.

(i i) The first draft for Batch 2 of the printed O&M Manual shall be submitted not later than 2 months after the commencement of the O&M Manual Programme specified in the Engineer's Programme in Appendix F.

(iii) The first draft for Batch 3 of the printed O&M Manual shall be submitted not later than 6 months after the commencement of the O&M Manual Programme specified in the Engineer's Programme in Appendix F.

(c) SEMP Stage 5

(i) The Contractor shall submit the final drafts of the printed O&M Manual in batches as defined in PS 26.7.1(g) at SEMP stage 5. Such submissions shall be provided within 2 months after issue of the Engineer's comments on the respective first drafts of the printed O&M Manual.

(ii) The final version of the printed O&M Manual shall be submitted for approval within 2 months after the issue of the Engineer's comments on the respective final drafts of the printed O&M Manual.

26.7.3. Amendments

(a) The Contractor shall make any necessary amendments to the printed O&M Manual during testing and commissioning of the trains and the Defect Liability Period. Amendments shall be submitted in the form of replacements leaflets and electronic files. A list summarizing the changes and the reasons shall be submitted with each set of amendments.

(b) Changes to the printed O&M Manual found necessary during testing, commissioning and the Defect Liability Period shall be completed within 2 months after the need for amendment is identified.

(c) Subsequent amendments shall be completed 1 month prior to the issue of the Final Acceptance Certificate.

26.8 As-built Drawings

26.8.1. Scope of the As-built Drawings

The Contractor shall provide all drawings necessary for the operation, maintenance and repair of the equipment, by the Commission. Such drawings shall cover, but not be limited to, the following:

(a) Equipment layout drawings for the complete cars and individual equipment

(b) Mechanical drawings of cars, equipment and components, with relevant information such as key dimensions, tolerances, material specifications, quantities, manufacturing and assembly specifications.

(c) System block diagrams for equipment systems and subsystems

(d) Control circuit schematics for all electrical, pneumatic and hydraulic systems.

(e) System architecture, control circuit schematics and signal flow diagrams for electronic equipment. Details provided in electronic circuit diagrams shall be down to circuit board level.

(f) Wiring diagrams detailing the identity and locations of cables, terminal and electrical equipment

(g) Piping diagrams detailing the identity and locations of pneumatic and hydraulic equipment systems

26.8.2. General Requirements

(a) All as-built drawings shall be prepared in AutoCAD™ release 13 or a later version as approved.

(b) The Contractor shall adopt the AUTHORITY's Engineering Drawing Standards and the standard title blocks and templates for producing drawings. Copy of the above Engineering Drawing Standards is available for Contractor's reference.

26.8.3. Deliverables

The deliverables for as-built drawings shall include the following:-

(a) Three complete sets of full size printed copies of all As-built Drawings

(b) Two complete sets of all As-built Drawings in electronic format on CD-ROM.

(c) Three copies of the schedule of As-built Drawings tabulating the drawing number, title, paper size, revision number and date of all as-built drawings.

(d) Two electronic copies of the schedule of As-built Drawings in Microsoft® Access or Excel Version 2002 compatible, stored in a CD-ROM.

26.8.4. Submission

(a) At SEMP stage 4, the Contractor shall submit for approval a list of all As-built Drawings to be delivered.

(b) At SEMP stage 5, the Contractor shall submit the As-built Drawings for approval not later than the handover of the first train. All submissions shall be completed within 4 months.

26.8.5. Amendments

(a) The Contractor shall make any necessary amendments to the as-built drawings, during testing and commissioning of the equipment and the Defect Liability Period.

(b) Amendments to as-built drawings shall be provided in both printed copies and electronic files as defined in PS 26.8.3. They shall be delivered within 2 months after the change concerned is approved.

(c) All amendments shall be completed 1 month prior to the issue of the Final Acceptance Certificate.

SECTION 27 QUALITY MANAGEMENT **2**

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27.2 ..... Design Control 3

27.3 ..... Purchasing 3

27.4 ..... Process Control 4

27.5 ..... Corrective Action 4

27.6 ..... System Engineering Management System 5

Section 27 Quality Management

27.1 General

27.1.1 All Work shall be executed and controlled by a quality management system in accordance with the requirements of International Organization for Standardization (ISO) ISO 9001 : 2000.

27.1.2 Within four (4) weeks of the date of the Contract is awarded, the Contractor shall submit to the Engineer for approval a Quality Plan. The quality plan shall include the following:

(a) A section detailing the approach and structure of the Contractor's quality management system in fulfilling the requirements of the Contract and ISO 9001.

(b) A quality policy statement signed by the chief executive officer of the Contractor (or other senior executive officer of the Contractor agreed by the Engineer) declaring that the Contractor shall ensure that quality management is given the highest practicable priority in all aspects of the Contract and in discharging his contractual obligations. In the event that the Contractor is a consortium, partnership or joint venture, statements signed by the chief executive officer (or other senior executive officer of the Contractor agreed by the Engineer) of each of the companies comprising the consortium, partnership or joint venture shall be submitted.;

(c) Detail of the records that the Contractor proposes to keep, the time during which they will be prepared and the subsequent period and manner in which they will be stored;

(d) Contract details including Contract name, Contract number, and location of the Contractor's main works and head office;

(e) A statement of conformity on the Contract requirements;

(f) A detailed organisation chart identifying the responsibilities, authority and

interrelation of all personnel who manage, perform and verify Work affecting quality. The organisation chart shall be specific to the Contract;

(g) Reference to all documented quality assurance procedures to be used by the Contractor for the execution of the Contract and in the fulfilment of the requirements of ISO 9001;

(h) A summary of the sub-contract process including details of how the Contractor proposes to manage these Subcontractors and to ensure that the relevant quality system requirements of ISO 9001/2 are observed and

implemented by the Subcontractors in the execution of the Works sub-contracted. This requirement also applies to the Contractor's control of suppliers; and

(i) A system to enable the Engineer to conduct compliance audits on any aspect of design and to allow the Engineer to trace the cause of material / workmanship defects back to design, through the manufacturing, installation, testing and setting to Work stages. This shall be supported by the Configuration Control Program (refer to PS 21).

(j) The Contractor's detailed audit programme for internal and Subcontractor and supplier quality assurance audits or reference to it.

(k) Reference to design verification and validation plan, purchasing plan and process control plan as described below in PS 27.2 to PS 27.4.

27.2 Design Control

27.2.1 The quality plan shall include or reference to details on how the Contractor shall develop the Contract requirements into concept design and then detailed design in a systematic manner with the SEMS approach (refer to PS 21).

27.2.2 As part of the quality plan the Contractor shall submit a design verification and validation plan for approval.

27.2.3 The design verification and validation plan shall include descriptions of how the following will be managed:

(e) system functional and interface requirements

(f) any assumptions made on system / subsystem parameters / characteristics

(g) technique used in design verification and validation for each system / subsystem that may include calculation, theoretical / numerical analysis, computer simulation, comparison with a similar proven design, tests and demonstrations using prototype or similar design equipment

(h) schedule of the design verification and validation activities

27.2.4 The results of the design verification and validation shall form part of the SEMP report and be submitted in accordance with the requirements of the SEMS (refer to PS 21).

27.3 Purchasing

27.3.1 As part of the quality plan the Contractor shall submit a purchasing plan for approval. The purchasing plan shall identify major systems to be purchased for the Contract and all activities to be conducted in assuring the quality of the purchased products / services.

27.3.2 The purchasing plan shall include descriptions or reference of the following :

(a) Major systems to be purchased

(b) Contractor's review and approval procedures of the purchasing documents in ensuring correctness and adequacy of the specified requirements

(c) Incoming goods / materials inspection procedures together with the inspection sample size and the acceptable quality standard

27.3.3 All the purchasing documents and the related product / service quality records shall be properly maintained by the Contractor and shall be made available to the Engineer on request.

27.3.4 The Contractor shall be responsible for the validation of all sub-contracted Work.

27.4 Process Control

27.4.1 As part of the quality plan the Contractor shall submit a process control plan for approval 3 months before the start of any one of the processes.

27.4.2 The process control plan shall include descriptions or reference of the following :

(a) Procedures defining the manner of production, installation and servicing

(b) Equipment used in these processes and the required working environment

(c) Methodology in ensuring compliance with the required standards / codes of practice

(d) Monitoring, control and approval procedures including in-process inspection and final product inspection for the process parameters, product characteristics, equipment and working environment

(e) Qualification of equipment and personnel required

27.4.3 Photographic Progress Records

(a) The Contractor shall submit photographic records to illustrate progress of manufacturing whenever appropriate, from SEMP Stage 4 upon completion of the Work.

(b) The photographic records shall be submitted with the monthly progress report.

27.5 Corrective Action

Corrective actions requiring changes to designs / procedures shall be properly documented and submitted for approval in accordance with the Configuration Control Program.

27.6 System Engineering Management System

As an integral part of the Quality Management System, the Contractor shall operate a System Engineering Management System (SEMS), as described in PS 21, to the extent that he is responsible for design or for the selection of particular items of the Work, take cognisance of the SEM, particularly safety, requirements and ensure that the design and performance of the Work are to the highest standards and compatible with the specified requirement, in particular, the safety standards of the AUTHORITY's railway system.

SECTION 28 ENVIRONMENTAL REQUIREMENTS 2

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Section 28 Environmental Requirements

28.1 Purpose

28.1.1. The policies and procedures presented in this Section establish a common frame of reference for developing the Environmental Management System (EMS) in accordance with the requirements of International Organization for Standardization (ISO) ISO 14001 : 2004 - Environmental Management System Specification.

28.1.2. These policies and procedures establish the basis for a systematic approach to meeting environmental obligations.

28.1.3. This Section shall apply to all Subcontractors and suppliers.

28.1.4. The Contractor shall establish and maintain the EMS in accordance with the specified policies and procedures.

28.2 Policies

28.2.1. In order to ensure that the quality of the Contractor's Works meet the quality requirements and to provide evidence of such quality to the Engineer, a Quality Management System to the ISO 9000 series (refer to PS 27) shall be adopted as an integrated part of the EMS.

28.2.2. The ISO 14000 series, in particular, the ISO 14001:2004 - Environmental Management System Specification, or the equivalent standards, such as, the National Sanitation Foundation (NSF) 110, the British Standards Institute's (BSI) 7750, the Eco-Management and Audit Scheme (EMAS), the International Chamber of Commerce (ICC) Sustainable Development Principles, and the Global Environmental Management Initiative (GEMI) shall be applied to implement an effective environmental management system.

28.2.3. Within four (4) weeks of the date of the Contract is awarded, the Contractor shall submit to the Engineer for approval an Environmental Management Plan (EMP). Detailed requirements of EMP shall refer to PS 28.4.

28.2.4. The confirmed commitments shall be able to:

(a) comply with the relevant environmental legislation;

(b) minimise the environmental impact;

(c) comply with the global initiatives, such as, the Montreal Protocol for the elimination of CFCs;

(d) set measurable performance goals for continuous improvement;

(e) audit progress against these goals;

(f) be specific to apply it to the Contract;

(g) be broad enough to meet the site requirements on different locations of production;

(h) protect the health and safety of the users of the trains, including the passengers, train operators and maintainers;

(i) be updated to reflect all necessary changes.

28.3 Environmental Management System (EMS)

28.3.1. The EMS shall be a systematic approach applied to the management of the Contractor's environment performance i.e. adherence to a suitable environmental policy, the meeting of environmental objectives and the ability to demonstrate to the Engineer that the policy requirements and objectives are met.

28.3.2. The EMS framework shall identify resources for developing, implementing, measuring, and periodically reviewing the Contractor's progress toward achieving the environmental policy.

28.3.3. The EMS framework shall include but not limited to the following items:

(a) the Contractor's organisational structure;

(b) planning activities;

(c) defined responsibilities; and

(d) standard practices, procedures and processes.

28.3.4. The EMS framework shall be recorded in an Environmental Management Plan (refer to PS 28.4) and submitted for approval.

28.3.5. An environmental performance evaluation mechanism shall be provided in the EMS to measure, analyze, assess and describe the Contractor's environmental performance particularly those associated with pollution preventions.

28.3.6. A life cycle assessment process shall be provided in the EMS to evaluate the environmental attributes, burdens and impacts associated with the product, process or service.

28.3.7. The life cycle assessment shall be able to measure the environmental impact of a product from raw material extraction to final disposal. It shall also include the impact of manufacturing, distribution and transportation, product use and recycling.

28.4 Environmental Management Plan (EMP)

28.4.1. The EMP shall include the following:

(a) A policy statement shall be provided to demonstrate the commitment of the top management of the Contractor.

(b) The statutory and contractual obligations regarding environmental protection imposed on the Contractor, and the means by which the Contractor shall supervise, monitor and audit his site environmental assurance system to ensure due compliance with these obligations. The Contractor shall develop and complete the environmental management plan (EMP) in accordance with the specific requirements of this Specification, the Environmental Impact Assessment and the manner in which he proposed to complete the Works. Any amendment to the approved EMP shall require subsequent approval. A schedule of the environmental impacts likely to be associated with the Works and a list of specific proposals for the elimination or mitigation of such impacts shall be included as well as a programme indicating when these measures shall be implemented;

(c) The Contractor's environmental staff organisational structure, which shall identify personnel to be engaged on site, their environmental assurance purposes and shall list their responsibilities;

(d) The responsibilities vested in the environmental staff which would enable them to take appropriate action to make unacceptable environmental working practices or other infringements of the environmental management plan or statutory regulations;

(e) Proposed interaction and communication procedures between the Contractor's construction personnel and environmental staff. In particular, the establishment of a regular communication and reporting system between the

environmental staff and the director responsible for the Contract and between the environmental staff and the site agent shall be demonstrated;

(f) The means by which environmental matters and requirements shall be communicated to Subcontractors of all levels and their due compliance with the environmental management plan and all relevant statutory regulations is ensured;

(g) Methods by which environmental procedures and practices proposed by Subcontractors shall be reviewed for compliance with the environmental management plan and statutory regulations. This is to include monitoring of environmental impacts by AUTHORITY staff and their consultants as well as an audit of the environmental management plan;

(h) Emergency procedures: The Contractor shall identify whether any environmental emergency could occur on site and formulate emergency procedures to deal with such situations;

(i) Procedures during typhoons and heavy rainstorms, including checklists of steps to be taken to maintain drainage on Site;

(j) Methods of promoting environmental awareness on site and environmental procedures amongst all persons directly or indirectly associated with the Works. This shall include proposals for on-Site publicity, award schemes, training courses, waste recycling etc.

28.4.2. Guidelines or standards on how to manage specific issues, such as, CFC elimination or energy conservation, shall be addressed at the management level. These guidelines or standards shall be formalised into specific procedures at the implementation level.

28.4.3. The general guidelines specified in the ISO 14004 : 2004 shall be followed as far as applicable.

28.4.4. In addition to the site arrangements specified in PS 30, the Contractor shall ensure that the legislation and regulations of Canada particularly the Environmental Protection Act of Ontario shall be complied with.

28.5 Environmental Conditions

28.5.1. Extract of the AUTHORITY's Engineering Design Standards is reproduced hereafter as

supplementary information to give details of the environmental information which shall be taken into account when designing the train. Copy of the above

Engineering Design Standards is available for the Contractor’s reference.

Item		Limit	Value	Notes
Ambient Temperature		Max	+40°C	-
		Min	-40°C	-
Relative Humidity		Max	100%	Condensing
		Min	20%	-
Rainfall		Max	64 mm/hour	-
		Max	102 mm/day	-
Ice Accretion		Max	15 mm/6 hours	Vertical surface
		Max	23 mm/6 hours	Horizontal surface
Snowfall		Max	65mm/hour	-
		Max	600 mm/day	-
Wind Speed		Max	20 m/s	Hourly mean
		Max	30 m/s	Peak gust
Salt Atmosphere		Typ	Typical for salted roadway	Usually classed as Severe Marine within 100m of
Airborne Particulates in Tunnels	Iron Particles	Typ	65%	Other airborne particulates includes carbon and dust from brake shoes. Ozone may also be present in levels above normal due
	Concentration	Typ	Varies	
	Size Range	Max	0.1 to 2.5 microns	
	Size Range	Typ	0.1 to 1.4 microns	

SECTION 29 SOFTWARE MANAGEMENT 3

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Section 29 Software Management

29.1 Introduction

The purpose of this Section of PS is to define the quality and control requirements on all software supplied under this Contract and shall apply to all Subcontractors and suppliers. It covers software that are supplied as a stand-alone entity, as a separately identifiable part of a larger system or as an integral to a system being supplied. The objective is to ensure that all software supplied are designed structurally and logically, fully documented, thoroughly tested in a systematic manner such that they can achieve high quality in terms of safety, reliability, testability, traceability and maintainability.

29.2 Standards

29.2.1 All software supplied by the Contractor shall comply with the requirements of

ISO/IEC 90003:2004 " Software engineering -- Guidelines for the application of ISO 9001:2000 to computer

software".

29.2.2 Guidelines for the Information Security Management Systems according to

the security standard of BS ISO/IEC 17799:2005 and BS 7799-2:2002 shall be followed, where applicable.

29.2.3 The software documentation generated under this Contract shall comply with

IEEE Std 1558-2004, Standard for Software Documentation for Rail

Equipment and Systems, and its associated IEEE software standards.

29.3 Definitions

29.3.1 The term "software" shall cover both software and firmware.

29.3.2 A software work package is defined as a group of software and/or firmware

items which fulfil the defined requirements and shall be validated and tested as one logical unit. In IEEE terminology, a software work package is referred

to as a Software Configuration Item (SCI).

29.3.3 The supplier of a software work package is defined as the organisation responsible for supplying or developing that software work package to fulfil Contract requirements.

29.3.4 Software Integrity Level

(a) Software Integrity Level (SIL) is a classification assigned to a software configuration item to indicate the sensitivity during the normal operation or during a possible fault within the package, to its impact on people or service

with respect to safety, customer service, environmental obligations and revenue.

(b) Each Subcontractor shall be responsible to assign a “Hazard Risk Index” for his software scope of work. The methodology for assigning a “Hazard Risk Index” is documented MIL STD 882D.

(c) The calculated Hazard Risk Index shall be correlated to Software Integrity Level (SIL) 1 to 4 as described in Section 4 of IEEE Std 1012-2004, Standard for Software Verification and Validation.

Risk Assessment	Software Integrity Level
High Risk	4
Medium Risk	3
Moderate Risk	2
Low Risk	1

(d) For safety critical software, classified as “High Risk” in the preliminary hazard analysis, the System Assurance group shall perform a number of activities to verify that safety critical software has features that mitigate the effects of faults on the system. Specific hazards identified in the Preliminary Hazard Analysis (PHA) and their proposed mitigation actions shall be flowed down to the System Specification Document (SSD), the Software Requirements Specification (SRS) and the Software Verification and Validation Plan (SVVP) in the form of constraints.

28.3.5 Development Level

(a) Development level is a classification assigned to a software configuration item (SCI) to indicate the level of development or change that has to be undertaken to produce software which meets the technical requirements. The level can be A, B or C.

(b) The Contractor shall define the development level of each SCI in the Software Quality Assurance Plan (SQAP).

(c) The development level of a SCI is defined as C if the package is a commercial, off-the-shelf or existing, service SCI with a demonstrable installation base, release history and proper documentation. The software can only be classified as level C if the source code, external interface, databases structure and parameters structure are used without any modification.

(d) The development level of a SCI is defined as B if the following conditions are met :

(iv) It is a service proven software (a service proven software is one which has been used in similar contracts at least six months prior to the Request For Proposal issue date and which has not been changed since then)

(v) Less than 20% changes of the functional or technical performance

(v i) Less than 20% changes of the number of lines of coding (excluding all comment lines) and the number of modules.

(e) The development level of a SCI is defined as A if neither B nor C is applicable.

(f) For all the SCI categorized as development level A or B, the procurement type 5, as defined by IEEE 1558-2004, shall be used. SCI categorized as development level C shall be managed according to procurement type 1.

29.4 Abbreviations

The following abbreviations are used in this Section of PS:

CPLD	Complex Programmable Logic Devices
FPGA	Field-Programmable Gate Arrays
SQAP	Software Quality Assurance Plan
SCI	Software Configuration Item
SCMP	Software Configuration Management Plan
SEMP	System Engineering Management Plan
SSD	System Specification Document
SPMP	Software Project management Plan
SRS	Software Requirements Specification
SRTM	Software Requirements Traceability Matrix
STP	Software Test Plan

STPr Software Test Procedure

SUM Software User Manual

SUTS Software Unit Test Specification

SVVP Software Verification and Validation Plan

UART Universal Asynchronous Receiver / Transmitter

29.5 GENERAL REQUIREMENTS

Where the software is to be provided by an organisation other than the Contractor, the Contractor shall pass on all requirements in their entirety and without modification to the organisation. The Contractor shall, however, remain responsible at all time for all the works.

29.6 Software Quality Assurance Plan

29.6.1 The Contractor shall submit to the Engineer for review a draft Software Quality Assurance Plan (SQAP) during SEMP stage 1 (refer to PS 21.9). The

draft Software Quality Assurance Plan shall clearly define the quality assurance activities relating to the supply of software.

29.6.2 Within thirty days of receipt of the Engineer's comments on the draft Software Quality Assurance Plan, the Contractor shall submit a final Software Quality Assurance Plan for approval incorporating the directions and requirements from the Engineer on the draft plan.

29.6.3 If the Software Quality Assurance Plan is to be revised at any time during the Contract then the proposed changes shall be sent to the Engineer for review. Changes to the Software Quality Assurance Plan shall only be made subject to approval. Any change made to the Software Quality Assurance Plan shall accord to the Contractor's configuration management procedures.

29.6.4 The Software Quality Assurance Plan shall comply to IEEE 730-2002, Standard for Software Quality Assurance Plans, as modified by IEEE 1558-2004. The following presents topics which can be part of the SQAP:

(a) Define the controls and methods necessary to ensure that the quality processes appropriate for the development are selected by the Contractor.

(b) Define the responsibility and authority of the key personnel responsible for the development, verification, testing and integration of the software.

(c) Define the organisational and working relationships between the Contractor and all the suppliers.

(d) Define the software lifecycle, or software lifecycles, that shall be used to control the development of software.

(e) Identify the SCIs to be produced and the development level that have been assigned with detailed justification. If prototyping techniques are employed for development, then the associated SCIs shall be of development level A

and detailed development and control procedures shall be submitted.

(f) List the inputs into and the outputs from each lifecycle phase. The list shall be specific and comprehensive and shall contain both software and documentation.

(g) List all contractual deliverables including all documents to be produced in each phase of the lifecycle(s).

(h) Specify the guidelines, standards, software metrics, codes of practice, methodologies including naming convention of parameters and variables, languages and tools to be applied at each lifecycle phase.

(i) Reference the Contractor's quality control and quality assurance procedure including the Configuration Control Program (refer to PS 21.14) that shall apply to the Contract.

(j) State the review points which shall clearly differentiate between internal activities and those which involve the Engineer.

(k) Specify and reference the procedure to be adopted to ensure the security of the software.

(l) Discuss all the internal and external risks including programme slip, uncontrollable external factor, supplier's staffing and experience involved and the contingencies planned.

(m) The software quality plan shall contain the content in Table 29-1.

29.7 Software Development Programme

29.7.1 The Contractor shall prepare and maintain a software development programme (schedule) for the Contract and shall submit the programme for approval. This programme shall be linked to the overall Contract Programme (schedule) and shall :

(a) Define the schedule of the whole software development effort.

(b) Define activities for each phase of the software lifecycle at individual software work package level.

(c) Highlight software related milestones.

(d) Define the schedule of activities for software testing.

(e) Define the critical path of software development of the Contract.

29.8 Software Lifecycle

29.8.1 The Contractor shall define the software lifecycle, or lifecycles to be used for the design, development, testing and integration of software in the Software Project Management Plan (SPMP).

29.8.2 The Contractor shall map the phases of the defined software lifecycle(s) against the phases of the reference lifecycle which is a 'V' shaped software lifecycle (sequential lifecycle model) as shown in Figure 20-1.

29.8.3 As a minimum, the Contractor shall ensure that the following phases for software work package of different development levels are incorporated in their lifecycle :

Software Lifecycle Phase	Development Level		
	A	B	C
System Requirements Analysis	Y	Y	Y
Software Requirements Analysis	Y	Y	Y
Software Architectural Design	Y	Y	-
Software Module Design	Y	Y	-
Software Module Coding	Y	Y	-
Software System Integration	Y	Y	Y
System Integration	Y	Y	Y
Acceptance Testing	Y	Y	Y
Defect Liability Period	Y	Y	Y

29.8.4 Lifecycle Phases

(a) System Requirements Analysis

(i) During this phase, the Contractor shall refine the initial concept and precise requirements for each system / equipment, as set out in the Contract documents, into a System Specification Document (SSD). All interfaces with external systems shall be identified in the SSD and fully described in Interface Control Documents (ICD).

(ii) System assurance activities shall be conducted for SCIs with software integrity level 3 and 4.

(b) Software Requirements Analysis

(i) During this phase, the Contractor shall define the functions and specifications of the software and the associated test requirements. Based on the System Specification Document (SSD) the Contractor shall express the requirements and functions of the software for each system / equipment into a Software Requirements Specification (SRS). All software interfaces with external

systems shall be clearly identified in the SRS and fully described in Interface Control Documents (ICD). The SRS document shall comply with IEEE Std 830-1998, Recommended Practice for Software Requirements Specifications, , as modified by IEEE 1558-2004.

(ii) The Software Test Plan (STP) shall be developed according to table A.12 of the IEEE Std 1558-2004 to provide a listing of the software test activities to be performed on the SCI. Once the content of the SRS has stabilized and a

software requirements baseline exists for the SCI, the software acceptance test specification (SWATS) shall be developed to validate the content of the Software Requirements Specification (SRS). The SWATS shall provide the customized procedures used in software qualification testing of a SCI. The SWATS shall conform to the Software Test Procedure (STPr) as described in table A.13 of IEEE Std 1558-2004

(c) Software Architectural Design

(i) During this phase, the Contractor shall transform the requirements for

software for each system / equipment as defined in the Software Requirements Specification (SRS) into an architecture that describes its top-level structure and identify all the software modules in the Software Design Document (SDD). The SDD shall comply to IEEE Std 1016-1998, Recommended Practice for Software Design Document, as modified by IEEE 1558-2004.

(ii) The Software Test Plan (STP) shall describe the software and hardware

integration activities that take place prior to software acceptance testing to ensure the software modules are adequately communicating togheter and interfacing with the hardware as stipulated into the software architectural design.

(d) Software Module Design

(i) Modular design shall be adopted for all software. During this phase, the

Contractor shall specify the software modules design in section 6, Detailed Design, of the Software Design Description (SDD), based on the SDD produced during the software architectural design phase. The SDD shall comply to IEEE Std 1016-1998, Recommended Practice for Software Design Document, as modified by IEEE 1558-2004.

(ii) The Software Test Plan (STP) shall describe the extent and approach used for

the project software module testing activities. The Software Module Test Specification (SWMTS), developed alongside with the Detailed Design section of the Software Design Description (SDD), describes the criteria which the completed module is required to satisfy before it is integrated into the rest of the software system.

(e) Software Module Coding

The Contractor shall code each individual software module to meet the requirements defined in the Detailed Design section of the Software Design Description (SDD). Module testing shall be performed in accordance with the software module testing activities described in the Software Test Plan (STP).

(f) Software Integration

The Contractor shall integrate the tested software modules to produce the complete software, according to the software integration activities described in the Software Test Plan (STP).

(g) System Integration

The Contractor shall integrate the tested software with the hardware to form a complete system. The complete system shall be tested in accordance with the software-hardware integration activities described in the Software Test Plan (STP).

(h) Acceptance Testing

(i) During this phase the software and / or system shall be submitted for acceptance by the Engineer. Test shall be carried out to demonstrate that the system or software meets all the technical requirements. Acceptance will be in two stages:

(1) Software Acceptance Testing: software acceptance tests (factory acceptance tests), shall be performed at the Contractor's site according to the Software Acceptance Test Specification (SWATS) procedure;

(2) System Acceptance Testing: system acceptance tests (site acceptance tests) shall be performed at the installation site, according to the System Qualification Test procedure.

(ii) Test reports, as described in table A.14 (STR) of IEEE Std 1558-2004, shall be submitted for both software and system acceptance testing.

(i) Defect Liability Period

Following completion of the Works, the Contractor shall implement a controlled cycle for software maintenance in line with the procedures defined by the software quality plan and software configuration management plan.

29.9 Software Integrity Level

29.9.1 SCIs with Software Integrity Levels 3 and 4 shall form part of the elements requiring to undertake the system assurance process (refer to PS 25).

29.9.2 The Contractor shall carry out all the system assurance tasks for these SCIs as stipulated in PS 25.

29.10 Software Development

29.10.1 The supply and development of software shall be governed by the Software Project Management Plan (SPMP). The SPMP shall define the software project roles and responsibilities, activities and work products including those to be delivered. The SPMP shall describe the applicable processes and procedures, methods, standard and practices related to the development and

qualification of software products. The SPMP shall conform to IEEE Std 1058-1998, Standard for Software Project Management Plan, as modified by IEEE 1558-2004.

29.10.2 The followings present examples of software development and design guidelines to be documented in the SPMP and used during the development lifecycle.

29.11 Structured Language

The Contractor shall use high-level programming languages for all software developments. Any exceptions to this requirement shall be submitted for approval prior to development. The Contractor shall specify, in section 6.2 of the SPMP, the methods, tools and techniques used for the software development activities, including the programming language(s) used.

29.12 Code of Practice

The Contractor shall follow a documented code of practice to develop and modify the software. The code of practice shall define the design rules, such as prohibited features and source codes layout rules. Alternatively, a documented method statement defining all the practices and rules for software development may be accepted. The Contractor shall specify, in section 6.2 of the SPMP, the methods, tools and techniques used for the software development activities, including code of practice such as a coding standard.

29.13 Traceability

The Contractor shall adhere to industrially recognised analysis methods and design methods during the requirements analysis phase and throughout the design process such that traceability of all levels of requirement, design and testing are maintained. The Contractor shall specify in section 5.3.1 of the SPMP, Requirements Control Plan, the requirements management activities to be used for the project. It shall include the production of a Software Requirements Traceability Matrix (SRTM) according to IEEE-1558:2004.

29.14 Compiler and Operating System

29.14.1 The Contractor shall specify, in section 6.2. of the SPMP, the methods, tools and techniques used for the software development activities including, for each SCI, the details of the development environment. This includes

identification and version number of the host and target Operating Systems (OS) as well as compiler, code generators, graphic engine and other software development tools used.

29.14.2 All undocumented and non-standard features of the language or operating system shall not be used.

29.15 Consistency

System which includes software categorized as Software Integrity Level (SIL) 3 and 4 shall possess fail-safe features preventing them to enter unsafe conditions if software irregularities or run-time errors occur. Defensive programming techniques shall be used for these software systems.

29.16 Unused Spare Interrupts

The software shall disable all unused spare interrupts and contain dummy returns at all unused interrupt vectors.

29.17 Safety Critical Fault Protection

For software driven systems having a Software Integrity Level of 4, a fully independent non-software system shall also be provided in case of software fault.

29.18 Software Design

29.18.1 The Contractor shall specify, in section 6.2 of the SPMP, the methods, tools and techniques used for the software development activities, including code of practice such as a coding standard. The followings present examples of software development design guidelines to be documented in the SPMP and used during software development:

(i) The software shall follow a structured and modular design. Each program or module should be designed such that it can be viewed in terms of its inputs and outputs alone, without reference to the details of how it processes them.

(ii) Each module should be totally independent of the particular algorithmic or programming techniques used in all the other modules.

(iii) Self-modifying program will not be allowed, with the exception of configuration and parameter files update by the software, which shall not be considered as self-modifying program features.

(iv) Header and comments shall be used to clearly specify the module and its logic.

The module size excluding comments and header should preferably not take up more than 150 lines of high level language or 250 lines of assembly level code.

(v) Independent and separate compilation of individual modules will be allowed.

(v i) Where structured programming techniques are used, a single entry and single exit point for each module shall be used. Unconditional branch statements shall not be used.

(vii) All garbage codes (codes that are not executed under any circumstances) shall be removed.

(viii) The format of the source code shall comply with the coding standard; it shall be standardized, properly indented, sufficiently and clearly commented. Each module should have a concise introductory comment section (header) describing the function of the module, the algorithm used, the significance of important internal variables, the data structure, the call convention, the meaning/format of the required inputs and generated outputs.

(ix) Constant parameters that are commonly used by different modules and those that require frequent tuning shall be named and defined in the global data definition area, instead of being incorporated into the program statements. They shall be referred to by name throughout the program.

(x) The naming of variables and parameters shall be standardized and meaningful such that they are clearly recognizable. The Contractor shall establish a naming convention as part of its coding standard, submitted as part of its SPMP.

(xi) Defensive programming methodology shall be employed. Validity range and plausibility checking on input/output parameters shall be performed. Upon detection of system irregularities or run-time errors, appropriate exception handling routines shall be invoked in order to recover the system to the normal operation state and a log file should be created to record the system status and the actions taken.

(xii) Each module should be able to be tested separately by feeding in simulation parameters or signals through the external hardware interface. Diagnosis code should be inserted where appropriate.

(xiii) Main and disk memory requirements should be minimized. Sub-routines that are shared by a number of different programs or modules should be put into the system library.

29.19 Millennium Issue

29.19.1 The performance and the functionality of the software / system shall not be

affected by any changes to the date format caused by the advent of the year 2000 and shall ensure the following :

(i) No value for current date shall cause any interruption in the operation of the software / system.

(ii) All manipulation of time-related data shall produce the desired results for all valid date values within the application domain.

(iii) Date elements in interfaces and data storage shall permit specification of the century without ambiguity.

(iv) Where any date element is represented without a century, the correct century shall be unambiguous for all manipulations involving that element.

29.20 Software Re-use

29.20.1 In this section, software re-use refers to a software item (component, module, SCI etc.) developed on a previous project and used as-is on this project, without any modification. In this case, less stringent requirements, are imposed on the item to allow for its re-use. Partial re-use, that is when a software item from a previous project is used as the starting point and adapted to the needs of the current software project, does not relieve the software item from any of the testing requirements of this section. However, deviations from the code of practice could be considered for the partially re-used software components, subject to approval from the Engineer.

29.20.2 For software of development level A and B, the Contractor shall employ software re-use techniques wherever practical to minimise the development, coding, testing, documentation and maintenance activities.

29.20.3 The Contractor shall identify the scope and extent of software item re-use for each SCI in section 6.2, Methods, Tools and Techniques, of the Software Project Management Plan (SPMP).

29.20.4 The first instantiation, i.e. the original or parent of any software design, module, program or product which is to be re-used shall not be constrained with the requirements of this Section of PS.

29.20.5 The first instantiation of any re-usable software shall be placed under the control of the Contractor's software configuration management procedures prior to issue for re-use.

29.20.6 Re-usable software shall not be issued for re-use until its development lifecycle and documentation are complete including testing and verification. Re-used software modules developed with lifecycles different to the reference model may be adopted subject to approval.

29.20.7 Traceability of all re-used software items shall be maintained through the software configuration management procedures. All re-used software items shall be clearly identified and shall include a reference allowing traceability to the original.

29.20.8 The Contractor shall not modify any aspect of a re-used item of software.

29.20.9 For each instantiation of a re-usable software item, the Contractor will not be required to repeat those phases of the development lifecycle up to the integration test phase which have been completed in the first instantiation.

Software and system integration, acceptance testing and defect liability shall be provided.

29.21 Software Verification and Validation

29.21.1 The Contractor shall be responsible to ensure and demonstrate the conformance of the final software to the Software Requirements Specification (SRS) through the software validation process that consists of verification and testing activities.

29.21.2 The Contractor shall be responsible to develop a Software Verification and Validation Plan (SVVP) that defines all the verification and testing activities. This plan shall cover all software delivered including those provided by Subcontractors or vendors.

29.21.3 Software Verification and Validation Plan

(a) The Software Verification and Validation Plan (SVVP) shall specify the timing, controls and methods necessary for the verification and validation activities of the software work products generated under this contract. The content of SVVP document shall be compliant to section 7 of the IEEE Std 1012-2004, Standard for Software Verification and Validation. The Software Verification and Validation Plan (SVVP) shall include the following :

(i) It shall define the organisation, schedule, resources, responsibilities, tools, techniques and methodologies for software verification and testing.

(ii) It shall define the software verification activities to be performed and the documentation to be produced.

(iii) It shall define the software testing to be performed and the documentation to be produced.

29.22 Software Verification

29.22.1 Structured review and software metrics shall be used to verify the software which include :

(a) Specification Review

(i) A specification review is concerned with ensuring that the requirements, design and test specifications generated during the software lifecycle adequately specify the software to be produced and the criteria on which the software shall be judged. The Engineer shall have the rights to send representatives (who may be an independent organization) to participate in these specification reviews.

(ii) The specification review shall :

(1) ensure that the specifications conform to the Contract requirements;

(2) confirm the adequacy of the technical solution;

(3) system requirements have been appropriately allocated to hardware and software items;

(4) software requirements are consistent, feasible, testable and accurately reflect system requirements;

(5) design implements proper sequence of events, inputs, outputs, interfaces, logic flow, allocation of timing and sizing and error definition, isolation and recovery;

(vi) ensure that the document is complete, clear and unambiguous.

(c) Record of the specification reviews shall be submitted in SEMP stage 3 and shall be presented for inspection during software audit on request.

(b) Module Code Review

(i) Software Configuration Items (SCI) assigned a Software Integrity Level (SIL) of 3 or 4 shall be subject to the code reviews as follows:

(1) All codes shall be examined to ensure that they are, testable, correct and compliant with requirements and coding standards. Design and requirements traceability shall be performed as specified in section 9.3, Traceability, of this document.

(2) All codes shall be examined to ensure that proper event sequence, consistent interfaces, correct data and control flow, completeness, appropriate allocation

timing and sizing and error definition, isolation and recovery have been implemented.

(3) As a minimum the module code review shall consist of a structured walkthrough of the software listings.

(4) Record of module code reviews, where applicable, shall be recorded in the Software Verification and Validation Report (SVVR) and submitted in SEMP stage 4 and shall be presented for inspection during software audit on request.

(c) Software Metrics

(i) For any software work package with a development level of A and B, software metrics shall be used throughout the entire software lifecycle to plan, manage and improve the process and to control and predict the quality of

software. The software project metrics to be collected to support software development activities shall be specified in section 5.3.6, Metrics Collection Plan, of the Software Project Management Plan (SPMP).

(ii) The following metrics are examples of metrics that can be collected at each individual software development phase :

Lifecycle Phase	Software Metrics to be collected
Requirements Analysis and Design Phases	(i) Defects found via specification review or in subsequent development stages (ii) Function size (iii) Number of calls from individual module
Software Module Coding Phase	(i) Cyclomatic complexity (ii) Module size (iii) Comment frequency (iv) Number of components successfully completed from design through module test

(iii) The Contractor shall define in the Software Quality Assurance Plan (SQAP) the metrics related to software quality assurance to be collected, at individual software development phases and establish goals to be achieved.

(iv) The Contractor shall use collected measures to track progress, adjust the process to correct out-of-bound conditions and to evaluate impacts of these adjustments.

