16 TRAFIC SIGNALS

16.1 GENERAL

16.1.1 Summary

1 This Part includes the provision of traffic signal equipment and related street furniture at controlled roadway junctions and pedestrian crossings.

2 For voltages and frequencies, regulations and requirements of Kahramaa and relevant authorities should be taken into account.

3 Related Sections

Section 1 .....General
Section 5 .....Concrete
Section 9 .....Mechanical and Electrical Equipment
Section 10 .....Instrumentation, Control and Automation
Section 21 .....Electrical Works

16.1.2 References

The following standards are referred to on this Part:
AASHTO Standard specification for supports for highway signs, luminaires, traffic signals

BS 88.....Cartridge fuses for voltages up to and including 1000 Vac and 150 Vac
BS 381C .....Specifications for colours for identifications
BS 1361 .....Cartridge fuses for a..c circuits in domestic and similar premises
BS 5493 .....Code of practice for protective coatings of iron and steel structures against corrosion.
BS 7430 .....Code of practice and regulations for earthing
BS 7671 .....Requirements for electrical installations

EN 1011 .....Process of arc welding carbon and carbon manganese steels
EN 12368 .....Road traffic signals
EN 13108 .....Fine cold asphalt
EN 60529 .....Degrees of protection provided by enclosures
ISO 1461 .....Hot dip galvanised coatings on iron and steel articles
EN 12899-1:.Fixed vertical road traffic signs
EN 12767: …Passive safety of support structures for road equipment – requirement, classification and testing methods
DIN 40050 .....Enclosures for electrical equipment
DIN 6163 Part 5 .....Diffusion lenses for traffic signals

QGEWC (E) Regulations for Electrical Installations
QGEWC (E) Regulations for Protective Multiple Earthing

16.1.3 Submittals

1 The Contractor shall submit to the engineer for approval shop drawings for each type of signal pole, gantry and mounting frame for signal heads to be provided under the Contract along with structural calculations. The drawings shall show materials specification and finishes for each component proposed for use. All weld types and sizes shall be identified on the shop drawings.

2 The Contractor shall submit to the engineer for approval design calculations for the proposed signal poles and gantries. The design calculations shall be carried out in accordance with the AASHTO Standard specification, EN 12767 or EN 12899-1 for supports for highway signs, luminaires, and traffic signals

3 The Contractor shall propose a design for the foundations for each type of signal pole and gantry and shall submit design calculations and drawings to the Engineer for approval.

4 The Contractor shall submit to the engineer for approval a schematic wiring diagram for all the installations. The Contractor shall also submit a wiring layout drawing for the cable loops and the cross-sectional details of the cut in the road surface.

16.1.4 Quality Assurance

1 Contractors for the works shall be experienced specialists in the field of traffic control systems with a minimum of 5 years experience of the installation, commissioning and testing of such systems in a similar environment.

2 The Contractor shall submit a technical submission for the proposed subcontractor giving details of previous installations date installed, client, technical data for proposed materials, and experience record of proposed installation staff, supervisors and management.

3 Installation of traffic signal equipment shall only be conducted by approved specialist subcontractors. The specialist subcontractors shall be approved by the PWA.

4 The performance and design requirements work shall be in compliance with QGEWC Regulations for Electrical Installations.

5 All equipment supplied shall, in general and where not in conflict with standards, conform to the same style, colours and functions as that already in place in Qatar. The supplier may be required to provide, at his own expense, samples of his proposed equipment.

6 All equipment and installation shall be in accordance with the latest edition of the Qatar Traffic Control Manual (QTCM). For all signalled intersections and pedestrian signal control crossings the timing sequence of signals displayed to drivers during phases shall be as per information given by the PWA and/or Traffic Police.

16.1.5 Delivery, Storage and Handling

1 Before delivering a traffic signal controller to site, the Contractor shall arrange a factory acceptance test in his workshop. The programmed and internally complete controller shall be connected to a labelled light board capable of simulating all traffic signal aspects controlled by that particular controller. The Contractor shall ensure that all equipment and devices are available to show that the controller fully complies with operational requirements. The factory acceptance test shall consist of the following checks:

(a) visual check of internal wiring and controller assembly
(b) operation of green conflict monitor
(c) intergreen times
(d) group times
(e) detector logic (where applicable)
(f) stage to stage change logic
(g) lamp switching.

2 The Contractor shall be responsible for the delivery of all items to the project site or to any site as required by the Engineer.

16.1.6 General Project/Site Conditions

1 All equipment and associated components shall be designed and suitably rated to ensure proper maintenance, continuous trouble free service under the prevailing climatic conditions. All equipment and installation shall operate satisfactorily in a temperature range of 0 °C to +55 °C and under humidity conditions ranging from 10 % to 100 %.

16.1.7 Warranties

1 All warranties and guarantees for traffic signal equipment shall commence from the day of commissioning. The warranty period shall be that as designated by the manufacturer but shall in any case not be less than 400 days

16.2 SUPPLY OF TRAFFIC SIGNAL EQUIPMENT

16.2.1 General

1 It shall be the Contractor's responsibility to ensure that all equipment supplied is approved. The Engineer will advise on approved suppliers.

2 It shall be the Contractor's responsibility to honour the designated warranty periods..

3 The Contractor, shall make himself aware of any lead times required for delivery of equipment and programme his works accordingly. It shall be the Contractor's responsibility to ensure that equipment is available as needed, any delays to works resulting from the unavailability of equipment shall be deemed to be the responsibility of the Contractor.

4 The Contractor shall be responsible for the correct delivery, storage and handling and storage of all equipment up to the time it is commissioned.

5 All equipment shall comprise of units of a type that have been used successfully in other installations in a similar environment, from a minimum period of six months and shall be subject to approval of the engineer. Particular attention shall be given in the selection and design of equipment and components to the exclusion of water, moisture and dust.

6 Components and materials that may perish and deteriorate in the climatic conditions of Qatar shall be avoided. All equipment shall be so constructed as similar units that shall be readily available and completely interchangeable both mechanically and electrically.

7 The location layout of each installation and the number of phases and stages for each traffic controller shall be as designated Controllers shall provide the signal sequences and phasing designated for each installation.

8 The structural design and traffic signal posts and traffic signal gantries shall be in accordance with provisions of AASHTO standard specification,EN 12767 or EN 12899-1 Supports for Highway Signs, Luminaires, Traffic Signals, or an approved alternative.

16.2.2 Identification of Equipment

1 The Contractor shall mark or clearly label all modules, units and main parts of a system with a functional code or title, type number, serial number as approved by the Engineer.

2 Marking shall maintain legibility throughout the life of the equipment under the prevailing environmental conditions.

3 The labelling system shall comply with the GIS system (as defined in the data dictionary) used by the Government of Qatar and the PWA.

