Taiwan Railways Administration, MOTC
68 Units of Electric Locomotive Project

Factory Test Procedure for EMC Test

Toshiba Infrastructure Systems & Solutions Corporation

		ASSESSED BY	(Technical Advisor) A. Ujiie
		VALIDATED BY	(Quality Assurance Manager) S. Murakami
ISSUED ON	March 08, 2023	**APPROVED BY**	(Expert) M. Matsuoka
REVISION	5	**CHECKED BY**	(Senior Expert) T. Michiba
DATE	Oct. 23. 2023	**PREPARED BY**	(Engineer) N. Pavan

LIST OF MODIFICATIONS

Rev	Date	Revised by	Checked by	Approved by	Verified by	Assessed by	Description
0	Mar 08, 2023	Engineer N. Pavan	Senior Expert T. Michiba	Expert M. Matsuoka	QA manger S. Murakami	Technical advisor A. Ujiie	Original issue
1	Jul.11, 2023	Engineer N. Pavan	Senior Expert T. Michiba	Expert M. Matsuoka	QA manger S. Murakami	Technical advisor A. Ujiie	Revised in accordance with TRA comment on 2023/5/30 (機車字第 1120006472 號) , IV&V comment on 2023/5/5 (L0208P2118U-lrs-230505-10) and minutes of meeting on 2023/6/20(機車字第 1120010033 號)
2	Aug.24,2023	Engineer N. Pavan	Senior Expert T. Michiba	Expert M. Matsuoka	QA manger S. Murakami	Technical advisor A. Ujiie	Revised in accordance with TRA comment on 2023/8/23 (機車字第 11200012900 號), IV&V comments on 2023/8/11 (L0208P2118U-lrs-230811-04)
3	Aug.29,2023	Engineer N. Pavan	Senior Expert T. Michiba	Expert M. Matsuoka	QA manger S. Murakami	Technical advisor A. Ujiie	Revised in accordance with IV&V comments on 2023/8/28 (L0208P2118U-lrs-230828-10)
4	Sep.26,2023	Engineer N. Pavan	Senior Expert T. Michiba	Expert M. Matsuoka	QA manger S. Murakami	Technical advisor A. Ujiie	Revised in accordance with IV&V comments on 2023/9/1 (L0208P2118U-lrs-230901-13)
5	Oct. 23.2023	Engineer N. Pavan	Senior Expert T. Michiba	Expert M. Matsuoka	QA manger S. Murakami	Technical advisor A. Ujiie	Revised in accordance with IV&V comments on 2023/10/20 (L0208P2118U-lrs-231020-01)

Table of Contents

List of Tables

List of Figures

List of Attachment

1. Introduction

This document is submitted according to the requirement of the TRA's Specification and Test Plan for Factory Test (EL68-SYS-PL-0007 [ECS-E7-0040]) Attachment 1 item No.17. The target date for this test is as shown in Table 5-1 of this document.

TRA specified electromagnetic compatibility (EMC) requirements in section 6.5 of the TRA Procurement of Specification for TRA 68 Units of Electric Locomotive Specification. In response to the Technical Specifications and TRA direction, TISS is performing an Electric Locomotive EMC Program.

TISS and Turner Engineering Corporation (Tenco) will perform Electromagnetic Interference (EMI) Factory Type Tests at Fuchu Factory Test Track to demonstrate that the TISS Electric Locomotives do not exceed conducted or radiated emission limits and that the new locomotives are electromagnetically compatible with themselves, with other TRA vehicles, and with TRA signal, communication, and traction power systems.

This Factory EMI Type Test can be used the comparison of test data which are planning to carry out Field EMI Type Test in Taiwan.