(v) Automated tools should be used to facilitate the metrics measurement process, where applicable.

(vi) Metrics measurements shall be recorded for verification and audit purpose.

29.23 Software Testing

29.23.1 The Contractor shall be responsible to develop a Software Test Plan (STP)

that defines the philosophy, objectives and schedule of test activities to be performed and the plan shall be submitted for approval. The STP shall be developed according to table A.12 of the IEEE Std 1558-2004.

29.23.2 The plan shall :

(a) Define the roles, responsibilities, independency and authorities of the key personnel responsible for the testing of the software.

(b) Identify the software items to be tested with a description of the features to be tested and features not to be tested.

(c) Describe the approach and method for testing, including how pass / fail criteria are defined, what are the suspension criteria and what are the resumption requirements.

(d) Define what are the test deliverables and submission schedule for each level of testing.

(e) Detail the tasks required for the testing. This shall include the environmental, staffing and training needs for testing.

(f) Define the schedule of testing in accordance with the software development programme.

(g) The Contractor shall demonstrate that there is sufficient processing power so that the execution of the time-critical tasks shall not take more than 80% of the real time under peak conditions and shall not take more than 50% under normal conditions.

29.23.3 Module Testing

(a) Every module shall be tested against the software module test specification (SWMTS) according to the software module testing strategy described in the Software Test Plan (STP) to ensure that it accurately represents the program design and that it conforms to the requirements of the Software Design Description (SDD).

(b) The tests shall be designed to demonstrate that :

(i) any valid input or combination of inputs produces a correct output;

(ii) any invalid input is correctly handled in a controlled manner;

(iii) error messages generated by the module are appropriate and meaningful.

(c) Every module shall be tested after the code has been proof-read by the programmer and has been successfully reviewed, as described in section 11.4.2.

(d) The record of the test shall remain available for audit by the Engineer.

29.23.4 Software Integration Testing

(a) Modules shall be combined in a controlled manner and tested as described in the Software Test Plan (STP) to ensure that the combination accurately

represents the program design and that it performs as required by the Software Design Description (SDD).

(b) The tests shall be designed to demonstrate that :

(i) any valid input or combination of inputs produces a correct output;

(i i) any invalid input is correctly handled in a controlled manner;

(i i i) message dialogues and sequencing between integrated modules are correct;

(iv) error messages are meaningful.

(c) The records of the test shall remain available for audit by the Engineer.

29.23.5 System Integration Testing

(a) The software and hardware shall be combined and tested, as described in the Software Test Plan (STP), to ensure that the software properly interfaces with the target hardware.

(b) Interface tests with external systems shall be performed to demonstrate full compliance of all interfaces to the System Specification Document (SSD) and Interface Control Documents (ICD).

(c) The records of the test shall remain available for audit by the Engineer.

29.23.6 Software Acceptance Test (Factory Acceptance Test)

(a) The Software Acceptance Tests are tests to be carried out in the Contractor's premises before delivery. The test shall demonstrate that the system, both hardware and software, meets the technical requirements as stipulated in the Particular Specification.

(b) The Software Acceptance Test Specification (SWATS) shall be prepared by the Contractor and submitted for approval. The philosophy of testing, indicating the reasoning leading to the choice of tests shall be explained in the Software Test Plan (STP).

(c) The test shall be carried out in a hardware and software environment which simulates the final configuration of the system. Only the functional or performance tests which cannot be conducted in a simulated environment, due to their nature and complications, may be combined with site acceptance test subject to approval.

(d) All tests shall be carried out exactly as detailed in the SWATS. Any deviations from the specified procedure shall only be made with prior

approval. The details of the deviation, the reasons and the signatures shall be recorded and form part of the test documentation to be submitted

(e) All SWATS, at every level, shall be subject to configuration management and change control by the Contractor.

(f) The result of the software acceptance tests, together with any re-testing as a result of failure, shall be recorded and signed by authorised personnel of the Contractor and the Engineer's representatives.

29.23.7 System Qualification Test (Site Acceptance Test)

(a) The System Qualification Tests are tests to be carried out on site after installation, which shall demonstrate that the system, or software, meets the requirement of this Particular Specification, in terms of functionality and performance.

(b) The Software Test Plan (STP) shall describe the tests part of the System Qualification Tests, including but not be limited to the following categories of tests:

(i) Integration Test with Other Contractors

The Contractor shall coordinate through the Engineer's representative with the Subcontractors (refer to PS 31) in preparing an integrated test specification and shall be submitted for approval at least 12 weeks prior to the test as per Approved programme.

The Contractor shall and the Subcontractors will provide the necessary equipment and manpower in carrying out the test for their own equipment and system which will be witnessed by the Engineer or its representative.

The Contractor shall plan for and carry out any additional tests which deem necessary for proving the complete and successful integration with the

interfacing systems.

(ii) Total Systems Integration Tests

Having completed the integrated tests with respective contractors individually, the Contractor shall perform total system integration tests to demonstrate that all system modules can coordinate their works with each other in harmony and that all functional requirements are satisfied. No clash or abnormality shall result from having various combinations of possible operations being carried out simultaneously.

(iii) System Performance Test

Having completed the total system integration tests, the Contractor shall carry out system performance tests to prove that all performance requirements laid down in the Particular Specification are met.

The Contractor shall set up continuous monitoring, recording the performance for a period of at least 4 weeks of service operation by the Commission. The result shall meet all the performance criteria described in the PS.

(c) Only Software Qualification Tests and Systems Qualification Tests are required for SCI of development level C. The approval for use of a particular commercial package does not imply the acceptance of the software. It is the responsibility of the Contractor to ensure that all these SCIs, either executed independently or integrated together, can achieve the desired functions as specified.

29.23.8 Regression Testing

The Contractor shall conduct regression testing throughout the testing phases following changes to the software. Regression testing shall test the particular changes that have been made and show that the unmodified software has not been corrupted by the change and the software meets its technical requirements.

29.23.9 Interface Protocol Testing

After the completion of a design interface with each interfacing system as per the Approved programme (schedule), the Contractor shall develop an interface test procedure to verify the interface compliance to the Interface Control Document (ICD) requirements and deliver it to the respective Subcontractor for its testing of the communication interface. Where applicable, a protocol simulator may be required to conduct such interface testing; in this case, the Contractor shall be responsible to develop and deliver the simulator to the involved Subcontractor(s).

29.24 Software Maintenance

29.24.1 The Contractor shall be responsible for the software correction and improvement during the Defects Liability Period to ensure that the

performance of the equipment fully satisfies the requirements in the Particular Specification.

29.24.2 Changes made to the software shall be controlled in a manner which achieve the same level of specification, review, implementation and testing as used for throughout the development life cycle.

29.24.3 All changes made to the software shall be made according to the defined software configuration management procedures.

29.24.4 The Contractor shall define how upgrade media is to be delivered to site, installed and tested.

29.25 Software Interface

29.25.1 A software interface shall be classified as an internal interface or external interface.

29.25.2 An internal interface is an interface between two SCIs within the scope of the Contract.

29.25.3 An external interface is an interface between a SCI within the scope of the Contract and works (systems) of other contractors'.

29.25.4 For all internal interfaces, the Contractor shall be considered as the prime interfacing party.

29.25.5 The Contractor shall be considered as the prime interfacing party for all Communication Interfaces (refer to Appendix I Annex 4) and Depot Interfaces (refer to Appendix I Annex 6). The Contractor shall be considered as the supporting interfacing party for all ATC Interfaces (refer to Appendix I Annex 3), with the exception of the common network interfaces shared by the ATC with all other systems for which the Contractor shall be considered prime interfacing partyy.

29.25.6 The prime interfacing party for a defined interface shall be responsible for:

(a) analyse interface requirements;

(b) prepare the Interface Control Document (ICD);

(c) define and agree with supporting interfacing parties and the Engineer a programme for exchange of design information and integrated testing;

(d) design and implement protocols;

(e) conduct integrated tests during the System Qualification Test (site acceptance tests) and commissioning.

29.25.7 The supporting interfacing party for a defined interface shall be responsible for:

(a) work with the prime interfacing party via the Engineer to agree interface specifications and programme;

(b) implement interface protocols in accordance with the Interface Control Document (ICD) and programme (schedule);

(c) conduct Software Qualification Test (factory acceptance test) and support System Qualification Test (site acceptance test) and commissioning.

29.26 Software Security

29.26.1 The Contractor shall define procedures to maintain the security of the software. Aspects to be considered shall include :

(a) Sabotage

The Contractor shall describe what measures are to be taken to protect the software against sabotage during the development phase. This description should define the physical restrictions as well as procedural measures and specific tests to be carried out on the software.

(b) Unauthorised Access

The Contractor shall describe what measures are to be taken to protect the software against unauthorised access and subsequent modification. This description should define both physical restrictions and procedural methods.

(c) Virus

The Contractor shall ensure software which is susceptible to viruses is developed in environments certified free from computer viruses. To achieve this, the Contractor shall use proper virus detection software and suppression tools, as Approved. approval of the software tools shall not relieve the Contractor of its obligations to ensure that the software is free of viruses.

29.26.2 All software delivered to site shall be accompanied by evidence that demonstrates the media is free of viruses.

29.26.3 The Contractor shall provide a Statement of Applicability which shall identify all security controls and justify why they are appropriate, and show why those control measures according to BS7799 that have not been chosen, are not relevant. The Contractor shall relate the selection of the controls by means of risk assessment and record in the hazard log (refer to PS 25.3).

29.27 Software Project Management

29.27.1 The Contractor shall perform software project management as follows :

(a) The Contractor shall be responsible for managing the performance of all software supplier(s) and the quality of their work. The Contractor shall be responsible for the validation of all sub-contracted work.

(b) The Contractor shall ensure that its software supplier(s) conform to the Approved Software Quality Assurance Plans (SQAP), software development programme (schedule) and Software Configuration Management Plan (SCMP).

(c) If an internal interface involves more than one software supplier, the Contractor shall act as the prime interfacing party.

(d) The organisational and working relationships between the Contractor and all the suppliers shall be described in the Software Quality Assurance Plan (SQAP).

(e) If any key member of the software team become unavailable, the Contractor shall inform the Engineer together with qualified replacement for approval. The replacements shall start working on the Contract at least one month before the departure of the original member.

(f) The Contractor shall freeze the Software Requirements Specification (SRS) and the Software Design Description (SDD) as a formal baseline for subsequent development phases upon the full approval of the specifications. Any necessary functional and/or technical changes to these documents shall be subject to approval.

(g) During System Qualification Tests and commissioning, the Contractor and its software supplier(s) shall provide technical staff at the test or commissioning site to support defect analysis, software configuration control over change requests and proper distribution and installation of software changes.

(h) The Contractor shall ensure that software defects shall be rectified, tested, validated, configured and delivered to the test or commissioning site in accordance with the Approved programme (schedule).

29.28 Software Design Documentation

29.28.1 The Contractor shall produce and submit software design documentation in accordance with the requirements for SEMP.

29.28.2 System Specification Document (SSD)

The System Specification Document (SSD) shall include :

(a) functions and capabilities of the system;

(b) Contract requirements;

(c) safety and human-factors engineering;

(d) interface specifications detailing the requirements of all interface with external systems;

(e) operations;

(f) maintenance requirements and

(g) design constraints

29.29 Software Requirements Specification (SRS)

29.29.1 The Software Requirements Specification (SRS) shall be compliant to IEEE Std 830-1998, Recommended Practice for Software Requirements Specifications, , as modified by IEEE 1558-2004. The followings present examples of SRS content:

(a) Functional and capability specifications including performance, physical characteristics, and environmental conditions under which the software is to perform;

(b) Specification of Interfaces external to the software including:

(i) the input and output communication ports;

(i i) communication protocols, procedures and performance;

(i i i) exception handling and recovery;

(i v) message formats (for example maximum message length) and message frequency.

(c) Safety specifications, where applicable, including :

(i) software failure detection, identification and isolation;

(i i) remedial procedures;

(iii) redundancy;

(i v) failsafe operation;

(v) fall-back procedures and reconstruction of destroyed or incorrectly altered data;

(d) Human-factors engineering specifications, where applicable, including :

(i) man machine interfaces and ergonomic factors;

(i i) operational procedures together with any potential unsafe actions and the possible cause of them;

(iii) human procedures within the system that are likely to be bottlenecks or cause any special problems;

(iv) areas needing concentrated human attention that require significant training or elaborate aids.

(e) Data definition and database requirements

(f) User operation and execution constraints / requirements that may include existing or imposed software or hardware platform, support availability and environmental conditions

(g) A functional requirements section including :

(i) a description of all the functional requirements;

(i i) a description of all input data including the sources of inputs, quantities, units of measure, timing and ranges of valid input;

(iii) a description of operations to be performed on the input data including validity check, operations sequence including timing of events, abnormal situations response (overflow, communication failure and error handling), parameters affected by operations, initialisation and re-initialisation requirements and any methods used for transforming the inputs into corresponding outputs (such as equations, mathematical algorithms, logical equations);

(iv) a description of all output data including the destinations, quantities, units of measure, timing and ranges of valid output including accuracies and tolerances.

(h) A performance requirements section including :

(i) a description of static numerical requirements including the number of simultaneous users to be supported, number of files and records to be handled and sizes of tables and files and

(ii) a description of dynamic numerical requirements including the number of transactions and tasks and the amount of data to be processed within certain time periods for both normal and peak workload conditions.

(i) A design constraints section including :

(i) a description of any limitations imposed by the software (for example use of a software may limit the number of simultaneous users) and

(ii) a description of any requirements for the software to operate inside various hardware constraints (for example limits on primary and secondary memory).

(j) An external interface requirements section including :

(i) a description of all the human interface to the software product including the required screen formats, page layout and content of any reports or menus, relative timing of inputs and outputs and availability of some form of programmable function keys;

(ii) a description of the logical characteristics of each interface between software and hardware including the devices to be supported and protocols or other peripheral interfaces required;

(iii) a description of the use of other required software products and interfaces including the name, mnemonic, specification number, version number and source of the software products;

(iv) a description of the communications interfaces such as local area network protocols.

(k) Database requirements for any database to be developed as part of the software including frequency of use, accessing capabilities, data element and file descriptors, relationship of data elements, records and files and static and dynamic organisation.

29.30 Software Design description (SDD)

The Software Design Description (SDD) shall comply to IEEE Std 1016-1998, Recommended Practice for Software Design Document, as modified by IEEE

1558-2004. It shall define the architecture of the Software Configuration Item (SCI). The followings present examples of SDD architectural content :

29.30.1 A general description including :

(a) a system description describing the computer hardware and peripheral equipment to be used and the external interfaces of the software;

(b) a summary of functions to be performed by the software;

(c) general constraints including regulatory policies, software limitation (for example due to operating system), hardware limitation (for example signal timing requirements), interfaces to other applications, parallel operation,

control functions, higher-order language requirements, signal handshake protocols (for example XON-XOFF, ACK-NACK), safety and reliability considerations, timescales and customer imposed constraints defined in the software requirement specification.

29.30.2 A general design section including :

(a) The breakdown of the software into modules and shall identify all modules to be developed or incorporated into the software.

(b) The global structures used in the software implementation including the structure of data types defined in terms of basic types of the programming language, structure of individual files and the distribution of data between files, structure of data in memory, code libraries which may be called on implicitly or explicitly by the software and interfaces with hardware and other software and the interfaces between the constituent modules. The use of global variables and direct access memory shall also be specified here.

(c) The overall structure of the software shall be formally described using a method suitable for the application including flow charts, pseudo code description and structured design methodologies. The constituent modules which make up the software and their inter-relationship shall also be formally described.

(d) The means by which the design structures can fulfil the functional requirements shall be described.

(e) The means by which the design structures can fulfil the performance requirements shall be described.

(i) The means by which the design structures can meet the design constraints requirements shall be described.

(ii) The means by which the design structures can fulfil the external interface

requirements shall be described.

(iii) The means by which the design structures can fulfil the database requirements shall be described.

29.30.3 A module requirements section including :

(a) Identification of all global variables and routines that are accessible by all modules and components.

(b) Identification of all software libraries which are available to the software.

(c) Individual module details including function of the module, entry and exit conditions which the module satisfies, failure conditions which the module handles, any register preservation, any mathematical formulae or principles which the module is required to use and any special requirements like module size or execution time.

29.31 Software Detailed Design (SDD)

29.31.1 The Software Design Description (SDD) document shall comply to IEEE Std 1016-1998, Recommended Practice for Software Design Document, as modified by IEEE 1558-2004. The software module detailed design specifications shall define each of the software modules identified in the architecture portion of the Software Design Document (SDD). The followings present examples of module detailed design specification found in the SDD :

(a) A brief summary of the module, its function and its components;

(b) General information of the module including :

(i) module entry conditions - how the module's components are entered/activated;

(ii) module exit conditions - how the module's components exit/terminate;

(i i i) any code insert statements used;

(i v) what failures and failure conditions are detected and reported;

(v) any registers used;

(v i) details of libraries used by the module including any libraries explicitly named in the module, any libraries implicitly used and any common procedures used and

(vii) initialisation process for the module.

(c) Data interfaces of the module including :

(i) input / output parameters - any input and output parameters passed during the activation and return from the module and shall be related to the entry and exit conditions;

(i i) any absolutes or constants used;

(i i i) any global variables used;

(i v) any local variables used within the module's components;

(v) any direct interfacing with hardware such as memory mapped UART (universal asynchronous receiver / transmitter) registers.

(d) Program description of the module including :

(i) any mathematical formulae or principles used;

(i i) an unambiguous written description of the components within the module;

(i i i) any special resources required at run-time (such as minimum and maximum number of disc accesses required, memory required);

(iv) flow chart or pseudo-code description of the components of the module and

(v) references to all relevant documentation.

29.32 Software Test Documentation

The Software Test Plan (STP), developed according to table A.12 of the IEEE Std 1558-2004, shall describe the test strategy for the SCI, provide a listing of all the test activities to be performed on the SCI and identify all the software test documentation to be delivered as part of the Contract.

29.33 Software Acceptance Test Specification (SWATS)

29.33.1 The Software Acceptance Test Specification (SWATS) shall describe the acceptance requirements of the delivered software product. It shall include :

(a) the purpose of the test and the relationship with the overall system acceptance testing;

(b) the tests to be performed including characteristics to be tested and the associated acceptance criteria and

(c) the test strategy describing any special test instruments, software, techniques or set ups that are mandatory.

29.33.2 Test data shall be selected so as to systematically test all requirements stated in the Software Requirements Specification (SRS).

29.34 Software Test Plan (STP)

As part of the test activities described in the Software Test Plan (STP), the software and system integration test activities required before proceeding to the software acceptance testing shall be described.

29.35 Software Module Test Specification (SWMTS)

29.35.1 The Software Module Test Specification (SWMTS) shall describe the criteria which the completed module is required to satisfy before it is integrated into the rest of the software system. The extent and approach for software module testing shall be described in the Software Test Plan (STP). The SWMTS shall include :

(a) the purpose of the test;

(b) the reference to the relevant requirement and design item;

(c) the tests to be performed including characteristics to be tested and the associated acceptance criteria and

(d) the test strategy describing any special test instruments, software, techniques or set ups are to be used.

29.35.2 Test data shall be selected so as to systematically test all sections of the software module design specification.

29.36 Software Configuration Management

29.36.1 The Contractor shall define and implement effective software configuration management procedures to control changes during the software lifecycle.

29.36.2 The Contractor shall use a commercially available software package to perform software configuration management functions.

29.36.3 Software Configuration Management Plan (SCMP)

The Contractor shall define the software configuration management procedures in the Software Configuration Management Plan (SCMP). The Software Configuration Management Plan (SCMP) shall comply to IEEE Std

828-1998, Standard for Software Configuration Management Plans, as modified by IEEE 1558-2004. The SCMP shall include the following :

(a) It shall define the controls and methods for identifying, organizing and controlling modifications to the software. The Software Configuration Management Plan (SCMP) shall be submitted for approval.

(b) It shall define configuration identification to enable the unique identification, content and build state to be determined for each software product, program and module. The software product, program and module shall form the configured items held under configuration control. The configuration control process shall identify the current and historic status of each configured item.

(c) It shall define a change control process to allow for software and documentation changes to be made whilst ensuring the functionality of the system is in a known and visible state. The change control process shall allow changes to be made from the development phase through site acceptance, commissioning and Defect Liability Period. These changes will typically arise from functional requirement changes, anomalies, maintenance upgrading or design changes.

(d) It shall define problem reporting by which problems with software or documentation are identified and the appropriate action is taken, tracked and verified.

(d) It shall define the media control process to be taken to ensure that software source code, databases and documentation are adequately archived. Such provisions shall allow the retrieval and regeneration of all software and documentation. Media control also covers the cataloguing of, and access to, the physical media on which source code, documentation and other relevant material is stored.

(e) It shall define the configuration audits, reviews and status accounting processes.

(f) It shall define how to perform configuration management and control on interfaces with other parties, including the Subcontractors and suppliers (refer to PS 31).

(g) It shall define how to perform configuration management and control on software supplied by Subcontractor / vendor.

(h) It shall describe the use of the configuration management software package in assisting the configuration management process.

(i) It shall contain the content in Table 29-2.

29.36.4 In the event that any software / system acceptance test is failed, the Contractor shall, at its own expense, take whatever action is deemed necessary, such as, rectification, re-adjustment or design changes to the satisfaction of the Engineer, in order to meet the testing requirement. The Engineer may, at its discretion, request the undertaking of further tests to validate the design changes undertaken at the Contractor's cost.

29.36.5 The Software Verification and Validation Report (SVVR), developed in accordance with table A.5 of the IEEE Std 1558-2004, shall contain a full report of all software testing activities, including the list of software test procedures and associated software test reports. The SVVR shall be submitted to the Engineer, who may require that a modification be carried out to rectify any defects thus encountered. The Engineer may, at its discretion, request the

undertaking of further tests to validate the design changes undertaken at the Contractor's cost.

29.36.6 Modifications required to make SCIs to pass tests shall be applied to all SCIs which use the modified software component and which could beneficiate from the modification.. Modification instructions, test instructions and modification programme (schedule) required on a released SCI (an SCI previously qualified through software acceptance testing and delivered to the Customer) shall be submitted for approval in accordance with the Software Configuration Management Plan (SCMP). Approval will not be granted unless the Engineer is provided with sufficient information to demonstrate that regression testing has been performed.

29.37 Software Audit

29.37.1 Auditing of the Contractor's software development activities will be carried out by the Engineer, or its representatives (who may be an independent organization) whenever appropriate during the normal business hours. Seven days of advance notice will be given to the Contractor. The Contractor shall co-operate with the audit team and shall provide timely and reasonable access to all personnel, activities, software, documentation, and records connected with the development activities. This shall include documentation which is not required to be submitted for formal review, and the Contractor's internal documentation and procedures governing the technical, quality and project management aspects of the Contract. The Engineer or its representatives (who may be an independent organization) shall agree to keep all information received during an audit confidential, except that such information may be used to make recommendations or request changes to Contractor.

29.37.2 The Contractor shall provide support to the audit team during any visit to the Contractor's site (hereafter referred as Contractor's site). Such support shall include the use of office space and facilities, telephone and fax machine, and the provision of a member(s) of the Contractor's staff sufficiently familiar with the Contract and the Contractor's procedures to enable the auditing activity to be progressed in an efficient manner.

29.37.3 Based on the information supplied by the Contractor during the tendering process, the Engineer will advise the Contractor of an audit plan at the start of the Contract. Depends on the Contractor's performance during the Contract the Engineer may escalate or de-escalate the auditing activities. The

Contractor shall accept that any variation to the plan necessitated by the Contractor's lack of performance is within the agreed scope of the Contract.

29.37.4 For SCI of development level C the audit plan shall be as follows :

(a) audit at Contractor's site prior to factory acceptance test

(b) audit at Contractor's site at the completion of factory acceptance test and prior to delivery

(c) audit at the installation site throughout the installation phase up to the completion of site acceptance testing

For the Contractor's guidance the above audits are anticipated to be of one man-day duration each.

29.37.5 For SCI of development level of A or B, the Audit Plan shall be as follows:

(a) audit at the Contractor's site during the requirements, design, coding and integration phases

(b) audit at Contractor's site prior to factory acceptance test

(c) audit at Contractor's site at the completion of factory acceptance test and prior to delivery

(d) audit at the installation site throughout the installation phase up to the completion of site acceptance testing

For the Contractor's guidance the above audits are anticipated to be of two man-days duration each. The audit shall be repeated at nominally three month intervals whilst these phases are in progress.

29.37.6 The Contractor shall, if requested at any time by the Engineer, support source code audits of SCI of development level A or B against the Contractor's codes of practice. This audit may be carried out by an independent organization on behalf of the Engineer. Such audits shall take place at the Contractor’s premises. Source code listings shall be made available to auditors for the purpose of the audit but is not required to be delivered to the Engineer or the independent organization. The Contractor shall co-operate with this audit and

provide detailed technical support on the software to the Engineer or its representatives.

29.38 Operation and Maintenance Documentation

29.38.1 The operation and maintenance documentation shall describe the system as installed and to provide sufficient information for users, maintainers and developers to execute their responsibilities throughout the working life of the system. All documentation shall be submitted for approval.

29.38.2 The operation and maintenance documentation shall comprise individual package of operation manual, software maintenance manual and development manual.

29.39 Operation Manual

The operation manual shall be part of the Software User Manual (SUM) which shall be developed in accordance with section A.15 of the IEEE Std 1558-2004. It shall include a general description of the facilities available to each operator who will communicate with the system, including those operators who will only receive outputs from the system or be affected in some other way by the system. All controls, screen and printout formats and keyboard layouts shall be fully described. A comprehensive list of all system error messages and log messages, including cause, consequence and recommended actions on the occurrence of each shall be included.

29.40 Software Maintenance Manual

29.40.1 The software maintenance manual shall be part of the Software User Manual (SUM) which shall be developed in accordance with section A.15 of the IEEE Std 1558-2004. It shall fully describe how to, rebuild and install the software after a change to the source code.

29.40.2 The manual shall also describe how system configuration changes can be made, for example changing parameter data or adding peripheral equipment.

29.40.3 Information requirements for software maintenance shall include, as a minimum, the following :

(a) Database and Parameters Change

Procedures for modifying the system database, displays, configurable system parameters, including guidelines describing the reasons for doing so.

(b) System Software Regeneration

Procedures for regeneration of the as-installed system software from source material, eg. operating system and language compiler.

(c) Application Software Regeneration

Procedures for regeneration of the application software from supplied source material or media. Module generation details - how the modules are generated together with the options used (for example compiler/assembler options);

(d) Security Copies

Procedures for maintaining security back-up copies of system software, application software, static data files and live data files, and the method of reconstituting these from the backup copy.

(e) Utilities

Operating instructions for all system utilities, eg. disk formatter, crash dump analyzer.

(f) Diagnostics

Diagnostic methods and any performance reporting facilities.

(g) (Moved to section 29.21, Development Environment),

29.40.4 The procedure for installing the released software at the operation and maintenance site(s) shall be described.

29.41 Source Code Listings

29.41.1 The source code for all software modules of SCI of development level A or B shall be put in escrow. Fully annotated source listings of all software modules shall be submitted to be put in escrow. Design, tests and requirements traceability shall be performed as specified in section 9.3, Traceability, of this document.

29.41.2 The source code listings shall be subject to validation by the Engineer or its delegate when put in escrow to make sure it is the up-to-date version of the software installed.

29.41.3 Data Structure Manual

All file structures, database records, internal lists and tables shall be comprehensively described.

29.41.4 Source-Code Escrow Agreement

Source-code escrow agreement with the Contractor shall be subject to the following conditions:

(a) The terms of the escrow agreement shall be mutually acceptable by both AUTHORITY

and the Contractor.

(b) The escrow agent shall be a reputable Canadian, preferably Ontario based,

commercial source-code escrow companies which shall possess a good record of providing source-code escrow service.

(c) AUTHORITY will be responsible for paying all fees that are required by the escrow

agreement. A special term of "release event" shall be specified in the escrow agreement that the escrow agent, who shall hold the escrowed materials including the source code in trust for both licensor and licensee, shall release immediately all escrowed materials to AUTHORITY.

(d) The duration of the escrow agreement shall not be less than the remaining design life of the train as measured from the time of delivery to AUTHORITY. Whenever a modification is made in the escrowed materials, the Contractor shall deposit all related maintenance modifications, updates, new releases or documentations. The Contractor shall also provide procedures allowing validation of the integrity and completeness of the deposit, compared to the previous version of the software and documentation as given.

(e) There shall be no effect to the Software Licenses and Ownership by entering the escrow agreement.

(f) The Contractor shall justify to the satisfaction of the Commission, that the software have been designed and built with maintainability in mind, such that software changes required for tuning / configuring normal operation and maintenance of the train, shall be made by just changing the software parameters without modifying the source code. Configurable software parameters shall be identified and defined in the Maintainability section of the Software Requirements Specification (SRS).

29.42 Development Environment

29.42.1 The Contractor shall deliver a comprehensive set of facilities for SCI of development level A or B to enable the Commission to carry out software maintenance and enhancement after the Defect Liability Period which include the following :

(a) All software development tools (for example requirement definition/traceability tool, design tool, test tool, compiler/translator) used by the Contractor throughout the entire software lifecycle;

(b) All data residing in or generated from these software development tools;

(c) All interfaces and/or supporting facility for interacting with these development tools.

29.42.2 A development manual shall be provided for each development environment including proprietary software packages. This shall include:

(a) System Manual;

(b) Reference Manual;

(c) User Manual;

(d) Installation Manual;

(e) Programming Manual;

(f) Quick Reference Manual;

(g) Tutorial Manual and

(h) Release Notes.

29.43 Software Licenses and Ownership

29.43.1 The Contractor shall provide AUTHORITY non-exclusive software licenses and the

ownership of the executable portion of the SCIs to be delivered under the Contract, which are required by AUTHORITY to operate and maintain the Work for the remaining design life of the train as measured from the time of delivery to AUTHORITY. The Contractor shall pay all required license or royalty fees at no extra cost to AUTHORITY.

29.43.2 In respect of SCIs of development level C, the Contractor shall ensure, prior

to procurement, that all licenses are granted or transferred to the Commission. Where possible, the Commission shall be a sub-licensee on all software licenses when they are originally procured by the Contractor. All licenses shall be granted or transferred to the Commission following site acceptance.

29.43.3 In respect of SCI of development level C originating within the Contractor's

organization including associated divisions, parent companies, and subsidiaries, and in respect of all SCIs of development level A or B, the Contractor shall deliver to the Engineer for retention by him a complete copy of the executable code, software design documentation (except for SCI of development level C), and any specialised development tools required for maintenance of the same, including editors, compilers, and linkers. The delivery shall occur following the site acceptance of the software release to be used in revenue service, as agreed between the Contractor and the Commission.

29.43.4 The source code placed in escrow as per section 20.5 may not be used by the

Commission without the prior written consent of the Contractor, except in the following circumstances:

(a) the owner of the software enters into any composition or arrangement with its

creditors or enters into liquidation whether compulsory, or voluntary (other than for the purposes of solvent reconstruction or amalgamation) or has a receiver or administrative receiver appointed over all or any part of its assets or undertaking or a petition is presented for an administrative order; or

(b) the owner of the software ceases to trade; or

(c) the owner of the software assigns copyright in the software and the Contractor fails within sixty (60) days of such assignment to procure in favour of the Commission, a licence from the new owner in the same terms as that required by the Contract; or

(d) the Contractor's employment is terminated under any agreement with the Commission for the operation and/or maintenance of the system or he is in breach of its obligations under the contract.

29.43.5 The Contractor shall ensure that all SCIs of development level C are still supported by the supplier at the time of delivery to AUTHORITY. Exceptions to this shall be reported to the Engineer at the time of delivery.

29.44 Software Design Life Cycle

29.44.1 SEMP Stage 1

The Contractor shall prepare and submit the following documents for approval during SEMP stage 1 :

(a) The Software Quality Assurance Plan (SQAP).

(b) The software development programme (schedule).

(c) The Software Verification and Validation Plan (SVVP).

(d) The Software Configuration Management Plan (SCMP).

(e) The Software Project Management Plan (SPMP).

29.44.2 SEMP Stage 2

The Contractor shall prepare and submit the following documents for approval during SEMP stage 2 :

(a) The System Specification Document (SSD) and preliminary Software Requirements Specification (SRS).

(b) The Software Test Plan (STP).

29.44.3 SEMP Stage 3

The Contractor shall prepare and submit the following documents for approval during SEMP stage 3 :

(a) The software architecture part of the Software Design Description (SDD) and partial software detailed design part of the SDD.

29.44.4 SEMP Stage 4

The Contractor shall prepare and submit the following documents for approval during SEMP stage 4 :

(a) The Software Module Test Specification (SWMTS).

(b) The Software Acceptance Test Specification (SWATS).

(c) The Software Verification and Validation Report (SVVR) containing the list of all testing and review activities.

29.44.5 SEMP Stage 5

The Contractor shall prepare and submit the following documents for approval during SEMP stage 5 :

(a)

(b)

Figure 29-1 Typical Software Lifecycle

Software Quality Plan

1 Purpose

2 Reference Document

3 Management

- 3.1 Organization
- 3.2 Tasks
- 3.3 Responsibilities

4 Deliverables

- 4.1 Purpose
- 4.2 List of Software Work Package and Development Level
- 4.3 Submission Requirements

5 Software Development Lifecycle

- 5.1 Mapping to the Commission's Reference Standard
- 5.2 Input and Output Document for each Phase

6 Standards, Practices, Conventions and Metrics

- 6.1 Assurance and Control of Compliance
- 6.2 Reference Standard
  - 6.2.1 Documentation Standards
  - 6.2.2 Design Standards
  - 6.2.3 Coding Standards
  - 29.2.4 Testing Standards
  - 6.2.5 Review and Audit Standards

7 Reviews and Audits

8 Test and Integration

9 Problem Reporting and Corrective Action

10 Tools, Techniques and Methodologies

11 Software Supplier Control

12 Records Collection, Maintenance and Retention

13 Training

Table 29-1 Sample Content of Software Quality Plan

Software Configuration Management Plan

1 Introduction

2 Software Configuration Management

- 2.1 Organization
- 2.2 Software Configuration Management Responsibilities
- 2.3 Applicable Policies, Directives and Procedures

3 Software Configuration Management Activities

- 3.1 Configuration Identification
  - 3.1.1 Identifying Configuration Items
  - 3.1.2 Naming Configuration Items
  - 3.1.3 Acquiring Configuration Items
- 3.2 Change Control
  - 3.2.1 Requesting Changes
  - 3.2.2 Evaluating Changes
  - 3.2.3 Approving or Disapproving Changes
  - 3.2.4 Implementing Changes
- 3.3 Problem Reporting
- 3.4 Media Control
- 3.5 Configuration Status Accounting
- 3.6 Configuration Audits and Reviews
- 3.7 Interface Control
- 3.8 Subcontractor / Vendor Control

4 Software Configuration Management Schedules

5 Software Configuration Management Resources

6 Software Configuration Management Plan Maintenance

Table 29-2 Sample Content of Software Configuration Management Plan

SECTION 30 OPERATION AND MAINTENANCE MANUAL 3

30.1 ..... Introduction 3

30.2 ..... Scope 3

30.3 ..... Organization of this Section of PS 4

30.4 ..... General Requirements for Operation and Maintenance (O&M) Manual 4

30.5 ..... Language and Style 5

30.6 ..... Format and Layout 5

30.7 ..... Paper 6

30.8 ..... Binding 7

30.9 ..... Software for the Production of the Manual 7

30.10 ..... Equipment Hierarchy 8

30.11 ..... Copyright 9

30.12 ..... Contents of Individual Volumes of the O&M Manual 9

30.13 ..... Volume I Technical Descriptions Manual 10

30.14 ..... Volume I Part A - Overall System Descriptions 10

30.15 ..... Volume I Part B - Technical Descriptions of Equipment Systems 11

30.16 ..... Volume II Train Operator's Manual

..... 11
30.17 ..... Volume II Part A - Operating Information
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Section 30 Operation And Maintenance Manual

30.1 Introduction

This Section of PS specifies the requirements for Operation and Maintenance (O&M) Manuals for the trains.

30.2 Scope

30.2.1 O&M Manual

The Contractor shall provide O&M Manuals printed on paper, hereafter referred to as the printed O&M Manual, in sufficient details to enable the Engineer to operate, test, maintain, overhaul and repair the trains to meet the specified performance requirements. As a minimum requirement, the O&M Manual shall include the following:

Volume I: Technical Descriptions Manual

Volume II: Train Operator's Manual

Volume III: Equipment Maintenance Manual

Volume IV: Fault Diagnostics Manual

Volume V: Illustrated Parts Catalogue

Volume VI: Software Manual

~~Volume VII: Special Tools and Test Equipment~~

Volume VIII: Vendor Documentation

30.2.2 Desktop Publishing Facility

A desk-top PC containing all the necessary software and hardware which allow it to act as a central server for the purpose of desktop publishing of the O&M Manual.

30.2.3 Interactive Electronic Manual

An Interactive Electronic Manual (IEM) that includes all information contained in Operation and Maintenance Manuals, Illustrated Parts Catalogue, Training Material, link to the Computer Based Training (CBT), link to Yard Maintenance Support System (YMSS) and link to Hazard Log shall be provided. Detail design shall be submitted for approval.

(Item 30.2.3 is a new item added)

30.3 Organization of this Section of PS

30.3.1 PS 30.4 to 30.11 describes general requirements for the O&M Manual.

30.3.2 PS 30.12 to 30.28 describes the contents of individual volumes of the O&M Manual.

30.3.2 PS 30.29 describes detailed requirements for the Desktop Publishing Facility.

30.4 General Requirements for Operation and Maintenance (O&M) Manual

30.4 General

30.4.1 The O&M Manual shall fully describe the operation and maintenance of all systems, sub-systems, equipment and components in the trains.

30.4.2 The Contractor shall co-ordinate, within the manuals, the cross-referencing of all interfaces and areas associated with interconnecting equipment and systems covered by the Contract.

30.4.3 The O&M Manual shall contain no irrelevant or ambiguous information and shall relate specifically to the Contract.

30.4.4 Nomenclature or references to any items of equipment, diagrams, figures, tables, numbers or units shall be consistent throughout the text. The naming convention as shown in Contract Drawing No. NST 072 shall be adopted. Unless otherwise approved, all measurements shall be in S.I. units.

30.4.5 The Contractor may use manufacturer’s data and handbooks for individual

items of equipment that are a sub-component of the overall system (including printed circuit boards), provided that they are integrated into the description of the equipment, and are identified in the table of contents.

30.4.6 Precautions and warnings regarding human safety and safety of equipment shall be included where applicable.

30.4.7 Where an item is not designed for local repair and shall be returned to the manufacturer as a unit for overhaul, the Contractor shall still provide information on the function, construction and working principles of the equipment. Instructions for assessing the performance of the equipment locally shall be provided in the O&M Manual. The type of repairs to be carried out by the manufacturer shall also be specified together with the associated commissioning tests and acceptance criteria.

30.5 Language and Style

The O&M Manual shall be written in simple and concise English. The style of writing shall follow the requirements specified in Figure 30-1.

30.6 Format and Layout

30.6.1 Page Orientation

Page orientation shall generally be portrait, unless tables or diagrams require the use of landscape orientation.