16.2.3 Traffic Signal Posts

1 Traffic signal poles shall be of the tubular steel type with a flanged base, having an internal electrical termination point accessible through a lockable inspection window. The supply of a traffic signal pole shall include; holding down bolts, nuts, washers and shims required for erection; pole; terminal block; locking cover for inspection window complete with three sets of keys; all grommets; glands and cable anchor points. Where required by the Engineer, allowance should be made for passive safe products and/or poles which can be used with retention sockets.

2 Traffic signal poles shall have dimensions conforming to those given in the contract Drawings.

3 The traffic signal poles shall be of mild steel construction. Corrosion protection shall be through the use of a hot dipped galvanised coating conforming to the requirements of British Standard BS 5493 and ISO 1461, depth of galvanised coating shall be 85 microns. All welded connections shall conform to British Standard EN 1011.

4 The termination point shall consist of a terminal block positioned internally within the traffic signal pole. The terminal block shall be fully accessible through a lockable inspection window. The terminal block shall be securely fixed to the traffic signal pole.

5 The terminal block shall be electrically isolated from the traffic signal pole and shall have a minimum capacity of 2 x 20 No. connectors. Each connector shall have a minimum rated capacity of 100 watts at 240 volts.

6 The connectors on the terminal block shall be in compliance with the requirements of the QGEWC.

7 The traffic signal pole shall have the facility to secure incoming cables at a point prior to them being connected to the terminal block

8 The traffic signal pole shall be fitted with an electrical earthing stud, such that at least four earth connections can be made to it.

16.2.4 Traffic Signal Gantries

1 Traffic signal gantries shall be of the tubular steel type with a flanged base, having an internal electrical termination point accessible through a lockable inspection window. The supply of a traffic signal gantry shall include: holding down bolts, nuts, washers and shims required for erection; pole caps; terminal block; locking cover for inspection window complete with three set of keys; all grommets, glands and cable anchor points. Traffic signal gantry shall be styled in accordance with Contract Drawings.

2 The traffic signal gantries shall have minimum dimension conforming to those given in the Drawings. The design of the gantries is open to submission by the supplier.

3 The supplier shall provide full details of the materials used and the method of construction employed when quoting for this item, this shall include workshop fabrication drawings, material specifications and calculations pertaining to the structural design of the gantry. The gantry shall be capable of supporting three aspect traffic signal heads, each having a total weight of 25 kg, inclusive of mountings. The number and position of heads are to be as designated.

4 With regard to termination points, cable anchor points and earthing points, these shall be as specified in Section 6 Part12 of this Specification

5 The supplier shall furnish full details of the foundation requirements for his proposed gantry, this shall include details of dimensions, reinforcement, quality of concrete and fixings. Anchor bolts shall be Grade 8.8 and shall be hot-dip galvanized to ISO 1461.

6 The gantry and foundation design shall be such that the gantry is completely detachable from the foundation, should this be required.

7 The gantry shall have a system such that it can be adjusted subsequent to installation, to allow for leveling and turning.

8 The supplier shall furnish full details of the proposed foundation for his proposed gantry, this shall include details of dimensions, reinforcement, quality of concrete and fixings. The gantry and foundation design shall be such that the gantry is completely detachable from the foundation, should this be required. Anchor bolts shall be Grade 8.8 and shall be hot-dip galvanised to ISO 1461. The gantry shall have a system such that it can be adjusted subsequent to installation, to allow for levelling and truing.

9 The electrical termination point shall consist of a terminal block positioned internally within the gantry. The terminal block shall be fully accessible through a lockable inspection window. The terminal block shall be securely fixed to the gantry.

16.2.5 Three-Aspect Traffic Signal Heads

1 Three-aspect traffic signal head dimensions shall be as designated in QTCM. The Contractor shall submit drawings of the proposed units.

2 Signal heads shall comprise of a polycarbonate body containing three traffic signal aspects, coloured red, amber and green and shall include:

(a) lamps

(b) reflectors

(c) lenses

(d) transformers

(e) visors

(f) anti-phantom devices (if designated)

(g) brackets, frames and all fixtures and fittings required for mounting

(h) backing board.

3 Signal heads shall be constructed, in as far as is possible, out of high quality polycarbonate plastic. Any metal fittings shall be suitably protected against corrosion.

4 The design and construction of signal heads shall allow for all of the following features:

(a) hinged lens panels to allow quick access to the lamps

(b) flexible, detachable visors

(c) easily adjustable mounting system

(d) capability of internally fitting optical arrow mask.

5 The signal heads shall use, for each aspect, a 10 volt halogen lamp of type SIG 64015/1 - 50W or SIG 64015 - 50W. The lamp holder and connectors shall be compatible with the type of lamp used. The lamps shall conform to EN 12368. The supply voltage to the signal head shall be 240 volts (± 5 %) and shall be converted to the lamp voltage by the use of a standard design transformer (El Type). Each aspect shall have an individual transformer, these transformers shall be fitted with noise suppression equipment. The transformers will be required to operate in ambient temperatures up to 60° C. The transformers shall have a minimum operational life of five years with an effective switch-on ratio of 3300: 4380. utilised.

6 Where required by the Engineer, Extra Low Voltage (ELV) and /or LED systems shall be used.

7 Signal heads shall be capable of being mounted on the traffic signal pole or gantry as designated or, in the case of traffic signal gantry, as may be proposed by the Contractor. The mounting system used shall be such that no predrilling or permanent attachment of brackets to the signal pole or gantry is required. The mounting system shall be such that the signal head shall be capable of being adjusted through an arc of 30 degrees about its vertical axis. It shall be possible to mount two three-aspect traffic signal heads side by side on a single pole such that the vertical faces being presented to oncoming traffic of each head remain in the same plane. It shall be possible to mount the signal heads asymmetrical from the centreline of the pole. The signal head shall be rendered splash proof by means of an IP54 enclosure. The item description covering signal heads shall include, where necessary, extra mounting brackets to enable the above facilities.

8 The optical reflector shall be made of a high grade aluminium, mirror finished. Diffusion lenses shall be constructed with an internal cobweb pattern and shall be coloured red, amber or green as defined by the colour limits laid down in the DIN Standard DIN 6163 Part 5.

16.2.6 Two-Aspect Pedestrian Signal Heads

1 Two-aspect pedestrian signal heads shall have the designated dimensions as required by QTCM. The Contractor shall submit drawings of the proposed units.