As an element of the Electromagnetic Compatibility Control Plan (EMCCP), TISS and Tenco produced this Factory EMI Type Test Procedure (FETP). This FETP specifies the factory type test measurements which TISS and Turner Engineering Corporation (Tenco) will perform to demonstrate that the Electric Locomotives comply with the TRA conducted and radiated emission limits in TRA specification section 6.5. This FETP is consistent with the TISS EMI Compatibility Control Plan (EMCCP), and the TRA specification.

The Factory EMI Type Test consists of:

- Radiated Emissions Test
- Conducted Emissions Test
- DC Return Current Test

TISS will perform the above test on one Electric Locomotive of first lot.

As in EN50121-3-1 Ch.6.3.2, "the recommended speed range is (50 ± 10) km/h for main line vehicles" Since the speed limit in TISS Fuchu Complex is 25km/h, it is not possible to carry out the Tests with the recommended speed by relevant standard. So all the test will be carried out in Taiwan.

1.1. Objectives of the Factory EMI Type Test

1.1.1. Radiated Emissions Test Objective

The Radiated Emissions Test (RET) objective is to demonstrate that the worst-case Electric Locomotive radiated emissions (RE) do not exceed TRA limits set in TS Section 6.5.3 and in EMCCP Section 5.1.2.

Worst-case RE due to operation of an Electric Locomotive must not exceed the greater of the TRA ambient electric field and the TRA TS EN limits per 50121-3-1.

Section 8.3.2 of this FETP provides the TRA Electric Locomotive RE limits. TISS and Tenco will demonstrate that Electric Locomotive worst-case RE are acceptable by performing and documenting a Radiated EMI Test per EN 50121-3-1.

1.1.2. Conducted Emissions Test Objective

The Conducted Emissions Test (CET) objective is to demonstrate that the worst-case Electric Locomotive conducted emissions (CE) meet TRA's requirements for psophometric current, per TS Section 6.5, and EMCCP Section 5.1.1.

Section 9.3.2 of this FETP states the TRA Electric Locomotive CE Limits. TISS and Tenco will demonstrate that the Electric Locomotive worst-case conducted emissions are acceptable by performing and documenting a Conducted EMI Test per EN 50121-3-1.

1.2. Overview of the Factory EMI Test Procedure

This FETP provides a test method, test arrangement, and related technical information for performing a required RET and CET for the Electric Locomotive.

RET Overview

Generally, TISS and Tenco will perform a RET to demonstrate that the worst-case RE do not exceed the greater of the TRA ambient and the TRA TS EN limits per 50121-3-1, in the specified frequency ranges. To accomplish this, TISS will operate the Electric Locomotive under test on a suitable section of factory test track to produce worst-case RE. Test instrumentation supplied by Tenco and TISS and described in section 8.1.1 will measure and record the amplitudes of RE from 150 kHz to 1 GHz. If the measured field strength does not exceed the applicable limit by a sufficient amplitude or for a sufficient duration to affect communications circuits, the new Electric Locomotives pass the RET.

TISS and Tenco will perform and document a RET compatible with EN50121-3-1, Railway applications – Electromagnetic compatibility Part 3-1: Rolling Stock – Train and complete vehicle, CENELEC European Standard, for whole train emissions.

TISS and Tenco will also demonstrate that the locomotive does not emit RE that could potentially interfere with specific Balise frequencies in use at TRA.

CET Overview

Generally, TISS and Tenco will perform a CET to demonstrate that the worst-case CE do not exceed the greater of the TRA ambient and the TRA TS EN limits per 50121-3-1, in the specified frequency ranges. To accomplish this, TISS will operate the Electric Locomotive under test on a suitable section of factory test track to produce worst-case CE. Test instrumentation supplied by Tenco and TISS and described in section 9.1.1 will measure and record the amplitudes of CE. If the measured CE does not exceed the applicable limits by a sufficient amplitude or for a sufficient duration to affect communications circuits, the new Electric Locomotives pass the CET.

TISS and Tenco will perform and document a CET compatible with EN50121-3-1, Railway applications – Electromagnetic compatibility Part 3-1: Rolling Stock – Train and complete vehicle, CENELEC European Standard, for whole train emissions.