30.6.2 Margins

The following margins shall be used for “Letter” pages:

Top = 0.7"

Bottom = 0.4"

Left = 1"

Right = 1"

30.6.3 Text Font and Size

Fonts and sizes for text shall be as follows:

normal text = Times New Roman (11pt)

Heading 1 = Arial (14pt - bold)

Heading 2 = Arial (13pt - bold)

Heading 3 = Times New Roman (11pt - bold)

30.6.4 Line Spacing

Line spacing shall not be smaller than 1.

30.6.5 Subdivisions

(a) Each individual volume in the O&M Manual may have a number of books depending on their size.

(b) Each volume shall be divided into chapters. Each chapter shall be divided into sections, sub-sections and further sub-division as appropriate.

(c) Each new chapter, section, sub-section and each new work instruction shall begin on a new page.

30.6.6 Numbering of Text

(a) The manuals shall be collated and numbered in proper order according to a logical and consistent system.

(b) Chapters, sections and subsections shall be numbered in Arabic numerals.

(c) Decimal numbers (1, 1.1, 1.1.1, ... down to the 3rd level) shall be assigned to sub-divisions under each section, or depending on the length of the document, subsections. Small letters or Roman numerals in parenthesis ((a), (b), (i), (ii), ...) and bullets points may also be used to facilitate presentation and reference.

30.6.7 Page Header

Each page of the O&M Manual shall have a header which contains the following information:

(a) the contract number of the Contract

(b) the volume number and title of the manual

(c) the number and title of the chapter, section and subsection to which the page belongs

(d) the revision number and date of the page

(e) the page number

(f) or work instructions, the title and reference number of the work instruction shall also be shown

30.6.8 Page Numbering

Each page of the manuals shall have a page number that is unique in the manuals. The page number shall be in the following format:

VV - cc - ss - bb - nn

where:

VV is the volume number

cc is the chapter number

ss is the section number

bb is the sub-section number

nn is a page number which begins from 1 for each subsection or work instruction

30.7 Paper

30.7.1 All manuals shall be printed on American paper sizes of Letter size (i.e. 8.5” × 11”) paper. Foldout diagrams or illustrations may be given in Ledger (i.e.

11” × 17”) paper. In such cases the title of the diagram or illustration shall be visible in the lower right corner when the sheet is folded.

30.7.2 The paper used shall be of good quality and of adequate thickness for frequent handling and shall be submitted for approval.

30.7.3 The paper and ink shall resist smearing, fading and deterioration with age and shall be suitable for use in a workshop environment.

30.8 Binding

30.8.1 All manuals shall have a locked binding of the “peg” or “ring” type, to avoid loss of pages through rough handling. The manuals shall be able to be laid flat when open at each page.

30.8.2 The binding shall allow for all changes and additions to be readily made.

30.8.3 A spine bearing the contract number, volume number, name of the manual, book number and the number and names of the constituent chapters shall be provided on each manual. Spines shall be colour coded: a different colour shall be given to each volume. Spines for manuals in the same volume shall be of the same colour.

30.8.4 The cover and spine shall be stiff and protected by plastic or other material to withstand frequent handling in a work floor environment.

30.8.5 A pocket shall be provided in the back of each binder for keeping loose drawings and notes.

Note: Spring-back, threaded and spiral binding will not be accepted.

30.8.6 Dividers with tabs shall be provided to separate each chapter and section in

the manuals. Chapter and section numbers shall be shown on the tabs.

30.9 Software for the Production of the Manual

30.9.1 The text of the Manual shall be produced in Adobe® FrameMaker® version 7.0 (or a later version as approved).

30.9.2 Drawings shall be produced using Autocad release 2000 (or a later version as approved). Under special circumstances, the Engineer may accept drawings that are scanned into documents.

30.9.3 Large tables of data shall be prepared in databases using Microsoft® Access or Excel Version 2002 compatible, linked into the text files.

30.9.4 File Naming Conventions

The Contractor shall propose a systematic convention for naming files in the O&M Manual for approval. The convention shall enable the identity of the document to be inferred readily from the file name.

30.9.5 Figures

The use of external figures is not recommended as there is a risk that some third-party tools such as ‘viewer’ may not support them.

30.9.6 Table of Contents

A table of contents shall be provided (refer to PS 30.12.2). This shall be generated by the software, not typed into the document.

30.9.7 Hyper-links

If possible, hyper-links should be built for each item in the table of contents. In addition, if a figure is referred to in a paragraph, a hyper-link should be built so that the figure can be more easily looked up.

30.9.8 Headers and Footers

Important information shall not be placed into a header or footer, due to the possibility of its being corrupted or lost during file conversions.

30.10 Equipment Hierarchy

30.10.1 Equipment on the train shall be organized under a classification scheme

hereafter called the equipment hierarchy. All equipment systems, assemblies, sub-assemblies, components, down to the smallest replaceable item shall be assigned to different levels in a hierarchial structure. The first level (level 1)

of the equipment hierarchy shall consist of the following:

1 Vehicle Structure
2 Structure and Vehicle Interior Fittings
3 Trucks and Suspension
4 Gangways and Couplers
5 Traction System
6 Brake System
7 Auxiliary Electrical System
8 Door System
9 Air Conditioning
10 Pneumatic and Air Distribution System
11 Train Information Management System
12 Communication Equipment

30.10.2 All equipment information in the O&M Manual shall be presented using the equipment hierarchy as a framework. A separate chapter shall be provided for each level 1 item in the equipment hierarchy. Separate sections and subsections shall be provided systematically for equipment and components under the level 1 item. Where appropriate, a chapter 0 with the title 'Train Complete' shall be provided to cover information that applies to the train as a complete system.

30.10.3 To facilitate reference, the same chapter, section and subsection numbers shall be used consistently for the same equipment throughout the O&M Manual.

30.10.4 The Contractor may propose modification to equipment hierarchy for approval.

30.11 Copyright

The content of all documentations shall become the property of the Commission, who shall have the right to reproduce any part or the complete documents, as he wishes.

30.12 Contents of Individual Volumes of the O&M Manual

30.12.1 General Requirements

The first part of each book of the O&M Manual shall contain the following:

(a) a title page specifying the volume number, title of the manual and the book number

(b) a revision control sheet detailing the amendments made to the manual

(c) A table of contents for the complete O&M Manual. It shall list the numbers and titles of all the volumes, parts and chapters in each book.

(d) A table of contents for the particular volume to which the book belongs. It shall list the numbers and titles of all the books, parts, chapters and sections in the volume.

(e) A general introduction detailing the purpose, use and limitations of the manual and reference to other manuals in the set.

(f) a list of abbreviations

30.12.2 A table of contents shall be provided for each chapter. It shall be placed immediately after the chapter divider. It shall list the number, title and

beginning and ending page numbers of each section in the chapter. The reference numbers and titles of individual checklists and work instructions shall also be listed in the table of contents.

30.12.3 A table of contents shall be provided for each section. It shall be placed

immediately after the section divider. It shall list the number, title and beginning and ending page numbers of each subsection or further sub-divisions in the section. The reference numbers and titles of individual checklists and work instructions shall also be listed in the table of contents.

30.13 Volume I Technical Descriptions Manual

30.13.1 General Requirements

30.13.1 This manual shall provide technical descriptions and performance specifications of the train and its subsystems. It shall include adequate information on the design of the trains to enable the Commission to carry out maintenance and modification to the equipment.

30.13.2 The manual shall consist of two parts:

Part A Overall System Descriptions

Part B Technical Descriptions of Equipment Systems

The contents of each part are detailed below.

30.14 Volume I Part A - Overall System Descriptions

This part shall contain technical information on the train as a complete system. It shall provide details on the following aspects:

30.14.1 General descriptions of the train and its subsystems.

30.14.2 Basic physical dimensions, kinematic envelope and weights

30.14.3 Overall design criteria and operation conditions such as duty cycle, useful life, power supply, environmental conditions

30.14.4 Performance data such as maximum speed, passenger capacity, acceleration and braking rates, ride comfort, acoustic performance, energy consumption and reliability.

30.14.5 A list of major equipment supplied, with quantity, model number and the name of the manufacturer

30.14.6 Numbering of equipment positions on the train

30.15 Volume I Part B - Technical Descriptions of Equipment Systems

30.15.1 This part shall contain technical information on individual equipment systems.

The descriptions shall be presented systematically using the equipment hierarchy as a framework. Information on microprocessor based equipment such as hardware configuration and expansion capabilities shall also be provided.

30.15.2 The information to be covered shall include, but not be limited to, the following:

(a) Descriptions of the system or equipment and its components, identifying any special features such as interlocks and protective devices.

(b) Locations of the system or equipment and its components on the train

(c) Functions of the system or equipment including inputs, outputs and interfaces with other equipment or systems, with the aid of functional block diagrams

(d) Descriptions of the control of the system or equipment covering all possible modes of operation

(e) Operation principles, including those for emergency and derated modes of operation

(f) Equipment layouts, arrangement drawings, location diagrams, control schematics, block diagrams, exploded views, wiring diagrams

(g) Overall design assumptions, system and equipment specifications and performance characteristics in terms of power, current, flow-rate, temperature, pressure and other relevant parameters. The minimum acceptable performance level in which an equipment shall be allowed in service, with due consideration of maintenance and operational requirements, shall also be

specified.

30.16 Volume II Train Operator's Manual

30.16 General Requirements

30.16.1 This manual shall provide operating information and instructions for both the train operator and any other operation staff that are required to handle the trains, including station staff. The information shall cover both normal operating conditions and emergencies.

30.16.2 Safety precautions and critical points shall be emphasised so that they are brought to the attention of the operation staff involved.

30.16.3 This manual shall consist of three parts:

Part A Operating Information

Part B Operation Instructions

Part C Fault Handling and Recovery Instructions

The contents of each part are detailed below.

30.17 Volume II Part A - Operating Information

This part shall detail the location, function and operating procedures for all operating elements, including train controls, the Train Information Management System, indicators, safety devices and emergency equipment.

30.18 Volume II Part B - Operation Instructions

This part shall consist of step-by-step instructions for all operating procedures such as those for preparing, starting up, normal running, shutting down, coupling and uncoupling under normal and emergency conditions. Such instructions shall be presented in the form of general work instructions as detailed in Figure 30-2.

30.19 Volume II Part C - Fault Handling and Recovery Instructions

30.19.1 This part shall contain handling and recovery procedures for both common faults and for more serious events such as derailments, locked axles and collisions. Such procedures shall be designed for train operators and operation personnel with the objective of minimizing service disruptions so that train service may be restored in the shortest possible time. They shall cover, but not

be limited to, all train failure scenarios defined in the Register of Train Failures described in PS 25.

30.19.2 Such instructions shall be presented in the form of general work instructions as detailed in Figure 30-2.

30.20 Volume III Equipment Maintenance Manual

30.20.1 This manual shall provide all documentation necessary for engineering personnel to carry out all types of maintenance work, including preventive and corrective maintenance and conditioning monitoring, on the trains. It shall cover all maintenance activities starting from those at train level through

equipment systems, assemblies and sub-assemblies down to the lowest level components that require maintenance attention.

30.20.2 This manual shall consist of three parts:

Part A General Maintenance Information

Part B Preventive Maintenance Schedules and Checklists

Part C Maintenance Work Instructions

30.20.3 Tabulated information, such as schedule of lubricants, torque values, master maintenance schedule and maintenance task matrices in the manual shall be prepared in the form of databases. Such databases shall be handed over to the Engineer as part of the O&M Manual submissions.

30.21 Volume III Part A - General Maintenance Information

This part shall consist of the following items which are applicable to the train as a whole:

30.21.1 A statement on the approved maintenance programme (refer to PS 26.1.1) and maintenance policy (refer to PS 26.1.2) for the trains . This shall specify the maintenance objectives, maintenance approach, basic assumptions, organization of preventive maintenance work (refer to PS 26.3.1), types of maintenance sessions (refer to PS 26.3.1(c)) and the associated maintenance intervals and maintenance logistics.

Where applicable, recommendations for the appropriateness of Condition Based Maintenance shall be given.

30.21.2 General standard practices applicable to the maintenance and repair of train equipment.

30.21.2 A schedule of all lubricants, cleaning agents, chemicals, and other consumable

materials stating:

- where used
- quantities
- brand and grade of recommended lubricant
- safety precautions
- storage and disposal requirements

30.21.3 Detailed data sheets for all hazardous substances

30.21.4 Torque schedule for various types of fasteners. Locking method and/or thread adhesives used for each application shall be stated.

30.21.5 A list of paints for structures and parts.

30.21.6 Material specification list for structures and parts.

30.21.7 List of items which are recommended to be returned to the original equipment manufacturer for repair / maintenance.

30.21.8 Schedules of frequently referenced acceptance criteria and equipment performance specifications for major equipment.

30.21.9 Schedule of equipment which are subject to deterioration with time and the corresponding shelf lives.

30.21.10 General descriptions and procedures for handling derailments, locked axles, collisions and similar events. The procedures shall enable maintenance personnel to clear the train from the site safely and rapidly so that train service can be restored in minimum time. Such procedures shall be presented in the form of maintenance work instructions as described in Figure 30-2.

30.21.11 Schedule of all cleaning work described in PS 26.5 covering all approved technical details according to PS 26.5.3.

30.22 Volume III Part B - Preventive Maintenance Schedules and Checklists

30.22.1 This part shall contain schedules and matrices which provide an overview and details of all preventive maintenance work to be carried out on the trains. It shall consist of items described in B.4.3.2 to B.4.3.4 below.

30.22.2 Master Maintenance Schedule

(a) The Master Maintenance Schedule shall tabulate all preventive maintenance actions to be carried out in-situ on the trains, including inspections, servicing, replacement / replenishment of consumable, non-destructive tests, removal of

equipment from cars for overhauls / scrapping, major part replacements during equipment overhauls as well as commissioning checks.

(b) The Master Maintenance Schedule shall be presented in the framework of the equipment hierarchy. Maintenance actions for the complete train or car, for example recommissioning tests, shall be presented under the title Train Complete.

(c) Maintenance actions shall be grouped into maintenance tasks as defined in PS 26.3.1(b).

(d) Each maintenance task shall have a unique task number and a title. They shall be organized around individual equipment in the equipment hierarchy and

shall form the basic building blocks of all service checks, car overhauls and scheduled equipment replacements.

(e) Each entry in the Master Maintenance Schedule shall contain the following information:

(i) Name of the equipment

(i i) Applicable car types

(i i i) Maintenance task number and title

(i v) Maintenance actions covered in the maintenance task

(v) Maintenance interval and tolerance

(v i) Required man-hours

(v i i) Reference number of relevant work instructions

30.22.3 Maintenance Tasks Matrix

(a) This is a table which specifies exactly which maintenance tasks are to be carried out at different service checks, car overhauls and scheduled equipment replacements for each type of unit, ranging from the lowest level checks up to mid-life overhauls.

(b) The principle of balanced-check defined in PS 26.3.2(b) shall be adopted in making up the contents of B service checks.

30.22.4 Maintenance Checklists

(a) A maintenance checklist defines all maintenance actions to be carried out on an unit in a service check, car overhaul or scheduled equipment replacement.

(b) A maintenance checklist shall be produced for each type of unit for different types of service checks, car overhauls and scheduled equipment replacements.

(c) The contents of a maintenance checklists shall contain, but not be limited to, the following:

(i) A unique reference number and a title

(i i) Maintenance interval in terms of running distance and service time

(i i i) Tolerance in maintenance interval

(i v) Downtime

(v) Manpower and skills requirements

(v i) A bill of materials listing all essential replacement parts

(v i i) Details of individual constituent maintenance tasks, i.e. maintenance task title,

task number, maintenance actions and reference to relevant work instructions

(d) Maintenance tasks in a maintenance checklist for service checks shall be grouped under the following stages:

(i) Preparation and safety precautions

(i i) Inspections and servicing with third rail power supply energized

(i i i) Inspections and servicing with the overhead line isolated

(i v) Testing and recommissioning to restore the train back to service condition, with the overhead line energized

(e) Maintenance tasks in a maintenance checklist for car overhauls shall be grouped under the following stages:

(i) Preparation and safety precautions

(i i) Car lifting (optional, depending on the design of the equipment)

(i i i) Replacement of equipment for overhauls

(i v) Inspections and servicing with overhead supply isolated

(v) Testing and recommissioning to restore the train back to service condition, with the overhead line energized

(f) Maintenance tasks in a maintenance checklist for scheduled equipment replacement shall be grouped under the following stages:

(i) Preparation and safety precautions

(i i) Replacement of equipment

(i i i) Testing and recommissioning to restore the train back to service condition

(g) Maintenance checklists shall be presented in the format of general work instructions described in Section 1 of Figure 30-2.

30.23 Volume III Part C - Maintenance Work Instructions

30.23.1 This part shall contain all work instructions for the maintenance of the trains.

30.23.2 Each maintenance work instruction shall provide detailed technical

information and step-by-step instructions for shop floor staff to carry out a specific maintenance work. They shall provide quantitative acceptance criteria for inspections / tests and define the performance level of the equipment to be achieved after the maintenance work.

30.23.3 Acceptance criteria and performance specifications that are frequently referred to shall be tabulated in schedules to facilitate standardization, reference from other documents and subsequent updating.

30.23.4 All maintenance work instructions shall be written in the format specified in Figure 30-2.

30.23.5 Maintenance work instructions shall be produced for the following maintenance operations:

(a) Details of maintenance actions referred to in maintenance tasks. Such actions shall be presented under individual items in the equipment hierarchy.

(b) System function tests and commissioning procedures (for example after corrective maintenance and car overhauls) to ensure that a train is in service condition

(c) Dismantling and re-installation of equipment from / to the cars (reference shall be made to testing and commissioning in (b) above)

(d) Equipment overhauls (refer to PS 26.3.1(d)), which shall include the following activities:

(i) testing and fault finding (for repairs of defective equipment)

(i i) dismantling

(i i i) cleaning and inspection

(i v) repair, reconditioning and adjustment

(v) re-assembly

(v i) calibration, testing and re-commissioning

(e) Repair to body structures for anticipated modes of damage throughout the life of the trains

30.24 Volume IV Fault Diagnostics Manual

30.24.1 This manual shall provide information and instructions for maintenance personnel to identify and rectify failures on the train.

30.24.2 The information provided shall include, but not be limited to, the following:

(a) Location, functions and interpretation of fault indications, alarms and fault messages

(b) User guides for onboard self-diagnostics and fault logging equipment, including the Event Recorder

(c) User guides for special diagnostic and test equipment

(d) Trouble-shooting procedures for common faults classified under items in the equipment hierarchy. Such procedures shall be prepared in the form of maintenance work instructions specified in Figure 30-2.

30.24.3 A trouble-shooting procedure shall consist of the following parts:

(a) A table or tree diagram showing all failure symptoms which may be found on the equipment

(b) Methods to identify the cause of failure down to the defective Line Replaceable Units plus the corresponding rectification procedure

(i) For failures where the cause and effect relationship is straight forward,

systematic tabulation of common symptoms, causes and rectification action shall be provided.

(ii) For failures which require complicated diagnosis and testing, the trouble-

shooting process shall be presented in the form of flowcharts, fault trees or cause and effect tables complemented with notes and explanations. Such information shall present an overview of the trouble-shooting process and shall enable maintenance personnel to take the shortest path in identifying and rectifying the failure.

(c) Quantitative acceptance criteria and performance specifications for tests and measurements to be made during trouble shooting.

(d) Tests and inspections to prove that the failure has been removed.

(e) Instructions and tests to restore the train back to service condition.

(f) Drawings for control schematics and signal flow diagrams with reference values at equipment inputs, outputs and test points

30.25 Volume V Illustrated Parts Catalogue

This manual shall consist of two parts:

Part A Equipment Hierarchy

Part B Parts Lists and Illustrations

30.25.1 Volume V Part A - Equipment Hierarchy

This part shall document the equipment hierarchy down to the first 3 sub-levels for each item defined in A.7 of this Section of PS.

30.25.2 Volume V Part B - Parts Lists and Illustrations

(a) General

(i) This part shall consist of combinations of parts lists and illustrations covering all equipment on the trains starting from the top of the equipment hierarchy down to the smallest replaceable component.

(ii) All parts lists and illustrations shall be cross-referenced to each other by proper indexing under the equipment hierarchy.

(iii) All parts must bear unique part numbers. Identical parts used in different locations shall be highlighted with inter-changeability information in the parts lists.

(iv) Standard items such as nuts, bolts, fixings, bearings, bulbs, resistors, capacitors, inductors and common electronic components can be described as such, and shall not necessarily require a part number unless it is a non-standard or specially made product. Descriptions for these standard items shall include the material and all necessary identification data and ordering parameters such as BS/DIN/ISO standards, voltage, rating, grade and dimensions.

(b) Parts Lists

(i) Parts lists shall be prepared in the form of databases. Such databases shall be handed over to the Engineer as part of the manual submissions.

(i i) A parts list shall include the following information:

Header:

- the reference number of the parts illustration
- the reference number of relevant engineering drawings
- title

Information for each item in the list:

- item number in the parts drawing
- part name and description
- unit of measure
- quantity per car / assembly
- part numbers assigned by the original equipment manufacturer (OEM) and the Contractor (if different). All parts shall bear unique part numbers
- name of the OEM
- applicable car type and interchangeability information

- space for the Commission's coding and reference (12 digits)
- special handling instructions (if any)

(c) Parts Illustrations

(i) These shall be cut away drawings and 3-dimensional exploded views for identification of all parts.

(i i) Each parts illustration shall have a unique reference number which shall be quoted in the relevant parts lists.

(i i i) All parts in the illustrations shall be clearly denoted by item numbers in sequence of their relativity, showing their exact positions within the assembly or equipment.

30.26 Volume VI Software Manual

30.26.1 General

(a) The software manual shall provide software documentation covering each software module in accordance with PS 29.

(b) The documentation shall be sufficiently comprehensive to allow any competent software programming organisation to make programme &/or system modifications, without recourse to the Contractor.

30.26.2 Contents of the Software Manual

The software documentation for each module shall include, but not be limited to the items listed below.

(a) General information on the software module including:

(i) functional description

(i i) linkage with other modules

(i i i) error routines, and any special considerations list of in/output data

(b) Memory maps for both internal and peripheral memory with descriptions for all the following items:

(i) programmes

(i i) data files

(iii) overlay areas, and

(i v) memory available for expansion

(c) Data flow diagrams

(d) Truth tables, state diagrams, equations.

(e) Initialisation and program loading requirements, test records, use of test software

(f) Program listing with comprehensive program comment statements

(g) Records of software modifications (date, reason, description)

(h) Programming manuals relevant to operating systems and languages

(i) Software environment configuration and the method of set up for the system and its development system

(j) Description and documentation of the software development method and tools employed eg. CASE tools

(k) Convention (in-house or international) used in the design/programming of the software

30.27 Volume VII Special Tools and Test Equipment

This volume shall contain comprehensive operation and maintenance information for all special tools and test equipment, including software and hardware, required for the maintenance and operation of the trains. As a minimum requirement, all special tools and test equipment supplied in accordance with PS 24 shall be covered. Such information shall include, but not be limited to, the following:

30.27.1 Technical specification and drawings

30.27.2 Application and functional description

30.27.3 Operation procedures

30.27.4 Maintenance and calibration procedures in the form of maintenance work instructions described in Figure 30-2.

30.27.5 Illustrated parts catalogues (if any) in a similar format to Volume III

30.28 Volume VIII Vendor's Documentation

30.28.1 This shall include all sub-suppliers documentation which are not included in other manuals. It shall only contain minor components.

30.28.2 Examples: Catalogue of small components (connectors, cables)

30.28.3 Manuals for standard hardware (for example, operation manual of a printer and software installation manuals for a PC)

30.28.4 Vendor's information on small parts (for example ballast for fluorescent tube) and other printed matter

30.28.5 These documents shall have a reference number and be filed in a logical order.

30.29 General Requirements for Desktop Publishing Facility

A computer server with the minimum system requirements of Intel® Pentium IV® processor, Microsoft® Windows® XP®, 256 MB of available RAM,

275 MB of available hard-disk space, CD-ROM drive, Video card capable of displaying 256 colors and equipped with software of Adobe® Reader® version 6.0 (or the latest version), Adobe® PostScript® printer, Adobe® FrameMaker® version 7.0 (or the latest version), Adobe® FrameMaker® Server 7.1 (or the latest version), shall also be provided to enable integration of printing and publishing features of the FrameMaker® with server-based applications. Such that all composed documents shall be delivered as *.PDF files to a Web browser or file server as part of the applications of server-based publishing. The server-based publishing systems shall be able to deliver content from the AUTHORITY's intranet Web server to each carhouses.

Figure 30-2 Typical Style for O&M Manual

1. General Writing Style

Level of Detail

1.1 Technical information shall contain all of the information necessary for the user to perform the task involved or to comprehend a description.

1.2 The O&M Manual shall retain enough information to permit the user to perform the documented maintenance without error or loss of time due to insufficient information.

1 . Comprehensibility

2.1 Present descriptive text in a logical order (for example, in operational sequence or in signal flow sequence) and include summary headers for individual paragraphs whenever needed for clarity.

2.2 Maintain consistent terminology, style, and format throughout the O&M Manual.

2.3 When procedural text is combined with graphics, use the following rules to abbreviate, so long as the meaning is not altered or obscured.

(a) Eliminate articles.

(b) Begin sentences with transitive verbs (action verbs).

(c) Use the imperative mood whenever appropriate.

4. Emphasis

Use bold text for all words and phrases which need to be emphasised.

Note: Words that require stronger emphasis are bold and capitalised.

Example:

This is an optional procedure. The safety switch SHALL be set before operation.

5. Notes and Examples

Some guidelines to follow when using these terms are:

5.1 the word is in bold text followed by a colon

5.2 there is an indent after the colon

5.3 the first word in the text is in initial capitals

5.4 the text shall word wrap and be a hanging indent, and

5.5 the label can be plural if there is more than one eg. Notes.

Example:

This is an example of how to present examples in an O&M manual.

6. Aligning Notes and Examples

Where there is a combination of notes and examples within one paragraph, they are to be aligned as shown below.

Example:

Example: This is an example.

Note: This is a note.

7. Multiple Notes

When there is more than one point to be included as a note, the label “Notes” is to be used, and each note is to be numbered.

Example:

Notes:

1 . This is the first note.

2 . This is the second note.

8. Spelling - Use of S/Z

In words that can be spelt using either s or z (eg. organize/organise) the letter s shall be used (eg. organise).

9. Paragraphs and Sentences

Limit paragraphs to a single idea. Limit sentences to a single thought; avoid compound or complex sentences. Whenever possible, limit words to those that are short and familiar to the target audience. Eliminate long, complex sentences and paragraphs through the use of lists. The resulting parallel portions of sentences shall be individually listed as follows:

The beat frequency oscillator has three components:

(1) ...

(2)...

(3)...

10. Capitalization

10.1 All equipment names are to have initial capitals.

10.2 Types of equipment, eg. indicator, switch, push button are to begin with:

initial capitals when they are part of an equipment name, eg. Emergency Switch, and lower case when they are used generically, eg. check all switches.

10.3 When referring to modes or positions, then mode and position does not begin with an initial capital, eg. normal position, test mode.

1 0 . Quotes

When it is necessary to use quotation marks, double quotation marks are to be used.

Example:

"quote"

12. Numbers in Documents

12.1 Use numerals for all numbers.

Examples:

1 to 99.

Steps 1 to 5.

Load 4, 8 or 16 modules.

12.2 When you have two numerals together, spell out one of the numbers.

Examples:

Ten 3-person teams.

Add 5 seven times.

12.3 Use numerals and leading 0 for decimals less than 1.

Example:

0.1253.

12.4 Spell out the number if it starts a sentence.

Example:

Ten operators are needed for this task.

13. Indicating Time

When it is necessary to indicate time, begin sentences with "when" clauses. Example: "When power supply voltage stabilizes..."

14. Bulleted Lists

14.1 A bulleted list shall not appear in the middle of a sentence. It appears at the end of an introductory sentence.

14.2 Use bulleted lists for:

lists within paragraphs, and points in a series (normally separated by commas in normal prose).

14.3 A bulleted list shall contain at least:

2 points if each point contains more than one word, or 3 points if each point contains only one word.

14.4 An introductory sentence shall always go before a bulleted list. The following table explains punctuation rules that apply to introductory sentences.

If the introduction...	then the introductory sentence shall end
is a complete sentence	full stop.

is not a complete sentence	colon.
assumes that a list is following, eg. ends in the word “follows” or “following”	colon.

14.5 Second Level Bullets

For second level bullets, the following is an example of spacing.

Example:

Things I need to do tomorrow are:

- get up and shower,

- eat breakfast, and
- drive to work, making sure to:

  stop at the dry cleaners, and

  get petrol.

Note: If the 2nd level bullets are all only one line, then there is no return between the 1st and 2nd level bullets.

15. Definitions

Definitions shall be given as a complete sentence, even if in a glossary.

Example:

A definition is the act of stating a precise meaning.

16. Abbreviations/Acronyms

16.1 The full form of an abbreviation shall be given when it first appears in the text. A list of abbreviations shall be provided in each volume of the manuals.

16.2 Do not use full stops between letters in acronyms.

16.3 The abbreviations ie. and eg. do not have a full stop between the letters.

1 6 . Style Related to Computer Systems

17.1 Entering Information

(a) When referring to general text which shall be entered onto a screen or form, use the word “Enter”.

Example:

Enter the train's speed.

(b) When referring to specific text which shall be entered onto a screen or form, use the word "Type" or "Write" and make the specific information bold, using capital and small letters as required.

Examples:

Type abc in the FUNCTION field.

Write XYZ in the Address field.

17.2 Field and Screen Names

Field and screen names appear in the document as they appear on the screen or form, including capital and small letters.

17.3 Key Strokes

When identifying keys on a keyboard or key pad, enclose them in square brackets.

Examples:

[Alt]

[A]

[F1]

17.4 Multiple Key Strokes

When two or more keys shall be pressed together, they are separated by +.

Example:

Press [Alt] + [F3].

17.5 Locating Information

(a) To point out information on the screen, use the following terminology:

- at the top of the screen (line 1)
- near the top of the screen (lines 2-15), and
- near the bottom of the screen (lines 16-24).

Example:

The screen name is at the top of the screen.

(b) System messages are written in quotation marks with an introductory sentence of "The following message is displayed:".

Example:

The following message is displayed: "The test is now completed".

17.6 Online

The word online is one word. There is no hyphen in this word.

17.7 Captions on Graphics

The text formatting for captions is:

- mixed case
- not bold
- Arial 10 point
- centred beneath the graphic

Figure 30-3 Typical Contents of Work Instructions

Note: All work instructions shall include items described under section 1 below as a minimum. Maintenance work instructions shall also include additional items as specified below.

1. General Work Instructions

1.1 Number and Title:

The number and title of the work instruction. Each work instruction shall have a unique reference number.

1.2 Application:

A statement of the type of cars, equipment, location and the circumstances (for example normal train operation, emergency and maintenance examination) under which the work instruction is applicable.

2. Safety precautions:

2.1 A clear statement of:

(a) any hazards associated with the equipment or procedures, and

(b) the actions required by operators or maintenance personnel to ensure safety.

2.2 All safety precautions shall be printed in bold capital letters.

3. Procedure:

3.1 Step-by-step instructions shall be clear, logical and sufficient for carrying out procedures or activities.

3.2 The instructions should be supported, where possible, by a flow chart and, where appropriate, by a check sheet.

3.3 The software used to produce the flow chart(s) shall be identified, to enable reproduction.

Figure 30-4 Additional Items to be Included in Maintenance Work Instructions

1. Special tools:

A list of special tools, jigs, and inspection, measuring and test equipment required for execution of the maintenance work.

2. Materials:

A list of materials and the quantities required to carry out the maintenance work.

3. Essential replacement parts:

A list of all parts which shall be replaced, regardless of their condition, during the maintenance work.

4. Illustrations:

A list of illustrations attached to, or included in, the work instruction.

5. Reference drawings and manuals:

A list of drawings by drawing number and title and/or supplier provided manuals which are referenced in the work instruction.

6. Reference forms:

Sample of record forms to be completed during the maintenance work.

Note: If any of the items listed above are not applicable, the paragraph heading shall still be included and the words “Not applicable” recorded below it.

SECTION 31 INTERFACE ARRANGEMENTS 2

31.1 ..... Introduction 2

31.2 ..... General Requirements 3

31.3 ..... Detailed Interface Management Requirements 3

Section 31 Interface Arrangements

31.1 Introduction

31.1.1. The Contractor shall perform all design duties and provide all materials, equipment and labour as defined in the PS to ensure satisfactory coordination with the equipment/systems provided by Subcontractors in accordance with designs which are mutually acceptable to all parties and to the approval of the Engineer.

31.1.2. The Contractor shall liaise and coordinate on the interface requirements with the third parties including Subcontractors and statutory authorities as described in the PS. The Contractor shall afford the Subcontractors reasonable access for design data, personnel, items of plant, equipment and building materials.

31.1.3. The detailed interface requirements with the Subcontractors, named suppliers and all third parties are described in details in Appendix I Annex 1 to Annex 6. Unless it is otherwise specified, no change in the existing wayside equipment shall be required in order to ensure compatibility between the T1 trains and the interfacing systems. The annexes cover the following areas:

(a) Annex 1 Trackwork Interface (Track Data) contains details of the track on which the trains will run.

(b) Annex 2 Third Rail Traction Power Supply System Interfaces defines the interface requirements for the third rail traction power supply system and the train system.

(c) Annex 3 ATC Interfaces defines the interface requirements for the SCS and the train system. Compatibility of the train with the existing track circuit system is also addressed.

(d) Annex 4 Communication Interfaces defines the interface requirements for all

Communications Equipment and the train system including Train Radio, VSS, PIS and Wireless LAN for Yard Maintenance Support System.

(e) Annex 5 Yard Interfaces defines the interface requirements for the yards and the train system.

31.1.4. The information provided with the above Annexes are intended to assist the Contractor for liaison and coordination with others. As such, these information shall not reduce the Contractor's responsibility to ensure the compatibility of their Work with that of others.

31.2 General Requirements

31.2.1. As an integral part of the SEMS, the Contractor shall perform interface management according to the requirements stipulated in PS 21.12.6.

31.2.2. The Contractor shall be responsible to purchase the systems/equipment from the named suppliers as described in Appendix I.

31.2.3. The Contractor shall be responsible for the system design and integration, purchase, installation, testing, commissioning, training, documentation and warranty of the purchased systems/equipment.

31.2.4. The Contractor shall assume full responsibility in ensuring the proper functioning of the purchased systems/equipment from the named suppliers.

31.2.5. The Contractor shall liaise with the named suppliers in ensuring that the purchased systems/equipment shall meet the intended functional and performance requirements of the systems/equipment as defined in the PS.

31.2.6. The Contractor shall investigate, at this own cost, all interface matters and satisfy himself regarding the availability of the required information for interface designs from the Subcontractors, named suppliers and all third parties. Any interface issues that may affect the performance of the Works shall be brought to the attention of the Engineer.

31.2.7. The Contractor shall implement interface change control and all changes in interface design shall refer to the Configuration Management detailed in PS 21.

31.3 Detailed Interface Management Requirements

31.3.1. The Contractor shall establish a coordination team whose duties are to provide

a link between the Contractor's design and installation staff and the teams established by Subcontractors and the Engineer. The Contractor shall provide approved professionally qualified and experienced co-ordinators who shall be assisted by such other approved technically qualified and experienced staff as may be necessary to check the drawings, and co-ordinate the design and installation of the Works with the works of Subcontractors, the Employer and public utility companies constituting part of the project. The Contractor shall nominate a single person as the interface contact for liaison and coordination with Subcontractors and the Engineer. The Contractor shall submit an organisation chart together with the associated Curriculum Vitae of the key design personnel of the above co-ordination team which shall be under the responsibility of the SEM representative (refer to PS 21.2.1).

31.3.2. By the end of the SEMP stage 1, the Contractor shall submit for approval

interface plan which shall include a detailed approach and methods on managing interface, strategy, contents of interface specification, change control and interface contacts. For this interface plan, there shall be a corresponding reference in an item-by-item manner to the respective interface requirements specified in the PS. In addition, a master interface index to summarise all interface requirements corresponding to the individual systems, shall be provided for easy reference.

31.3.3. By the end of the SEMP stage 2, the Contractor shall submit all required System Specification Documents including a detailed interface specification for each interfacing system/equipment according to PS 21. The interface specification shall include:

a . interface definitions in terms of functionality, electrical, physical location and quantity details;

b . division of responsibility;

c . Implementation and installation aspects;

d . test strategy and verification matrix containing verification methods for each interface; and

e . EMC and software interface aspects

31.3.4. By the end of the SEMP stage 3, the Contractor shall submit all required System Design Documents to demonstrate how the proposed design will comply with all interfacing functions according to PS 21.

31.3.5. By the end of the SEMP stage 4, the Contractor shall submit all required interface design proposals which shall form part of the Level 4 Design Data (refer to PS 21).

31.3.6. By the end of the SEMP stage 5, the Contractor shall submit a schedule of Integrated Test (refer to PS 22.12) for each interfacing system/equipment for approval. The Contractor shall obtain agreement with the associated Subcontractors, named suppliers and all third parties beforehand regarding the scopes of work, methodologies, responsibilities, test site arrangements, expected test date, test procedures, durations and reports beforehand and record in the above Integrated Test Schedule.

SECTION 32. KEYS AND LOCKS 2

32.1 ..... Introduction 2

32.2 ..... General Requirements 3

32.3 ..... Design Life Cycle 4

Section 32. Keys And Locks

32.1 Introduction

32.1.1. This Section of the PS contains details of standard keys and locks to be used on the trains.

32.1.2. Scope of Supply:

Key Type	Key	Lock
Maintenance Key*		
Mode Selector Key		
Staff Key*		
Cab door key*		

Legends:

* - existing AUTHORITY's keys

- shall be provided

- not required

32.1.3. The Contractor shall provide a locking devices compatible with the existing AUTHORITY's keys. Consideration shall be given on the design of the locking devices to ensure materials compatibility and minimum mechanical life of 50,000 cycles without any need for maintenance.

32.1.4. Medeco® type of keys and locks shall be purchased from the Named Supplier (refer to Appendix D) and used for the maintenance access control according to the following arrangements:

(a) For VSS hard drive (refer to PS 10.2.7(c)(iv)), supplier's part number: 65-2651T-102-66.

(b) For Event Recorder (refer to PS 10.2.5(g)), supplier's part number: 65-2151T-011-66.

(c) For other maintenance access locker (refer to PS 26.2.3), supplier's part number: 60-035T-245-66.

to be keyed to 8F8218102 Medeco® blind code.

32.1.5. The numbers of mode selector key required shall be two thousand (2,000).

The Contractor may propose the use of similar type of Medeco® type of keys and locks on the application of mode selector, provided that a different part number of lock shall be used to differentiate its unique application.

32.2 General Requirements

32.2.1. A co-ordinated keys and locks system shall be used for the trains according to the following levels of security:

Levels of Security	AUTHORITY's Personnel	Key Type	Remarks
3	Maintainer	Maintenance Key	PS 26.2.3
		Mode Selector Key	PS 9.5.6 PS 26.2.3
		Staff Key	PS 26.2.3
		Cab door key	
2	Motorman	Mode Selector Key	PS 9.5.6 PS 26.2.3
		Staff Key	PS 26.2.3
		Cab door key	
1	Guard and Station Staff	Staff Key	PS 26.2.3 PS 26.2.
		Cab door key	

32.2.2. The system shall ensure that staff are only allowed to operate or have access to equipment as required in the course of their duties.