2 Signal heads shall comprise of a polycarbonate body containing typical three signal aspects,coloured red,green and ambor ,and / or two pedestrian signal aspects, coloured red and green or combination of both and shall include:

(a) lamps

(b) reflectors

(c) lenses

(d) transformers

(e) visors

(f) anti-phantom devices (if designated)

(g) brackets, frames and all fixtures and fittings required to mount the signal head.

3 The material, electrical and mounting requirements for the signal head shall be the same as the requirements for the three aspect traffic signal head.

4 The optical requirements for the signal head shall be the same as the requirements for the three aspect traffic signal head with the additional requirement that each aspect of each two aspect pedestrian signal head be supplied with a 'Walking Man' and 'Stopping Man' optical mask.

16.2.7 Traffic Signal Controllers

1 Traffic signal controllers shall be microprocessor based and capable of meeting all the designated requirements in QTCM or project specifications. The Contractor shall submit drawings of the proposed units.

2 Supply shall include:

(a) basic control hardware including relays housings and cabinets

(b) all required additional modules and circuits

(c) all internal wiring

(d) all detector modules and control circuits

(e) plates, fixings and fastenings, glands, seals and clips.

3 The controller shall be provided with the following operational modes:

(a) computer control

(b) standby co-ordinated

(c) local mode with multi-plan operation

(d) flashing

(e) manual mode

(f) signal on/off mode.

4 Means will be provided within the controller housing to select and to test each of these modes of operation.

5 For pedestrian crossings the controller shall be capable of showing a green flashing man before the end of each pedestrian phase.

6 All controllers shall include a dimming feature.

7 Controllers shall be of a manufacturers type approved by the PWA and/or Traffic Police.

8 All equipment supplied shall be compatible with the existing traffic signal controllers in use in the state of Qatar.

9 Where the supplier cannot provide evidence of his equipment having been previously successfully used with the above traffic signal controllers, he shall be required to demonstrate, at his own expense, the compatibility of his equipment.

10 Traffic signal controllers shall be programmed as designated and as agreed with the Engineer. It shall be the Contractor's responsibility to provide competent personnel to programme the controller.

11 Each controller shall be supplied with full documentation which shall include :

(a) wiring diagrams

(b) timing charts

(c) intergreen tables

(d) stage diagrams

(e) any other relevant information relating to the operation.

Three copies of the documentation shall be supplied with each controller.

12 The controller shall be housed in the cabinet of sufficient size to accommodate the controller and all other associated equipment and shall provide easy access for maintenance and test purposes. The controller and associated equipment shall be arranged within the cabinet so that they will not interfere with the entry and exit cables. The cabinet to house signal controllers shall be constructed of aluminium sheet of thickness 3 mm in accordance with EN 12368 or with non-metallic materials where the properties for abrasion resistance, exposure to the elements are equal or better than aluminium cabinet. Cabinets shall be painted to a colour and specification agreed by the Engineer. The cabinet shall be weatherproof, rain proof and dust proof and be able to maintain proper operation of equipment. The Contractor shall construct a suitable foundation for the cabinet. and it shall allow for the entry and exit of all cables. The cabinet shall be secured to the foundation by anchor bolts.

13 The traffic signal controller shall be micro-processor based and capable of meeting all the requirements of the operational Specification and any further requirements as specified by the Engineer. The supply of a traffic signal controller shall include for: the basic control hardware including relays housings and cabinets, all additional modules and circuits required to meet the operational Specification, all internal wiring, all detector modules and control circuits, plates fixings and fastenings glands, seals and clips.

14 Traffic signal controllers shall be of an approved type and supplied by an approved manufacturer taken from the most recent list prepared by the Public Works Authority.

15 Traffic signal controllers shall be programmed according to the operational Specification and as agreed with the Engineer. It shall be the Contractor's responsibility to provide competent personnel to programme the controller.

16 The traffic signal controller shall also have the following capabilities:

(a) To give a flashing red pedestrian man before switching to a red man at the end of pedestrian cycle.

(b) The controller shall include a timing feature.

(c) The controller shall support two power supply inputs coming from two different substations. The purpose is to continuously operate the controller in case of power failure on one substation by automatically transferring to the other power supply input.

(d) The controller shall be made to ensure that the dual power supply input is stabilized at 240 volts.

(e) The controller can be operated manually.

(f) The controller shall be capable of providing flashing green before switching to yellow/amber at the end of vehicle green phase

(g) The controller shall be capable of providing continuous flashing yellow/amber.

17 Each traffic signal controller shall be fully documented, this shall include: wiring diagrams, timing charts, intergreen tables, stage, diagram and any other relevant information relating to the operation. Three (3) No. copies of the documentation shall be supplied with each controller.

16.2.8 Pedestrian Operated Push-Buttons

1 Pedestrian operated push-buttons shall comply with the requirements and regulations of the QGEWC.

2 The push-button shall include traffic signs as per the Qatar Traffic Control Manual either as an integral part, or be mounted separately on the traffic signal pole or gantry.

3 Push-buttons shall comprise of a metal or plastic body containing a push-button switch and an illuminated text panel in Arabic and English.

4 The unit shall have a light that provides confirmation after a pedestrian has pushed the button.

5 The dimensions and position of the push-buttons shall be proposed by the supplier and approved by the Engineer.

6 Push-buttons shall be constructed of metal or high grade plastics.

16.2.9 Flexible Traffic Signal Cable

1 Flexible traffic signal cable shall comprise of four cored, PVC coated, internal core PVC coated, cable. The cable shall be PVC sheathed wiring, catalogue description being NYM-J, page 2/3 or equivalent.

2 The cable shall be of a rated voltage and current carrying capacity suitable for the proposed cable runs. The Contractor shall submit calculations showing the voltage drop for the cable.

3 Cable shall be supplied in 500 metre lengths and wound onto a suitable cable drum.

4 Cable shall have a minimum cross-section area of the conductor in each core of 1.5 mm2 and the overall diameter of the cable shall be 11 mm. The individual core may be either solid or stranded. Each core shall be uniquely identifiable by coloured PVC sheathing.

16.2.10 Armoured Traffic Signal Cable

1 Armoured traffic signal cable shall comprise of a multi-cored (number of cores as specified), PVC coated, copper wire armoured, internal core PVC coated, cable. Catalogue description being, PVC-CWA-PVC or equivalent.

2 Cable shall be supplied in 500 m lengths, wound onto a suitable cable drum.

3 Cable may be supplied in three sizes, 7 core, 12 core or 19 core. The minimum area of the conductor in each core shall be 1.5 mm2. The individual cores may be either solid or stranded.

Each individual core shall be uniquely identifiably by either having a uniquely coloured PVC sheathing or by its PVC sheathing having a unique, repetitive marking.