TISS and Tenco will perform the CET per IEC62236 or EN50121-3-1,and confirm compliance with TRA psophometric current limits.

1.3. Contents of this Procedure

This EMI Factory Test Procedure consists of this introduction and the following sections.

Section 2, Abbreviations

Section 3, References

Section 4, TRA Requirements

Section 5, Test Schedule: The Test Schedule section shows the test preparation, test performance, and test reporting activities in a Gantt presentation, and describes the task milestones.

Section 6, Electric Locomotive Configuration Under Test: The Train Configuration Under Test section specifies the general configuration of the Electric Locomotive relevant to EMI, including traction system and auxiliary system ; current and voltage ratings for power units; and other EMI-related devices; and the values of any items or parameters which could affect EMI performance, such as active converter-inverters of Traction system and APU/HEP, Traction and APU/HEP software version numbers.

Section 7, TRA Depot Track: TRA Depot Track section describes the test track and configuration planned for the test.

Section 8, Radiated Emissions Test: The Radiated Emissions Test section details the planned RET, including equipment configuration, test runs, and test methods.

> **Radiated Emissions Test Equipment Configuration:** The Radiated Emissions Test Equipment Configuration section details TISS's planned RET equipment configuration, including the list of test equipment, connection diagram, and the planned calibration method.
>
> **Radiated Emissions Test Runs:** The Radiated Emissions Test Runs section provides a list of Electric Locomotive runs TISS plans in order to identify the Powering, Regenerative Braking, and Auxiliary supply at worst-case conditions. For each run, the Test Run List provides an identifier including failure condition; operating mode, direction, and speed; and notes as required on the run purpose or condition.
>
> **Radiated Emissions Test Methods:** The Radiated Emissions Test Methods lists the test steps TISS plans to perform the tests. This section notes any differences or modifications to the test steps described in the referenced specifications.

Section 9, Conducted Emissions Test: The Conducted Emissions Test sections details the planned CET, including equipment configuration, test runs, and test methods.

Conducted Emissions Test Equipment Configuration: The Conducted Emissions Test Equipment Configuration section shows TISS's planned CET equipment configuration, including the list of test equipment, connection diagram, and the planned calibration method.

Conducted Emissions Test Runs: The Conducted Emissions Test Runs section provides a list of Electric Locomotive runs TISS plans in order to identify the Powering, Regenerative Braking, and Auxiliary supply at worst-case conditions. For each run, the Test Run List provides an identifier including failure condition; operating mode, direction, and speed; and notes as required on the run purpose or condition.

Conducted Emissions Test Methods: The Conducted Emissions Test Methods lists the test steps TISS plans to perform the tests. This section notes any differences or modifications to the test steps described in the referenced specifications.

Section 10, DC Return Current Test: The DC Return Current Test section details the planned tests, including equipment configuration, and test methods.

Section 11, Test Data Collection: The Test Data Collection section describes the test data to be collected and gives examples of the data format to be used and how it is to be recorded, indexed, and organized.

2. Abbreviations

Table 2-1 lists the abbreviations used in this document.

Table 2-1 List of Abbreviations

No.	Abbreviation	Meaning
1	A	Amperes
2	AC	Alternating Current
3	APU	Auxiliary Power Unit
4	ATP	Automatic Train Protection
5	CE	Conducted Emissions
6	CENELEC	European Committee for Electro technical Standardization
7	CET	Conducted Emissions Test
8	CISPR	Comite International Special des Perturbations Radioelectriques (a special committee under the sponsorship of the IEC)
9	CNS	Chinese National Standards
10	CT	Current Transducer
11	DAT	Digital Audio Tape Recorder
12	DCRCT	DC Return Current Test
13	dB	Decibel
14	dBuV/m	Decibel Microvolts per Meter
15	dBuA/m	Decibel Microamperes per Meter
16	DC	Direct Current
17	EBV	Electronic Brake Valve
18	EMC	Electromagnetic Compatibility
19	EMCCP	Electromagnetic Compatibility Control Plan
20	EMI	Electromagnetic Interference
21	EMU	Electrical Multiple Unit
22	EN	Euro Norm
23	FETP	Factory EMI Type Test Procedure
24	FFT	Fast Fourier Transform
25	HEP	Head End Power
26	Hz	Hertz
27	IEC	International Electro technical Commissions
28	IF	Intermediate Frequency
29	ITU-T	International Telecommunication Union Telecommunication Standardization Sector