32.2.3. It shall not be possible for unauthorised staff or passengers to open cubicles or cabinets, or operate equipment, using commonly available tools or implements.

32.2.4. The keys and locks designs shall be complied with the operability requirements according to PS 21.5.

32.2.5. The Contractor shall submit a schedule of keys and locks in accordance with the Configuration Management (refer to PS 21), specifying the quantity of

each type to be supplied and functions of the various types with listing for each type of all cubicles, cabinets and equipment which they will operate.

32.2.6. The number of different types of keys and locks shall be kept to a minimum.

32.2.7. Indications shall be provided to show the lock is in closed position.

32.2.8. Keys and locks shall not be able to be broken by normal manual forces.

32.2.9. Keys and locks shall be designed not to subject to excessive wear such that their ability to continue to function satisfactorily for the life of the train (refer to PS 4.5.5) will be impaired.

32.3 Design Life Cycle

32.3.1. SEMP Stage 1

The Contractor shall submit a conceptual keys and locks system design to demonstrate correct understanding of the requirements specified in this Section of PS.

32.3.2. SEMP Stage 2

The Contractor shall submit a co-ordinated keys and locks system with a schedule of keys and locks in accordance with the Configuration Management.

32.3.3. SEMP Stage 3

The Contractor shall carry out the tests to verify and validate the strength requirements before manufacture of panel and equipment case locks. Two (2) samples of each type of key and lock shall be supplied for approval.

32.3.4. SEMP Stage 4

The Contractor shall carry out operational test and inspection with the associate panel or equipment case to check the effectiveness of locking in addition to easy assess.

32.3.5. SEMP Stage 5

The Contractor shall submit all test results for approval.

APPENDIX A SCHEDULE OF DRAWINGS..... 2

APPENDIX A Schedule Of Drawings

Drawing No.	Title	Sheet
NST 001	Route Map of Subway System	1
NST 002	Main Vehicle Dimensions	1
NS2 003	Maximum Moving Dimension Line on Tangent Track Subway Vehicles	1
NST 004	Undercar Equipment Gauge Line - Centre and End Subway Car.	1
NST 005	Subway Track Equipment Gauge Line	1
NST 006	General Arrangement of Subway Car	16
NST 007	Carbody Jacking Pads Location Diagram Subway Cars	1
NST 008	Operator Air Ride Seat Subway Cars	3
NST 009	Cab Door Key Subway Cars	1
NST 010	Refer to NST-006	-
NST 011	Refer to NST-006	-
NST 012	Arrangement of Anticlimber Subway Cars	1
NST 013	Glass Details For Subway Cars	3
NST 014	Recovery Dolly Arrangement Subway Vehicles	2
NST 015	Refer to NST-006	-
NST 016	Door Barrier Assembly Detail for Defective Doors	2
NST 017	Door Sealing Passenger Side Doors Subway Cars	1
NST 018	Door Edge Rubber For Side Doors Subway Cars	1
NST 019	Refer to NST-006	-
NST 020	Auxiliary Electrical Systems	1
NST 021	Destination Sign Layout Subway Cars	1
NST 022	Run Number Sign Assembly Subway Cars	1
NST 023	Refer to NST-006	-
NST 024	Interior Advertising Sign Frame On Door Pocket - Subway Cars	1
NST 025	Commission By-Law Notice Subway Cars	1
NST 026	Not Used	-
NST 027	Not Used	-
NST 028	Stick for Lifting Contact Shoe - Subway Cars	1
NST 029	Typical Schematic Door Control Circuit Subway Cars	1
NST 030	Bell and Buzzer Circuits for 2-Car Unit Subway Cars	1
NST 031	Refer to NST-006	-
NST 032	Staff Key Gauge Details Subway Cars	1
NST 033	Narrow Flange Contour 28" Wrought Steel Wheel Class "C"	1

Drawing No.	Title	Sheet
NST 034	Coupler Radial Slide Bar - Subway Cars	1
NST 035	Extension Bar for Uncoupling Lever Subway Cars	1
NST 036	Subway Car Radio System	4
NST 037	Communication System For Subway Vehicles	2
NST 038	Not Used	-
NST 039	Not Used	-
NST 040	Grease Guard Above Wheels on Truck Subway Cars	1
NST 041	Jacking Locations, Wheel Grinding and Truck Equipment Clearance, Wheel Turning - Subway Cars	1
NST 042	Axle Centre Details Subway Vehicles	1
NST 043	Not Used	-
NST 044	28" Wrought Steel Wheel For H6 and T1 Cars	2
NST 045	Refer to NST-006	-
NST 046	Shoe Details - Current Collector Subway Cars	3
NST 047	Receptacle for 600 Volt Shop Power Supply - Subway Cars	1
NST 048	Isolating Test Switch and Test Plug Circuit - Subway Cars	1
NST 049	Test Stud for Isolating and Test Switch - Subway Cars	1
NST 050	Subway Vehicle Interior and Exterior Noise Criteria	1
NST 051	Refer to NST-006	-
NST 052	Refer to NST-006	-
NST 053	Track Chart – D Subway	1
NST 054 to NST 058	Track Chart – C St. Subway	1
NST 059 to NST 062	Track Chart – E Subway	1
NST 063	Rail Chronicle – D Wye	1
NST 064	Speed on Horizontal Curves	1
NST 065	Staff Key Switch	1
NST 066	Arrangement of Master Control Switch	1
NST 067	Arrangement of Door Control Master Switch Panel	3
NST 068	Arrangement of Console Indicator Panel	1
NST 069	Arrangement of Cab Interior and Control Panel Layout	1
NST 070	Subway – Standard Data for Contact Rail at Switch Points and Transitions	1
NST 071	Contact Rail 74 kg/m Rail Section	1
NST 072	Conceptual Train Consist	3
NST 073	Interior Advertising Sign Frame	1
NST 074	Conceptual Interior Design	1
NST 075	Naming Conventions	1
NST 076	K Carhouse Plan	2
NST 077	Passenger Door Gap Measurement Gauge	1
NST 078	Not Used	-
NST 079	Not used.	-
NST 080	Details Of Lifting Claws And Working Range Of Existing Above Floor Car Lifting Equipment	2
NST 081	Not used.	-
NST 082	Not used.	-
NST 083	Details Of Pneumatic Connectors For Underframe Reservoirs	1
NST 084	Cab End Mechanical Coupler	1
NST 085	Wheelchair Restraint Unit	1

Note: The above drawings shall be used for illustration purpose only and shall not be used for manufacturing without design review and approval from the Commission.

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APPENDIX B Schedule Of Tests

1. Introduction

1.1 According to PS 22, all tests specified in this Appendix shall constitute the Works Tests, Commissioning (Tests in CITY), Tests on Completion and Integrated Testing of the trains as the minimum testing requirements which are acceptable to the Engineer.

1.2 The Contractor may offer alternative testing proposals which are equivalent to or better than those herein, and which the Contractor shall justify to the satisfaction of the Engineer.

1.3 The tests related to the train level shall follow the IEC 61133 : 1992 where applicable.

1.4 The tests related to the major system/component level tests shall follow the specified testing requirements of this Appendix and the approved test specifications prepared by the Contractor.

1.5 The tests related to the other system/component level tests which are not mentioned in this Appendix, shall refer to the approved supplier's recommendation provided by the Contractor or individual PS section where applicable.

1 . Works Tests

2.1 Car Body Structure and Exterior

2.1.1 Car Body Structure

(a) The Contractor shall undertake a series of Type Tests to demonstrate that the requirements of the following PS sections have been achieved: PS 6.4.1 (excluding subsections (b), (h) and (I)), 6.4.3(b) at the coupler level only and 6.4.3(c)(ii). The tests shall include, but not be limited to, all the load cases specified in PS 4.5.3.

(b) A preliminary Type Test report which shall detail general stress levels, and shall highlight any areas of excessive stress and explain what corrective action is proposed, shall be submitted for approval.

(c) Following this corrective action retest shall be required and a final report shall be submitted for approval.

(d) This report shall contain a full commentary on the test results, together with a comparison of the measured stresses against the stresses predicted by the Finite Element Analysis (FEA).

2.1.2 Train Sway Test

The Contractor shall submit for approval and carry out a static vehicle sway test to verify his method for calculation of the Kinematic Envelope and to confirm that the requirements of the Kinematic Envelope given in PS 5.1 have been achieved.

2.1.3 Water Resistance Test

The Contractor shall submit for approval and carry out tests to ensure that all trains will remain water tight under all operating conditions. The testing shall confirm that there is no penetration of water into passenger, train operator or equipment areas, or into any area where the presence of water or cleaning fluid may cause malfunction or in any way adversely affect any part of the train.

2.1.4 Window Test

~~The Contractor shall submit for approval a procedure and carry out tests to ensure that all windows and glazing meet the requirements of PS 6.11.~~

The Contractor shall submit for approval procedures and carry out tests to ensure that all windows and glazing meet the requirements of PS 6.11."

2.2 Car Body Interior

2.2.1 Ergonomic Trials

The Contractor shall submit for approval a procedure and carry out ergonomic trials to optimise the design of the saloon interior facilities including the seat profile, passenger retentions, passenger alarm device, passenger information display system and interior maintenance access panels.

The Contractor shall conduct design and mock-up review exercises with the AUTHORITY to carry out ergonomic trials to optimize the design of the saloon interior facilities including: the seat profile; passenger retentions; passenger alarm device; passenger information display systems; and interior maintenance access panels.

2.2.2 ~~Strength Test of Panels, Seats, Passenger Retentions, Draught-screens and~~ Passenger Alarm Emergency Handles of the PEL

The Contractor shall conduct tests to verify the strength requirements as specified in PS 7 have been achieved.

The Contractor shall conduct tests or analyses to verify the strength requirements as specified in PS7 have been achieved.

2.2.3 ~~Flooring Tests~~

(a) ~~The floor covering in combination with sub floor shall be tested to PS 21.10~~.

(b) ~~The Contractor shall submit for approval a full abrasion test programme~~ and ~~carry out tests to confirm that the floor covering~~ show no signs of wear and shall remain colour fast to BS 1006:1990 test conditions for the specified service life.

The Contractor shall submit for approval a full abrasion test programme and carry out tests to confirm that the floor covering show no signs of wear and shall remain color fast to BS 1006:1990 test conditions or equivalent for the specified service life. Previous testing results illustrating floor resistance for wear and color fade can be submitted to the Engineer as an equivalency approval consideration to this PS requirement.

2.2.4 Lighting Tests

(a) All light fittings shall be tested to IP 54, IEC 60529 : 2001.

(b) The lighting levels of the normal and emergency lightings shall be tested to confirm that the requirements in PS 7.11.3 and 7.11.4 have been achieved.

2.3 Cab Facilities and Layout

2.3.1 Ergonomic Trials

The Contractor shall submit for approval a procedure and carry out ergonomic trials on the foamcore mock-up and the full-scale engineering mock-up with an aim:

(a) to optimise the design of the cab facilities including the driver/auxiliary seats, cab controls, detrainment device and interior maintenance access panels.

(b) to ensure the cab pictograms are fit for purpose.

2.3.2 Panels and Controls

(a) All panels and controls shall be tested as per PS 8.7.3.

(b) The Contractor shall carry out tests to confirm that the pictograms and legends on the panels, indicators and pushbuttons shall have minimal degradation of colour and shall remain legible for the whole service life.

2.3.3 Lighting Tests

The lighting levels of the main, reading and detrainment lights shall be tested to confirm that the requirements in PS 8.14 have been achieved.

2.3.4 Switchgear electrical and mechanical endurance tests to IEC 60077 - Part 1 to 5 where applicable.

2.4 Operation and Control

2.4.1 Test for correct operation to IEC 61133 clause 5.7.

2.4.2 Checks for the prevention of accidents to IEC 61133 clause 5.13.

2.4.3 Test for speed regulation and over speed protection systems to IEC 61133 clause 6.6.

2.5 Train Information Management System

The Contractor shall carry out tests to prove that the requirements have been met and that the PS requirements is satisfied according to PS 10.

2.6 Traction and Braking Equipment

2.6.1 Traction Equipment

(a) A complete system test is required to be performed on the traction package in order to demonstrate compatibility of all train systems.

(b) The tests shall be conducted using simulated running conditions and as a minimum shall be conducted on one complete traction equipment including all line input protection devices and filters, traction electronics both power and control, traction motors and auxiliary equipment.

(c) The test shall also include all on board and wayside equipment and systems and shall demonstrate that the requirements of the design, to satisfy the requirements of the PS, have been complied with.

(d) At the appropriate stage some of the results obtained shall be used in the energy consumption calculations as detailed in Appendix C Clause 2.2.6.

(e) The Contractor shall carry out combined tests on the traction equipment according to IEC 61377 : 1996.

2.6.2 Traction Motors

(a) General

(i) All tests shall be in accordance with IEC 61377 - Part 3 : 2002 and IEC 60349 – Part 1 to 2 where applicable. The first two machines of each type of each separate contract, and every fortieth of the remainder, shall be type tested. Routine tests shall be carried out on every machine.

(b) Test Through Gearing

A test shall be carried out with the gear drive assembled to a motor and dummy axle for the purpose of demonstrating that noise and lubrication arrangements are to the satisfaction of the Engineer.

(c) Impedance and Inductance Measurement

The total motor resistance and inductance shall be determined at the propulsion chopper operating frequencies.

2.6.3 Braking Resistors

All braking resistors shall be tested to IEC 60322 : 2001.

2.6.4 Transformers and Reactors

All transformers and reactors shall be tested to IEC 60310 : 2004.

2.6.5 Power Converters

The power converters shall be tested to IEC 61287-1:1995.

2.6.6 Miscellaneous Electric Traction Equipment

All miscellaneous electric traction equipment shall be tested to IEC 60077 - Part 1 to 5 where applicable.

2.6.7 Brake Equipment

(a) The Contractor shall submit for approval a dynamometer test to indicate the adequacy of the truck mounted friction brake equipment.

(b) The tests shall demonstrate that the requirements of PS 11.9 have been satisfied.

2.6.8 Tread Brake Units

Type tests shall comprise:-

(a) Functional checks such as working stroke, slack adjuster operation and action of parking brake.

(b) Recording of block force against cylinder pressure over the working range.
(c) Plotting of curves of brake force against pressure in all conditions of operation of main cylinder and parking brake.

(d) Carrying out of a vibration test as defined in IEC 61373 sections 8 to 10 where applicable.

2.6.9 Brake Control Equipment

Individual items of electro-pneumatic equipment shall be type tested as follows:

(a) Mechanical Operation and Endurance

As defined in IEC 60077 - Part 1 to 5 where applicable.
o

(b) Vibration and Shock

As defined in IEC 60077 - Part 1 to 5 where applicable.

(c) Air Tightness

Generally as IEC 60077 - Part 1 to 5 where applicable except as varied by particular requirements specified in the Contractor's design specification.

(d) Electrical Tests

These shall be generally in accordance with IEC 60077 - Part 1 to 5 where applicable and shall include checking operation at lowest permitted voltage at 0 C ambient.

(e) Characteristic Tests

Each item of equipment having a pilot or transducing function, shall be tested to confirm compliance with the Contractor's design data, and oscillogram shall be produced in support.

2.6.10 Wheel Slide Protection System

The wheel slide protection system shall be tested to the International Union of Railways i.e. Union Internationale des Chemins (UIC) UIC 541-05 : 2005 “Brakes - Regulations Concerning The Construction Of The Various Brake Components - Wheel Slip Prevention Equipment”.

2.7 Truck and Suspension

2.7.1 Truck Static Test

(a) The Contractor shall carry out a static proof test on a strain gauged truck to confirm that all the requirements of PS 12.9.3 have been achieved.

(b) Strain gauges shall be placed in any area where the stress level predicted by FEA is greater than 80% of the yield stress or 0.2% proof stress of the material, and where the predicted damage over the life of the truck computed in accordance with PS 12.9.3(b) is greater than 0.7. The positioning of strain gauges shall be submitted for approval.

(c) The reporting on the proof test shall include, but not be limited to, a comparison between the stresses measured during the proof test with those predicted by the FEA. In all areas where the measured stress differs from the stress predicted by FEA by more than 10% of the predicted value, a detailed explanation for the difference shall be given.

2.7.2 Truck Dynamic Test

(a) The Contractor shall carry out a dynamic test on the truck to demonstrate that the requirements of PS 12.9.3 have been achieved.

(b) Strain gauges shall be placed in all areas where the cumulative fatigue damage, evaluated in accordance with PS 12.9.3(b) is greater than 0.7.

(c) The tests shall be carried out over a representative length of track in both directions at the design speed profile and shall cover all loading conditions from tare to crush laden.

(d) The strain gauge signals collected during the testing shall be counted using the rainflow method, or other counting technique and shall be submitted for approval.

(e) The results shall then be used in conjunction with the fully laden passenger mass given in PS 4.5.4 to assess the fatigue damage over the life of the truck.

(f) The truck shall be assumed to travel 15 million km throughout its life.

2.7.3 Wheel Off-loading Test

The Contractor shall carry out tests to confirm compliance with the wheel off-loading performance specified in PS 12.5.

2.7.4 Truck Rotational Resistance Test

The Contractor shall carry out a test to measure the rotational resistance of the trucks to confirm that the requirements of PS 12.6 have been achieved.

2.7.5 Train Ride Test

(a) The Contractor shall carry out tests to demonstrate that the requirements of PS 12.2 have been achieved.

(b) Additionally the train shall be ride tested with the air suspension deflated to demonstrate compliance with PS 12.11.2.

(c) The tests shall be carried out on the Existing Subway Lines in both directions.

2.7.6 Axlebox Bearing Test

The Contractor shall propose and carry out a test to demonstrate that the axlebox bearings will resist the ingress of water and cleaning fluids.

2.7.7 Truck Frame Fatigue Test

The truck frame shall be subjected to a fatigue test in accordance with BS EN 13749:2005 “Railway Applications. Methods Of Specifying Structural Requirements Of Truck Frames”.

2.8 Pneumatics and Air Distribution Systems

The Contractor shall carry out compressor capacity, duty cycle, charge up time, air dryer test, leakage test, air reservoirs test, shock and vibration test to satisfy the requirements of PS 13 .

2.9 Gangways and Couplers

2.9.1 The Contractor shall carry out Type Tests, including but not be limited to the following, to demonstrate that the gangways are capable of withstanding the movements, loadings, deflections and aerodynamic effects in accordance with the approved Design Data submitted to satisfy the requirements of PS 14 .

(a) Strength Test

(b) Water Tightness Test

2.9.2 Couplers

The Contractor shall carry out Type Tests to demonstrate that the couplers are capable of withstanding the movements, loadings and deflections, in accordance with the approved Design Data submitted to satisfy the requirements of PS 14.

2.10 Heating, Ventilation And Air Conditioning (HVAC) Systems

2.10.1 Mechanical Endurance, Vibration and Shock Type Tests

With the HVAC unit mounted in a manner fully representative of the on-car arrangement including any flexible or resilient mounting, the unit shall be subjected to the following tests:

(a) The test shall comprise a minumin of 20 000 start-run-pump down-stop cycles with a suitable cycle duration and time interval between each cycle. The timing shall be submitted for approval.

(b) Routine maintenance shall be carried out at intervals equivalent to the maintenance intervals as defined in PS 26, in line with the specified maintenance instructions. A record of all maintenance activities shall be kept for inspection.

(c) A full report of all failures occurring during testing shall be submitted to the Engineer, who may require that a modification be carried out to rectify any defects thus encountered.

(d) Following such a modification it may be necessary to repeat the endurance test at the discretion of the Engineer and shall be at the cost of the Contractor.

(e) One prototype set of equipment type, fully representative of the production equipment, shall be subjected to vibration and shock tests to BRB/RIA 20:1995.

(f) Any module or equipment frame used in the test shall not subsequently be used for a train supplied under this or any subsequent contract.

2.10.2 Pressure Test

Pressure tests shall be carried out before and after the vibration and shock tests of the HVAC unit for any leakage by an approved method.

2.10.3 Equipment Base Performance Test

(a) The Contractor shall provide facilities to enable an air-conditioning unit to be artificially provided with sensible and latent thermal load so that it may operate at full capacity.

(b) The test shall also include the measurement of air flow to demonstrate the HVAC unit delivers the specified air flow rates.

(c) Suitable instrumentation shall be provided to permit results to be checked against approved Design Data.

(d) The motor temperature rise shall not exceed that permitted according to IEC 60349 – Part 1 to 2 where applicable : 1991, when tested continuously under the full load conditions.

(e) The Type Test shall also include measurements of equipment noise to meet the equipment noise specifications in accordance with PS 21.8.

(f) The Type Test shall also include measurements of equipment vibration levels to meet the requirements of BRB/RIA 20:1995.

(g) The Contractor shall carry out the Routine Tests to certify every HVAC unit are capable to achieve the specified cooling capacity.

2.10.4 Vehicle Base System Performance Test

A Type Test on vehicle base shall be carried out with the carbody equipped with all interior finish and underframe mounted equipment representative to the production vehicle to demonstrate the effectiveness of the equipment in meeting the requirements of the PS. The tests shall include, but not be limited to, the following:

(a) Air Flow Tests

Tests shall be carried out to measure the air flows at the outside air intake, return air inlet and exhaust air outlet under all modes of air conditioning operation to achieve the specified air flow requirements in PS 15.

(b) Air Distribution

Tests shall be carried out to verify the requirements of PS 15.6 for evenly distribution of supply air. The static pressure head inside the car shall be measured and recorded under all modes of air conditioning operation.

(c) Air Conditioning

Tests shall be carried to demonstrate the capability of the HVAC system to maintain the required saloon conditions as specified in PS 15. This test shall include the artificial generation of sensible and latent heat load inside the saloon and the required ambient conditions outside the car.

2.11 Doors

2.11.1 Endurance Tests on Exterior Saloon and Cab Doors

(a) An endurance test shall be performed on two sets of saloon door leaves and their operating mechanisms (refer to PS 16.6) to

(i) identify, analyse and rectify design problems and

(i i) to demonstrate compliance with the reliability target as apportioned from the overall train reliability target (refer to PS 25.5.9 and PS 25.5.10).

The test shall be carried out for a minimum of 500,000 complete open/close cycles for each door set.

(b) Similarly, an endurance test shall be performed on two sets of cab door leaves and their operating mechanisms (refer to PS 16.6) for a minimum of 100,000 complete open/close cycles for each door set.

(c) The endurance test for the saloon door mechanisms shall be designed to simulate a door obstruction every 1,000 cycles.

(d) Routine maintenance shall be carried out at intervals equivalent to the maintenance intervals defined in PS 26, in line with the specified maintenance instructions. A record of all maintenance activities shall be kept.

(e) A record of the door leaf velocity profile shall be taken, at the beginning and end of the test and any maintenance activities, to compare with the profile pre-programmed in the door control unit. Any deviations discovered shall be reported.

(f) The Contractor shall produce a full report of all failures occurring during

testing and shall calculate the reliability together with the associated confidence level of the door mechanisms at the completion of the test.

(g) The Contractor shall propose design modifications for approval should the agreed reliability target has not been met. The Engineer may require that a modification be carried out to rectify any defects encountered during the test. The Engineer may, at his discretion, request the undertaking of a further endurance test sequence to validate the design changes undertaken at the Contractor's cost.

(h) Upon completion of the endurance test, all parts of the doors and their actuators shall be dismantled for inspection by the Engineer. The door

components shall be rigorously examined for incipient failure and wear and a report submitted on the condition of all parts. Any parts exhibiting such signs shall be subject to redesign at the discretion of the Engineer following which the endurance test may be required to be repeated at the Contractor's cost.

(i) Any module or equipment used in these tests shall not subsequently be used for a train supplied under this or any subsequent contract.

2.11.2 Mechanical Strength Test

The Contractor shall undertake tests to demonstrate the structural strength and stability of the door leaves and suspensions and their deflection when loaded (refer to PS 16.2.5).

2.11.3 Vibration Tests

Vibration tests to BRB/RIA 20:1995 shall be carried out on door leaves, suspensions and operating mechanisms of the saloon door, cab door and the emergency detrainment door systems.

2.11.4 Emergency Detrainment Device Type Test

(a) The Contractor shall perform a Type Test to demonstrate, to the satisfaction of the Engineer, that the detrainment device is fit for purpose and that it satisfies the requirements specified in PS 8.16 for the basic mode of operation, namely, train-to-track detrainment.

(b) Load Test

A static load test (refer to PS 8.16.6) shall be performed at fully deployed condition without permanent deformation. The test shall simulate the correct heights relative to the car floor level and the ramp resting on track when the car being stopped on a curve of 300m radius. The device shall continue to function within its prescribed operating parameters on completion of the test.

(c) Endurance Test

The emergency detrainment system shall be tested for endurance with a total of 100 cycles for ramp mode and re-stowed back to normal operative state. The device shall be operated within the specified deployment and stowage time (refer to PS 8.16) throughout the test. The Contractor shall calculate the reliability and the associated confidence level of the detrainment door mechanism.

(d) Any failure of the tests, the Contractor shall make necessary rectification through readjustment or design changes to the satisfaction of the Engineer.

The Engineer may, at his discretion, request the undertaking of further test sequence to validate the design changes undertaken at the Contractor's cost.

2.12 Auxiliary Electrical Supply

2.12.1 A complete system test is required to be performed on the auxiliary supply system in order to demonstrate compatibility of all train systems.

2.12.2 The tests shall be conducted using simulated running conditions and as a minimum shall be conducted on one complete auxiliary equipment including all line input protection devices and filters, control electronics both power and control, compressor motors and auxiliary equipment.

2.12.3 The test shall also include all emergency equipment and systems and shall demonstrate that the emergency requirements have been complied with.

2.12.4 The Contractor shall carry out tests on the power converters according to IEC 61287-1 : 1995.

2.12.5 Auxiliary Machines (other than compressor sets)

(a) General Remarks

(i) All machinery shall be tested to IEC 60349 – Part 1 to 2 where applicable insofar as applicable, or if test specifications exist and are already agreed between the Engineer and the Contractor then these tests shall be to these specifications unless otherwise agreed.

(ii) For those auxiliary drives where the actual loading conditions cannot be accurately calculated in advance or conveniently simulated at the manufacturers' work, for example, fans and pumps, the electrical driving motors chosen for the application shall be tested to a declared continuous rating which shall subsequently be verified to be adequate by prototype tests

on the train. Similarly, the fan or pump chosen shall be type-tested at the manufacturers' works to prove the design characteristics and their suitability for the application subsequently proved by tests on the train. In the case of components which belong to the manufacturers' standard range, test certificates referring to published performance data may be acceptable at the Engineer's discretion.

(iii) It follows from the preceding paragraph that the appliance and its driving motor need not be tested together as one unit although this method is preferred. If tested separately, due regard must be given to possible interaction between components after assembly, particularly as regards vibration. However, when integral construction is adopted for the appliance and its electric driving motor it shall be tested as a complete unit.

(b) Low Voltage Starting Tests (AC machines only)

It shall be demonstrated that the motor at a starting temperature of 0oC and with a load having similar torque/speed characteristic to that with which the motor will operate in service, will start and run up to normal speed when supplied at a voltage corresponding to the lowest specified voltage and frequency.

(c) No Load Run (AC machines only)

This run shall be made at rated voltage and the stator current, watts and the speed shall be recorded.

(d) Locked Rotor Test (AC machines only)

This test shall be made at rated stator current and the terminal voltage and watts shall be recorded.

(e) Compressor and Motor Set

(i) These shall be in accordance with IEC 60349 – Part 1 to 2 where applicable or if test specifications exist and are already agreed between the Engineer and Contractor then these tests shall be to these specifications.

(ii) Oil consumption tests on two sets selected by the Engineer shall also be required.

2.12.6 Battery Charger

The equipment shall be supplied at nominal supply voltage and a load shall be applied consisting of:

(a) Maximum normal auxiliary load, for example, lighting and control.

(b) A discharged battery of the type to be used with the charger, when supplied by an auxiliary inverter, also of the type to be used with the charger.

(c) The test shall be continued until maximum temperature conditions are reached.

(d) Tests shall be carried out to determine the characteristics of the charger at minimum, nominal and maximum input voltages over the full range of load.

(e) Measurements shall be made of input voltage, input current, input power, output voltage and output current.

(f) The measurements shall include the conditions with the output terminals open-circuited.

(g) Cathode ray oscillogram of the output quantities shall be made for selected conditions of supply and load. These shall include examples of the transient response to switching the supply and the load on and off.

Rating and characteristic type tests shall be made on a completely assembled charger with all covers in position.

2.12.7 Miscellaneous Auxiliary Equipment

All miscellaneous auxiliary equipment shall be tested to IEC 60077 - Part 1 to 5 where applicable.

2.13 Communications Equipment

2.13.1 General

The cars, units and trains shall be tested generally in accordance with the requirements of IEC 61133:1992 to an approved specification. Unless agreed otherwise the tests required by the approved specification shall be carried out at the Contractor's works, and may be performed either on individual cars, units or trains as appropriate.

2.13.2 Train Radio

(a) The Contractor shall agree with the Engineer, a range of tests as recommended by the Named Supplier to be conducted, prior to the dispatch of any equipment from the Named Supplier's works. Visual, electrical and functional tests shall be conducted for each individual element (refer to Appendix I Annex 4) and the assembled system / equipment.

(b) When the equipment is delivered to the Contractor's works, the Contractor shall agree with the Engineer, a range of tests as recommended by the Named Supplier to be conducted, prior to the installation of the equipment on train.

(c) The Contractor shall conduct commissioning tests to demonstrate that all the equipment have been correctly installed and adjusted and that the system fulfil all the requirements as stipulated in this Specification.

(d) The train radio shall be re-programmed to satisfy the frequency plan for Existing Subway Lines. The Contractor shall undertake tests to demonstrate full functional compliance of the train radio for Existing Subway Lines.

2.13.2 VSS, DVAS & PA, PIS and Wireless LAN for YMSS

(a) The Contractor shall undertake tests for VSS, DVAS & PA, PIS and Wireless LAN for YMSS to demonstrate full compliance of PS 18 and the tests shall cover all interface with TIMS.

(b) The Contractor shall agree with the Engineer, a range of tests to be conducted, prior to the installation of the equipment on train. Visual, audio, electrical and functional tests shall be conducted for each individual element as specified in PS 18 and the assembled system / equipment.

(c) The Contractor shall conduct commissioning tests to demonstrate that all the equipment have been correctly installed and adjusted and that the system fulfil all the requirements as stipulated in the PS.

2.14 Cab Simulator

The Contractor shall carry out tests to prove that the requirements have been met and that the PS requirements is satisfied according to PS 19.

2.15 EMC and Software Integration Tests

The Contractor shall carry out tests to prove that the requirements have been met and that the PS requirements are satisfied according to PS 21.7 and PS 29.

2.16 Cables

The Contractor shall carry out tests to prove that the requirements have been met and that the PS requirements are satisfied according to PS 20 and PS 21.10.

2.17 Pneumatic Equipment

The Contractor shall carry out tests to prove that the requirements have been met and that the PS requirements are satisfied according to PS 13.

2.18 Fire Performance

The Contractor shall carry out tests to prove that the requirements have been met and that the PS requirements are satisfied according to PS 21.10.

2.19 Wheelset

The Contractor shall carry out tests to prove that the requirements have been met and that the PS requirements are satisfied according to PS 12.

2.20 Collector shoe

The Contractor shall carry out tests to prove that the requirements have been met and that the PS requirements are satisfied according to PS 11, 12 and Appendix I Annex 2.

2.21 Battery

The Contractor shall carry out tests to prove that the requirements have been met and that the PS requirements are satisfied according to PS 17.4.2.

2.22 Noise Performance

The Contractor shall carry out tests to prove that the requirements have been met and that the PS requirements are satisfied according to PS 21.8. Noise testing shall be performed at the Contractor's test track.

2.23 Operability Performance

The Contractor shall carry out tests to prove that the requirements have been met and that the PS requirements are satisfied according to PS 21.5.

2.24 Keys and Locks

The Contractor shall carry out tests to prove that the requirements have been met and that the PS requirements are satisfied according to PS 32.

2.25 Other Type Tests

2.25.1 Type Tests on Electronic Equipment

Unless otherwise specified, all electronic equipment used in the train system shall be tested to BRB/RIA 13:1990.

2.25.2 Brake System Tests

(a) A complete set of brake equipment comprising all items of equipment from the Brake Controller to a transducer, measuring the force at the brake unit push rod, shall be set up. This shall include identical lengths and diameters of pipe to those on a Cab Car.

(b) The appropriate reservoir volumes shall be included where these are critical in any way to the correct functioning of the system. The rig may be fed from a suitable air supply other than the car compressor if required.

(c) A complete series of tests shall be carried out on this rig to demonstrate the function of the brake system as a whole both in manual modes.

(d) The Contractor may combine the test of individual items with the system test.

2.25.3 Shock and Vibration Tests

All equipment modules which include the equipment contained in the module, the mounting frame or box, and the mountings, including mounting bushes and fasteners, which will be mounted on the underframe or inside the vehicles, shall be subjected to a shock and vibration test in accordance with BRB/RIA 20:1995.

2.26 Completed Car, Unit and Train Tests

2.26.1 Train System Performance Test

(a) The train system performance test shall be the testing of a complete function of train from the power collection to its end function, the train operator and train system interface. All individual sub-systems of this function shall be successfully tested before, hence all the sections of system shall be connected together by their intended interfaces.

(b) The tests required by IEC 61133 that are applicable to the train shall be carried out at the Contractor’s test track prior to the delivery under the conditions of:

(i) the train under type test shall be equipped with all interior finish and with all underframe mounted equipment; and

(ii) the tests shall be carried out at the nominal system voltage.

(c) Notwithstanding the above requirements, it shall be a requirement that some of the important type and routine tests as mutually agreed between the Contractor and the AUTHORITY, shall be repeated in CITY as part of the commissioning tests.

2.27 Tests on Contractor's Track

2.27.1 In order to eliminate the initial design defects and hence reduce the duration of commissioning the trains, the first train manufactured shall undergo the following adjustment tests, ATC system combined test, reliability proving test and investigation tests in the Contractor's test track prior to its delivery to CITY.

2.27.2 Adjustment Tests

(a) The adjustment tests shall be carried out to prove the complete function of train according to the IEC 61133:1992 clause 4.2.

(b) The adjustment tests shall include both static and dynamic tests under the conditions of:

(1) with and without loads; and

(2) fully receptive, partial receptive and non-receptive traction power supply.

(c) All individual sub-systems particularly the traction system combined test specified in Clause 2.6.1 above shall be successfully tested beforehand.

(d) The results of the adjustment test, such as the response times and level setting of the individual systems, sub-systems and equipment, shall be recorded and formed the baseline to develop the associated commissioning test specifications, such that all trains shall be properly adjusted according to the above adjustment test results before submitting to the commissioning tests.

2.27.3 ATC System Combined Test

In order to eliminate the initial design defects and hence reduce the duration of commissioning the trains, the first train manufactured shall undergo the following adjustment tests, ATC system combined test, reliability proving test and investigation tests in the Contractor's test track prior to its delivery to CITY.

2.27.4 Reliability Proving Test

(a) Following the completion of the adjustment tests and ATC system combined test, the reliability proving test shall be carried out according to the following operation profiles in order to simulate the actual service pattern:

(i) with the train under test is in tare load, start the train with maximum motoring demand to its maximum speed and then stop with maximum service braking demand (note that re-motoring is allowed if necessary and re-generative braking shall be used for this test purpose);

(ii) perform the platform duties during stop i.e. operate the door and DVAS & PA (note that the train shall not be stop for more than 20secs);

(iii) repeat (i) and (ii) again until the accumulative mileage of the train runs reached 10,000km which is approximately equal to 1 month of operation cycle.

(b) For training purpose, a team of experienced train operators may be provided to the test site as the testing crews at the discretion of the Engineer (refer to PS 23.8.1).

(c) For the above 10,000km reliability proving runs, there shall be at least 5,000km runs cumulatively is free from any major equipment failure, such as any failure(s) that cause the train to impact passenger service on the line by 5 or more minutes.

(d) In the event that the requirement of 5,000km fault free runs cannot be met due to a failure(s) causing the train to impact passenger service provided by 5 or more minutes, the Contractor shall, at his own expense, investigate the failure, rectify the fault and take whatever action is deemed necessary to meet the requirement.

(e) In the event that the 5,000km fault free runs is not achieved, the 5,000km fault free runs shall be repeated until the 5,000km fault free requirements set out in Clause 2.27.4(a) is achieved.

2.27.5 Investigation Tests

The investigation tests shall be carried out to obtain those essential information of train characteristics according to the IEC 61133:1992 clause 4.4.

3. Commissioning (Tests in CITY)

3.1 Check Tests

3.1.1 Check tests shall be performed on each car on arrival, first stationary and then running at low speed in the test tracks at K Carhouse, to establish that all equipment is operating correctly. The Contractor shall itemise these tests for approval.

3.1.2 During initial trial runs, the manufacturer may make adjustments after which the tests below shall be carried out. The ATC Systems shall be checked and adjusted concurrently with these tests and brought into operation in

preparation for the acceptance tests on the trains.

3.1.3 An interference test shall be carried out together with the ATC contractor as an acceptance test to ensure the traction equipment will not interfere with the signalling equipment.

3.1.4 Inspections shall be performed on each car after completion of the commissioning tests to verify that the required workmanship are met and that no deterioration in performance has taken place during the shipping, erection

and commissioning processes. The Contractor shall make good any defect thus found at his own cost.

3.1.5 An Electro-Magnetic Interference (EMI) Conducted and Induced Emission Characterization Test shall be carried out on an existing T1 train. The purpose of this test is to record the as-built T1 EMI characteristics which shall form part of the acceptance criteria of the TR in order to ensure the TR traction equipment will not interfere with the AUTHORITY's signaling equipment by generating equal or less than T1 EMI. (Item 3.1.5 is a new item added)

3.2 Site Arrangements for Tests

3.2.1 The availability of track space in CITY will be limited by the fact that passenger train service will be in operation during the testing period.

3.2.2 Such testing as may be carried out may, of necessity, be done at night during the period when the service is shut down (from 01:30 to 05:00 hours approx.).

3.2.3 For this reason it is essential that the maximum amount of testing is carried out at or near the Contractor's Works.

3.3 Scope of Tests

The tests specified in Clause 4 below shall be carried out by the Contractor to verify the train performance in the Commission's railway systems.

4. Tests on Completion

4.1 ATC System Combined Test

4.1.1 The ATC system combined test shall be carried out to validate the interface design and performance according to the requirements specified in the Appendix I Annex 3.

4.2 In addition to the commissioning tests, the Tests On Completion shall demonstrate that the performance requirements of the train are suitable for passenger service in the Existing Subway Lines systems.

4.3 The Contractor shall demonstrate by these test results that the train system is applicable to the conditions in CITY and that no deterioration in performance has taken place during the shipping, erection and commissioning processes.