16.2.11 Loop Cables

1 Loop cables shall consist of a heat resistant coated core cable. Loop feeder cables shall comprise of a communication type cable, PVC coated having six pair of individually coated cores. The Loop shall be manufactured by Never Fail Loop Systems.

2 Loops shall be constructed from polypropylene conduit with 9.5mm inside diameter and 16mm outside diameter. Conduit shall be filled with hot rubberised asphalt which allows the loop to remain flexible once cooled to prevent incursion of moisture and set the turns of wire firmly in place. Loops shall have 127mm expansion/contraction joints at intervals along the loop to allow for movement. Each expansion/contraction joint shall have a 229mm long schedule 80 polypropylene cover slide to be placed over the joint.

3 Lead-in wires shall be encased in a non-conductive 2250 psi flex hose constructed with a seamless extruded polyester fiber braid reinforcement and a non-conductive, seamless extruded urethane non-perforated jacket. Fill lead-in hose completely with hot rubberised asphalt. Twist wires in all lead-ins with a minimum of three turns per 305 mm for the entire length of the lead-in. Attach lead-ins to loop heads with a sch. 80 CVPC tee.

4 Loop cable shall have one individual core, the conductor of which shall have a cross-sectional area of 1.5 mm2. The loop cable such that the coating is able to withstand direct application of temperatures up to 175 °C.

16.2.12 Loop Feeder Cables

1 Loop feeder cable shall have six pairs of individual cores, each of which having a conductor of cross-sectional area of 0.6mm2. Each individual core shall be uniquely identifiable by either, having a uniquely coloured PVC-U sheathing or by its PVC-U sheathing having unique, repetitive marking.

2 The use of alternative types of cable may be permitted with the express written permission of the Engineer.

3 Each individual core shall be uniquely identifiable by either having a uniquely coloured PVC sheathing or by its PVC sheathing having a unique, repetitive marking.

16.2.13 Pulling Chamber Cover

1 Pulling chamber covers shall be of ductile iron.

2 The pulling chamber covers shall have a square opening of the dimensions shown on the project drawings.

3 The pulling chamber covers shall be inscribed with wording to identify the type of service and the system reference. The exact wording shall be to the approval of the Engineer.

16.2.14 Unplasticised Polyvinyl Chloride (PVC-U) Ducts

1 Unplasticised Polyvinyl Chloride shall be supplied in two different sizes, 2 inches diameter or 4 inches diameter (50mm or 100mm). The colour shall be dark gray. The PVC-U shall be either encased burial type or direct burial type. Catalogue description being, PVC-U Electrical Conduit & Tubing and Utility Duct, NEMA TC-6 or NEMA TC-8 or equivalent.

2 Unplasticised polyvinyl chloride ducts shall be supplied in 6 metre lengths with solvent weld socket on one end. The minimum wall thickness shall be 1.52 mm for 2 inches diameter and 2.08 mm for 4 inches diameter.

16.2.15 General Compatibility

1 All equipment supplied shall, in general, conform to the same style, colours and functions as that already in place in Qatar. The supplier may be required to provide at his own expense, samples of his proposed equipment. These samples shall become the property of the PWA, whether or not an order is placed.

2 All equipment supplied shall be compatible with the approved traffic signal controllers and supplied by an approved manufacturer according to the most recent approved list of the PWA.

3 Where the supplier cannot provide evidence of his equipment having been previously used successfully with the above mentioned traffic signal controller, he shall be required to demonstrate, at his own expense, the compatibility of his equipment.

16.3 INSTALLATION OF TRAFFIC SIGNAL EQUIPMENT

16.3.1 General

1 It shall be the Contractor's responsibility to ensure that all traffic signal installation work is conducted by skilled, competent personnel.

2 The Engineers approval of any subcontractor or individual personnel in no way relieves the Contractor of his responsibility to ensure that traffic signal equipment is correctly installed.

3 The Engineer shall reserve the right to inspect and approve all installation practices.

4 Installation of traffic signal equipment shall only be conducted by approved companies taken from the most recent list prepared by the PWA.

16.3.2 Poles, Gantries and Signal Heads

1 Signal posts and gantries shall be installed onto their prepared foundations, using two levelling nuts or an appropriate fixing method approved by the Engineer. The pole or gantry shall be plumbed square, irrespective of the orientation of surrounding features.

2 The Contractor shall take every precaution to prevent damage to the pole or gantry's protective coating, during installation. Where the protection is damaged or breached the Contractor shall take immediate action to make repairs.

3 Where designated, posts and gantries where necessary shall be painted with an approved paint, colour grey (BS 381C) before installation of signal heads and push-buttons..

4 Signal heads and push-buttons shall be installed as shown on the contract drawings. Final positioning and fixing shall not be undertaken without the Engineer's approval.

5 Signal heads, once fixed, shall be covered with an opaque protective material such that it is clear to motorists that the signals are not in operation.

16.3.3 Installation of Traffic Signal Controller

1 The Contractor shall install the controller housing in the position defined by the Engineer. The Contractor shall ensure that the housing is positioned so that when the access doors are opened to their fullest extent they will not obstruct the sidewalk or cause a danger in any way to members of the public. The housing shall not be positioned adjacent to the kerb as to render it liable to damage by vehicles or so that the safety of persons working on the controller is not endangered.

2 The Contractor shall organise the connection of the electricity supply to the controller housing and any other peripheral equipment requiring an electricity supply by direct liaison with the QGEWC (E) Consumer Section. The Contractor shall ensure that the power supply is contained within its own separate duct, up to the point at which it enters the controller housing. The electrical supply shall at no point share the same ducts or chambers as the traffic signal cabling. The Contractor, where necessary, shall be responsible for providing any housings required for QGEWC apparatus. Where a separate housing is required it shall be positioned directly adjacent to the controller housing.

3 The Contractor shall endeavour to complete as much of the internal wiring of the controller as possible inside his workshop, such that on-site work within the controller housing are kept to a minimum. All external cables terminating within the controller shall be clearly labelled as to their function, destination and nominal voltage. These cables shall, on entering the controller housing, be clamped and supported such that any stress or strain on the cables themselves shall not be transmitted to the controllers internal components. Spare or redundant cables entering the controller housing are to be terminated in such a fashion that they do not interfere in any way with access to the controllers internal components. The conductors of these cables are to be electrically isolated and sealed against the ingress of moisture.

16.3.4 It shall be the Contractor's responsibility to provide all competent personnel and specialist equipment to enable the controller to be programmed. Cabling

1 The Contractor shall install all cables in the ducts as designated. He shall take all reasonable care to ensure that no undue stress or strain is placed on the cable during installation and shall adhere to the cable manufacturer's published data with regard to allowable minimum radius of curvature. The Contractor shall ensure that duct drawstrings remain in place subsequent to cable installation.