5. Integrated Testing

5.1 The Integrated Testing shall consist of Integrated Tests and Test Run.

5.2 Integrated Tests

5.2.1 Objective

(a) The Integrated Tests shall verify that the compatibility requirements between the train and the Existing Subway Lines systems are met.

(b) The Contractor shall demonstrate by the result of the Integrated Tests that all interface requirements specified in the associated interface specifications are met.

5.2.2 The Contractor shall carry out all required tests according to the relevant approved interfacing specifications of Appendix I in the Existing Subway Lines systems. The system interfaces shall include:

(a) Trackwork Interface (refer to Appendix I Annex 1),

(b) Third Rail Traction Power Supply System Interface (refer to Appendix Annex 2),

(c) ATC Interface (refer to Appendix I Annex 3),

(d) Communication Interfaces (refer to Appendix I Annex 4), and

(e) Depot Interface (refer to Appendix I Annex 5).

5.2.3 Specific (Type) Interface Tests

In addition to the requirements specified in the interface specifications, the following specific tests shall be carried out on a type test basis to verify the compatibility between the trains and the specific interfacing system/equipment.

5.2.4 Third Rail Traction Power Supply System Interface

To measure interference current generated by the traction and braking and auxiliary supply systems when they appear in the traction supply under both normal and worse case conditions.

5.2.5 ATC interface

(a) Rolling Stock / Signalling

(i) Conductive Interference

To measure the spectrum of the traction and braking and auxiliary supply systems generated harmonics for both continuous and transient conditions.

(ii) Inductive (Magnetic) Interference

To measure direct induction effects in track circuits i.e. "close up"conditions.

(iii) Inductive Interference

To measure direct induction effects in SCS Transponders.

(iv) To measure the spectrum of disturbance voltage induced in the traineborne SCS Transponder aerial systems for the traction and braking and auxiliary supply systems generated interference.

(b) Rolling Stock / Signalling / Third Rail Traction Power Supply

(i) To measure the spectrum of disturbance voltage induced in the trainborne SCS Transponder aerial systems for traction supply generated interference due to the train system.

(i i) Measure the range of ripple voltages over the range of load current to be conducted on site and the simulated failure mode shall be defined.

5.2.6 Yard Interface

(a) Compatibility with abovefloor and underfloor lifting equipment (refer to Clause 3.3, Appendix I Annex 5)

(b) Compatibility with existing accommodation trucks (refer to Clause 3.4,

Appendix I Annex 5)

(c) Handling of underframe mounted equipment (refer to Clause 3.5, Appendix I Annex 5)

(d) Towing by tractor (refer to Clause 3.6, Appendix I Annex 5)

(e) Automatic external cleaning facilities (refer to Clauses 4.1 and 4.2, Appendix I Annex 5)

(f) Compatibility with underfloor wheel lathe, including towing winch (refer to Clause 5, Appendix I Annex 5)

(g) Compatibility of miscellaneous interfaces (refer to Clause 6, Appendix I Annex 5):

(i) Pneumatic connector

(i i) Shore auxiliary supply

(i i i) Recovery equipment for derailment and locked axle

5.3 Test Run

5.3.1 "Test Run" means that period immediately prior to Trial Run when the Designated Contractors shall be testing their plant and equipment and run the same in conjunction with the Commission.

5.3.2 After the completion of the Integrated Tests (refer to Clause 5.2), each train shall undergo a Test Run one by one in the Existing Subway Lines to verify the reliability requirements between the train and the Existing Subway Lines systems are met. The Contractor shall provide a competent engineering personnel to attend the Test Run to provide technical advice to the train operator when it is required, such as, during fault recovery of the train.

5.3.3 In order to simulate the actual service pattern, the Test Run shall be carried out according to the following operation profiles:

(i) with the train under test is in tare load, operate the train according to the service schedules provided by the Automatic Train Regulation system of the Existing Subway Lines.

(ii) A special test path will be assigned to the test train during passenger service periods and no passenger shall be allowed to go abroad of the test train. The Contractor shall provide appropriate means, such as, to erect barriers at all doors, on the test train to prevent passengers from boarding the test train, as shall take any other precautions to meet the Commission's operating requirements, as instructed by the Engineer.

(iii) At the discretion of the Engineer, another special test path may be assigned to the test train during the non-traffic hours at night, the Contractor shall ensure that the required attendant (refer to Clause 5.4.4(a)) is provided:

(1) perform the platform duties during stop i.e. operate the door and DVAS;

(2) repeat (i) to (iii) above again until the accumulative mileage of the test train runs reached 805km (500 miles).

5.3.4 For the above 805km (500 miles) reliability proving runs, the test train shall be free from any of the following failures:

(i) failures defined in the Register of Train Failures (PS 25.3.4);

(ii) failures that the Engineer considers would endanger the safe operation of the Railway.

5.3.5 In the event that the requirement of 805km (500 miles) fault free runs cannot be met due to any failure specified in Clause 5.4.3(c), the Contractor shall, at his own expense, investigate the failure, rectify the fault and take whatever action is deemed necessary to meet the requirement.

5.3.6 In the event that the 805km (500 miles) fault free runs is not achieved, the 805km (500 miles) fault free runs shall be repeated until the 805km (500 miles) fault free requirements is achieved.

5.3.7 The distance travelled of the train recorded by the Train Information Management System (refer to PS 10.6.1(b)) shall be used for the 805km (500 miles) fault free measurement.

APPENDIX C ENERGY CONSUMPTION DATA (FOR WEIGHT AND ENERGY EFFICIENCY MANAGEMENT) 2

1. INTRODUCTION..... 2

2. PERFORMANCE COMPUTATION..... 2

Appendix C Energy Consumption Data (For Weight And Energy Efficiency Management)

1. Introduction

1.1. This Appendix defines the requirements for the computation, verification and validation of the specific energy consumption of the train.

1.2. The requirements stipulated below shall be achieved by a train over a complete round trip of the route of which the alignments, gradients and speed limits are shown in the "Track Chart" of the M Line (refer to Contract Drawings No.: T1 052 - T1 063).

1.3. Computer simulation techniques shall be used to provide evidence of compliance with the specified train performance. Simulations shall be carried out in three stages as defined in Clause 2.2 below.

1.4. The Contractor shall make copies of all simulation programs and data used to produce the energy usage calculations submitted at the Proposal stage and shall deposit those copies in a safe place to ensure that they will be available when needed.

1.5. In order to minimise the energy costs, great importance shall be placed on achieving practical designs of minimum weight whilst meeting all specified structural and performance requirements.

2. Performance Computation

2.1. For the purpose of the performance computation, the following information shall be used: [3]

2.1.1. Line voltage shall be taken as 580VDC in motoring and 720VDC in braking.

2.1.2. The maximum power taken from the third rail at 580VDC including all train borne systems shall be specified.

2.1.3. The train resistance formulae used for these calculations for tunnel and open sections shall be nominated by the Contractor and shall take into account the aerodynamics of the vehicle body design.

2.1.4. Wheel diameter shall be the half worn value.

2.1.5. 50% line receptivity shall be assumed during braking.

2.1.6. Jerk limit shall be taken as 0.8 m/s .

2.1.7. All out run-time is the time for which the train motors at full power to the maximum speed allowed, and runs at the maximum speed allowed at all times when it can be achieved.

2.1.8. The percentage of coast shall be calculated as:-

$$\frac{\textit{Interstation Journey - All Out Run Time}}{\textit{All Out Run Time}} \times 100\%$$

2.1.9. Unless otherwise specified, the maximum train speed shall be 80 km/h. And the speed restriction due to horizontal curve shall refer to Contract Drawing No. NST 064.

2.1.10. Passenger loading is a constant of W4 load (refer to PS 4.5.3).

2.1.11. Station dwell time is a constant of 15s and Terminus turnaround time is 120 seconds.

2.1.12. Commercial speed is 33km/h (20.5 mph) with 8% coasting.

2.2 Deliverables

2.2.1. The following items which shall have been provided at the Proposal stage:

(a) Name and version of the simulation program used for the performance computation. For future evaluation purpose, this software shall be compatible with IBM© personal computers and operation systems of Microsoft ® Windows XP compatible.

(b) Simulation results. Unless otherwise stated, all simulation results shall be in S.I. units per train per a complete round route. The submission of simulation results shall include but not be limited to the following items:

(i) Train Consist

This shall indicate the number of motor and trailer cars in the train and the configuration of the propulsion power circuit

(ii) A description of the performance characteristics and the control strategy of the propulsion equipment in motoring and braking

(iii) The tractive effort-speed and current-speed curves in motoring and braking, excluding jerk limit, at the voltages defined in Clause 2.1.1.

(iv) The resistances of the filter inductors at their normal working temperature

(v) The electrical and mechanical efficiency of the propulsion system

(v i) Tare Weight

This shall be the total unladen weight without passengers for the above consist.

(vii) Overall Weight

This shall be the specified passenger load.

(viii) Coasting Margin

This shall identify the percentage of coasting being used in the performance computation.

(ix) Rotational Mass Allowance

This shall be the equivalent mass added to the train mass to take account of the inertia of the rotating parts, for example, wheelsets and motors.

(x) Train Resistance Formulae

This shall be the train resistance formulae used to take account of the dynamic resistances to motion of the train consist.

(xi) Distance

This shall be the interstation distance used for the performance computation in the specified journey.

(xii) Interstation Run Time

This shall be the elapsed time between leaving one station and arriving at the next.

(xiii) Total Interstation Run Time

This shall be the sum of the interstation run time.

(xiv) Percentage Coast Achieved

Increase in journey time over the all out journey time for each interstation run, expressed as a percentage.

(xv) Line Input Energy

This shall be the energy drawn from the third rail traction supply by the train propulsion equipment whilst in the motoring mode.

(xvi) Line Regenerative Energy

This shall be the energy returned to the third rail traction supply by the train propulsion equipment whilst in the braking mode.

(xvii) Friction Energy

This shall be the mechanical braking energy required to compensate the dynamic brake if required.

(xviii) Specific Energy Consumption

This shall be the difference between line input energy and line regenerative energy in the unit of kWhr per train per one complete round trip.

(xix) Line R.M.S. Current

This shall be the continuous round trip r.m.s. current drawn from the traction supply during motoring.

(xx) Motor R.M.S. Current

This shall be the continuous round trip r.m.s. motor current including motoring and braking of the motor.

(xxi) Dwell Time

The time during which the train is stationary at a platform.

(xxii) Speed Regulation

The speed restrictions due to horizontal.

(c) Any assumptions made in the calculations, such as allowance for rotational mass, train resistance formulae and equipment efficiency.

(d) The characteristic curves for the motor, in motoring and braking for each train consist, including the following features:

(i) Tractive Effort (kN) vs Speed (km/h)

(i i) Motor Line Current (A) vs. Speed (km/h)

(i i i) Motor Line Voltage (V) vs. Speed (km/h)

(i v) Motor Slip Frequency (Hz) vs. Speed (km/h)

(v) Motor Speed (rpm) vs. Speed (km/h)

(v i) Motor Efficiency (%) vs. Speed (km/h)

(v i i) Gearbox Efficiency (%) vs. Speed (km/h)

(v i i i) Inverter Frequency (Hz) vs. Speed (km/h)

The above shall be drawn for line voltages of 580VDC in motoring, 720VDC in braking, with half worn wheels. The gearbox ratio shall also be stated.

2.2.2. After the award of Contract, the simulation program which shall be identical to the one being used for the performance computation at the Proposal stage (refer to Clause 2.2.1 above) shall be submitted. It is essential that this software shall be compatible with IBM© personal computers and operation systems of Microsoft ® Windows XP compatible. The simulation program shall be submitted in the form of:

(a) CD-ROM and installation instruction, if required; and

(b) hardcopy of full list of source codes.

2.2.3. The Contractor shall ensure that the same simulation results as submitted at the Proposal stage can be obtained by the Engineer with the use of this simulation program.

2.2.4. The following data obtained from the above simulation results shall be verified and validated during the specified SEMP stages:

(a) Total interstation run time (refer to Clause 2.2.1(b)(xiii)); and

(b) specific energy consumption (refer to Clause 2.2.1(b)(xviii)).

2.2.5. Based on the updated design information, the data specified in Clause 2.2.4 shall be verified during the SEMP stages 3 and 4 (refer to PS 21.3.4) by using the same computer simulation program and the information given in Clause 2.1. The verified data shall be submitted under the associated SEMP reports

(refer to PS 21.3.5).

2.2.6. Based on the finalised manufacturing information and testing results, the data specified in Clause 2.2.4 shall be validated during the SEMP stage 5 (refer to PS 21.3.4) by using the same computer simulation program (refer to Clause 2.2.1(a)) and the information given in Clause 2.1. The validated data shall be submitted under the associated SEMP report (refer to PS 21.3.5).

2.2.7. It is a requirement that the continuous rating of the motor shall be a minimum of 10% higher than the greatest r.m.s. current obtained from the performance computation.

APPENDIX D LIST OF NAMED SUPPLIERS..... 2

APPENDIX D List Of Named Suppliers

1. The Contractor shall note that the equipment included in this Appendix do not imply the Approval of a specific equipment. It is the responsibility of the Contractor to ensure full compliance with the requirements of the PS for all materials and working practices to be used.

2. The Contractor shall not be required by the Commission or be deemed to be under any obligation to employ any Named Supplier against whom the Contractor may raise reasonable objection in writing. And the Contractor shall nominate an alternative subcontractor for approval.

3. The Contractor shall procure the following equipment from the corresponding Named Suppliers :

Item No	Description	Supplier	Details	PS Reference
1.	SCS equipment	Alcatel	To be Advised	Appendix I Annex 3
2.	Driver's Seat	Recaro North America 905 W. Maple Road Suite 100 Clawson, Michigan United States 48017-1005	B100W TRANSIT BUS SEAT S41X4011B1GDS21	PS 8.13.2
3.	Collector Shoe	Ferraz Shawmut Sa Rue De Vaucanson F-69270 St-Bonnet De Mure France Tel: +33 4 72 22 66 11	Current Collector with fuse box assembly D109721	PS 11.6.1(c)(i)

4.	Fire Extinguisher	Sava Fire Equipment Inc 1825 Dundas Street East, Mississauga, ON L4X 2X1 Canada (905) 238-6400	Fire Extinguisher (ABC multi-purpose dry chemical unit model # B417, 2-1/2 LB): 66010009S	PS 7.16.1
5.	Maintenance Key	Medeco Of Canada 141 Dearborn Place Waterloo, Ontario	For VSS hard drive: 65-2651T-102-66. For Event Recorder:	PS 32

Item No.	Description	Supplier	Details	PS Reference
		N2J-4N5 Tel: 888-633 3264	Other maintenance access locker: 60-035T-245-66 to be keyed to 8F8218102	
6.	Trip Switch	Wabco, Passenger Transit Division 475 Seamen Street Stoney Creek, Ontario CANADA L8E 2R2	Emergency Trip Switch P/N: 0676970	Appendix I Annex 3 Clause 2.2.2(c).
7.	Radio	Trak Com Wireless Inc. 3780 14th Avenue, Unit 101 Markham Ontario L3R 9Y5	AUTHORITY OCU and AUTHORITY CTW Mobile	PS 18.2

APPENDIX E SUBWAY PROFILES MEASUREMENT SERVICE 2

APPENDIX E SUBWAY PROFILES MEASUREMENT SERVICE

1. The Scope of Work of the subway profiles measurement service shall include the following areas:

1.1 Gauging survey (a.k.a. clearance survey)

1.2 Platform gauge measurement at all stations

1.3 Development subway profile measurement database

1.4 New Subway Train gauge clearance analysis

1.5 System clearance drawings

1.6 Measuring rail roughness and adhesion

1 . The services of gauge survey and platform gauge measurement shall be carried out on the following two options:

2.1 Option (a): M and SHE lines plus the complete W, K and U Yards. The Contractor shall conduct walk out surveys to assess route and gauge clearances and the condition of rail infrastructure.

2.2 Option (b): Option (a) above plus BD lines.

2 . The gauge survey and platform gauge measurement shall include review of available rail line and track information to determine the correctness and reliability of the information; identify clearance problems; identify improvement options at problem locations; and develop designs and construction cost estimates.

4. Upon the completion of the above services, all data shall be verified, processed, stored and maintained in a form of database, namely, the subway profile measurement database.

5. Upon the completion of the development of the subway profile measurement database, the Contractor shall provide the system clearance drawings. The system clearance drawing shall show the actual worst case obstruction outline and the clearance buffer which shall be proposed by the Contractor, that the vehicle equipment shall not infringed.

6. To optimize the stepping distance between the carbody of the New Subway Train and the platform edge, the Contractor shall provide proposal of solutions to platform clearance problems by redesigning the platform edge to ensure safe clearance of the vehicle door threshold. Possible solutions are, for example, horizontal coping stone adjustment, vertical coping stone adjustment and track re-alignment.

7. Based on the subway profile measurement database, the Contractor shall carry out a New Subway Train gauge clearance analysis, including the development of the kinematic envelope of the New Subway Train, to ensure compliance to the design of the New Subway Train and the existing infrastructures of AUTHORITY.

8. The best surveying techniques shall be used. The Contractor shall use optical or electronic measuring methods to automatically obtain the necessary information. The frequency of locations measured shall be no more than every fifty feet (50') on surface and elevated portions of the track and no more than every three feet (3') in tunnels.

9. The service shall include, but not be limited to, all fixed installations, wayside equipment including associated items such as equipment boxes, piping and cabling. In addition to measuring and documenting the available clearance throughout the AUTHORITY system, the study shall determine the actual locations of all items that directly interface with the vehicles such as third rail and cover board assemblies, signal stop arms and platforms.

10. The Contractor shall liaise with the CABSIM Subcontractor to ensure all required information are available on time for the CABSIM design.

11. The Contractor shall provide method statements, procedures and report for Approval.

12. The Contractor shall determine a network of reference points that shall be adapted as efficiently and economically as possible, but without loss of accuracy or reliability, to a constantly increasing number of surveyed control points. The minimum positional accuracies shall be as follows:

12.1 Distances 2.0 mm per km.

12.2 Horizontal bearings 0.0004gon.

12.3 Height difference 10.0 mm per km.

1 2 . From a safety aspect, the service shall be carried out by the non-destructive

type of acquisition of data.

14. The clearance studies shall be carried out to investigate any likely clearance impacts which could be created by the introduction to the new subway train. Feasibility schemes for possible solution shall also be proposed and developed for all those sites on the M Line where problems maybe identified.

15. The measurement of rail roughness and adhesion shall be carried out to serve the following objectives:

15.1 Rail roughness data as design input to the noise predictions (refer to PS 21.8.6) shall be performed as per ISO 3095 at five (5) specific track sections on the AUTHORITY network, preferably where the noise qualification test will be performed.

15.2 Rail adhesion data as design input of physical limits on traction and braking forces.

Because rail roughness and adhesion depend strongly on the environmental conditions, such as, rain, wet leaves, snow, and ice. Adequate samples shall be collected in order to maintain high level of data reliability. Adhesion measurements shall be performed on five (5) track sections representing typical operational conditions, to assess the rail coefficient of friction variation. Measurements should be repeated three (3) times over a year span for track sections in open cut, to cover the four seasons environmental conditions.

16. The Commission will allow the Contractor's staff and any authorised sub-contractors full, free and unhindered access to the track at no cost for up to fourteen (14) days. The track access time will be approximately from 2:00 A.M. to 5:00 A.M. Monday to Saturday and 2:00 A.M. to 8:00 A.M. on Sunday.

APPENDIX F PROVISION OF IT SUPPORT SERVICE 2

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Appendix F Provision Of IT Support Service

1. IT Equipment Support Services

1.1 For the purpose of this Appendix, the Information Technology (IT) system shall include the following items / equipments:

(a) YMSS computer network and all associated computer equipment (refer tp PS 18.6);

(b) CABSIM computer network and all associated computer equipment (refer to PS 19); and

(c) All computerised special tool and testing equipment (PS 24.3).

1.2 The "specified period" shall mean the duration of the IT Equipment Support Services. Unless otherwise stated, the specified period shall be started from the date of issue of the Handing Over Certificate for the first train / CABSIM till the date of issue of the Certificate of Completion.

1.3 Throughout design, implementation, testing, and field installation, the Contractor shall supply engineering data and services, as required by the AUTHORITY, regarding the necessary site preparations, communication facilities, field installation of equipment, and solutions to technical problems related to the IT system. These support services shall apply to IT system hardware, software, and operational needs. For rapid field support, these services shall be available within the CITY.

2. IT System Field Implementation Plan

2.1 By the end of SEMP 2, the Contractor shall submit a preliminary IT System Field Implementation Plan which shall include an implementation programme showing the exact date and overall periods of when the installation of the IT system will be required. The Contractor shall at all times be required to work with or in close proximity to other Contractors in restricted areas, and it is essential for the smooth and orderly execution of the Works that the Contractor, in consultation with the Engineer, prepares a realistic installation and commissioning programme. Indication of inability or possible inability to meet a programmed date shall be given to the Engineer at the earliest possible moment.

2.2 The basic information of the IT System Field Implementation Plan required to be submitted shall include but shall not be limited to:

(a) Technical Information:

(i) details of Site establishment and use of Works Areas;

(i i) references to Drawings;

(i i i) details of the manufacturing or assembly facility;

(i v) a method statement describing the layout and operation of the manufacturing and assembly facility, method and sequence of transporting and placing assembled units;

(v) the construction materials to be used and their sources;

(v i) method and particular requirements for manufacture and testing of IT system prior to delivery to CITY;

(v i i) method and particular requirements for delivery and transportation of IT system to CITY and to and across the Site;

(v i i i) an appreciation of any access and phasing constraints;

(i x) details of the implement team;

(x) installation proposals;

(x i) method and procedure for testing and commissioning of IT system installed; and

(x i i) policy for training of operators in the use and maintenance of IT system.

(b) Policy for allocation of work, computer and design resources, manning levels and responsibility for supervision.

(c) Method of management and co-ordination of interfaces between the Contractor and its Subcontractors.

(d) A statement outlining the method which will be used by the Contractor to monitor and report progress of the Works to the Engineer throughout the period of the Contract including details of any computer software package which may be used.

2.3 Sixty (60) Days prior to the planned or actual commencement date of any new operation in the various parts of the IT system, the Contractor shall submit a method statement to the Engineer which shall include but not be limited to:

(a) Description of main operation and sub operation.

(b) Sequence of sub operations.

(c) Quantities of the work and production rates to be achieved.

(d) Resources to be employed.

(e) Quality check to be carried out and supervision being exercised.

(f) Safety precaution to be employed.

2.4 Working closely with the AUTHORITY, the Final IT System Field Implementation

Plan shall be developed by the Contractor and submit for approval by SEMP 3. The Field Implementation Plan shall provide a detailed plan for the installation, testing, and placement of the interim system and the new IT system into service. The plan shall include a schedule identifying all critical activities and responsible parties, all requirements for the Contractor's work, AUTHORITY participation requirements, and potential impacts to the daily AUTHORITY service.

2.5 The above plans shall be consistent with and supportive of all AUTHORITY

requirements and constraints, including other AUTHORITY projects that may be in progress after award of this Contract.

3. System Preparation, Packing, and Shipment

3.1 The Contractor shall prepare, pack, and ship the IT system in a manner that is consistent with Original Equipment Manufacturer (OEM) recommendations and shall do nothing that invalidates any manufacturer's warranties or precludes the start of a commercially available maintenance Contract.

3.2 Preparation for Shipment

3.2.1 The IT system shall be prepared for shipment to avoid damage in transit and to facilitate installation. Verification of proper operation of the hardware, powering down, disconnection, separation into shipping groups, installation of any required shipping brackets, securing of cables and other parts, and all recommended shipping preparations shall be performed under the supervision of the computer OEM.

3.2.2 The equipment shall be refurbished, as necessary, prior to shipment. All external surfaces shall be thoroughly cleaned, and all paint chips, broken parts, and other signs of use shall be repaired. The enclosures shall be carefully vacuumed to remove dust and all loose hardware. The IT system shall be shipped in an "asnew" condition.

3.2.3 The Contractor shall ensure that the shipment packages are sized to be consistent with a viable route into the AUTHORITY’s facility where the equipment is to be installed, without requiring any modification to or introducing risk of damage to the equipment or the facility.

3.2.4 The AUTHORITY will inspect the system prior to packing to determine its suitability for shipment. If any procedure has not been performed to the AUTHORITY's satisfaction, the Contractor shall take remedial measures before the system is packed.

3.3 Packing

3.3.1 All material and equipment shall be packed, crated, or otherwise suitably protected to withstand shipment to its destination. Packing methods shall meet or exceed equipment OEM recommendations. Equipment shall be shipped assembled and completely wired wherever possible.

3.3.2 The size and nature of available doors, bays, elevators, and shafts used to access to the AUTHORITY's control room and computer room, and temporary staging areas for equipment, if needed, shall be inspected by the Contractor. The IT system shall be shipped in modules that can be moved into place without requiring structural alteration of any building.

3.3.3 Each package, crate, or part shall be clearly marked with the name of the consignee, shipping destination, the AUTHORITY order number, and other such markings, as appropriate. Complete packing lists shall be supplied showing contents and identity of each package. One copy of the list shall be securely attached to the outside of each shipping unit, and two copies of the list shall be sent to the AUTHORITY by overnight express on the day of shipment.

3.4 Shipment and Delivery

3.4.1 The IT system shall be shipped via dedicated, air-cushioned, padded vans to the AUTHORITY's site in CITY. The Contractor shall notify the AUTHORITY two (2) weeks prior to any shipment and again 48 hours prior to arrival of equipment.

3.4.2 The equipment shall be delivered during the hours when AUTHORITY's maintenance staff is on duty; no staff is on duty between the hours of 1:30 and 4:00 ??. The Contractor shall be responsible for offloading and placement of the equipment in the designated areas.

4. Technical Support

After final acceptance of the IT system, the Contractor shall provide continuing technical support for the specified period of the system. Consultation with knowledgeable Contractor technical support personnel and trained field service personnel shall be readily available on a time-and-materials basis to assist the AUTHORITY in maintaining, expanding, and enhancing the IT system.

5. Change Notification Service

The AUTHORITY shall be informed of all alterations or improvements to the hardware and software supplied under these Specifications. The AUTHORITY shall be placed on the Contractor's mailing list to receive announcements of the discovery, documentation, and solution of hardware and software

problems as well as other improvements that could be made to hardware and software provided with the IT system. The service shall begin at the time of Contract Award, and shall continue for the specified life of the system. The Contractor shall also include a subscription to hardware and software Subcontractors' change notification service from the time of Contract Award through the specified period, with a AUTHORITY renewable option for extended periods.

6. System Maintenance

In this section, system maintenance requirements prior to shipment, and during installation, field test, warranty and thereafter are discussed. All maintenance performed by the Contractor, Subcontractors, or OEMs shall be

in accordance with procedures and schedules recommended by the OEMs of all equipment and software.

7. Maintenance Records

7.1 The Contractor shall be responsible for keeping hardware and software maintenance records for the duration of the project. Software maintenance activities shall be recorded via the code management system, beginning with the start of software integration; hardware maintenance activities shall be recorded in a hardware maintenance log, beginning with the start of hardware integration. All records shall be maintained in electronic form for AUTHORITY records. The Contractor shall provide monthly updates of these files to the AUTHORITY.

7.2 Corrective maintenance entries in the hardware maintenance log shall include the following information:

a . Identification of the item repaired, replaced, or upgraded

b . Name of the person who performed the repair

c . Date and time when the malfunction was detected

d . Description of the malfunction

e . Date and time when the malfunction was corrected

f . Description of the corrective action taken.

g . Preventive maintenance entries in the hardware maintenance log shall include the following information:

h . Identification of the element being maintained

i . Name of the person who performed the maintenance

j . Date and time when the maintenance was performed

k . Detailed list of the maintenance procedures performed

l . Description of any problems encountered.

7.3 The log shall be available to the AUTHORITY at all times including between the

monthly updates, upon AUTHORITY request.

8. Maintenance Prior to Shipment

The Contractor shall be responsible for performing repairs and preventive maintenance on all system elements during development, integration, and factory testing.

9. Maintenance During Installation, Field Tests, and Transition

9.1 The Contractor shall be responsible for performing repairs and preventive maintenance on equipment through end of the specified period, unless specifically waived by the AUTHORITY.

9.2 As the system will become operational during the specified period.

9.3 Following the specified period, but prior to the availability testing, the

Contractor shall have the equipment certified by its OEM as acceptable for the OEM's Contract maintenance service, should the AUTHORITY procure such services.

10. Equipment Maintained by the AUTHORITY

10.1 Beginning with the start of the IT support service, the AUTHORITY will participate in

system maintenance as part of the training process.

10.2 Emergency repairs by the AUTHORITY shall not affect the warranty.

10. Software Support

The Contractor shall provide technical assistance as deemed necessary by the AUTHORITY for all IT system software until successful completion of the specified period.

12. Warranty Support

12.1 The Contractor shall provide hardware and software support of all products

supplied under this Contract and shall cooperate with the AUTHORITY's representatives, as required, in order to keep the system operational and available 24 hours/day, seven days/week.

12.2 The Contractor shall supply OEM support that shall include, as a minimum,

emergency pager support for critical issues during regular and non-business hours, including:

Hardware:

a . Preventive and corrective maintenance

b . Twenty-four hour on-site response time seven days per week for critical processors and peripherals and critical network equipment.

c . Two day on-site response time, eight hours per day, five days per week for non-critical processors, peripherals, workstations, network equipment and local PC-based consoles

d . Parts and labour

e . Once a problem is demonstrated, qualified service personnel will be dedicated full-time to correcting the problem until the problem is resolved to the satisfaction of the AUTHORITY.

Software - technical assistance may be in the form of trouble shooting or program repair and shall meet the following service levels:

f. Telephone consultation with knowledgeable personnel shall be available within 24 hours.

g . The warranty shall include regular phone support for critical and non-critical issues during regular business hours

h . Remote troubleshooting via the remote diagnostic port shall be available within one working day

i . Support shall be available on-site within two working days, when deemed necessary by the AUTHORITY, at no additional cost to the AUTHORITY.

13. Maintenance Support Equipment

13.1 As part of the IT system, the maintenance support equipment shall be included that will support the continuing field maintenance of the IT system.

13.2 The Contractor, through the specified period, shall provide all special diagnostic and test equipment and other special devices necessary to troubleshoot and repair all IT system equipment. If it becomes necessary prior to acceptance of the IT system to modify the complement of supplied hardware (such as, use a different type, size, or configuration of equipment) to meet the requirements of these Specifications, the Contractor shall provide all modifications and additions at no cost to the AUTHORITY. This working complement shall be maintained by the Contractor first and ultimately will be transferred to the AUTHORITY.

13.3 The complement of special diagnostic and test equipment provided for the IT system shall be the basis for its maintenance through the specified period, when the Contractor is responsible for maintenance, and beyond, when the AUTHORITY assumes this responsibility.

13.4 All test equipment and other special devices necessary deemed necessary for field maintenance and to troubleshoot and repair the system shall be delivered with the IT system.

13.5 The complement of standby replacement parts judged necessary to maintain the equipment through the specified period shall be the responsibility of the Contractor. The AUTHORITY will select its standby parts complement such that it will be available beyond the specified period. The Contractor shall assist the AUTHORITY in its selection by making recommendations concerning the complement of equipment based upon the Contractor's past experience. An example of a recommendation might be the recommendation of a whole unit in lieu of a kit of parts for each subsystem of the unit.

14. IT System Life Span

14.1 The IT system design, as installed, shall be able to continue operating for the design life of the train with the Contractor providing the support structure for continued operation.

14.2 The Contractor shall notify the AUTHORITY whenever item supplied under the PS, including equipment purchased from Subcontractors, will no longer be supported with either spares or repair services. This shall include both hardware and software elements.

14.3 Notice shall be given sufficiently far in advance of the end of the production of any subassemblies (such as printed circuit boards, modular power supplies, and custom integrated circuits) to permit the AUTHORITY to purchase a suitable supply of standby equipment parts for the subassemblies. In addition, the Contractor shall make available, at no cost to the AUTHORITY, the manufacturing drawings and rights to manufacture those subassemblies including subassemblies not included in the original procurement. For each subassembly, the specific parts supplied shall be identified and referenced in supplied documentation.

15. Recommendations for Long-Term Maintenance Contract

15.1 The Contractor shall submit recommendation for long term system maintenance i.e. extended maintenance beyond the specified period, as a proposal for separate Contract. Recommended maintenance Contracts shall include Contracts from the Contractor, the computer OEM, or other equipment OEMs for long term maintenance of IT system equipment.

15.2 The Contract recommendations shall be individually identified such that the AUTHORITY can optionally select the specific equipment and coverage to be provided. The AUTHORITY will also review software maintenance or update services recommended by the Contractor. The specific maintenance Contracts to be purchased by the AUTHORITY, if any, will not be selected prior to acceptance.

15.3 In addition to the Contractor's recommended maintenance approaches, the Contractor shall include in their proposal options to provide the following levels of service beyond the specified period renewable on a yearly basis:

a . Emergency Pager Support – 24 hours a day, 1-hour response

b . Regular Phone Support – Normal business hours, 2-hour response, including remote login support.

15.4 The initial Contractor recommendation for hardware training, standby parts, and maintenance requirements, shall assume that the AUTHORITY will not purchase a maintenance Contract and that all hardware will be fully maintained by the AUTHORITY. Any alternative maintenance Contracts that are presented shall (1) fully

describe the impact of the alternative on the proposed training and standby parts and (2) state all advantages to the AUTHORITY of using the alternative.

15.5 The Contractor shall ensure that all computer and peripheral equipment maintenance shall satisfy the following requirements:

a . Preventive and corrective maintenance

b . Four-hour on-site response time, 24 hours per day, seven days per week for critical processors and peripherals and critical network equipment

c. Two-day on-site response time, eight hours per day, five days per week for non-critical processors, peripherals, workstations, network equipment and local PC-based consoles

d. Parts and labour.

15.6 Once a problem is demonstrated, qualified service personnel shall be dedicated full-time to correcting the problem until the problem is resolved to the satisfaction of the AUTHORITY.

15.7 If necessary to ensure maintenance contracts are available to the AUTHORITY, the Contractor shall carry an OEM maintenance contract on the OEM equipment through the specified period.

16. Recommendations for Long-Term Software Maintenance Service

The Contractor shall submit recommendation for long term software maintenance service i.e. extended maintenance beyond the specified period, as a proposal for separate contract. Recommended software maintenance and update services shall include support services options for the following contract support levels described as follows:

16.1 Software Version Support Option:

This option shall include:

1. Update of supplier's software to the latest commercially stable revision level
2. Phone support for AUTHORITY installation of new revision level
3. Support to include at least one, but no more than two, software revision update(s) in the one year period following the installation.

16.2 Full Software Support Option:

This option shall include:

1. Maintenance and upgrading of the system software (including operating system, networking software, and software utilities).
2. Third-party software package updates (such as database managers)

3 . Software Version Support (as described above)

4 . Development of new application software (estimated time and material, with minimum service charge).

APPENDIX G SCHEDULE OF MILESTONES AND SCHEDULE OF DELIVERY 2

PART 1 - SCHEDULE OF MILESTONES *2*

Milestone Number A *2*

Milestone Number B *3*

Milestone Number C *4*

Milestone Number D *5*

Milestone Number E *6*

Notes to Schedule of Milestones: *7*

PART 2 - SCHEDULE OF DELIVERY *8*

APPENDIX G Schedule Of Milestones And Schedule Of Delivery

PART 1 - SCHEDULE OF MILESTONES

Milestone Number A

Milestone	Preliminaries, Design and General Requirements Activity	NTP +
A1	* Approval in Principle (AIP) of major sub-contractors and equipment	2
A2	* Approval of SEMP Stage 1	10
	* Orders placed for major equipment	7
	* Approval of specified plans	3
A3	* Approval in Principle (AIP) of the full-scale foam core cab mock-up	8
	* Approval of Design, Manufacturing & Commissioning Programme and Design Submission Plan	3
A4	* Approval of detailed Manufacturing and Delivery Programme	3
A5	* Approval of SEMP Stage 2	13
	* Engineer's confirmation of effective operation of programme	12
	* Engineer's confirmation of effective operation of specified plans	12
A6	* Approval in Principle (AIP) of full-scale engineering cab - saloon mock-up	12
A7	* Approval of preliminary test plan	12
	* Approved in Principle (AIP) of underframe mock-up and layout	12
	* Completion of preliminary maintenance database structure for YMSS	12
	* Approval of YMSS wireless coverage scheme	12
A8	* Approval of YMSS communication protocol and data structure	12
A9	* Approval of SEMP Stage 3	16
	* Approval of training plan	17
A10	* Completion of training for test crew, training instructors and train	31
A11	* Approval of SEMP Stage 4	21
	* Complete delivery of running, maintenance and commissioning - warranty spares	28
A12	* Completion of technical training	32
	* Complete delivery of special tools and testing equipment	32
A13	* Approval of batch 2 printed O&M Manuals	29
	* Completion of defect recovery training	32
A14	* Approval of SEMP Stage 5 and Reliability Run Of Pilot Train	37
	* Approval of As Built Drawings and O&M Manuals	40

(a)

Note :

Specified plans are defined as Safety Plan, Quality Plan and Environmental Management Plan.

(b) NTP means Notice to Proceed.

Milestone Number B

Milestone	Manufacture and Supply Activity	NTP +
B1	* Approval of material control schedule	3
B2	* Sub-assembly tooling complete	14
B3	* Car shell tooling complete	16
B4	* Approval of design for sub-assembly of underframe, roof and body	9
	* Delivery of trucks for first train	16
B5	* Complete sub-assembly of first car body shell and available for Compression test	16
B6	* First delivery of traction equipment including all underframe	13
	* Delivery of mechanical systems and trucks for first three trains	36
B7	* Complete assembly of first manufactured train for testing at	28
B8	* Availability of first manufactured train at Contractor's test track	29
	* Complete delivery of mechanical systems, trucks, electrical systems and traction & braking systems for 7 trains	39
B9	* Availability of first train at K Carhouse for testing and	33
	* Approval of type test report on the first train	40
	* Approval of interface design between TIMS and YMSS	21
B10	* Availability of 13 trains at K Carhouse for testing and	45
	* Approval of first report for each type test	38
B11	* Availability of 26 trains at K Carhouse for testing and	51
B12	* Availability of 39 trains at K Carhouse for testing and	57

Milestone Number C

Milestone	Delivery, Testing and Commissioning Activity	NTP +
C1	* Approval of structural test report on car body	21
C2	* Approval of TIMS integrated test	37
	* Approval of combined test	37
C3	* Completion of YMSS software integration test	37
	* Completion of YMSS Interface Design Verification Test	37
C4	* Completion of the adjustment, dynamic and reliability proving tests at	32
C5	* Availability of 13 trains for operational service on M Line	47
	* Completion of YMSS System Integration Test	37
C6	* Availability of 26 trains for operational service on M Line	53
C7	* Complete commissioning at K Carhouse and availability of 39	58

Milestone Number D

Milestone	Cab Simulator Activity	NTP +
D1	* Full delivery of cab simulator design data from Contractor for software development	21
D2	* Full delivery of hardware from Contractor for construction of	28
D3	* Full delivery of the cab simulator	28
D4	* Completion of cab simulator	30

Milestone Number E

Milestone	Finalization	NTP +
E1	* Full delivery and acceptance of all Maintenance Manuals * Full Delivery and Acceptance of CBT Modules 1-4	41 41
E2	* Full delivery and acceptance of all As Built Drawings	41
E3	* Successful completion of Reliability Goal of 480,000 Miles MDBF	61

Notes to Schedule of Milestones:

1. For those Milestones which require the Engineer's confirmation of satisfactory implementation of Specified Plans (which comprise Safety Plan, Quality Plan and Environmental Management Plan) and Programming Management System, the satisfaction of said obligations by the Contractor shall be ascertained by means of an audit carried out by the Engineer as follows:

1.1 Specified Plans

Not less than four weeks prior to the date for achieving the Milestone, the Engineer will undertake a detailed audit of the Contractor's Quality Management System, Safety Plan and Environmental Management System. Any non-conformances arising from the audit shall require corrective actions from the Contractor. The corrective actions are to be Approved. All corrective actions are to be implemented and satisfactorily completed by the date for achieving the Milestone to enable the Engineer to certify the requirements of the Milestones as having been achieved.