2 A single dedicated cable shall service each individual traffic signal pole. This cable shall be of the designated size and shall have a minimum of 10 % spare capacity. On entering the signal pole the cable shall be firmly anchored to the pole. At least 3 m of spare cable shall be allowed for within the signal pole, over and above that length which is required to reach the termination block.

3 Spare or redundant cores within the cable shall be terminated at the termination block and labelled 'Spare'. The core acting as earth protection shall be connected directly to the body of the signal pole by means of the pole's earthing stud. The cable armouring shall not be used as the protective earth conductor.

4 With the exception of loop cable to loop feeder cable connections, the jointing of cables shall not be permitted. Where jointing of the cables is permitted, this shall be undertaken using a suitable jointing kit of an approved type which allows the integrity of the protective earth conductors to be maintained. Loop cable to loop feeder cable joints shall only be located within an access chamber.

16.3.5 Circuit Protection and Earthing Requirements

1 The Contractor shall provide protection against dangerous earth-leakage currents by the use of fuses or excess-current circuit breakers compliant with the QGEWC (E) Regulations for Electrical Installations. The Contractor shall ensure that all installations shall be such as to allow for the operation of the protective devices to operate upon the occurrence of a fault within the time period specified for fixed equipment installations and that all non-current carrying metallic parts shall be connected to the earth terminal in such a manner as to ensure that a hazardous voltage cannot exist on exposed conductive metalwork. All cabinets, posts and other metal hardware comprised by the traffic signalling equipment shall be bonded via protective conductors to the main earth terminal with an earthing conductor to the main terminal by a protective conductor.

2 The main earthing terminal or bar shall comply with QGEWC (E) Regulations for Electrical installation and shall be connected to the earthing point provided by the QGEWC (E) with a copper earthing conductor in accordance with the Regulations. It shall have a minimum cross-sectional area of 6.00 mm2 and shall be green/yellow stripe coded. The earthing conductor is defined as a protected conductor connecting a main earthing terminal or bar of an installation to an earth electrode of other means of earthing. Where a residual current circuit breaker is used, the cross sectional area of the earthing conductor shall comply with the requirements of QGEWC (E) Regulations.

3 The connection to metalwork shall be made internally to a secure terminal on a part of the enclosure which is a permanent fixture. The terminal shall be constructed of a material which will minimise chemical corrosion resulting from contact with the protective conductor or other metal part. Conductor terminations shall be by the use of soldered or crimped connectors or screwed terminations, or other approved methods.

4 Earth and other protective conductors shall be selected and installed so that they comply with the QGEWC (E) Regulations for Electrical Installations, the BS 7430, BS 7671 and the Regulations for Protective Multiple Earthing where appropriate. All protective conductors shall be colour coded green/yellow stripe. Where protective conductor is part of a multicore cable and a green/yellow stripe colour coded core is not available, the Contractor shall ensure that the protective conductor is adequately identified. Each cable shall enter the controller housing via a stuffing gland in the gas plinth gland plate. The stuffing gland shall be so designed as to prevent the diffusion of gas and support the cable. The earth stud of the cable terminator shall be correctly bonded to the earth bar in accordance with the QGEWC (E) Regulations, using a 6.00 mm2 conductor (2.50 mm2 for loop feeder cables).

5 The earthing requirements at the head of each traffic signal pole shall be as follows:

(a) the earth terminal of the gland, shall be connected to the earth terminal of the pole with a protective earth conductor correctly terminated with crimp connectors and having a minimum cross-sectional area of 6.00 mm2

(b) the protective conductors from each signal head, pedestrian head, push-button unit or other equipment shall be connected together at the head of each pole and connected to the earth terminal in the controller housing by means of one dedicated core of the armoured signal cable servicing that pole

(c) the earth connection at the head of the pole specified in (b) above, shall be connected to the earth stud of the pole with a bonding conductor having a minimum area of 6.0 mm2 and by means of a crimped connector, or similar

(d) push-button units fixed to a signal pole shall be earthed to the earth stud of the pole with a separate protective conductor terminated with crimp connectors and having a minimum cross-sectional area of 6.00 mm2

(e) There shall be electrical connections by means of conductors having a copper equipment cross-sectional area of not less than 6.00 mm2 between the earthing terminal and all metal structures, metal pipes and other metalwork (not being metalwork forming part of a telegraphic, telephone or signalling circuit) which

(i) are, or may reasonably be expected to become, in electrical contact with the general mass of earth

(ii) are so situated that simultaneous contact may reasonably be expected to be made by any person with such structures, pipes or other metalwork (or any metalwork in electrical contact therewith).

These connections shall be made as near as practicable to locations where users or maintenance staff approach the facility.

16.3.6 Permanent Electrical Power Supply

1 The Contractor shall be responsible for liaison with QGEWC (E) to provide a power supply to the traffic signal controller and shall be responsible for all works required to provide this supply.

2 The electricity supply shall be 240 V AC 50 Hz single phase.

3 The Contractor shall organise, with the approval of QGEWC (E), one of the following earthing systems:

(a) TN-S System. Where QGEWC (E) will provide an earthing point which affords a continuous metallic return path to the earth of the supply system. The Contractor's earthing conductor shall be connected to this point

(b) TN-C-S System (PME). Where QGEWC (E) will provide a combined neutral earth supply. The earthing Contractor's earthing terminal and a lead from the earth terminal shall be left available for the QGEWC (E) to connect to the incoming supply. A similar neutral conductor lead shall also be left available for the same purpose

(c) TT System. Where a means of earthing will not be provided by the QGEWC (E) the earthing terminal will be connected to an effective earth electrode compliant with the QGEWC (E) Regulations for Electrical installations. Where the TT System is provided by the QGEWC (E) the Contractor shall install an earth leakage circuit breaker to comply with the QGEWC (E) Regulations.

4 The Contractor shall ensure that the equipment complies in all respects with the regulations and requirements of the QGEWC (E).

5 The Contractor shall be responsible for all cable laying and jointing.

6 It shall be the responsibility of the Contractor to inform the Engineer of the earliest date when he will be ready for the QGEWC (E) to make the service connections.

7 The Contractor shall supply the equipment to be terminated to the QGEWC (E) service with phase and neutral conductors of not less than 4 mm2 and earthing conductor of not less than 6 mm2. The QGEWC (E), shall connect the controller conductors and earth conductor to the terminal provided by the QGEWC (E).

8 The QGEWC (E) cut-out shall incorporate a high breaking capacity fuse carrier and fuse to BS 88 or BS 1361 of the correct rating. The rating shall be specified by the Contractor to comply with the type requirements of the QGEWC (E) Regulations. The maximum permissible earth fault loop impedance shall be those stated in the QGEWC (E) Regulations.