1.2 Programming Management System

Not less than eight weeks prior to the date of the Milestone, the Engineer will undertake an audit of the Contractor's compliance with the requirements of the General Conditions of Contract as to the adequacy and quality of the Contractor's programme and reporting submissions and advise the Contractor of any corrective actions which are to be implemented and satisfactorily completed by the date of the Milestone.

2. The Engineer will require confirmation either by verification audit, the submission of further documents or by review of the outstanding non-conformances, that all corrective actions required to be completed by the date of the Milestone have been satisfactorily completed to enable the Engineer to certify the requirements of the Milestone as having been achieved.

PART 2 - SCHEDULE OF DELIVERY

Train Number	Delivery to K Carhouse (Nos. of Week from NTP)	Availability of Train for Operational Service on M Line (Nos. of Week from NTP)
1	158	172
2	163	175
3	164	176
4	168	178
5	172	180
6	176	184
7	179	187
8	182	190
9	186	194
10	188	196
11	190	198
12	192	200
13	193	201
14	195	203
15	197	205
16	199	207
17	201	209
18	203	211
19	207	215
20	209	217
21	211	219
22	213	221
23	215	223
24	217	225
25	219	227
26	220	228
27	222	230
28	224	232
29	227	235
30	229	237
31	230	238
32	232	240
33	234	242
34	236	244
35	238	246
36	240	248
37	242	250
38	244	252
39	245	253

Notes :

(1) Availability of train for operational service means that the train has completed satisfactorily the Tests on Completion.

(2) The numbers of week showed above are based on the assumption of NTP date of September 1, 2006. Same durations between the date of NTP and the associated weeks of delivery/availability shall be applied to the actual date of NTP.

APPENDIX H ATTENDANCE 2

1 ATTENDANCE DURING TESTING, COMMISSIONING AND DEFECTS LIABILITY PERIOD..... 2

1.1 ..... Site Office 2

1.2 ..... Contractor's Representative 2

1.3 ..... Response Time 2

2 ATTENDANCE BY THE CONTRACTOR TO THE DESIGNATED CONTRACTORS..... 2

3 ATTENDANCE BY THE DESIGNATED CONTRACTORS TO THE CONTRACTOR 3

APPENDIX H Attendance

1 Attendance During Testing, Commissioning and Defects Liability Period

1.1 Site Office

(a) During the Testing, Commissioning and the Defects Liability Periods, the Contractor shall maintain a site office with the AUTHORITY train service hours in CITY time as follows:

- On weekdays and Saturdays, from 6:00am until 1:30am; and
- On Sundays or Public Holidays, from 9:00am to 1:30am;

(b) The Contractor shall provide a telephone hot line or a fax enquiry service in order to maintain a 24-hour contact between the Engineer and the Contractor's representative on all issues regarding train failures and site matters.

1.2 Contractor's Representative

(a) The site office shall be manned by a technically competent Contractor's representative.

(b) The Contractor's representative shall represent the Contractor on all matters concerning train reliability, defects liability and site issues. The Contractor's representative shall be required to carry out whatever actions that are necessary to ensure the RAMS performance of the train meeting the requirements in PS 25.

1.3 Response Time

(a) The Contractor's representative shall respond within ten minutes to a train failure reported by the Engineer.

(b) If required by the Engineer, a technically competent person shall be provided by the Contractor within thirty minutes for an on site repairing work in order to minimise the downtime of the defective train.

(c) Any failure by the Contractor to respond to a train failure reported by the Engineer within the required response time as specified in Clauses 1.3(a) and (b) above and cause the train not available for the scheduled service (refer to PS 25) will constitute a defect.

2 Attendance by the Contractor to the Designated Contractors

For works to be undertaken by other Designated Contractors on the train, the Designated Contractors will liaise and coordinate via the Engineer with the Contractor in planning for the dates and times of works. Within reasonable notice, the Contractor shall endeavour to provide access to the trains. At the discretion of the Contractor, attendance shall be provided by the Contractor at his own expense where appropriate. However, the ultimate responsibility of the security and proper caring of the train equipment shall rest with the Contractor in any cases until the formal handover of the train.

3 Attendance by the Designated Contractors to the Contractor

For works to be undertaken by the Contractor in the areas of other Designated Contractors, the Contractor shall liaise and coordinate via the Engineer with the Designated Contractors in planning for the dates and times of works. The Contractor shall work under the attendance of the other Designated Contractors. It is also the responsibility of the Contractor to tidy up and maintain the areas in a similar working condition before the works when the Contractor finish each session of works. The Contractor shall be liable to compensate in full for any damage to the areas of the Designated Contractors as a result of the Contractor's works.

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ANNEX 1 TRACKWORK INTERFACE 2

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2 . YARD 2

1 . MAIN LINE
..... 2

2 . TRACK PARAMETERS
..... 2

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APPENDIX I Designated And Interfacing Contracts
ANNEX 1 Trackwork Interface

1. INTRODUCTION

This Annex of Appendix I contain details of the track over which the trains will run. This Annex shall read in conjunction with PS 5 and PS 12.

2. YARD

Minimum lateral curve radius at centre line of track:

Yard operation, coupled Subway Cars	70.1 m (230')
Corresponding superelevation	51 mm (2")
Corresponding speed limit	16 km/h (10 MPH)
Track gauge, 70.1 m (230') radius curve	1502 mm (4' 11 1/8")

Minimum reverse curve definition for yard operation:

First curve radius at centre line of track	76.2 m (250')
Tangent section	3.5 m (11.5')
Second curve	AUTHORITY #6 turnout

3. MAIN LINE

Minimum lateral curve radius at centre line of track:

Main line operation, coupled Subway Cars	116 m (380')
Corresponding superelevation	102 mm (4")
Corresponding speed limit	32 km/h (20 MPH)
Minimum vertical curve radius	610 m (2000')
Track gauge, tangent	1495 mm (4' 10 7/8")

Rail wear maximum, vertical	19 mm (3/4")
Rail wear maximum, lateral	13 mm (1/2")

4. TRACK PARAMETERS

	Double Pads	**Double Tie**
Track vertical stiffness, N/mm (lb/in)	16 637 (95,000)	21 190 (121,000)
Track lateral stiffness, N/mm (lb/in)	3 152 (18,000)	9 631 (55,000)
Fastener spacing, mm (ft)	610 (2)	610 (2)

Rail support modulus, N/mm/m of rail(lb/in/in of rail)	27 274 (3,958)	34 378 (5,042)
Mass of the double tie		
Box structure kg (lbm)	N/A	2 466 (5,425)
Tubular structure kg (lbm)	N/A	1 557 (3,425)
Length of the double tie in the direction of travel		
Box structure mm (ft)	N/A	1 435 (4.708)
Tubular structuremm (ft)	N/A	1 435 (4.708)

Note: Static stiffnesses are shown, for dynamic stiffness multiply those by 1.20.

5 SUPPLEMENTARY INFORMATION

5.1. The running rail type is of 115 lbs/yard RE section standard carbon steel.

Head hardened or fully heat treated rail having a Brinell hardness number of 365 to 380 is installed on both rails of main line curved track having a radius less than 600m (1968.5’). At all other locations, running rail is standard carbon rail.

5.2. For those curve section of central radius less than 600m (1968.5’), a

restraining rail is installed. The restraining rail is of 100 lbs/yard A.R.A. – Type “A”, horizontally oriented, parallel to the running rails of a track, the head of which is contacted by the back of a wheel flange to hold the wheels in correct alignment and reduce premature wear of the high rail. Restraining rail is typically started on tangent track 3 m (10’) prior to the beginning of a spiral or circular and extend 15 m (49’) beyond the end of a spiral or circular curve. The restraining rail is located at a gap of 50.8 mm (2”) (minimum) to 63.5 mm (2.5”) (maximum) adjacent to the gauge side of the low rail i.e. inside rail. Such gap is also known as flangeway. For flangeway compatibility, the back to back wheel gauge shall be 1 475 mm ± 1.6 mm (4' 10 1/16" ± 1/16").

5.3. For those curve section of central radius less than 600m (1968.5’), a wayside

track lubricator is installed to reduce rail wear and noise. The lubricator is located at the start of a horizontal curve at the point of first full wheel flange – rail contact, whereas the exact contact location is site-specific depending on curve radius, cant deficiency and train speed. Only the gauge side of the high side rail and the contact face of the restraining rail will be lubricated.

5.4. The rail corrugations will be limited to a depth of 0.2 mm on installation and

0.5 mm for the design purpose.

5.5. The vehicle shall interface with the trip arm assembly in such a way that under the worse case scenarios, e.g. maximum rail wear, maximum flangeway width, minimum wheel and flange wear plus the maximum installed tolerance of the trip arm assembly position, the truck mounted trip switch (refer to PS 12.9.1(d) and Appendix I Annex 3 Clause 2.2.2(c)) shall still be able to operate

correctly i.e. contact with a raised trip arm and apply emergency brakes. Typical arrangement of the trip switch shall refer to Contract Drawing No. NST 051.

The vehicle shall interface with the trip arm assembly in such a way that under the worse case scenarios, e.g. maximum rail wear, maximum flangeway width, minimum wheel and flange wear plus the maximum installed tolerance of the trip arm assembly position, the truck mounted trip switch (refer to PS 12.9.1(d) and Appendix I Annex 3 Clause 2.2.2(c)) shall still be able to operate correctly i.e. contact with a raised trip arm and apply emergency brakes. Typical arrangement of the trip switch shall refer to Contract Drawing No. TC-115-0006-1 Rev. M.

APPENDIX I DESIGNATED AND INTERFACING CONTRACTS..... 2

ANNEX 2 THIRD RAIL TRACTION POWER SUPPLY SYSTEM INTERFACES..... 2

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2 . GENERAL DESCRIPTION OF THE 3RD RAIL SYSTEM 2

3 . PERFORMANCE REQUIREMENTS OF THE 3 RAIL SYSTEM AND TRAIN SYSTEM INTERFACES 3

4. DESIGN CONSTRAINTS 5

APPENDIX I Designated And Interfacing Contracts ANNEX 2 Third Rail Traction Power Supply System Interfaces

1. Introduction

1.1. This Annex defines the interface requirements for the 600VDC side-contact third rail traction power supply system (hereafter referred as the 3rd rail system) and the train system.

1.2. The physical interface point for the Contract shall be defined as the point of contact between the collector shoe and the 3rd rail system contact rail.

1.3. In accordance with the interface requirements of PS 31, the Contractor shall, via the Engineer, liaise with the 3rd rail system contractor to provide interface specification, design study, delivery schedule, installation, testing and setting to work plan.

2. General Description of the 3rd rail system

2.1. The supply of traction power to the train will be at a nominal voltage of 600VDC derived from the 4.16kVAC, 13.8 kVAC or 27.6 kVAC supplies via the Rectifier Transformer and Rectifiers (T-R) units at traction substations. The traction power supply system utilizes 6-pulse or 12-pulse rectifications with corresponding ripple frequencies of 720 Hz. The rectifier output is typically operated at not more than 2 % ripple content. Harmonics of these frequencies would also be present. System voltages are as follows:

Nominal direct voltage of the high voltage system	600 VDC
Average voltage at collector shoe	580 VDC
Minimum voltage at collector shoe	350 VDC
Maximum voltage at collector shoe	720 VDC

2.2. Currents will be supplied to the train by the 3 rail system and will return to the traction substations via the running rails. The 3 rail system will be connected such that the 3 rail is at positive potential and is mounted on insulators to the outside of and slightly higher than the running rails. The return of the circuit is via the running rails. The current is collected by the train through the collector shoes, attached to the trucks, which slide along the top of the contact rail. Polarity is negative grounded to the running rail and the negative running rail is floating with respect to ground in some areas.

2.3. The 3 rail system will consist of a number of traction substations such that it

forms a continuous system which will supply power to the trains without interruption under normal conditions. The 3rd rail system will, however, be divided into a number of electrical sections between the traction substations to meet the operational requirements.

2.4. The typical traction gap (refer to Clause 4.3(a) below) distance is 21.03 m (69 feet) and the existing contact rail arrangement shall refer to Contract Drawing No. NST 070.

2.5. The third rail, a.k.a. contact rail, supplies the 600 VDC traction power to the vehicle via a sliding current collector shoe. The collector shoe rides on the top surface of the contact rail. The contact rail is of 74 kg/m rail section, having a cross-sectional area of 9420 mm^2. The metallurgical properties and electrical resistance shall refer to Contract Drawing No. NST 071. The collector shoe shall maintain adequate contact pressure as required to interface with the contact rail under specified conditions and the most adverse combination of all manufacturing and service tolerances, dynamic movements and maximum wear on all related components on both the train and the 3rd rail system

3. Performance Requirements of the 3rd rail system and Train System Interfaces

3.1. Supply Voltage

The nominal 3rd rail system voltage is 600 VDC. All train performance requirements in motoring, except as otherwise stated, shall be met or surpassed at all voltages from 580 VDC and 720 VDC. Between 350 VDC and 580 VDC, the train may operate at reduced performance, by reducing the base speed. This shall maintain the traction line current below the maximum level specified in section 3.4 below.

3.2. Supply Transient

(a) Transient voltages of either polarity in excess of 1.2kV can be expected on the high voltage circuits of the Subway Car due to energy discharge from on board magnetic storage elements at icy third rail conditions. The characterization of the energy available is related to the size and behaviour of the on-board energy storage elements and the equipment. All high voltage

equipment shall be designed to withstand without damage or degraded performance, the transient voltages that are to be expected from either the on-board equipment or the third rail system.

(b) Whilst the terms "nominal 3 rail system voltage" or "600 VDC" are used in this Specification, these shall be construed as intending to describe circuits with design voltage range of 580 VDC and 720 VDC inclusive. All train equipment shall be protected from damage resulting from transient over and

under-voltage conditions which may occur in the actual operating environment or as a result of the train design. The Contractor shall provide suitable transient suppression.

(c) The train shall be protected against the transient voltages of either polarity up to 1.2k VDC for 1 milli-second with an energy of approximately 20 joules.

3.3. Overcurrent Protection

The maximum fault level appearing at any one DC busbar is expected to be 2.5kA steady state. Each DC track feeder circuit breakers will be fitted with instantaneous overcurrent trips having a maximum setting of three times of the above steady state current for 150 ms. In view of the fact that severe service interruption will be caused by the operation of the DC track feeder circuit breaker due to an overcurrent fault, the design of the train system shall

be capable to clear the overcurrent fault of the train equipment, such as, the traction system (refer to PS 11), without causing superfluous operation the 3rd rail system DC track feeder circuit breaker.

rd

rd

3.4. Current Limit

(a) The T1 Train peak starting current is limited to 800A for 50 msecs per car i.e. 4,800 A per 6 Car train. If the line current exceeded 1 450 A per car, the traction overload protection device will be operated to cut-out the associated car from the 3 rail traction power supply system. In order to avoid nuisance tripping of the 3 rail system DC track feeder breaker, the design of the traction system (refer to PS 11) of the train shall not exceed the current limits of the T1 train. rd

(b) The inrush current shall be limited to be no greater than 150 A/ms per car, or 900 A/msec per 6 Car train, under all operating conditions.

rd

3.5. Radio Frequency Interference

The Contractor shall ensure that the collector shoe system shall not radiate radio frequency interference (RFl) or cause RFl to be generated by the 3 rail system above the typical level presently emitted by the T1 trains under the same operating conditions.

3.6. Compatibility Test

3.6.1. An interface test to confirm the compatibility of the collector shoe with the 3 rail system under the worst operating conditions shall be carried out by the Contractor.

3.6.2. This test shall include a measurement of each individual and the total cumulative arcing times excluding the traction gap (refer to Clause 4.3(a)

below).

3.6.3. It is a requirement that for each arcing time, it shall be less than 0.1s.

3.6.4. For the total cumulative arcing time, it shall be less than 1.0% of the total run time.

4. Design Constraints

4.1. Corrosion, Moisture and Snow

4.2.1. Equipment mounted on the train will be subjected to saline dripping which may include other salts that can be deposited on the collector shoe, for example, lime. In addition, air in tunnels carries a heavy dust content, both induced by the ventilation system and caused by the railway operation. The combination of the above will have an adverse effect on the insulation creepage surfaces and the life of the metal components.

4.2.2. The general atmosphere contains a high level of industrial pollutants and salt spray.

4.2.3. Top contact rails are susceptible to ice and snow contamination in cold climates.

4.2.4. No lubrication of the contact material shall be necessary.

4.2. Collector Shoe Clearance Envelope

The collector shoe shall not infringe the Subway Car Equipment Gauge Line as shown in Contract Drawing No. NST 005.

4.3. Traction Gap and Collector Shoe Interface

(a) The continuity of contact rails will be broken at junctions in the track to allow continuity of the running rails. As such, traction gaps exist which may cause momentary loss of power to the train and excessive arcing. A traction gap detection shall be provided to interface with the traction gaps (refer to PS 11.6.1(c)(vi)).

(b) Inside the carhouse of the AUTHORITY's Subway System Yards, there will no contact

rail available from the 3 rail system. For the purpose of ensuring safety of the maintainer, provision shall be made in such a way that when the train is entering the carhouse, as long as the last collector shoe of a train leaves the contact rail and potential as measured by the traction and braking system is below 350VDC, the 600VDC high tension circuit shall be shutdown and all Rail Gap Contactors shall be disconnected immediately, in order to ensure that

no dangerous residue voltage originating from the car exists in the collector shoes and will not put the maintainer at any risk of electrical shock hazard when standing near the collector shoes.

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ANNEX 3 ATC INTERFACES..... 2

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APPENDIX I Designated And Interfacing Contracts
ANNEX 3 ATC Interfaces

1. General

1.1. Introduction

1.1.1. This Annex defines the interface requirements for the Automatic Train Control (ATC) system which includes both the existing signalling system and the Speed Control System (SCS), and the train systems.

1.1.2. The Named Suppliers of the existing signalling system (e.g. the trip switch) and the Speed Control System (SCS) who will be called hereafter the ATC Named Supplier, shall be in accordance with Appendix D. The Contractor shall purchase from the Named Supplier all ATC equipment as stipulated in this Annex. Deliverables shall be limited to existing T1 SCS documentation as revised to meet design changes if applicable.

1.1.3. The baseline interface design of the ATC and train system shall be based on the T1 train. Wherever there is any requirements as specified in this Annex duplicate requirements for a particular criterion of the baseline interface design, the more stringent requirement shall apply. Any conflict in requirements shall be brought to the attention of the Engineer.

1.1.4. Unless otherwise specified, the Contractor shall ensure hardware inter-changeability of all SCS equipment between the T1 train and the train.

1.1.5. The SCS shall provide continuous on-board enforcement of train operating speed limits and shall realize important safety benefits in the subway. The system shall eventually replace the existing signalling system which adopts the current Grade Timing method of speed enforcement and uses timer relays as well as lunar white and flashing red aspects to enforce speed limits.

1.1.6. In order to ensure the compatibility between the existing signalling system / SCS and the train systems, the following system requirements and design constraints for the ATC interface are specified according to the experience

gained from the operation of the Existing Subway Lines.

1.1.7. The Contractor shall proof by the system assurance process (refer to PS 25), the compatibility between the ATC system and the train system according to the baseline interface design of the as-built T1 train. The Contractor may offer alter the above baseline interface design which are equivalent to or better than those herein, and which the Contractor shall justify to the satisfaction of the Engineer.

1.1.8. For illustration purpose, the basic interfacing signal diagram of the SCS unit is depicted in Figure App-I-Annex-1. Detailed requirements of the interfacing

signals are specified in Clause 2.3. The Contractor shall ensure that all required signals and functions are provided for the SCS system.

1.1.9. The Contractor shall identify all required SCS interface design information and ensure that all these information shall be available by the ATC Named Supplier prior to the commencement of SEMP 2, such that the Contractor shall be able to carry out final design and vehicle build according to the information given beforehand.

1.1.10. The Contractor shall be responsible for the test and commissioning of all ATC equipment that are supplied by the Contractor and those purchased from the Named Suppliers.

1.1.11 The SCS software shall have the same functionality as provided by the SCS Sub-contractor, for the existing subway cars, except where a change is specifically approved by AUTHORITY. Any proposed changes to the SCS software shall be submitted for approval.

1.2. General SCS System Requirements

1.2.1. Each car with driving cab shall be equipped with one set of SCS equipment i.e. one Vehicle On-Board Computer (VOBC) sub-rack which includes a power supply module, one transponder interrogator (TI) sub-rack, one Train Operator Display (TOD) which is comprised of a speed display which is made up of rows of LEDs and each LED represents 1 km/h, to be installed on the driver's desk, and one transponder antenna to be installed on the underside of the car. Compared to the T1 cars, the SCS antenna shall take the same location on the new 6-car train, relative to the top of the cab-car coupler, unless otherwise approved by the Engineer. The two speed sensors shall be installed on the number 1 truck (refer to Contract Drawing No. NST 072 for naming convention).

1.2.2. The Contractor shall provide accommodation including mounting points, equipment cabinets and cable access for the installation of the SCS equipment in line with the requirements specified by the ATC Named Supplier.

1.2.3. The Contractor shall be responsible for providing an interface circuit between

the ATC and the train systems as specified in the PS.

1.2.4. Due consideration shall be given to ensure that no wiring fault of this interface circuit shall cause a wrong side failure.

1.2.5. The Contractor shall ensure that the equipment can be easily operated, removed and replaced.

1.3. Extent of Work

1.3.1 For those interface that are related to the SCS, Radio and Trip Switch, the Contractor shall liaise with the relevant Named Suppliers (refer to Appendix D) to incorporate appropriate interfaces, power supply, delivery schedule, installation, testing and setting to work.

1.3.2 For those interface that are related to the future Automatic Train Operation (ATO) system, the Contractor shall provide the following items:

(a) ATO cubicle. Apart from those antennas and sensor as stated in Figure App-I-Annex-3-5, all remaining ATO equipment will be installed in the same location of SCS as an add-on item. Further to Clause 4.1, additional space for all equipment according to Figure App-I-Annex-3-5 shall be provided. Except those mounting that are required for the SCS equipment, no additional mounting is required for the ATO equipment.

(b) Interconnection cables. Separate cable conduit of 1” in diameter for the future interconnection cables of those antennas and sensor that are mentioned in Figure App-I-Annex-3-5, shall be provided. No interconnection cable is required.

(c) Non-vital signal interfaces.

(i) The following non-vital outputs which shall be implemented as per the Contractor’s vehicle trainline and control scheme as specified in PS 9, shall be provided at the dedicated terminal block (item 11 of Figure App-I-Annex-3-5) when applicable:

- Motoring (refer to PS 9.6.2);
- Braking (refer to PS 9.6.2);
- Forward (without SCS bypass switch operated, refer to PS 9.5.2(c));
- Reverse (without SCS bypass switch operated, refer to PS 9.5.2(b));
- Door Open (Left, refer to PS 9.8.1);
- Door Open (Right, refer to PS 9.8.1);
- Parking Brake Apply (refer to PS 9.12.6); and
- Two spares.

(ii) The following non-vital data type signals which shall be implemented per the Contractor's vehicle trainline and control scheme as specified in PS11, shall be provided at the dedicated terminal block (item 11 of Figure App-I-Annex-3-5) when applicable:

- Tractive Effort (refer to PS 11.3.5); and
- Future Serial Communications.

(iii) The following non-vital inputs which shall be implemented per the Contractor's vehicle trainline and control scheme as specified in PS 9, shall be

provided at the dedicated terminal block (item 11 of Figure App-I-Annex-3-5) when applicable:

- Door Loop Circuit (completed state, refer to PS 9.9.7);
- Modes of Operation (refer to PS 9.5);

(d) Vital signal interfaces.

(i) The following vital binary type inputs which shall be implemented as per the Contractor's vehicle trainline and control scheme as specified in PS 9, shall be provided at the dedicated terminal block (item 11 of Figure App-I-Annex-3-5) when applicable:

- Brake Loop Circuit (completed state, refer to PS 9.9.6);
- Safety Proving Circuit (completed state, refer to PS 9.9.5); and
- Two spares.

(ii) The following vital binary type outputs which shall be implemented as per the Contractor's vehicle trainline and control scheme as specified in PS 9 and PS 11, shall be provided at the dedicated terminal block (item 11 of Figure App-I-Annex-3-5) when applicable:

- Door Enable signal (refer to PS 9.8.6);
- Two spares.

1.4. Contract Demarcations

1.4.1. Based on the interface requirements stipulated in this Annex, a detailed interface specification shall be provided with the liaison of the ATC Named Supplier (refer to PS 31.3) and submit for approval.

1.4.2. The Contractor shall specify in the above detailed interface specification all additional design information required on system interfaces which are not

provided in this Annex. A programme for the submission of interface design information shall also be submitted for approval.

1.4.3. For those interface designs that may affect the manufacturing programme shall be finalised prior to the commencement of SEMP 3. In the event that the required interface design information are not available from the ATC Named Supplier by the period specified in the above programme, the Contractor shall carry out interface design based on his own judgement and submit for approval.

1.4.4. Subject to the detailed interface specification, the contract demarcations specified in this Clause shall be complied with.

1.4.5. The Contractor shall provide the following items, as a minimum requirement:

(a) Accommodation of the SCS equipment according to Clause 4.1.

(b) All cables with cable identifications for the functional links between the VOBC cubicle and others SCS equipment according to Clause 2.3. Unless otherwise specified, all cables shall be adequately rated according to the voltage free contact specified in Clause 1.4.5(d). Special attentions shall be paid on the identification of safety wires and the shielding requirements for EMI protection.

(c) Except those special electrical plugs and sockets that are directly connected to the SCS equipment, all interconnections and the associated cable terminals and electrical connections for the above SCS equipment shall be provided. All these electrical connections mounted in the external area, including underframe, shall be sealed to IEC 60529 IP65.

(d) Interfacing signals for the VOBC cubicle according to Clause 2.3. Unless otherwise specified, a voltage free contact rated at least 2 A DC inductive loads with a time constant of 15ms at 37.5 VDC shall be provided for the above signal interfaces. An interface cable terminal bars and all associated cables and terminals of the above interfacing signals shall be provided nearby the VOBC cubicle.

(e) All remaining cables together with the cable identifications between the interconnection points (refer to Clause 1.4.5(c)) or interface terminal bars (refer to Clause 1.4.5(d)) and the SCS equipment shall be provided, properly secured, protected and capsulate.

(f) Installation of all trainborne SCS equipment on all trains except the first manufacturing train (refer to Clause 5.4) and all necessary inspections, checks and testing for ensuring the quality of workmanship of these installation works.

1.4.6. The ATC Named Supplier shall provide the following items:

(a) All SCS equipment according to Clause 4.1.

(b) All electrical plugs and sockets that are directly connected to the SCS equipment.

(c) Interfacing signals for the VOBC cubicle according to Clause 2.3. Unless otherwise specified, a voltage free contact which be adequately rated for the above signal interfaces between the train system with the SCS equipment.

(d) Connecting all VOBC required cables in between the interconnection points (refer to Clause 1.4.5(c)) or interface terminal bars (refer to Clause 1.4.5(d)) and the SCS equipment.

the SCS equipment shall be provided by the car builder.

(e) Unless otherwise specified, an additional voltage free contact for all VOBC relays (refer to Clause 1.4.6(c)) for control feedback purpose.

(f) Installation, testing and commissioning of all trainborne SCS equipment.

(g) A competence testing Engineer throughout the period of the tests and commissioning to participate and facilitate all ATC system related interface tests.

(h) A service team to immediately make good, repair and replace all defective items in the event that any failure occurred in the ATC system supplied for the period of the tests and commissioning without interrupting the tests and commissioning programme.

(i) In order to facilitate the ATC system combined tests (refer to Clause 5.4), one complete set of ATC system including all the required trainborne and trackside equipment shall be provided and installed onto the test train and the Contractor's test track respectively.

(j) For the purpose of the above ATC system combined tests, the complete set of ATC system supplied shall be successfully tested to confirm its intended function and performance before delivery to the Contractor's test track.

(k) Installation, inspections, checks and testing of quality and workmanship of all trainborne SCS equipment on a train which is used for the above ATC system combined tests.

(l) All required instructions, drawings and special tools (if necessary) to facilitate the Contractor to perform the works as specified in Clause 1.4.5(f).

(m) Site supervisions and training to facilitate the Contractor to perform the works as specified in Clause 1.4.5(f) in order to ensure the Contractor’s workmanship is meeting the quality of work as required by the ATC Named Supplier.

1.5. Interface Design Management

The Contractor shall comply with the following specific arrangements in order to maintain an effective interface design management with the ATC Named Supplier:

(a) At SEMP stage 1, the Contractor shall obtain finalized EMC requirements from the ATC Named Supplier and incorporate this EMC requirements into the EMC plan.

(b) At SEMP stages 2 to 4, the Contractor shall carry out all required EMC study and submit the associated results. The Contractor shall ensure that a mutual agreement on the detailed interface specification is reached with the ATC Named Supplier.

(c) Before SEMP stage 5, the Contractor shall obtain agreement with the ATC Named Supplier on the test case for test and commissioning purpose according to PS 31.3.6.

(d) At SEMP stage 5, the Contractor shall conduct on-site tests and measurements to validate the ATC interface including the EMC performance. The above activities shall be performed at:

(i) Contractor's test track;

(i i) K Carhouse test track and main running line in the M.

2. Performance Requirements of the SCS and Train System Interfaces

2.1. General

The design of the train system shall ensure that the main objectives of the ATC system as summarized below are achieve:

2.1.1. Station Operation

In order to ensure passenger's comfort, the existing function of passenger information management are provided by the ATC via the Radio. This function is to provide information for the Radio (refer to PS 18.2) via an audio link to inform the train passengers of the name of the next station and the destination of the train. For the NST, this function of providing passenger information management by the ATC shall be implemented by the interface between the ATC and the communication equipment (refer to PS 18.2) via the serial link connection which shall be identical with the above interface between the ATC and radio (refer to Appendix I Annex 4).

2.1.2. Automatic Train Protection (ATP)

The ATP system is to determine the maximum safe speed for the train and compare it with the actual speed. If the maximum safe speed is exceeded, the ATP system shall cause the emergency brake to be applied. For SCS mode (refer to PS 9.5) of operation, the maximum safe speed is 80 km/h (50 MPH).

2.1.3. Driving information management

To provide driving information to the train operator through the train operator display (TOD).

2.1.4. Failure management

Fault record of VOBC shall be transmitted to the TIMS via a dedicated RS232 serial link, the TIMS shall send the critical fault event to the TCC via the radio link (refer to PS 10.3.5(e)). In the event of unrecoverable SCS failure and it is required to completely disconnect the VOBC from the train control, a sealed type SCS By-pass Switch shall be provided to cut-out the power of the VOBC and override all SCS related interlocking functions. Other requirements of the SCS By-pass Switch shall refer to PS 9.5.2.

2.2. Detailed Functions

2.2.1. Station Operation

With the existing T1 interface design, when the VOBC receives the wayside transponder Tag ID number, this information, in a form of coded message, will be sent to and decoded by, the Radio via a dedicated RS232 serial link. Based on the above tag information, the Radio will be able to inform the train passengers by the built-in Station Stop Announcement System through the PA system accordingly. With the NST interface, when the VOBC receives the wayside transponder Tag ID number, this information shall be sent from the VOBC to the communication equipment via a serial link connection which shall be identical with the above interface between the VOBC and radio (refer to Appendix I Annex 4). Based on the above tag information, the communication equipment shall be able to inform the DVAS and PIS so station stop announcement is provided to train passengers.

2.2.2. ATP control

(a) Two axle mounted speed sensors shall be provided for speed measurement of two axles for the VOBC unit. In order to minimize the speed errors caused by the slip problem which shall adversely affect the normal operation of the ATP system, the truck on which the axle mounted speed sensors are installed shall be a non-powered one (refer to PS 11.3.16). The Contractor shall provide a toothed wheel which shall be able to generate 128 pulses per wheel rotation, to interface with the above speed sensor. The Contractor shall also provide the

toothed wheel housing complete with an appropriate mounting facilities to properly install the speed sensor. In addition, the design of the speed sensor interface shall facilitate an easy access for assembling and disassembling the speed sensor.

(b) In order to limit any roll-back movement, a roll-back detection is provided by the ATP to ensure that when a roll-back movement is occurred more than 15

m at station and 3 m (subject to be confirmed with the SCS sub-contractor) elsewhere, an emergency brake shall be applied. The performance of the traction system shall ensure that the above roll-back distance limit shall not be exceeded, particularly under recovery conditions (refer to PS 4.4.3), in order to avoid nuisance operation of the emergency brake.

(c) The Contractor shall provide appropriate mounting facilities to accommodate the trip switch which shall be purchased from the Named Supplier. The following particular requirements shall be met:

(i) One truck mounted trip switch shall be provided on the right hand side at the cab end of each car and shall have adjustable brackets to allow setting of height and lateral position with respect to the top of the running rail. The nominal height of the train stop arm above the running rail and the location are shown on the Contract Drawing No. NST 051. One truck mounted trip switch shall be provided on the right hand side at the cab end of each car and shall have adjustable brackets to allow setting of height and lateral position with respect to the top of the running rail. The nominal height of the train stop arm above the running rail and the location are shown on the Contract Drawing No. (i) One truck mounted trip switch shall be provided on the right hand side at the cab end of each car and shall have adjustable brackets to allow setting of height and lateral position with respect to the top of the running rail. The nominal height of the train stop arm above the running rail and the location are shown on the Contract Drawing No. (i) One truck mounted trip switch shall be provided on the right hand side at the cab end of each car and shall have adjustable brackets to allow setting of height and lateral position with respect to the top of the running rail. The nominal height of the train stop arm above the running rail and the location are shown on the Contract Drawing No. TC-115-0006-1 Rev. M.

(ii) The trip switch actuating lever shall, during normal forward motion of the train when contacted by the train stop arm in its raised position, cause ~~interruption of the brake loop circuit (refer to PS 9.9.6) and resulting in the emergency brake application. Once the trip switch is operated, the actuating~~ lever shall be returned automatically to its operative position together with the switch contacts. Operation of the trip switch actuating lever in the opposite direction of movement (i.e. back tripping) shall also cause interruption of the brake loop circuit and resulting in an emergency brake application.

(iii) When a faulty trip switch is remotely isolated by the TIMS (refer to PS

10.3.7(b)), an indication shall be activated as specified in Section 9.9.12. When a faulty trip switch is bypassed (refer to PS 10.3.7(b)), an indication shall be activated as specified in Section 9.9.12

2.2.3. Driving Information Management

The TOD is located in the driving cab and composed of:

- Speedometer to display three speeds: actual, authorized, and target;
- Overspeed indication and alarms;
- LED indications to inform the train operator of the ATC system status and fault indicators;
- Fault codes;
- Pushbuttons of SCS Override and Key-by/EB Reset.

Design consideration of mounting arrangement and location shall be provided to ensure the good operability and ergonomic performances of the above TOD are achieved.

2.3. Signals Interfaces of the Train-borne ATC Unit

The nomenclature of the signals as specified below are for reference only.

2.3.1. Input Signals

(a) Power Supply

(i) The vehicle Low Voltage Power Supply (LVPS) shall feed a dedicated 37.5VDC power supply module as part of the VOBC sub-rack to supply the ATC unit continuously as long as the train is started up (refer to PS 9.2).

(i i) The typical power consumption for the SCS equipment is shown in the following table:

SCS Equipment	Maximum Power (Watt)
VOBC	130
Transponder Interrogator	25
Train Operator's Display	25

(iii) In normal circumstances, no power supply interruption shall be allowed once

the train system is initialized.

(iv) Two independent power supplies circuits, including positive and negative poles, shall be provided. No physical link shall exist between the two power supply circuit.

(v) In order to avoid electro-magnetic interference due to the others trainborne equipment, each polarity of the power supply circuits shall be connected directly to the general train line, independently of the others equipment and protected by two dedicated micro-circuit-breaker (MCB): (1) one 5A rated MCB shall be provided for the TOD; and (2) one 10A rated MCB for the VOBC.

(vi) The negative polarity of the battery shall be connected to the car body. No direct connection shall be made by the SCS equipment between the battery voltage and the mechanical ground.

(vii) Two grounding copper nickelled plates with a terminal stud shall be provided for the VOBC cabinet and the driver desk near the speedometer respectively.

(viii) The shielding of all screened cables shall not be connected at all truck mounted end.

(ix) Multi-point earthing scheme of a train consist with one single point of earthing connection locally on each car for the shielding of all intercar screened cables shall be adopted.

(b) Emergency Brake Triggered

(i) For safety reason, the application of an emergency brake request activated from any trainborne equipment, such as, the emergency push buttons and traction brake controller, shall be totally independent of the VOBC emergency brake request.

(ii) For ATP function, the emergency brake request as made by any trainborne equipment which shall be a dedicated dry contact of the two Safety Proving Relays (refer to PS 9.9.5) connecting in series, shall be sent to VOBC each time the train emergency brake is triggered.

(c) Relay Status

Status of the Emergency Brake Relay shall be fed back to the ATC system.

(d) Control Mode

(i) Status of the mode selector (refer to PS 9.5) shall be fed back to the ATC system. All contacts shall be of "break before make" type.

(ii) When the mode selector is moved away from the OFF position, the logic state of "Cab Status" shall be "1".

(iii) The design of the above circuit inputs shall be a fail safe manner according to the following requirements:

(1) the design of the contacts shall ensure that these contacts shall only be closed if the mode selector is placed on the related positions.

(2) no failure of the wiring shall generate a wrong side fault.

(e) Sensors

(i) According to the ATC requirement, appropriate cable shall be provided for connecting the VOBC cubicle to the underframe-mounted speed sensors and transponder antenna.

(i i) Consideration shall be given to the design of the earthing arrangement of these

sensor cables in order to ensure the screening protection is adequately provided.

2.3.2. Output Signals

(a) Emergency Brake Relay (EBR)

The Emergency Brake Relay as provided by the SCS to enable/disable the Safety Proving Circuit of the train (refer to PS 9) in order to release/apply the emergency brake when it is required by the SCS.

2.3.3. Communication Interfaces between VOBC and TIMS

(a) A serial interface of RS232 shall be provided for the data transmission between VOBC and TIMS.

(b) The serial protocol shall contain the following three layers:

- Physical layer which shall be replaced by the EIA RS-232C standard handshake.
- Data link layer provides the mechanisms required to exchange packets of data between the VOBC and the TIMS.
- Message layer assembles the data packet for transmission and disassembles the data packet received.