16.3.7 Inductive Loops for Vehicle Detection

1 Slot cutting shall be carried out by a specialist subcontractor. The Contractor shall be responsible for marking out all slot configurations and shall supervise the work of the subcontractor. The slot cutting subcontractor shall make arrangements to provide an adequate water supply to enable him to carry out the necessary works. The approximate position of inductive loops and route of feeder cables will be as designated. The Contractor shall specify the loop configurations at each site, the detailed layout of individual loops and the number of turns per loop. This information shall be supplied to the Engineer. When loop configurations are specified by the Engineer, such information as required will be supplied to the Contractor. In order to obtain a high standard of installation, the Contractor's staff and subcontractors shall be fully briefed by the Contractor and given written instructions describing the technical requirements of this specification and method of installation. This shall cover depth and preparation of slots, backfilling, jointing, ducting under kerbs, earthing and commissioning of equipment.

2 Subsurface detector housings for loop detection equipment are not acceptable to the Engineer. Detector housings shall be positioned so as to reduce the possibility of damage in the event of a road traffic accident and shall not present an obstruction or visual intrusion. In cases of doubt, the advice of the Engineer shall be sought. Positions of detector housings shall be to the approval of the Engineer. Where a remote detector housing is used, each one shall be connected to the controller by 'Twinflex' cable. The cable will be ducted to the controller unless the Engineer's agreement is obtained to cutting a slot in the carriageway. Voltages on this cable shall not exceed 50 V AC or 120 V DC whether between conductors or to earth. The Contractor shall provide two sets of keys to all equipment housing supplied as initial issue. The Contractor shall be responsible for removing all surplus materials from site at the completion of the works.

3 The cable specified may in exceptional circumstances be replace with an armoured multicore cable (i.e.. triple vehicle extensions with speed discrimination) double vehicle extensions with speed assessment. The cable specified shall be terminated at the controller with a cable gland or castellated bar approved by the Engineer. The gland shall be bonded to the earth point using a 4 mm2 flexible earthing cable terminated with crimp connection tags. The remote end of the cable shall be connected to the plate and 4 mm2 flexible earthing cable terminated with crimp connection tags or by other means approved by the Engineer. In addition one core of the armoured cable shall be used as an earth continuity conductor and shall be bonded to the earth point on the controller and to both the equipment earth and the metalwork of the housing at the remote end of the cable. The cable specified shall be provided with a minimum of 25 percent spare conductor capacity (armoured and non-armoured multicore cables only).

4 The detector shall operate satisfactorily with a feeder up to 100 metres in length. The feeder is defined as the cable between the loop tails and the detector housing. Where adjustments are required to sensitivity and presence time, these shall be made during initial setting-up and no further adjustments shall be necessary. The equipment, including loop and feeder, shall operate correctly within all carriageways of reasonable condition without any reduction in performance as follows:

(a) air temperature (-10°C to 60°C)

(b) relative humidity up to 100 % (non-condensing)

(c) carriageway flooded under 1 cm water, or dry

(d) carriageway subjected to continued heavy use by buses and heavy goods vehicles

(e) sidewalk and kerbs subjected to misuse by vehicles

(f) feeder assumed to be buried in soil or sand which may be dry or wet

(g) the detector shall not operate from electrical noise pick-up on the loop or feeders.

5 Slot-cutting operations shall not be conducted in wet weather. Wet weather to be defined as such conditions where the Engineer considers it would be unsafe to carry out slot cutting operations. Slots shall be cut using a motorised machine fitted with a diamond saw blade. The layout of the loop configuration shall avoid areas of poor reinstatement in the road surface caused by other roadworks or works. Slots shall be cut at least one metre from any such disturbance. Slots shall be cut at least one metre from any ferrous objects such as manhole covers. In concrete road surface, the Contractor shall not cut slots less than 1.5 metres from transverse joints between adjacent concrete sections. The depth of loop slots shall be (50 + 7.0 n) mm with a tolerance of + 10.0 mm / - 0.0 mm. In concrete surfaces the depth shall be (25 + 7.0 n) mm with a tolerance of + 5.0 mm / - 0.0 mm where 'n' is the number of cables and the first figure is the minimum depth of cover. The depth of each slot shall be checked with a depth gauge along the whole length of the slot. The Contractor shall ensure that there are no irregularities in the base of the slot. Where an angle more acute than 13 degrees in formed at the junction of two adjacent loop slots, then the slot junction shall be truncated with a saw cut at the apex of the junction; i.e., one blade thickness from the inside edge of the slot corner, and this cut shall be to the same depth as the adjoining slots. The junction shall not be truncated with a cold chisel. Slots cut for feeder cables shall be 20 mm wide (core cables 25 mm) with a tolerance of 3 mm, to give a cover of 65 mm in bituminous surfaces (45 mm in concrete surfaces) with a tolerance of + 10.0 mm / -0.0 mm. Only one feeder cable shall occupy each slot.

6 The loop feeder cables shall take the most direct route to the indicated cable chamber. This slot is specified as being 20 mm wide, therefore care shall taken not to obliterate any road markings in whole or part. In the first instance the most direct route from the loop position to the kerb line shall be taken. The loop feeder cables shall be joined in the carriageway only with the approval of the Engineer. The joint slot shall be 10 mm wider and 10 mm longer than the overall dimensions of the completed joint. The depth of the slot shall be sufficient to give a minimum 40 mm cover above the joint. The joint slot shall be positioned either at a traffic lane boundary or at crown of the road so that it is not subjected to the maximum stresses exerted by road vehicles. Each loop shall be separated from adjacent loops by a minimum of 100 mm. The Contractor's supervisory staff shall check the quality of workmanship before laying cable and backfilling. All debris and slit shall be cleared from the base of the slot and the slot blown dry with compressed air before cable laying.

7 For laying loop cables the cable shall be dry before installation. The Contractor shall ensure that the cable lies evenly in the bottom of the slot, and shall secure the cable in such a position if necessary. Sharp implements shall not be used to seat the cable in the slot. Loop tails shall not extend more than 20 metres from the loop before being joined to the feeder cable. Loop tails shall be twisted. Each twisted tail shall have a dedicated slot to the joint with feeder cable. Loop tails shall normally be joined to the feeder cable within cable inspection chambers. Cables shall not be bent to a radius of less than 12 times their diameter or less than a radius recommended by the manufacturer whichever is the greater. Where cables enter the sidewalk a small area of carriageway is to be excavated and a uPVC duct laid through the kerbs for each feeder cable. The duct shall be level with the base of the slot from which the feeder cable emerges. The excavated area shall be backfilled with fine aggregate concrete to the duct invert level. The cables shall then be backfilled with compacted fine cold asphalt and hot oxidised bitumen R85/40. The kerb stone shall be reinstated. Feeder cables in soft verge or beneath sidewalks are to be laid in ducts at a minimum depth of 500 mm below ground level unless otherwise specified by the Engineer. Feeder cables laid unducted in trenches shall be laid on a 75 mm bed of sand free from stones and other sharp materials with a further 75 mm of similar sand placed over the cable. Where feeder cables are laid unducted in soft verges, the cable position shall be indicated with a plastic warning tape laid at a depth of 150 mm to 200 mm from ground level and vertically above the cable. The tape shall be printed with suitable warning message repeated at one metre intervals. Where feeder cables are required to cross French drains or other coarse bed materials in central reservations, the cable shall be looped and protected with flexible plastic ducting. Ducting is to be provided by the installation Contractor.

8 Cable joints shall be approved by the Engineer. Feeder cables shall be electrically connected to the loop tails with insulated crimp connector using a ratchet type of crimping tool. The Contractor shall ensure that the cable conductor has been correctly crimped by visually checking the cable and also by applying a vigorous pull test to the cable on either side of the joint. The electrical connectors shall be encased in a joint approved by the Engineer and the Contractor shall ensure that the connectors are staggered to avoid the possibility of any short circuits. The Contractor shall ensure that any instructions issued by the cable joint manufacturer are provided in writing to his installation and supervisory staff. These instructions shall form part of this specification. The Contractor shall ensure that the joint is waterproof before backfilling. With the exception of cable joints between loop and feeder cables, no other joint shall be permitted in the loop/feeder configuration. Cables shall be terminated in the controller or detector housing using terminal connection blocks which are adequate in size for the diameter of conductors used. Screws shall not bear directly onto conductors, either a protective leaf in the terminal or a crimped pin on the end of the conductor shall be used.

9 Immediately before backfilling, the Contractor shall ensure that all slots are clean and dry and that all silt and debris has been removed from the base of the slot. Loop slots shall be backfilled with a low viscosity epoxy resin, approved by the Engineer, to give a minimum of 10 mm cover above the uppermost cable. The resin specified shall be poured at a viscosity of between 500 and 1000 pascal seconds. The Contractor shall provide the Engineer documentary evidence from the resin manufacturer of the temperature necessary to achieve this viscosity. The Contractor shall satisfy the Engineer, before epoxy resin operations commence, that the specialist subcontractor's on-site equipment is able to raise the epoxy resin and maintain it at the temperature necessary to achieve the viscosity specified. The remaining volume of loop slot shall be backfilled with blown grade hot oxidised bitumen to the level of the road surface. Feeder cable slots shall be backfilled with fine cold asphalt compacted around the cable. The upper 20 mm of the slot shall be filled with hot oxidised bitumen. Joint slot shall be backfilled with epoxy resin to a level 10 mm above the completed joint. The remaining volume shall be filled with hot oxidised bitumen. The hot oxidised bitumen specified shall be heated to a pouring temperature of 185 °C and shall be poured from an enclosed container which shall be preheated before use. The fine cold asphalt specified shall comply with the requirements of EN 13108. The asphalt shall be soft and easily worked when applied, and shall be hand compacted to the satisfaction of the Engineer. Alternative compounds proposed by the Contractor shall be approved by the Engineer.

10 The contractor shall be responsible in determining the exact location of the loops and shall supervise the work of the sub-contractor. The sub-contractor shall mark the locations of the performed inductive loops. Each shall be separated from adjacent loops by a minimum of 100mm and shall be laid on top of the road base or 230mm form the road surface.

11 The cable shall be dry before installation. The sub-contractor shall lay the performed inductive loops and stretch it as per the marked locations. The T-joint of the loops shall be positioned to the nearest chamber/pull box/detector hand hole. The loops shall be fixed by using a clamps and nails to achieve the desired shape

12 The loop wires from the preformed loop to the adjacent chamber/pull box/detector hand hole shall be twisted together into a pair with minimum of three turns per 305mm and encased in polypropylene conduit and/or 2250 psi hydraulic hose between the performed loop and the adjacent chamber/pull box/detector hand hole. Lead-in conduit shall be 100% injected with hot asphalt sealant to prevent the entrance of water at the chamber/pull box/detector hand hole.

13 Asphalt shall be manually laid around the loops to protect it from the pavement machine/equipment.

14 Upon completion of the installation works, the Contractor shall lay the asphalt on the entire carriageways by using the approved pavement machine.

15 Each loop shall be tested sequentially by three methods: by megger (measured by mega ohms), by resistance (in ohms), by inductance (measured in micro henries).

16 In case of existing pavement, a groove shall be cut by using a slot cutting machine. The frames and home-runs shall be placed into the cuts. The cuts shall be filled with hot melted asphalt-rubber sealant conforming to the manufacturer's recommendations.

17 All the installation works shall conform to the manufacturer's specifications.

16.4 TESTING AND COMMISSIONING

1 Before delivering a traffic signal controller to site, the Contractor shall arrange a factory acceptance test in his workshop. The programmed and internally complete controller shall be connected to a labelled light board capable of simulating all traffic signal aspects controlled by that particular controller. The Contractor shall ensure that all equipment and devices are available to show that the controller fully complies with operational requirements. The factory acceptance test shall consist of the following checks:

(a) visual check of internal wiring and controller assembly

(b) operation of green conflict monitor

(c) intergreen times

(d) group times

(e) detector logic (where applicable)

(f) stage to stage change logic

(g) lamp switching.

2 All traffic signal equipment shall be commissioned to the satisfaction of the Engineer.

3 It shall be the responsibility of the Contractor to supply all equipment and personnel required to commission the traffic signal equipment.

4 On completion of installation, and before commissioning, the Contractor shall undertake the following tests to the satisfaction of the Engineer and in accordance with the QGEWC (E) Regulations.

(a) visual inspection

(b) continuity test of all protective conductors

(c) insulation resistance test; insulation resistance shall not be less than 100 megaohms

(d) polarity check

(e) earth loop impedance test.

5 Where a residual current circuit breaker is installed, tests in accordance with the QGEWC (E) Regulations shall be complied with. The Contractor shall provide the equipment necessary to complete the tests and shall provide all other test equipment to demonstrate that the installation is compliant.

6 After the traffic signal and controller equipment is installed on site and after it is connected to all its associated equipment, the Contractor shall arrange for a site acceptance test. The site acceptance test will recheck all the points covered in the factory acceptance tests and in addition shall include visual and electrical tests on all posts, gantries, heads, push-buttons and cabling. The Contractor shall ensure that the area of site covered by the installation being tested is cleared of all debris, plant and machinery. The Contractor shall be responsible for the supply of any personnel required to conduct the site acceptance test. The Contractor shall provide any vehicles required to conduct the site acceptance test. The Contractor shall ensure that all equipment and devices are available to show that the controller fully complies with the operational requirements.