(c) Identical interface requirements according to the serial interface between the VOBC and the Car Monitoring Unit (CMU) of the T1 train, shall be applied to the serial interface between the VOBC and TIMS. The Contractor shall be responsible for obtaining the latest design information from the ATC Named Supplier and ensure that the TIMS shall be complied with the interface

requirements between VOBC and CMU.

3. Inter-system Electromagnetic Compatibility (EMC)

3.1. The Contractor shall ensure that all train equipment are designed and constructed to ensure proper functioning.

3.2. Consideration shall be given to the EMC of the complete ATC and train systems.

3.3. The Contractor shall interface with the ATC Named Supplier through the

Engineer to ensure that EMC is achieved between all ATC and train systems.

3.4. The Contractor shall, through this interface, develop an EMC interface specification including a Signalling Compatibility Specification. This shall define the levels of susceptibility and emissivity for all the trainborne equipment which shall guarantee compatibility.

3.5. Equipment shall be EMC tested to the requirements of the PS. An appropriate technical construction file shall be developed in accordance with the EC EMC Directives and be certified by an appropriate Competent Body for the compliance of the EMC Directives.

3.6. The following electro-magnetic disturbance sources shall be taken into account in the interface design:

3.6.1. harmonics generated by rectifiers in the traction substation;

3.6.2. main frequency harmonics in the traction supply;

3.6.3. transients generated by switching action of the inverter controlled traction and auxiliary equipment;

3.6.4. magnetic sources of the train, for example, chokes;

3.6.5. magnetic field generates by the current in the third rail;

3.6.6. radiated electric field from the trainborne equipment; and

3.6.7. radiated field from the third rail.

3.7. The Contractor shall submit a computer simulation result to predict the expected magnitudes of the above electro-magnetic disturbances, normal and fault conditions shall be considered, at SEMP stage 2, verify these simulation results by test during SEMP stage 3 and conduct an on-site measurement to validate the actual train performance by SEMP stage 5.

3.8. The total electromagnetic interference induced by vehicle equipment to the ATC equipment shall be regarded as permissible conducted current on rail and permissible radiated emissions from train.

4. Design Constraints

4.1. Accommodation of the SCS equipment

4.1.1. Typical dimensions and arrangements of the SCS equipment shall refer to Figure App-I-Annex-3-2 to App-I-Annex-3-4.

4.1.2. Subjected to the detailed mounting requirements of the above SCS equipment of which shall be provided by the ATC Named Supplier prior to the commencement of SEMP stage 3, as a minimum requirement, the following mounting arrangements shall be provided:

(a) For the VOBC cubicle:

(i) a removable steel support framework with adequately sized shall be provided for mounting the two 19” 3U sub-racks which include the Electronic Unit and the Transponder Interrogator, in a vertical plane. The associated mounting holes shall be drilled on this steel support framework by the ATC Named Supplier when required;

(ii) shall be adequately shielded to withstand a minimum level of RF radiated interference which shall be mutually agreed between the Contractor and the ATC Named Supplier;

(iii) the front panel and side covers shall be removable for easy maintenance access;

(iv) ventilation of natural cooling by the air inside the driving cab shall be provided;

(v) no special protection against ingress of water or solid bodies shall be required;

(vi) For the EB Panel. Two safety relay of Mors Smitt AM 400 type relay shall be installed; and

(vii) the accelerometer shall be floor-mounted underneath the VOBC sub-racks. The preferred position of the accelerometer is as close to the longitudinal centre of the car as possible.

(b) For the transponder antenna and speed sensor, the Contractor shall ensure that the requirements for all underframe, truck and axle mounted equipment as specified in PS 12.9.3 are met.

(c) For the TOD, a removable steel metal sheet shall be provided for mounting the TOD in an inclined plane on the Train Operator Console (refer to PS 8.8).

4.1.3. Unless it is defined by the detailed mounting requirements of the above SCS equipment of which shall be provided by the ATC Named Supplier prior to the commencement of SEMP stage 4, no special protection against the shock and vibration shall be required for all SCS equipment.

4.2. EMC Constraints

The radiated emission from any component of the train equipment shall not be greater than those maximum allowable electro-magnetic interference (EMI) level of the ATC system that shall be obtained by the Contractor by SEMP stage 2. Any sub-sequent alternation of this EMI level shall be mutually agreed between the Contractor and the ATC Named Supplier, and submitted for approval.

4.3. Wheelset Impedance

The maximum impedance per wheelset assembly shall be not greater than 0.06 ohms from DC to a frequency ranges of 13 Hz to 140 kHz and capable of operating the track circuits and axle counters.

4.4. Power Supply Interfaces between the ATC and Auxiliary Supply System

4.4.1. A DC power supply shall be continuously provided to supply the SCS equipment with the specified characteristics (refer to PS 17.4)

4.4.2. The DC power supply shall be supplied from the supply wire as specified in PS 17.4.1(e)) via a dedicated miniature circuit breaker (MCB). This MCB shall be calibrated according to the VOBC power supplies characteristics.

4.5. Maintenance Performances

4.5.1. The maintenance access to the SCS equipment inside the driving cab shall be restricted by means of a lockable cubicle.

4.5.2. Access to the VOBC cubicle shall only be gained from the front and by the means of an approved key (refer to PS 32).

4.5.3. All electronic racks of the VOBC equipment inside the driving cab shall be removed by the front.

4.5.4. The VOBC equipment inside the driving cab shall be accessible by the front and the adjacent side to remove relays and to disconnect connectors.

4.5.5. Easy access for maintainer shall be provided.

4 . Confirmation of Design Information

5.1. In addition to the train performance requirements specified in PS 4, for compatibility reason with SCS, the Contractor shall ensure that all the required train level performance parameters are achieved.

5.2. Any change to the above train performance parameters shall be submitted for approval according to the configuration control program (refer to PS 21.3.11).

5.3. The following additional information shall be submitted before the end of SEMP stage 3:

5.3.1. Maximum wheel diameter (mm)

5.3.2. Minimum wheel diameter (mm)

5.3.3. Overhanging distance (m) i.e. the distance between the antenna and the utmost front of the train including the coupler tip

5.3.4. Motor characteristic curves showing:

(a) Tractive effort (kN) at wheel tread against train speed (km/h); and

(b) Motor current (A) against train speed (km/h).

5.3.5. Coefficient of rotating mass:

(a) for non-cab car (%)

(b) for cab car (%)

5.3.6. Maximum train length (m)

5.3.7. Minimum train length (m)

5.3.8. Technical specification of the safety proving relays.

5.3.9. Train mass data

5.3.10. Train resistance formulae

5.4. ATC System Combined Test

5.4.1. In order to validate the interface design, an ATC system combined test shall

be carried out on the first train manufactured at the Contractor's test track which shall form part of the Tests on Contractor's Track (refer to Appendix B Clause 2.27) during the SEMP stage 5.

5.4.2. The ATC system combined test shall demonstrate that the train system is properly built, setup, configured and operated to fully meet the interface requirements with the ATC system according to the intended performance specified in this Annex.

5.4.3. For the purpose of this test, one set of ATC system which shall include all the required equipment of both trainborne and trackside, and shall be able to represent / simulate the ATC system for testing purpose, shall be provided and installed onto the test train and Contractor's test track respectively.

5.4.4. In order to ensure that the test train performance is fit for the purpose of this test, the train under test shall be successfully tested prior to the commencement of the ATC system combined test according to the

requirements of Works Tests specified in PS 22.9 particularly those items related to the ATC system interfaces.

5.4.5. The results of the above tests, shall be recorded and formed the baseline to develop the associated integrated and commissioning test specifications, such that all trains shall be properly adjusted and modified, if necessary, according to the above adjustment test results before submitting to the integrated and commissioning tests.

5.4.6. As far as practicable, the Contractor shall carry out the Specific Interface Tests specified in Appendix B Clause 5.2.3 for investigation and adjustment purposes, such that all trains shall be properly adjusted and modified, if necessary, before submitting to the formal integrated tests in CITY.

5.4.7. The Contractor shall make the necessary provision for the use of the ATC Named Supplier at the Contractor's test track, for example, access to maintenance pit (in the Contractor's factory only for the inspection of the trainborne ATC equipment). All provision shall be mutually agreed between the Contractor and the ATC Named Supplier.

Figure App-I-Annex-3-1 SCS System Overview

Item	Description	QTY per	H Inch	W Inch	D Inch	Est. Weight lb. (Max.) [kg]
1	VOBC	1	5.25	19.00	15.30	14.00
2	Transponder	1	5.25	19.00	9.92	12.00
3	TI Antenna	1	2.00	22.00	8.00	8.00
4	TI Antenna bracket	1	17.87	14.25	22.50	35.00
5	Accelerometer	1	1.90	3.20	5.40	1.00
6	Train Operator's	1	7.50	7.50	3.00	8.80
7	Circuit Breaker for	1	2.50	0.750	3.00	0.25
8	Circuit Breaker for	1	2.50	1.520	3.00	0.50
9	SCS Bypass	1	1.50	1.75	2.50	0.25
10	Terminal Block	2	2.50	19.00	2.00	3.00
11	EB Relay Assy	1	2.50	19.00	2.50	1.00
12	Speed Sensors	2	-	-	-	1.50
13	Cable Kits	1	-	-	-	63.00
14	VID Plug	1	1.50	3.00	1.50	0.25
Total Weight						166.6

Figure App-I-Annex-3-3 Typical Speed Sensor Dimension (in inches)

Figure App-I-Annex-3-4 Typical TI Antenna Mounting Arrangement

Item	Description	QTY per	H Inch	W Inch	D Inch	Est. Weight lb. (Max.) [kg]
1	ATO Subrack	1	5.25	19.00	15.30	14.00
2	Data Communication Unit (DCU)	1	5.25 [133.4]	19.00 [482.6]	15.30 [388.6]	14.00 [6.4]
3	Roof Mounted	2	2.00	22.00	8.00	8.00
4	Radio Antenna	2	17.87	14.25	22.50	35.00
5	ATO Accelerometer	1	1.90 [48.3]	3.20 [81.3]	5.40 [137.2]	1.00 [0.46]
6	Interface Relay	1	5.25	19.00	15.30	14.00
7	Circuit Breaker	1	2.50	0.750	3.00	0.25
8	Circuit Breaker	1	2.50	1.520	3.00	0.50
9	Circuit Breaker					
10	Platform Door Communication Unit (PDCU)	1	5.25 [133.4]	19.00 [482.6]	15.30 [388.6]	14.00 [6.4]
11	Terminal Block Assy	To be deter	-	-	-	-
12	Truck Frame Mounted Proximity	1	1.57 [40]	3.15 [80]	3.58 [91]	4.41 [2.0]
13	Cable Kits	To be deter	-	-	-	
14	ATO VID Plug	1	1.50	3.00	1.50	0.25
15	Underframe Mounted PDCU	2	2.52 [64]	12.01 [305]	2.99 [76]	7.72 [3.5]

Figure App-I-Annex-3-5 Typical ATO Equipment Parameters

APPENDIX I DESIGNATED AND INTERFACING CONTRACTS 2

ANNEX 4 COMMUNICATIONS INTERFACES 2

1 INTRODUCTION 2

2 TRAIN RADIO 3

1 YARD MAINTENANCE SUPPORT SYSTEM
5

APPENDIX I Designated And Interfacing Contracts ANNEX 4 Communications Interfaces

1 Introduction

1.1 This document defines the interface requirements for all the trainborne communications equipment and the train system.

1.2 Each car with driving cab will be equipped with all the trainborne communications equipment as defined in PS 18.1.2.

1.3 The Contractor shall install all the communications equipment as stipulated in PS 18. All the required connectors, interfacing plugs and sockets, earthing connections and all associated mounting materials shall be provided by the Contractor.

1.4 The Contractor shall provide accommodation including mountings, equipment cabinets and cable access for the installation of all the communications equipment, appropriate power supply, including the power supply interface and the protection device to all the communications equipment, all required EMI protective measures, such as special EMC cubicle, to protect the communications equipment and incorporate appropriate interfaces, power supply, delivery schedule, installation, testing and setting to work. The Contractor shall ensure that the equipment can be easily operated, removed and replaced.

1.5 The Contractor shall be responsible for the test and commissioning of all communications equipment that are supplied by the Contractor and those purchased from the Named Suppliers.

1.6 EMC Consideration and Constraints

1.6.1 The Contractor shall ensure that all train equipment is designed and constructed to ensure proper functioning of all the communications equipment.

1.6.2 The Contractor shall interface with all the Named Suppliers to ensure that

EMC is achieved between all the communications equipment and train systems. Special consideration shall be given on the positioning and protection of the Train Radio antenna, PIS receivers, real time data receivers and trainborne transceivers for PIS in order to ensure that each communication equipment shall be fully functional without suffering interference from any other communications equipment.

1.6.3 The Contractor shall, through this interface, develop a Communication

Compatibility Specification which shall identify the possible interference sources and define the levels of susceptibility and emissivity for all the trainborne communications equipment that will guarantee compatibility in

SEMP Stage 2. A Communication Compatibility Study shall be developed in SEMP Stage 3 to document the steps taken to ensure that the defined level of susceptibility and emissivity is achieved for all communications equipment and train systems.

1.6.4 Train systems and equipment shall be EMC tested in SEMP Stage 4 to demonstrate compliance with the PS. An appropriate technical construction file shall be developed in accordance with the EC EMC Directives and be certified by an appropriate Competent Body for the compliance of the EMC Directives.

2 Train Radio

2.1 The Named Supplier of Train Radio shall be in accordance with Appendix D.

The Contractor shall purchase from the Named Supplier all train radio equipment as stipulated in clause 2.2 below and PS 18.2.

2.2 Each driving cab shall be fitted with the following train radio equipment:

(a) a train mobile unit with part number (To be Advised) comprising of a radio unit (transceiver), a data interface unit, antenna isolator, junction box and dc-dc converter mounted in an equipment enclosure

(b) a control head with part number (To be Advised)

(c) a loudspeaker with part number (To be Advised)

(d) a handset with part number (To be Advised)

(e) an antenna with part number (To be Advised)

(f) all interconnection cables.

2.3 All interconnection cables including the RF feeder cable shall be provided and installed by the Contractor.

2.4 The system block diagram of the Train Radio is shown in Contract Drawing Nos. NST 036 to NST 037 which indicates the interconnection between the various units.

2.5 Performance Requirements of the Train Radio and Train System Interfaces

2.5.1 General

The design of the train system shall ensure that the main objectives of the Train Radio summarised as below are achieved:

(a) To provide a two way half duplex secure speech communication between TCC and an individual train or a group of trains or between trains (with TCC acting as central despatch)

(b) To provide a two way half duplex secure speech communication between yard controller and train

(c) To allow PA messages to be transmitted from the train operator / TCC to the passengers of the train

(d) To provide silent message / data call function that allow TIMS to send data message to the TCC

2.5.2 Detailed Functions

(a) Two way half duplex speech communication between TCC and an individual train or a group of trains or between trains will be provided by the Train Radio in normal mode.

(b) Two way half duplex speech communication between yard controller and train will be provided by the Train Radio when the train is operating in the yard.

(c) PA messages from train operator / TCC to the passengers of the train will be able to be transmitted to the DVAS and PA for broadcast to passengers. An ~~balanced audio output is provided by the Train Radio to the DVAS and PA for~~ broadcast of the received audio message to passengers.

2.5.3 ~~Com~~munication Interfaces between the TIMS and Radio

(a) ~~A serial interface of RS232 shall be provided for the data transmission~~ between TIMS and Radio. This interface is used for "Real-Time ~~data transmission".~~

(b) Identical interface requirements according to the serial interface ~~between the Radio and the Car Monitoring Unit (CMU) of the T1 train, shall be applied to the serial interface between the Radio and TIMS. The Contractor shall be responsible for obtaining the latest design information from the Named Radio~~ Supplier and ~~ensure that the TIMS shall be complied with the interface requirements between Radio and CMU.~~

(a) A serial interface shall be provided for the data transmission between TIMS and Radio. This interface is used for "Real-Time data transmission".

(b) Similar interface requirements according to the serial interface between the Radio and the Car Monitoring Unit (CMU) of the T1 train, shall be applied to the serial interface between the Radio and TIMS. The Contractor shall be responsible for obtaining the latest design information from the Named Radio Supplier and ensure that the TIMS shall be complied with the interface requirements between Radio and CMU."

3 Yard Maintenance Support System

3.1 The Contractor shall provide a YMSS Wireless LAN System to support the interface between the PIS Communication Equipment and the Yard Maintenance Support System (YMSS) computer. The YMSS shall be a computer network running on Microsoft© Network OS or an alternative specified by the Engineer.

3.2 The design and construction of the interface together with the Wireless LAN for YMSS shall ensure that all the requirements as stipulated in PS 18.6.3 are fully satisfied.

3.3 The interface together with the Wireless LAN for YMSS shall ensure that:

(a) The time required to initiate the transfer of diagnostic and performance monitoring data recorded by the TIMS from trains to the interface with YMSS computer (via the Wireless LAN for YMSS) shall be 5 sec maximum.

(b) The Bulk Data Transmission Facilities will provide a secure communication link to allow DiCU's of PIS to receive scheduling list, advertising messages and other information on certain strategic locations in the Existing Lines.

3.4 Design Constraints

3.4.1 Power Supply and Electrical Requirement

The Contractor shall liaise with the Yard Maintenance Support System Subcontractor to define and provide power supply and electrical interface for the interface with the YMSS computer.

3.4.2 Accommodation Requirement

The Contractor shall liaise with the Yard Maintenance Support System Subcontractor to define the physical requirements (location and dimensions) to accommodate the interface with the YMSS computer.

3.4.3 License

The Contractor shall apply and secure a license, if necessary, for the operating frequency band of the wireless LAN transceiver to be legally operating in CITY.

3.4.4 Coverage

In the K Carhouse, the Contractor shall provide adequate number of YMSS wireless LAN hubs in order to give full coverage to the 3 areas,

namely, Running Maintenance, Heavy Cleaning and Stabling Tracks as illustrated in Contract Drawing No. NST 076. The system shall consist of the daisy chain connection of hubs connected to the interface computer by a coaxial cable.

3.4.5 Interface Provisions

The Contractor shall provide the following interface provisions between the TIMS and the YMSS Wireless LAN.

(a) Minimum data rate of 1.6 Mbps, the effective data rate can be improved over 10 times faster with the data compression method.

(b) Incorporate handshaking and acknowledgement for the communication

(c) Provide time-out to abort any incomplete data communication so as to avoid the occurrence of infinite waiting

(d) Facilitate the mechanism of information resending, which shall avoid infinite looping or retry, for any unsuccessful data transfers

(e) Built in error checking and correction mechanism in the signal modulation and transmission technique to prevent transmission of incorrect data and the omission of data

(f) Illustrate the proposed frequency spectrums for the YMSS Wireless LAN System that the specified frequencies do not interfere with each other

(g) Interference to any of the AUTHORITY's systems including Rolling Stock, Signaling and Communications equipment in the yard are not allowed

(h) Technical requirements of wireless LAN interface equipment between TIMS and YMSS according to the following specification:

Frequency	2.4 GHz
Modulation Method	4FSK
Error Detection / Correction	Spread spectrum encoding / decoding
Radio Data Rate	1.6 Mbps per channel
Media Access Protocol	CSMA / CA (IEEE802.11)
Ethernet Standard	Ethernet packet types compliance
Output Power	100 mW

Range	Up to 500 feet (150 meters) in typical office environments Up to 1000 feet (300 meters) in open space

Frequency	2.4 GHz Reducing to 5 to 10 meters with the use
Network Architecture	Supports ad hoc pier-to-pier networks and communication to wired o o Ethernet or Token Ring
Temperature Range	-20 C to +60 C
Humidity	10 to 90% typical (Non-condensing)
YMSS Interface	Standard network method which is available for IBM compatible PC such as TCP/IP via 10

3.5 Confirmation of Design Information

3.5.1 Site Survey

(a) By the end of SEMP stage 2, the Contractor shall conduct a site survey in order to satisfy himself that all the required information for the wireless LAN design are available. The Contractor shall submit a site survey plan for approval prior to the commencement of the site survey.

(b) A site survey report shall be provided by the Contractor after the completion of the site survey. As a minimum, the following details shall be included in the site survey report:

(i) A summary of the design and installation requirements of the wireless LAN.

(i i) Estimated coverage areas based on the site survey measurements. This shall be divided into areas with good coverage, marginal coverage, and weak coverage. It may also site potential trouble spots if the signal strength measurements allow for it.

(i i i) A description of the locations of all access points, along with their

configuration which shall include, the access point name, its operating channel, approximate coverage area, IP configuration, antenna type and configuration (including direction for directional antennas) and any other vendor-specific information.

(iv) A detailed floor plans or physical network maps showing the detailed access point placement information. Estimated coverage areas shall be noted on the map and serve as the basis for frequency reuse planning. Any antenna requirements (external antennas, antenna types, and adjustments to default transmission power) for achieving the noted coverage area shall also be recorded.

(v) Technical details shall be provided for future installation to complete the network build-out.

3.5.2 Any change in the design constraints (including power supply,

accommodation and interfacing arrangement) as stipulated in clause 5.4 above shall be submitted for approval in accordance with the Configuration Control Program (refer to Appendix P) before the end of SEMP Stage 3.

APPENDIX I DESIGNATED AND INTERFACING CONTRACTS..... 2

ANNEX 5 YARD INTERFACE 2

1 INTRODUCTION 2

2 RUNNING MAINTENANCE AREA..... 2

3 LIFTING / HEAVY MAINTENANCE AREA 3

1 CLEANING 6

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APPENDIX I Designated And Interfacing Contracts ANNEX 5 Yard Interface

1 Introduction

The trains will be stabled and maintained at the existing AUTHORITY's K Carhouse which include a test track, yards and workshops. This Annex defines the standards for interfaces between the trains and the AUTHORITY's train maintenance facilities. The design of the trains shall aim to make the best use of existing equipment provided for the Existing T1 Trains, both to ensure compatibility and to minimize the number of different maintenance facilities for similar functions across the AUTHORITY's fleet.

2 Running Maintenance Area

2.1 General

2.1.1. The following activities will be carried out at the Running Maintenance Area of a yard:

(a) Preventive maintenance service checks (refer to PS 26.3.2)

(b) ~~Corrective maintenance (refer to PS 26.4)~~

(c) In-situ cleaning of HVAC Units using high pressure hot water. In some yards, ~~cleaning of roof mounted HVAC Units will be carried out at a Heavy Cleaning Track (refer to Clause 4.4 below) provide with roof level access platforms.~~

(d) Replacements of equipment that do not require car lifting or overhead cranes

(e) Re-commissioning of trains after car overhauls

2.1.2. The Running Maintenance Area will consist of raised tracks on a depressed floor each of 6-car long. A typical cross-section is shown in Contract Drawing No. NST 076.
The Running Maintenance Area will consist of raised tracks on a depressed floor each of 6-car long. A typical cross-section is shown in Contract Drawing No. NST 080.

2.1.3. The following service supply points will be provided at regular intervals along each running maintenance track:

(a) single phase voltage of 120VAC, 60Hz and three-phase 60 Hz, 208 V r.m.s. line-line electrical power supply

(b) compressed air at 9.31 bar (135 PSI).

2.1.4. Routine charging of the batteries shall be carried out at the W Yard by

a stationary battery charger. The battery set shall be designed in such a way that by using a fork lifting truck, the complete battery set shall be removed and replaced within 30 mins.

2.2 Access to Trainborne Equipment

2.3.1. Access to the underframe of the trains will be provided by raised tracks in the Running Maintenance Area.

2.3.2. Access to the interior of the trains and to the outside of the car body will be either from the emergency door of the cab front or provided by mobile platforms fitted with ladders or stairs.

2.3.3. Access to roof mounted equipment will be provided by a fixed high level platform running along the full length of a train on one side. Access to roof mounted equipment will be provided by a fixed high level platform running along the full length of a train on both sides.

2.3 Drainage for HVAC Units

2.3.4. Drainage points for condensate from trainborne HVAC Units shall be positioned at the corners of the cars, in order that the condensate will be collected at special channels on the floor.

2.3.5. During the in-situ cleaning of HVAC Units, the drainage points will be connected to a hose so that the effluent from the cleaning process can be directed to a suitable location for treatment and disposal. The design of the drainage points shall enable such connections to be made.

3 ~~Lifting / Heavy Maintenance Area~~

~~3.1 General~~

3.1.1. The following activities will be carried out at the Lifting / Heavy Maintenance Area of a yard:

(a) Car overhauls

(b) Replacements of equipment that require car lifting or overhead cranes

3.1.2. The Lifting / Heavy Maintenance Area will consist of tracks laid on a flat floor area and will be provided with abovefloor or underfloor car lifting equipment. The cross-section of a typical Lifting / Heavy Maintenance Area is given in Contract Drawing No. NST 076.
The Lifting / Heavy Maintenance Area will consist of tracks laid on a flat floor area and will be provided with above-floor or under-floor car lifting equipment. The cross-section of a typical Lifting / Heavy Maintenance Area is

given in Contract Drawing No. NST 080.

3.1.3. The following service supply points will be provided at regular intervals along a heavy maintenance track:

(a) single phase voltage of 120VAC, 60Hz and three-phase 60 Hz, 208 V r.m.s. line-line electrical power supply

(b) compressed air at 9.31 bar (135 PSI)

(c) an overhead travelling crane will be provided above the lifting / heavy maintenance tracks for the replacement of roof mounted equipment, such as, HVAC. The Contractor shall provide any special lifting attachments or load spreaders required for handling roof mounted equipment, as part of the special tools specified in PS 24

3.1.4. No 3rd rail will be provided at the Heavy Maintenance Area.

3.2 Access to Equipment

3.2.1. Access to the underframe and underframe mounted equipment will be provided by car lifting equipment. Cars under car overhauls will be supported on accommodation trucks.

3.2.2. Disconnection of trucks and bar couplers will be carried out at pitted tracks or underfloor car lifting berths.

3.2.3. Access to the interior of a car and to the outside of the car body will be either from the emergency door of the cab front or provided by mobile platforms fitted with ladders or stairs.

3.2.4. Access to roof mounted equipment will be provided by fixed high level platforms. Maintenance access to the roof shall be limited to replacement of the roof mounted equipment or light duty of maintenance task only, such as, touch up of paint.

3.3 Car Lifting/Truck Drop Table

3.3.1. Jacking points shall be provided and located according to Contract drawing No. NST 007 on the cars so that they can be lifted to allow access to and replacement of trucks and heavy underframe mounted equipment. The cars shall allow lifting either individually as single cars, or as a complete unit coupled together without dismantling the bar couplers.

3.3.2. The design of the cars shall allow both abovefloor and underfloor car lifting equipment to be used. Details of lifting claws and working range of existing abovefloor car lifting equipment are given in Contract Drawing No. NST 080.

3.4 Accommodation Trucks

3.4.1. Cars undergoing car overhauls will be placed on accommodation trucks to provide an ergonomic height for working on equipment mounted on the underframe. The accommodation trucks also allow the cars to be moved around. The design of the cars shall allow existing accommodation trucks of the T1 train to be used for such purposes.

3.4.2. The Contractor shall propose for approval any necessary modifications to existing accommodation trucks so that they can accommodate the cars supplied. Such modifications shall not affect the existing functions of the accommodation trucks. In the event that special work is required each time to convert the accommodation trucks between existing cars and the new cars as supplied by the Contractor, the conversion for each truck shall be completed within 15 minutes with not more than 0.5 man-hour.

3.4.3. Relative horizontal movements between the car body and accommodation trucks shall be constrained by mechanical stops to allow braking of the cars during shunting.

3.4.4. The design of the underframe of the trains shall allow accommodation trucks to be installed or removed from the cars using the car lifting equipment described in Clause 3.3 above.

3.5 Handling of Underframe Mounted Equipment

The design of the trains shall facilitate handling of underframe mounted equipment as follows:

(a) Mobile scissors platforms and fork lift trucks will be used for removing and refitting underframe mounted equipment. For mobile scissors platform, the LRU size shall be limited to 60” (L) × 26” (W) × 41” (D) and for the fork lift truck, the LRU size shall be limited to 36” (L) × 15” (W) × 24” (D). The safety working load of both mobile scissors platform and fork lift truck is 4000 lbs.

(b) Trucks will be removed from the cars by raising carbodies on car lifting equipment or using the truck drop table as described in Clause 3.3 above. When the truck is removed from the car, it will be rolled out under the cars along the length of the track.

(c) Truck turntables will be provided for transferring trucks between adjacent tracks.

3.6 Towing

3.6.1. Cars standing on the heavy maintenance tracks will be pulled or pushed by a tractor fitted with road wheels. The tractor will be positioned at the ends or sides of the car to be moved. Towing points shall be provided at the 4 corners of each car to accommodate a tow bar for such shunting movements. Arrangement of towing points on existing T1 Trains shall be adopted.

3.6.2. Towing points shall also be provided on each car or each truck to allow towing by a winch at the underfloor wheel lathe for positioning the wheels over the cutting tools.

3.6.3. Each towing point shall be designed to withstand the force required to move and stop a 6-car train on a level track at 200 m (656') curve radius.

4 Cleaning

The design of the trains shall aim to adopt the same external cleaning processes for existing T1 Trains without additional external cleaning operations.

4.1 Automatic External Water/Detergent Washing

4.1.1. A drive-through automated water / detergent wash plant fitted with sprays and rotating brushes will be available for external cleaning as the trains enter the yard from service.

4.1.2. The train will be driven through the plant at 5 km/h (3MPH) on its own power. A mixture of water and detergent will be sprayed on the carbody, followed by brushing and a final rinse with fresh water.

4.1.3. The exterior of the complete carbody between cantrails and solebar, including the end faces, will be washed.

4.1.4. The following chemicals are used for the water / detergent washing of

Existing T1 Trains with aluminium bodies:

Chemical Ingredients	Diluted to (% w/w)
Sodium dodecylbenzene sulphonate	1-5
Sodium Hydroxide	0.5 – 1.5
Sodium metasilicate	1 – 5
Dipropylene glycol methyl ether	1 – 5
Sodium nitrllortriacetate	1 – 5

4.2 Automatic External Acid Washing

4.2.1. Where the external finish of the trains requires acid washing, a drive-through automated acid wash planted fitted with sprays and rotating brushes will be available for acid wash.

4.2.2. The train will be driven through the plant at 5 km/h (3MPH) on its own power.

A mixture of water and acid will be sprayed onto the body and left to stand for a length of time. The mixture is then removed by water and brushes, followed by a final rinse with fresh water. The process may be repeated a few times to achieve the required standard of cleanliness.

4.2.3. The exterior of the complete carbody between cantrails and solebar will be washed.

4.2.4. The following chemicals are used for the acid washing of Existing T1 Trains with aluminium bodies:

Chemical Ingredients	**Diluted to (% w/w)**
Oxalic acid	7 – 13
Linear alcohol ethoxylate /propoxylate	1 – 5

4.3 Cleaning of Windows

4.3.1. To prevent the accumulation of water stains, the outside surface of Existing T1 Train windows are cleaned at regular intervals using hand-held power brushes and the proprietary chemical Glass Clear (a water solution containing hydrofluoric acid and silicon dioxide particles).

4.3.2. The Contractor may submit alternative cleaning methods, or suitable treatment that obviate such cleaning for approval.

4.4 Heavy Internal Cleaning

Heavy internal cleaning will be carried out with the train berthed at a heavy cleaning track. Access to the trains will be provided by platforms at floor level along the full length of the train. Power supply points and water taps will be provided at regular intervals along each platform. The trains shall be designed to utilize such facilities for internal cleaning.

5 Underfloor Wheel Lathe

5.1. The wheels of the trains will be reprofiled by an underfloor wheel lathe. The design of the truck, wheelset and axle box shall be compatible with the AUTHORITY's underfloor wheel lathe, so that wheels can be re-profiled without dismantling any trainborne equipment and no equipment shall be installed at the axle end. Both ends of each axle shall be machined as shown on the Contract Drawing No. NST 042 to accept wheel lathe centres.

5.2. As an alternative, the Contractor may provide a suitable device, as part of the

special tools in accordance with PS 24, which can be installed on the AUTHORITY's underfloor wheel lathes to provide the hold down function. Such device shall satisfy the following requirements:

(a) Installation or removal time: not more than 15 minutes

(b) Number of staff required: not more than 2 persons

(c) No crane or lifting equipment shall be required for handling the device

The design of the device shall be submitted for approval.

6 Miscellaneous Interfaces

6.1 Pneumatic Connector

6.1.1. Quick release pneumatic connectors shall be provided at strategic points in the pneumatic system to facilitate maintenance activities such as pressure measurements and charging of the system.

6.1.2. As a minimum, quick release pneumatic connectors shall be provided for the following purposes:

(a) All air pressure measurements during preventive maintenance work (refer to PS 26.3)

(b) For charging of the main air system from a shore supply

(c) Measurement of brake cylinder pressure

(d) Measurement of air suspension pressure

6.1.3. Quick release pneumatic connectors shall be compatible with the 'Schrader' plug connector shown in Contract Drawing No. NST 083.

6.2 Shore 600VDC Supply for Auxiliary and Traction Equipment

6.2.1. For safety reasons, the sheds of the carhouse are not equipped with the third rail, hence, a supply through a long lead is provided. For third rail systems, the shore supply cables are usually fed from electrified rails suspended from the shed roof. The cables are hung from trolleys running along the rails so that the supply is available along the whole track. The lead is plugged into a socket on the side of the train. One adequately rated Carhouse Receptacles in a form of female plugs for both auxiliary and traction systems, shall be provided to accept the above shore supply (refer to PS 11.6.1(d)).

6.2.2. Design consideration shall be given to ensure that the auxiliary and traction systems are able to automatically differentiate the operations of traction gap detection (refer to 11.6.1(c)(vi)) and the above receptacles. (No specifications text modifications required.)

6.3 Recovery from Derailment and Locked Axle

6.3.1. The design of the trains shall aim to utilize the existing recovery equipment with minimum requirement for additional hardware:

(a) In the event of a derailment, the derailed car will be restored to the running rails using a set of specialist re-railing equipment which consists of hydraulic jacks, re-railing bridge and roller carriages. The working principles of existing rerailing equipment are shown in Contract Drawing No. NST 014.

(b) In the event of a locked axle, a pair of emergency recovery dolly will be fitted to the affected axle by jacking under the truck frame or axle boxes. The design of existing emergency recovery dolly is shown in Contract Drawing No. NST 014. The truck frame assembly shall be designed to accept the above emergency recovery dolly. Underframe clearance shall be provided sufficient to allow the car to negotiate, without physical interference, over the minimum radius curve while the recovery dolly is in place at any of the four axle positions.

6.3.2. The Contractor shall provide additional equipment, or modifications to existing equipment, for recovery of the trains from derailments and locked axles, as part of the special tools specified in PS 24. As an alternative, the Contractor may provide a suitable rerailing equipment, such as, a wheel skate, as part of the special tools in accordance with PS 24, which can be installed underneath the wheel to meet the above recovery requirements. Four (4) complete set of such equipment shall be provided and no adjustment shall be required when applying it to put a derailed car on the track.

6.3.3. All jacking points, including those that will be used for applying the wheel skates described in Clause 6.3.1(b) above, shall be painted with the alternate yellow and black stripes pattern. Same positions of jacking points of the T1 train according to Contract Drawings No. NST 007 and NST 041 shall be adopted. For an efficient emergency operation, free access to all jacking points shall be provided without the need of dismantling any equipment from the car. Due design consideration shall be given to the design of the jacking point in such a way that the head of the hydraulic jack shall not displace easily from its position during the jacking process. Same positions of jacking points of the T1 train according to Contract Drawings No. NST 007, NST 041 and AUTHORITY-111-0004-4 (truck

jacking pads) shall be adopted. For an efficient emergency operation, free access to all jacking points shall be provided without the need of dismantling any equipment from the car. Due design consideration shall be given to the design of the jacking point in such a way that the head of the hydraulic jack shall not displace easily from its position during the jacking process.

6.3.4. Design consideration shall be given to ensure the jacking clearance which is the vertical clearance of 250mm (9.8”) as measured from the vehicle clearance envelope to the ceiling, shall not be exceeded.

APPENDIX J SERIALISATION STANDARDS 2

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Appendix J Serialisation Standards

Serial Numbers and Component Identification

1. General

1.1 Equipment and components expected to be removed from the Subway Car for repair, maintenance, servicing or overhaul shall require unique identification. A serial number, description and stock code along with bar coding where possible is required. AUTHORITY's maintenance philosophy requires strict adherence to serialised parts tracking and computerised record keeping so that a complete component history is always up to date and available. Serial exchanges of components along with original installations for the first time or subsequent times along with other attributes requires documenting on AUTHORITY Work Orders for central processing into a computerised Work Order System. Upon request, the interfaces between AUTHORITY computerised Work Orders System and Contractor's Maintenance, Repair and Overall database may be developed to allow for electronically data exchange. The Contractor shall provide submit the development proposal for approval.

2. Equipment Label

2.1 Essentially a fixed plate is attached to major equipment, an appropriate label for other equipment that supports permanent adhesion and or etching or other methods can be used on cast components. The method of serialisation along with the data content shall be submitted for approval during SEMP 2 to SEMP 3. AUTHORITY will provide, at Notice To Proceed (NTP), a list of common plates and labels currently used to assist with labelling requirements.

2.2 For purposes of clarity a T1 serialisation "Blue Book" will be provided to the car-builder, at NTP, to demonstrate our expectations. A new "Blue Book" for NST cars shall need to be produced and delivered in electronic format by the car-builder, incrementally once sub-systems, system product SEMP 3 are completed.

2.3 Prior to delivery of each product or Subway Car, the serialised configuration

of each car must be provided in electronic format and paper format (electronic format to be supplied by AUTHORITY, at NTP) and approved and signed off by AUTHORITY's on-site inspector before shipment from the car-builder. Approval to ship the car will not be granted until this is signed off.

2.4 After delivery of each Subway Car to AUTHORITY property the record keeping

activity of serialised components must be maintained using AUTHORITY Work Orders

and by electronically exchanging Work Order data to and from Contractor database.

2.5 Any warranty exchange for a serialised component must also be recorded in

AUTHORITY's Work Order system and by electronically exchanging Work Order data to and from Contractor database.

2.6 Once the a serialized product or a vehicle is delivered to AUTHORITY property any

work performed on a Subway Car or its components must be carried out using a AUTHORITY Work Order and by electronically exchanging Work Order data to and from Contractor database. Carrying out work without a Work Order goes against AUTHORITY policy and standard operating procedure. If required a work station will be provided to the Contractors onsite support personnel in order to efficiently process Work Order information. Upon the request of the Contractor, AUTHORITY may provide training in this area to a limited number of onsite car-builder personnel. Sub-vendors shall need to perform work through the Contractor and or AUTHORITY personnel. All work order processing and data entry is to be performed by AUTHORITY and or trained Contractor personnel only. Controls of this nature are very strict due to the use of restrictive status codes where processes are required to release cars for use on the mainline or yard areas. The car-builder shall therefore be required to manage all sub-vendors activities in this regard.