7 Each loop and feeder configuration of the vehicle detection system shall be tested as follows and the results given in a test certificate for the loop installation. This certificate shall include all pertinent information for the testing. The Contractor shall submit a pro-forma certificate to the engineer before carrying out the commissioning.

(a) With the loop circuit disconnected from the detector, the impedance to earth of the two loop and feeder conductors shall be measured at a test voltage of 500V DC applied for at least one minute. This shall not be less than 10 megaohms. The two ends of the loop circuit shall be connected together for this test

(b) With the armouring of the feeder cable disconnected from the earth point, the impedance to earth of the armouring shall be measured at a test voltage of 500V DC applied for one minute. This shall not be less than 10 megaohms

(c) With the armouring of the feeder connected to the earth point of the equipment housing, the impedance to earth of the armouring shall be measured. This impedance shall not be greater than 0.5 ohms

(d) The inductance of the loop and feeder circuit shall be measured. This shall be comparable with the theoretical value previously supplied to the Engineer

(e) The frequency of operation of each configuration shall be measured. Where two loop circuits share a common feeder cable their frequency of operation shall be separated by at least 5 kHz

(f) The Contractor shall adjust the sensitivity and presence time of each detector to the requirements specified by the Engineer. The Contractor shall demonstrate correct operation of the detector at the sensitivity specified

(g) The Contractor shall ensure that an inductance change caused by vehicles in one loop shall not induce spurious observations in any adjacent loop system.

8 Any loop or feeder which fails these tests shall be replaced by the Contractor at his expense.

9 Upon satisfactory completion of the factory acceptance and site acceptance tests, and when the Engineer is fully satisfied that correct installation and adherence to the operational requirements has been attained. The PWA will issue a final commissioning certificate. The installation, or any part thereof shall not be opened to general traffic until this certificate is received.

16.5 GUARANTEED MAINTENANCE OF TRAFFIC SIGNAL EQUIPMENT

16.5.1 General

1 During the initial maintenance period complete record of component failures shall be kept by the Contractor in order to provide information on the reliability of various components.

16.5.2 Operational Maintenance

1 The Contractor shall provide full operational maintenance coverage for a period of 400 days subsequent to the issuance of the final commissioning certificate.

2 The Contractor shall use only maintenance contractors approved for this work by the PWA.

3 During the maintenance period, the Contractor shall be responsible for providing coverage for the following:

(a) Replacement or repair and installation of any failed equipment

(b) Daily corrective maintenance

(c) Quarterly maintenance

(i) Check the cycle length, green time, intergreen time and all other signal timing parameters as given in the timing chart.

(ii) Check the timings of the different signal programmes and test the switch over them manually and by time clock.

(iii) Test loop detectors for activation and re-tune if necessary.

(iv) Test ELCB and any other circuit breakers.

(v) Replace any items that show significant wear and/or are operating outside of the manufacturer's tolerances.

(vi) Test operations of pedestrian push buttons

(vii) Check timing of Flashing Units

(viii) Service controller in accordance with manufacturer's specifications

(ix) All signal heads, reflectors, optical lenses and backing boards shall be cleaned (both internally and externally) in accordance with the manufacturer's specifications

(d) (Bi-annual maintenance - The following works are to be carried out in addition to those described in section (c)

(i) All protective earth conductors shall be inspected and tested.

(ii) All lamp fittings and connectors shall be dismantled and cleaned.

(iii) Signal heads shall be checked for correct alignment and all brackets and clamps tightened.

(iv) All electrical connectors are to be checked and cleaned where necessary.

(e) Annual maintenance - The following works shall be carried out in addition to those described in sections (c) and (d)

(i) All signal poles and gantries shall be painted and renumbered. The signal poles and gantries shall be coated with primer, red-oxide, and two coats of colour grey paint. The paint specification/colour shall be approved by the Engineer.

(ii) All inspection chambers shall be cleaned properly.

(iii) Timings for all signals shall be altered as directed by the Engineer at the beginning and end of the month of Ramadan.

(iv) Minor changes to the controller's operational configuration (Changing of phasing /staging, green times and intergreen times) as deemed necessary by the PWA's traffic signal engineer.

4 The Contractor shall ensure that personnel are available to maintain equipment such that failed equipment shall be replaced or repaired within four hours of notification of the fault. Where controller configuration changes are required, the Engineer shall allow a reasonable period for the Contractor to respond.

5 Failed equipment shall be replaced/repaired within 4 hours of notification of the fault.

6 Where controller configuration changes are required, the Engineer shall allow a reasonable period for the Contractor to respond.

16.5.3 Emergency Maintenance

1 In the case of accidental damage or 'knock downs' or any other equipment failure deemed to be outside of the Contractor's control, shall not be required to take responsibility for repair or replacement. However it shall be the Contractor's responsibility to provide the immediate on-site response to a police or the PWA request.

2 Upon the PWA having effected a remedy to any emergency maintenance requirement, it shall be the Contractor's responsibility to ensure that all repairs or replacements have been conducted to a standard such that no warranties become invalid.

3 If the Contractor feels that any repair or replacement is not of sufficient standard to maintain his warranty he shall notify the PWA with 14 days of any such repair or replacement having been conducted.

16.5.4 Contractor's Vehicles

1 The Contractor shall arrange a vehicle mounted hydraulic platform with boom and any additional vehicle for the use of his staff whenever required throughout the maintenance period.

2 The vehicles shall be provided with a flashing amber roof light array.

3 The contractor shall be responsible for any cost associated with the vehicles.

4 The hydraulic platform shall be capable of performing the required vertical and horizontal manoeuvres safely and satisfactorily, including adequate platform capacity and boom articulation.

5 The contractor shall gain approval from the Engineer as to the vehicle acceptability prior to supplying the said vehicle.

16.5.5 Contractor's Equipment

1 The Contractor shall be responsible for supplying any regular or special equipment or tools required for the satisfactory undertaking of the works. In particular this shall include, but not limited to:

(a) Specialised commission/testing equipment for all the current traffic signal (Siemens, Futurit, Peek and Tyco) controllers to allow Factory Acceptance Tests (FAT) and Site Acceptance Tests (SAT).

(b) Portable keyboard interfaces to allow interrogation and on-site programming of micro-processor signal controllers for all the traffic signal systems.

(c) Workshop based aspect simulators to allow for Factory Acceptance Tests.

END OF PART