3. Serial Number Allocation

3.1 Since the serial number and component description act together as a unique

identifier, it is preferable to keep the serial number a relatively short number. The serial may contain leading or trailing letters. Contractor and Supplier defined serialization program shall be submitted to AUTHORITY for information

3.2 Where an interchangeable component type is delivered with the NST vehicles

that can be used on previous AUTHORITY type vehicles the rules of existing serialisation for numbers and identification must be maintained to avoid duplication. AUTHORITY will submit at NTP a list of existing AUTHORITY serialized component that includes Manufacture part number,

AUTHORITY stock Code and AUTHORITY short description.

3.3 Components that shall be serialized shall fall in one of the following categories:

3.3.1 Assemblies for which a First Article Inspection is required, except for exterior and interior lighting, floor heaters, and passenger seats.

3.3.2 All circuit card assemblies, where space permit.

3.3.3 Suppliers serialized components.

3.4 Any serialized components that are commercially available shall not be bar-coded in compliance with this Appendix requirement. Supplier bar code shall be used and it shall be to the discretion of AUTHORITY to include these items in the car builder serialization package.

3.5 The number of serialized component, per car, shall not exceed 400 unique line of data entry.

4. Serialised Component Description

4.1 Each component group or type requires a unique descriptive identifier (up to 15 characters) in addition to a serial number. The format of each description generally follows a common theme where short forms or simple acronyms are put together to create this description. An example of a NST traction motor could be "MotorTMNST" where "Motor" is a common description, "TM" is the subsystem identifier and "NST" is of course the vehicle type. The "Blue book" is a good example to follow. AUTHORITY will submit to the Contractor T1 Blue book at NPT.

5. Serialised Component Hierarchy

5.1 The structure of serialised components can sometimes be multi-leveled. AUTHORITY makes use of the structure by each component having a next higher assembly (NHA). In some cases this NHA is the vehicle itself, in others is can be an assembly where it could have sub-assemblies. It is cases like this where an assembly that has sub-assemblies can be exchanged that AUTHORITY has created this NHA relationship. This structure is sometimes referred to as parent and child relationship. AUTHORITY's Work Order system makes efficient use of this NHA identifier and automatically maintains the configuration of any sub-assemblies during its exchange. Each component must have at least one NHA identifier. As an example the "MotorTMNST" could have either "Truck1NST" or "Truck2NST". This way when a truck is exchanged the axle sets, gearboxes, brake cylinders and any other truck mounted equipment are still attached to the truck and configuration is maintained.

6. Stock Code

6.1 The Stock code is a AUTHORITY supplied stock code based on vendor supply data,

cross referenced through Material Systems information. Each component (serialised or not) should have a AUTHORITY assigned stock code. From the drawing approval cycle of SEMP 2 and SEMP 3, AUTHORITY will assign Stock Code Number and Description to allow the Car-builder to assign a specific one to each component. Where a serialised component is concerned this stock code shall

be part of the identification Label. An electronic summary of all stock codes referencing all manufacturing ordering information shall be required prior to the first Subway Car delivery.

7. Bar Code

7.1 A bar code shall be part of the serial plate and or label where possible. This

bar code shall be made up of the serial, description and stock code so that a reference table can be utilised with scanning methods to automatically return all appropriate component information. This electronic file format will be provided by AUTHORITY at SEMP 1, and is to be delivered by the Contractor prior to the delivery of the first Subway Car. The Bar code requirement is primarily for AUTHORITY's in-house Materials system. Shall the Contractor or its Supplier already has a bar coding process in place, it is acceptable to have two bar code installed.

8. Master file Definition

8.1 Each Serialised Component shall be defined by record in AUTHORITY's Work Order

System. Each record shall have the following structure and format:

Field #	Field	Description	Type	Max. Width
1	Lvl	Hierarchy level	Numeric	2
2	Supp Code	Supplier acronym code	Character	3
3	PN	Supplier Part Number	Alpha	
4	Stock	AUTHORITY Stock Code		
5	Mod	Part modification level	Alpha	25
6	SW V	Software version	Alpha	25
7	Description	Full description as it appears in drawing block	Character	50
8	SN	Serial number	Alpha	30
9	Descrip	AUTHORITY short	Character	15
10	Pos	Physical part position	Character	20

8.2 Contractor information is to be approved and finalised by AUTHORITY. Using

the

Blue Book example along with AUTHORITY's assistance using a generic rule set (to be provided by AUTHORITY) the Contractor shall enforce this requirement on all sub vendor serialised parts. Final AUTHORITY approval shall be required before this requirement shall be considered complete. Master file definition shall be approved during SEMP 2 thru SEMP 3. At SEMP 3 the list shall be finalized to permit the Contractor and Supplier to be able to produce bar code before a First Article Inspection is scheduled and a first production unit be produced.

9. Car Builder serial configuration package with each vehicle delivered

9.1 As per the defined Master file above each the Contractor shall provide the complete Serial configuration of each serialized product or vehicle as delivered to AUTHORITY property with records in the following format:

Field	Type	Width
DATEIN	Date	8
SERIAL	Character	10
EQUIP	Character	10
SERIAL IN	Character	10
DESCRIP	Character	15
SERNHA	Character	10
NHA	Character	15

Each Serialised component shall have an individual record.

10. Sub-System Event data coding, Type and Format

10.1 The contractor shall ensue that all sub-systems protocol shall follow the data coding requirements, such as the 4 character coding structure, as described in this Appendix and compatible with the TIMS particularly the Event Recorder as specified in PS 10.

10.2 All events from the vehicle sub-systems which shall be transmitted by TIMS, either through the Radio as critical real-time events or through the Yard YMSS equipment as maintenance events. In either case the four (4) character event code shall have a specific meaning which shall be compatible with the AUTHORITY's Work Order system in order to disseminate the information of the events by means of a tree-structure. This shall enable printing\sorting event data by sub-system, function and or by specific event. It is a requirement that all event data regardless of which format as detailed in this Appendix, a unique 4 char code shall be provided with a break down structure in accordance with, but not limited to, the following rules.

(a) The first character shall be a sub-system character where

(i) b=Brake System

(i i) a=Air Compressor System

(i i i) s=Static Converter

(i v) d=Doors

(v) p=Propulsion

(v i) c=cab and or passenger device (PAA or Emerg)

(v i i) m=Monitoring System

(v i i i) z=Speed Control System

(b) The second where possible shall be a breakdown by function

(i) Contactors

(i i) Sensors

(i i i) Overload

(i v) Armature Control

(v) Specific equipment identifier

(c) The third or fourth characters shall be used as alphanumeric characters to describe the event with acronyms to have meaning that is readable where possible. Examples are as follows.

(i) doim – would mean door open in motion.

(i i) brkh- would mean brakes holding

10.3 The AUTHORITY currently imports T1 trains event data into a networked Work Order

System so all vehicle activity is complete with Cleaning, Inspection, repair and overhaul works record. Hence, for consistency purpose, it is a requirement that when importing an event, it shall be compatible with the AUTHORITY's existing Work Order System according to the specified format(s).

10.4 When importing an event, the following requirements of the existing AUTHORITY's

work order system shall be met:

(a) Inside the event file, only ASCI characters from CHR(32) inclusive to CHR(255) shall be provided and accepted by the existing AUTHORITY's work order system.

(b) Each Event shall be sequentially stored and delimited by a "*" ASCI CHR(48).

(c) Inside each event, the following Format(s) shall be allowed:

(i) It is the content that when interpreted by the AUTHORITY work order system, shall be

discrete the event differently based on distinctive content.

(ii) When the AUTHORITY W.O. system has finished importing the event data file, it shall

erase the file as delivered by the YMSS.

10.5 Each event shall be presented in the following three formats as stored in the maintenance file:

(a) Common Event format

Common Event Format

<equipID>< sw version><timestamp><event code><text><space><count>

*	a delimiter separating events st	1
<equipID>	Vehicle number installed on (5000)	4
< sw version>	current software version 8 characters	8
<timestamp>	Seconds since Apr 8, 1999,12:15:28=2.11790376928E+11	17
<event code>	descriptive event code 1 char sub-system leading letter	4
<text>	up to 40 characters of text	upto 40
<space>	a space ASC 32	1
<count>	event count (0 to 9999)	1to4 *
a delimiter separating events	1	

(b) Strip Chart Event Format

Strip Chart Event Format st

<equipID>< sw version><timestamp><event code><an><dg><rd><tr><ddd><sig><data><count>

*	a delimiter separating events	1
<equipID>	Vehicle number installed on (5000)	4
< sw version>	current software version 8 characters last char "c"	8
<timestamp>	Seconds since Apr 8, 1999,12:15:28=2.11790376928E+11	17
<event code>	descriptive event code 1 char sub-system leading letter	4
<an>	number of analog signals (00 to 99)	2
<dg>	number of digital signals (00 to 99)	2
<rd>	number of readings (currently up to 100)	3
<tr>	the trigger reading number (currently up to 100)	3
<ddd>	the actual char "ddd" to denote data dump strip chart	3
<sig>	signal names starting with 2 spaces then 4 alpha char	var
	names separated by commas with no last char comma.	
<data>	repeating sequence of time interval between last read	var
	value of analogs in order	
	Value of digitals in order	
	Where time is expressed in milliseconds (.004)	3
	Analogs is -11.0 to +11.0 where ASC(int(11/.1)+143)	1
	Digitals expressed in Hex each group of 8 is 00 toFF	2,4,6…
*	a delimiter separating events	1

(c) Speed Control System Event Format

Speed Control System Event Format

<equipID><SCS sw version><timestamp><event code><actspeed><cmdspeed ><location><space><count>

field	description	characters
*	a delimiter separating events	1
<equipID>	Vehicle number SCS installed on (5000)	4
<SCS sw version>	current software version 8 characters	8
<timestamp>	Seconds since Apr 8, 1999,12:15:28=2.11790376928E+11	17
<event code>	descriptive event code starting with “z”	4
<actspeed>	actual speed of vehicle in Kph	2
<cmdspeed>	commanded speed of vehicle in Kph	2
<location>	last known location id tag	6
<space>	a space ASC 32	1
<count>	event count (0 to 9999)	1to4
*	a delimiter separating events	1

10.6 By SEMP stage 3, the Contractor shall submit a complete Event coding for each sub-system for Approval. For those Event codes which are already in practice on existing AUTHORITY fleets, it shall be reused as long as the meaning is the same in order to ensure consistency.

11. Vehicle Numbering Conventions

11.1 The contractor shall ensue that all vehicle numbers shall follow the car numbers arrangement according to the table below:

Trainset Number	Car Numbers					
1	5381	5382	5383	5384	5385	5386
2	5391	5392	5393	5394	5395	5396
3	5401	5402	5403	5404	5405	5406
4	5411	5412	5413	5414	5415	5416
5	5421	5422	5423	5424	5425	5426
6	5431	5432	5433	5434	5435	5436
7	5441	5442	5443	5444	5445	5446
8	5451	5452	5453	5454	5455	5456
9	5461	5462	5463	5464	5465	5466
10	5471	5472	5473	5474	5475	5476
11	5481	5482	5483	5484	5485	5486
12	5491	5492	5493	5494	5495	5496
13	5501	5502	5503	5504	5505	5506
14	5511	5512	5513	5514	5515	5516
15	5521	5522	5523	5524	5525	5526
16	5531	5532	5533	5534	5535	5536
17	5541	5542	5543	5544	5545	5546
18	5551	5552	5553	5554	5555	5556
19	5561	5562	5563	5564	5565	5566
20	5571	5572	5573	5574	5575	5576
21	5581	5582	5583	5584	5585	5586
22	5591	5592	5593	5594	5595	5596
23	5601	5602	5603	5604	5605	5606
24	5611	5612	5613	5614	5615	5616
25	5621	5622	5623	5624	5625	5626
26	5631	5632	5633	5634	5635	5636
27	5641	5642	5643	5644	5645	5646
28	5651	5652	5653	5654	5655	5656
29	5661	5662	5663	5664	5665	5666
30	5671	5672	5673	5674	5675	5676
31	5681	5682	5683	5684	5685	5686
32	5691	5692	5693	5694	5695	5696
33	5701	5702	5703	5704	5705	5706
34	5711	5712	5713	5714	5715	5716
35	5721	5722	5723	5724	5725	5726
36	5731	5732	5733	5734	5735	5736
37	5741	5742	5743	5744	5745	5746
38	5751	5752	5753	5754	5755	5756
39	5761	5762	5763	5764	5765	5766

Note: Subject to the Engineer's confirmation by SEMP 2, flexibility for replacing the 5xxx series by one to three alphabetical series, e.g. ABCxxxx, shall be provided.

APPENDIX K PROVISION OF STATIONARY BATTERY CHARGER..... 2

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Appendix K Provision of Stationary Battery Charger

11. General

This Appendix specifies the requirements of the battery charger and discharging system for the Nickel-Cadmium batteries, hereafter called, the Charger, which shall be installed in the existing Battery Maintenance Facility at the Carhouse of the W Yard.

[1]

12. Schedules

Task	Activity	Weeks
1	Approval of hardware design	5
2	Approval of software design	17
3	Approval of complete Charger FAT	20
4	Full delivery of the Charger	25
5	Completion of Charger	30

Note:

[1] Numbers of week after the Option 6 – Provision of Stationary Battery Charger (refer to PS 3.10.6) has been executed between the Commission and Contractor under the Contract.

13. Background

3.1 The backup battery sets on the subway, streetcar and SRT vehicle fleets

require preventative maintenance and testing on a regular basis. This testing requirement is based on a current fleet size of 600 battery sets. That is 350 sets from subway/SRT vehicles and 250 sets from streetcars plus the battery sets (refer to PS 17.4.2) from the train (also known as the New Subway Train in this Appendix).

3.2 It is a requirement that, based on a 5 year cycle, one 8 hour shift per day and a 5 day work week, the existing productivity of processing of a battery set on every 2 days shall be maintained by using the Charger.

14. Definitions

4.1 Battery Cell Block – In certain battery sets the cells come in 2 cell or 3 cell packages called Blocks.

4.2 Battery Set – A specific number of cell blocks connected together to get the proper terminal voltage for the vehicle type. For example, an H6 battery set has two 3 cell blocks and ten 2 cell blocks for a total of 26 cells.

4.3 Test Stub – The software subroutine that controls a specific function of the whole battery set test. For example the subroutine that governs the discharge process.

4.4 Charge Rates - The current that a Charger supplies to the battery is normally expressed as a fraction of the theoretical current (for a given battery) needed to charge the battery completely in 1 hour. This theoretical current is called the nominal battery capacity rating and is represented as “C.” For example, a current of 0.1 C is that current which, in 10 hours, theoretically, would recharge the battery fully. The required charging rates for various styles of recharging shall refer to the battery manufacturer’s manual.

4.5 Thermal Runaway - If the constant current is applied past the point when the battery reaches approximately 85% of its fully charged state, the excess heat will cause “thermal runaway” to occur. Under thermal runaway conditions, the excess heat in the battery will cause its voltage to drop. The drop in voltage will cause the charge rate to increase, generating more heat and accelerating the cycle. The temperature and internal pressure of the battery will continue to rise until permanent damage results.

4.6 Operator - The qualified battery maintenance personnel of the AUTHORITY.

15. Scope of Work

5.1 The scope of work shall comprise, unless specifically excluded, the design, manufacture, supply, delivery, installation, testing, commissioning and rectification of defects during the 2 Years Warranty Period for the Charger and the associated equipment necessary to facilitate operation and maintenance of the battery sets which include special tools and testing equipment, spare parts and Operation and Maintenance Manuals and training, as specified in this Appendix.

5.2 The Charger shall be able to perform the following duties:

5.2.1 Normal duty: charging and testing two (2) battery sets simultaneously;

5.2.2 Peak duty: simultaneously testing and conditioning an additional two (2) battery sets; and

5.2.3 Conditional duty: charging, testing and capacity recovering an individual battery cell or one Battery Cell Block; or

5.2.4 Future duty: being expandable to simultaneously testing and conditioning up to eight (8) battery sets in the future.

5.3 The Charger shall be a service proven, automatic, computer-controlled, switching power electronic featured and self-contained.

16. Performance Requirements

6.1 The Charger shall be suitable for the cell chemistry of the specified battery sets.

6.2 Automatic protection against overcharging shall be provided.

6.3 The Charger design shall also match the required battery charging and discharing requirements within the desired time.

6.4 The power source shall be the AC mains i.e. three-phase 60 Hz, 208 V r.m.s. line-line.

6.5 The Charger may be integrated with the controlled electronics and computer for automatic controlling, monitoring and reporting purposes of battery charging and discharging functions.

6.6 The Charger shall incorporate a data logging facility in order to identify individual battery sets and store key data about their history.

6.7 Appropriate indication shall be provided to indicate the progress of the charge and warning messages.

6.8 Automatic charge control shall be provided in such a way that trickle charging shall be performed after a pre-selected time if the battery remains connected to the charger after charging has been completed. And the trickle charging shall be completed as a normal main charging routine.

6.9 All subassemblies of the Charger shall be modular in design and compatible with the standard 19” Eurorack cabinet system. The Charger shall be encased within an Eurorack cabinets with dual access from the front and rear by lockable door of 180º door opening angle. The front door shall be fully glazed with safety glass. The enclosures shall be constructed of 10 gauge steel. Seams shall be continuously welded and ground smoothly. Doors incorporate continuous hinges and EMI gaskets that shall be compressed by a three point latching system.

6.10 The enclosure for the electronics rack shall have the following characteristics:

6.10.1 The cabinet shall be built to NEMA 12 and be dust tight.

6.10.2 The size of the cabinet shall be approximately 27 in. wide by 31 in. deep. The overall height shall be 92 in. excluding cable inlet bracket at the top of the cabinet.

6.10.3 The effective mounting depth shall be minimum 20 in. The effective mounting width between the 19 in. mounting angle shall allow for mounting 19 in. standard equipment. The "effective" mounting width is the width between the mounting holes which is smaller than the physical width.

6.10.4 Both front and rear doors shall be left hand hinged open to 180 degrees and be removable. Three latch points shall be provided for each door. Gasket seal shall be non toxic and non flammable material.

6.10.5 The cabinet shall include four leveling wheels with locking device.

6.10.6 The cabinet shall be painted grey.

6.10.7 The cabinet shall meet the following requirements:

(a) Mounting dimensions to DIN 41494 part 1/EIA-RS-310C/IEC 297-1

(b) External dimensions to DIN 41488/IEC 297-2 and based on DIN 41494 part 7

(c) Protection type IP 40 to DIN 40050/NEMA 12

(d) Grounding to VDE 0806,VDE 0160 and VDE 0411 part 100 with grounding kit

6.10.8 Large opening with brush strips for cable ducts shall be provided at the top.

6.10.9 Two 110 VAC convenience outlet to provide power for additional testing equipment shall be provided.

17. Speific Requirements

7.1 The Charger shall meet the following requirements:

7.1.1 It shall be capable of giving accurate C_5Ah capacity ratings to 1.0 V per cell for each cell in the battery set. The capacity rating figures from the test at ambient room temperature shall also be provided adjusted to 5 °C (degrees Celsius).

7.1.2 It shall be capable of giving an accurate 1 hr, current capacity, to 1.0 V per cell at both room temperature and corrected to -20 °C.

7.2 The Charger control shall meet the following requirements:

7.2.1 The Charger control shall be an IBM© compatible workstation equipped with a software which shall be compatible with the operating system of Microsoft© Window® XP (or later version, if approved), to allow data access.

7.2.2 All extracted data shall be compatible with the commercially available database format of Oracle DataBase for Window® or an alternative specified by the Engineer.

7.2.3 The Charger control shall be able to store the data during Charger operation in realtime. The stored data shall be read out with the above workstation or external IBM® compatible notebook computer via a serial communication link. The data as stored shall include events counters and end-of-charge data. The events counters shall count the number of specific arising states, such as, system faults. The end-of-charge data shall store the end-of-charge voltage of the last 50 charge/discharge cycles, the loaded Ah number, and any faults that may have arisen. Evaluation of the events counter and the end-of-charge data shall enable the operator to draw sound conclusions from the operation of the Charger and batteries.

7.2.4 The workstation shall be Eurorack mounted Personal Computer with Intel® Pentium® IV 2.0 GHz, 256 MB of DDR-SDRAM, panel mounted 15.0” XGA TFT Active Matrix Color Display, integrated DVD & CD-R/RW Combo Drive, 1.44 MB Floppy Disk Drive, integrated 56K modem, and 40 GB Hard Disk Drive, and integrated 10/100 Ethernet. Slide-in features shall be provided for key board and mouse. A color laser printer for various paper sizes of letter, legal and executive shall be provided.

7.3 The Charger shall provide the following Charge control functions:

7.3.1 State of Charge (SOC) Determination. The Charger shall be able to provide information of the SOC of the battery or of the individual cells in the battery sets. This information shall be able to provide the operator with a reliable indication of the capacity left in the battery.

7.3.2 State of Health (SOH) Determination. The Charger shall be able to provide information of the SOH which is a measure of a battery's capability to deliver its specified output. This information shall be able to aid the operator for assessing the readiness of the battery sets and shall be a reliable indicator of whether maintenance actions are needed. The acceptable way to measure the SOH of a battery is by impedance testing or by conductance testing . Both of these tests shall be carried out without discharging the battery, but the monitoring device shall remain in place providing a permanent on line measurement. This shall allow the operator to have an up to date assessment

of the battery condition so that any deterioration in cell performance can be automatically detected and appropriate maintenance actions can be planned.

7.3.3 Cell Balancing Functions. In a battery set, small differences between cells due to production tolerances or operating conditions tend to be magnified with each charge / discharge cycle. Hence, weaker cells become overstressed during charging causing them to become even weaker, until they eventually fail causing premature failure of the battery. The Charger shall be able to provide battery cell balancing functions in oder to compensate the weaker cells by equalising the charge on all the cells in the battery set and thus extending battery life.

7.3.4 History Function. The Charger shall be able to provide monitoring and storing functions of the battery's history in order to estimate the SOH of the battery set. Parameters such as number of cycles, maximum and minimum voltages and temperatures and maximum charging and discharging currents shall be recorded for subsequent evaluation. This can be used as the tool to verify the capacity of the new subway train battery sets (refer to PS 17.4.3(h)(vi).

7.4 The Charger shall be able to charge and discharge the following battery sets:

7.4.1 Battery Set of the New Subway Train

7.4.2 T1 Subway Vehicles. SBM287E-1, per Saft data sheet: 25 blocks, 25 cells, Capacity – 287 AH, Discharge – 28.7 A, Overcharge – 34.7 A, Capacity Discharge – 48.8 A, Service Charge – 28.7 A

7.4.3 H6 Subway Vehicles. SBL199, per Saft data sheet: 10x2 cell blocks, 2x3 cell blocks, Capacity – 199 AH, Discharge – 19.9 A, Overcharge – 33.8 A, Capacity Discharge – 19.9 A, Service Charge – 33.8 A

7.4.4 CLRV Streetcars. SBM112, per Saft data sheet: 6x4 cell blocks, Capacity – 110 AH, Discharge – 11 A, Overcharge – 22 A

7.4.5 ALRV Streetcars. SBM287, per Saft data sheet: 6x4 cell blocks, Capacity –

170 AH, Discharge – 17 A, Overcharge – 34 A, Service Charge – 34 A

7.4.6 SRT. SM100, per Saft data sheet: 26 cells and two empty ‘dummy cells’,

Capacity – 100 AH, Discharge – 10 A, Overcharge – 20 A

7.5 The design of the Charger shall provide flexibility of battery configurations

for future change of battery cell block capacity, size or quantity of battery cells. Such that the operator shall be able to define and save new configurations, including the appropriate manufacture performance data as well as the graphical connection diagram. In order to aid the operator and ensure proper connections a graphical interface shall be provided to show the proper connections for each set type.

7.6 The Charger shall provide the discharge function. The discharge function shall include two modes of operation:

7.6.1 Equalization Mode

(a) When a battery set is to be tested and the state of charge is unknown, the Charger shall be able to allow the battery set to be discharged until the voltage across all cell falls to 1.0 Volt.

(b) And each cell shall not be allowed to discharge any further and shall be maintained at 1+/- 0.05 Volt until all other cells have reached that threshold.

(c) If a cell has an unexpected reaction and drops below 0.9 volts it is to be switched out of the circuit and the software shall indicate this state to the operator.

(d) When voltage across all of the cells has fallen to 1 Volt and the equalization process is complete, the initial voltage, final voltage and time to discharge for each cell shall be recorded in the history file as part of the history function.

7.6.2 Capacity Check Discharge Mode

(a) Capacity Testing. According to the battery manufacturer's recommendation, the Charger shall be able to program and carry out the constant-load test in order to determine the capacity of a battery. This test shall be conducted by connecting a predetermined load to the battery and then recording the amount of time needed to discharge the battery to a predetermined level.

(b) Assuming 100% receptivity, the Charger shall be able to recycle the battery discharging energy back feeding to the AC line. The recycled voltage distortion shall not be exceeded the 5% limit as set out in the IEEE Std 519-1992 "IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Chargers". Monitoring device complied with the IEEE Std 1159-1995 – "Recommended Practice on Monitoring Electric Power Quality" shall be provided to ensure the power quality of the recycled electricity. The guidelines of the power quality requirements according to the "FIPS PUB 94, Guideline on Electrical Power for ADP Installations. U.S. Department of Commerce, National Bureau of Standards", shall be followed where applicable.

(c) The operator shall be able to keep track of all cell capacities and produce an overall battery set capacity report based on the actual individual results. This report shall be viewed on screen, exported to a database file or printed to hardcopy, in such a way that it shall indicate the individual cell capacity and the resultant battery set capacity. Any cells that are below 75% capacity shall be flagged and announced to the operator via a graphical interface. Constant feedback of the test results shall be available to the operator in realtime.

(d) For those measured capacity of the battery set which is less than 80% of the rated capacity, the battery set shall be flagged as service required.

7.7 The Charger shall provide the charge function. The charge function shall include two modes of operation:

7.7.1 Service Charge Mode

(a) The battery set shall be charged using a constant current charging method until the voltage across all cells reaches the manufacturer's specification for that battery set type. The target voltage shall be configurable for future expansion. No single point failure of the Charger shall any cell be allowed to surpass the target voltage.

(b) As each cell reaches its full charge it shall be switched out of the charge circuit but remain monitored until all cells have reached the proper voltage. The Charger shall adjust the charge currents appropriately to maintain the manufacturer recommended charge rate on the remaining cells. If any cell voltage starts to decrease after it is switched out it shall be switched back in and brought back to the target voltage. The software shall record the time it took for the cell to initially reach the target voltage and record it in the history file and display it to the operator via the interface. When all cells reach their target voltage the battery set is fully charged and ready for duty. The software shall announce to the operator any cells that have a large variance in charge time from the rest of the set.

7.7.2 Capacity Check Overcharging Mode

(a) It is a requirement that in order to check the capacity of a battery set, it shall first be equalized and then overcharged. The battery set shall be charged at a rate corresponding to manufacturer specifications for overcharge. At the end of the appropriate charge time, any cell which has a voltage 20% lower than the target voltage shall be flagged and logged as a faulty cell. The charging cycle shall be considered as completed when all cells are at the proper terminal voltage.

(b) When the battery cells are disconnected from the battery set/block, the

Charger shall be able to charge all cells individually or isolate faulty cells to ensure one faulty cell does not stop the whole charge process.

7.7.3 The Charger shall be able to provide the following functions:

(a) Optimising the charging rate (a.k.a. Stabilising)

(b) Knowing when to stop (i.e. Terminating)

18. Software Requirements

8.1 Software requirements as specified in PS 29 shall be complied with.

8.2 It is a requirement that the Charger shall be fully automated by software and take a minimum of skill to operate. The order or combination of software test processes shall be configurable by a technical maintenance staff (who is not the operator). Specifically maintenance staff, with password access, shall be able to recombine existing stubs to create new stubs such as conditioning, charging, discharging, service charging, etc, as well as the ability to define (within reasonable limits) voltage and time parameters. This new test sequence can then be saved and then will be selectable on the top menu by the technical maintenance staff.

8.3 The Charger shall have a default flagging charge capacity of 80 %, which shall be operator settable to other percentage values.

8.4 The test data shall be related to a serial number and a work order number (refer to Appendix J) that is entered by the operator along with their employee badge number. The Charger shall track the work orders on battery sets by serial number and date. Historical data shall be stored in an industry standard database that is exportable and readable by existing AUTHORITY database programs. The database and format shall be approved by AUTHORITY.

8.5 The Charger shall be capable of networking to the YMSS fixed LAN (refer to PS 18.6) via CAT 5 cable for data backup, archive and access.

19. Workmanship Requirements

9.1 Wiring and Cabling

9.1.1 All wiring and cabling shall be designed and installed in accordance with the

requirements outlined in this document and the National Electrical Code of NFPA 70 “National Electrical Code, 1996 Edition. Massachusetts, National Fire Protection Association”.

9.1.2 All wiring and cabling shall be run in an orderly and efficient manner. All unused cabling shall be removed so as to avoid air-flow obstructions and to allow for future installations. Orderly cabling shall minimize the potential for disruption due to disconnection of cables when work is taking place.

9.1.3 Whenever possible, data and power cables shall intersect perpendicularly so as to minimize the potential for generation of disruptive electronic noise on

the lines. For the same reason, it is requirement to run data and power cables at least 6 inches apart when they are parallel. Cables shall not be cut in place and left inside the cabinet or on the floor.

9.1.4 Temporary extension cords shall not be used. Proper safety precautions shall be taken to ensure that all jumper cable or flying lead wires which are used for connecting the battery set and the Charger, shall not create any tripping hazard, and that they shall not be damaged.

9.2 Grounding:

All sub-assemblies or sub-racks of the Charger shall be grounded to grounding bus bars within the cabinet by way of copper braided ground straps. The grounding bus bar shall be in turn tied to the rails of the cabinet. The rails of the cabinet are connected to a threaded ground stud that shall be tapped through the case of the cabinet. The case of the rack shall be tied to copper detailing which runs above the cabinet. Cabinet to copper detailing connections shall be made by way of a copper braided ground strap. The overhead copper detailing shall be routed and terminated to earth ground of the room.

9.3 Cable Routing:

All cable routing shall ensure separation of power, control and signal cables, where practicable. Since a current carrying cable radiates magnetic and/or electric fields and therefore is a radiating source of EMI, proper cable routing of these cables limits the effects of cable to cable interference coupling, shall be assured.

20. Safety Requirements

10.1 The Charger shall observe, as a minimum, the following normal safety procedures:

10.1.1 It shall have short circuit protection.

10.1.2 It shall continuously monitor the state of the battery cells and ensure no overcharging takes place.

10.1.3 It shall alert the operator if the apparatus is connected incorrectly.

10.1.4 To avoid fire/explosion hazard due to spark, potential-free contact for controlling the Charger, shall be used.

10.1.5 For equalizing charging, it shall be necessary to actuate a key inside the charger before the battery is connected.

10.1.6 The safety functions of the Charger shall prevent damage to the battery.

Safety monitoring of the charging program shall be based on the charged Ah. The Charger shall be automatically switched off after more than 50% of the rated battery capacity has been charged, and a fault shall be displayed if this shall be happened.

10.1.7 Adequately rated circuit breakers shall be used to provide protection to the wiring and components of the Charger in the event of a short circuit or other condition that produces a sudden rise of current. The breakers shall be able to act as an on/off switch to remove power to the Charger subracks, shall any service work need to be done on one of these units.

10.1.8 Automatic detection circuit shall be provided, such as, temperature sensor or a voltage sensor, to detect when the battery is approaching the thermal-runaway conditions. When near the thermal runaway conditions are indicated, an alarm shall be issued to alert the operator and the Charger shall be automatically reduced or shut off the current entering the battery set.

10.1.9 The Supplier shall provide a hazard identification document for the supplied equipment in order to demonstrate the safety requirements are met.

10.2 Protection

The Charger power supply inputs shall be protected against surges and transients occurring on the source lines. The AC/DC converter modules shall be equipped with inrush current limitation, over and under voltage protection circuits.

10.3 Earthing

The Charger shall be designed for connection to earth ground. The internal subassemblies shall be strapped to the cabinet earth ground system such that

all chassis and frames have the same electrical potential at all times. During installation, the rack ground system shall be connected to the room grounding system prior to operation.

10.4 Other Safety Features

10.4.1 Connection of input power to the Charger shall strictly follow the Canadian electrical code regulations.

10.4.2 All exposed metal surfaces shall be grounded for personal safety. And all exposed metal surfaces shall be smoothed or deburred to prevent injury to

personnel due to contact. Surface temperatures shall not be of sufficient levels to cause burns or ignite adjacent materials.

10.4.3 Appropriate warning labels and covers shall be used for components and connections utilizing voltages in access of 85VAC. Potentials exceeding 300VAC shall not be presented.

21. Environmental Requirements

11.1 Operating Environment

11.1.1 The Charger shall be designed to be installed indoors and operate under the following environmental conditions:

(a) Ambient Temperature Range: Operating -20ºC to +70ºC

(b) Humidity: Operating Max - 95 % non-condensing, Min - 0 %

(c) Vibration: Operating 5 to 20 Hz - 0.07" p-p, 20 - 200 Hz 1.5 g p

(d) Shock: Operating Mounted (11 msec pulse) - 10 g peak

11.2 Non-operating Environment

11.2.1 The equipment is designed to withstand the following environmental conditions during non-operational circumstances.

(a) Ambient Temperature Range: Non Operating -20ºC to +70ºC

(b) Humidity: Non Operating Max - 95 %, Min - 0 %

(c) Vibration: Non Operating 5 to 20 Hz - 0.07" p-p, 20 - 200 Hz 1.5 g p

(d) Shock: Non Operating Shipping (11 msec pulse) - 10 g peak

11.3 Electromagnetic Compatibility

11.3.1 The Charger are tested to the following Electromagnetic Interference and

Compatibility (EMI/EMC) requirements:

(a) Mil-Std 461E, (Army Ground Equipment Category) including:

(i) Conducted Susceptibility (Audio Frequency, Radio Frequency, and Transient);
(ii) Conducted Emissions (Radio Frequency and Transient);

(iii) Radiated Susceptibility (Magnetic Field, Electric Field); and

(iv) Radiated Emissions (Magnetic Field, Electric Field).

(b) IEC 801-2 (EN 61000-4-2):

(i) Electrostatic Discharge.

(c) FCC Part 15:

(i) Conducted Emissions (Radio Frequency); and

(ii) Radiated Emissions (Radio Frequency).

22. Testing Requirements

12.1 Acceptance Testing

12.1.1 All sub-racks of the Charger shall pass the associated Factory Acceptance Test (FAT) to ensure correct operation. Separate FAT shall be carried out on each sub-racks first, then the FAT shall be completed on a fully assembled Charger. No FAT shall be carried out without prior approval of the associated FAT procedures.

12.1.2 For those sub-racks that are standard of the shelf items, they shall be tested independently or certified individually by the corresponding manufacturers.

12.1.3 Special test facilities and tools shall be specified in the corresponding FAT procedures.

12.1.4 The successful completion of an acceptance test at the Contractor's facility shall be required before delivery.

12.1.5 The acceptance test shall included, as a minimum, a total cycle test of two (2) battery sets as supplied by AUTHORITY.

12.1.6 All functions as listed above shall be successfully verified and validated.

12.2 Charge and Discharge Modes Test

The Charge/Discharge mode tests shall measure the ac energy consumed / regenerated during one charge and discharge cycle of the Charger operation. The power values shall be recorded during the test period at a fixed sampling interval, and the total duration of the test period shall be noted. The purpose of this test is to measure the efficiency of the Charger in a form of the extractable energy from the battery associated with the Charger.

12.3 On-Site Commissioning Test

Commissioning test shall consist of a total cycle test of two (2) battery sets supplied by AUTHORITY. There shall then be a 30 day run-in test period when AUTHORITY will use the equipment to test all of it features and functionality. Acceptance of the Charger is subject to successful completion of the above tests without any major defect found.

23. Documentation And Training

13.1 A Charger Design Manual document outlining the AUTHORITY requirements contained herein and how the Charger meets them, shall be provided for approval by AUTHORITY prior to delivery.

13.2 Four (4) sets of Operation and Maintenance manuals shall be supplied with the test equipment. They shall have 3 sections as follows:

13.2.1 Operational Procedures;

13.2.2 Hardware details, schematics, circuit descriptions and trouble-shooting procedures; and

13.2.3 Software description and flow charts.

13.3 A training program shall be provided for four (4) AUTHORITY personnel members on the operational procedures.

13.4 Training of a AUTHORITY designated trainer and Training Material shall be provided.

13.5 Warrantee of the Charger, its components and software shall be provided for a period of two (2) years, from commissioning acceptance.

24. Reliability And Maintainability

14.1 Reliability

14.1.1 The MTBF for the Charger shall be 8760 hours or 3 years of operation (8 hours per day, 365 days per year).

14.1.2 The failure rate shall be determined using the parts stress analysis method

of MIL-HDBK-217F in a ground fixed environment at 30ºC. It shall be a basic failure rate and therefore includes all parts serially.

14.2 Maintainability

14.2.1 For ease of maintenance and to improve the system availability, the sub-racks or sub-assemblies of the Charger shall be the LRU (refer to PS 26). Connectors shall be utilized to enable ease of installation and maintenance. The Mean Time To Repair (MTTR) for the Charger shall be 0.5 hours. For troubleshooting/maintenance purposes, any LRU can be replaced by a spare unit.

14.2.2 No special tools shall be required to remove or install LRUs.

14.2.3 The Charger shall be based on a proven technology that has been in use for a minimum of 2 years.

14.2.4 A list of recommended spare parts shall be compiled and included in the documentation supplied to AUTHORITY. The list shall itemize the components and quantities required for 2 years of normal operation based on the field experience.

25. Site Requirements

15.1 The following provision will be made by AUTHORITY:

15.1.1 The battery room will be emptied and ready for contractor's work for one month continuously after the delivery of the Charger is approved.

15.1.2 There will be different types of battery sets available for commissioning test. And the condition of these sample battery set under test will be kept in a reasonable states of charge for the purpose of meaningful tests.

15.1.3 There will be one qualified battery maintainer available for participating the commissioning test during normal working hours.

15.1.4 The typical power supply to be provided by AUTHORITY for the Charger are 115 Vac,

and 208 Vac, 60 Hz. A document stating the electrical and mechanical connections or interface required by the Charger shall be forwarded to AUTHORITY prior to its installation.

15.2 The intent of the above provision is to identify the minimum generic site requirements for the Charger. The Contractor shall be responsible for the identification and implementation of additional facility specific requirements and recommendations based on the site.

15.3 Prior to the installation of Charger, a final inspection shall be performed. All

electrical and mechanical systems shall be tested to ensure proper operation. Environmental conditions in the room shall be brought to optimal levels prior to the installation of the hardware.

15.4 All hardware shall be thoroughly inspected prior to installation. All packaging shall be examined for signs of physical damage to the packing materials. Any damage to the packing materials or evidence of water or fire exposure shall be noted on the shipping receipt. The equipment shall then be unpacked (at its final location) and visually examined to identify any damage to the unit itself. Any such damage shall also be duly noted prior to acceptance.

15.5 The hardware shall not be exposed to dramatic fluctuations in temperature.

The equipment shall be allowed to acclimate to conditions for at least 24 hours prior to installation.

15.6 The Contractor shall plan the access route from the delivery point to the installation area in order to ensure adequate clearance.