No.	Abbreviation	Meaning
30	kph	Kilometers per hour
31	MPU	Main Power Supply Unit
32	OCS	Overhead Contact System
33	PC	Personal Computer
34	PWM	Pulse Width Modulation
35	RE	Radiated Emissions
36	RET	Radiated Emissions Test
37	RF	Radio Frequency
38	RMS	Root Mean Square
39	Tenco	Turner Engineering Corporation
40	TISS	Toshiba Infrastructure Systems & Solutions Corporation
41	TPSS	Traction Power Substation
42	TRA	Taiwan Railways Administration
43	TS	Specification for TRA 68 Units of Electric Locomotive
44	V	Volts
45	VAC	Ventilation, and Air Conditioning
46	VCB	Vacuum Circuit Breaker
47	W	Watts

3. References

3.1. Reference Documents

Table 3-1 lists the references used for this document.

Table 3-1 List of References Documents

No.	Document No.	Title of Document
1	19-GF2-00133	Specification for TRA 68 Units of Electric Locomotive
2	ECS-E7-0001-02	Electromagnetic Compatibility Control Plan

3.2. Reference Standards

Table 3-2 lists the references used for this document.

Table 3-2 List of References Standards

No.	Document No.	Title of Document
1	EN 50121-3-1:2017	Railway applications – Electromagnetic Compatibility, Part 3-1: Rolling stock – Train and complete vehicle
2	EN 50121-1:2017	Railway applications – Electromagnetic Compatibility, Part 1: General
3	ITU-T O.41: 1994	Specifications for Measuring Equipment Equipment for the Measurement of Analogue Parameters Psophometer for use on Telephone-type circuits
4	IEC 62236-1:2018	Railway applications – Electromagnetic Compatibility, Part 1: General
5	IEC 62236-3-1:2018	Railway applications – Electromagnetic Compatibility, Part 3- 1: Rolling stock – Train and Complete Vehicle
6	EN 50121-2	Railway applications - Electromagnetic compatibility Part 2: Emissions of the whole railway system to the outside world
7	EN 55016-1-1	Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-1: Radio disturbance and immunity measuring apparatus - Measuring apparatus (CISPR 16, CNS 13306 1-1)
8	IEEE std C95.1:2019	IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 0 Hz to 300 GHz
9	EN 50500:2008 +A1:2015	Measurement procedures of magnetic field levels generated by electronic and electrical apparatus in the railway environment with respect to human exposure

4. TRA Requirements

Table 4-1 TRA Requirements shows the requirements extracted from the contract spec “19-GF2-00133”. These items are relative to “EMC” and their compliance status is shown below:

Table 4-1 TRA Requirements

No.	Chapter of TRA Spec.	TRA Spec. Requirement	Comply Status (*)	Description for Compliance
1	6.4-(4)	The maximum degree of interference of the power system For the maximum horsepower output of the locomotive and the catenary voltage of 25KV, the maximum value of Psophometric Weighted shall not exceed 10 amps; within the range of 10% range of change, the maximum interference value shall not exceed 12 amps. The calculation of the above data should take into account the Appendix K: "Taiwan Railway Administration Substation and Overhead Catenary System (OCS) Data".	C	The maximum value of Psophometric Weighted should not exceed 10 amps. The maximum interference value should not exceed 12 amps. Refer to section 9.3.2.
2	6.5.1-(1)	The electromagnetic compatibility (EMC) requirements for locomotives include the electromagnetic compatibility between different on-board equipment, signaling equipment, communication equipment, power supply equipment, and other electrical equipment within the adjacent external appliances.	C	EMC requirements include the electromagnetic compatibility between different on-board equipment. Refer to section 8.3.2 and 9.3.2
3	6.5.1-(2)	All vehicle-mounted equipment supplied by the contractor shall be capable of reliable operation in the electromagnetic environment of the TRA, and shall not affect systems and equipment of third parties within or near the TRA.	N/A	This requirement will be covered as part of Commissioning Test / EMC Test Procedure
4	6.5.1-(3)	If the provided equipment affects any system in operation, including the operation, service support, and railway safety of the TRA, the equipment will not be allowed to continue working until the contractor has eliminated the interference affecting the system.	C	TISS has eliminated the interference affecting the system. Refer to section 8, 9 and 10.

No.	Chapter of TRA Spec.	TRA Spec. Requirement	Comply Status (*)	Description for Compliance
5	6.5.2-(1)	The contractor shall ensure that there is sufficient protection to avoid any electromagnetic interference (EMI) from components and equipment on the locomotive, and electromagnetic interference (EMI) within the area of the TRA with nearby systems to ensure the electromagnetic compatibility of the locomotive.	C	TISS should ensure that there is sufficient protection to avoid any EMI. Refer to section 8 of ECS-E7-0001-02 (EMCCP).
6	6.5.2-(2)	The contractor shall use design techniques (such as balancing, filtering, masking, isolation and modulation techniques, etc.), construction methods, selection of equipment and materials, etc. to prevent and avoid any sources of interference (e.g. radiation, conduction, radio frequency, etc.) from affecting the normal operation of adjacent facilities (including associated electromechanical equipment/devices), locomotives' own components and equipment, and passengers' belongings (such as cardiac pacemakers, mobile phones, etc.) along the TRA line.	C	TISS should ensure that there is sufficient protection to avoid any EMI. Refer to section 8 of ECS-E7-0001-02 (EMCCP).
7	6.5.2-(3)	The design, manufacture and testing of the electromagnetic compatibility of various on-board components and equipment of locomotives shall comply at least with the relevant requirements of IEC61000, EN50121 or equivalent specifications. The contractor shall submit the electromagnetic environment investigation report, the electromagnetic compatibility design details of the locomotives (including relevant control measures for electromagnetic interference) and the design standards adopted by it to the TRA for review.	C.C	TISS complies with IEC61000 and EN50121 for EMC of components and equipment of the locomotive. Refer to section 8, 9 and 10. Electromagnetic environment investigation report will be covered as part of Commissioning Test / EMC Test Procedure
8	6.5.3-(1)	The maximum level of radiated electromagnetic interference and	C	All locomotive-mounted equipment

No.	Chapter of TRA Spec.	TRA Spec. Requirement	Comply Status (*)	Description for Compliance
		the radiation generated by locomotive-mounted equipment shall not exceed the levels specified in IEC 62236, EN 50121 or equivalent specifications.		should not exceed the levels specified in IEC 62236, EN 50121 or equivalent specifications. Refer to section 8
9	6.5.3-(2)	Ensure electromagnetic compatibility of communication and signal processing equipment by adhering to related radiation restriction requirements.	C	Refer to section 8
10	6.5.3-(3)	The leakage flux density of the traction power equipment on locomotives in any output condition measured by any point on the top surface of the track shall not exceed 10 Gauss.	N/A	This requirement will be covered as part of "Commissioning Test / EMC Test Procedure
11	6.5.3-(4)	The measured value of the time-varying magnetic field in the locomotive cab shall comply with the regulations of “Guidelines for Limiting Exposure from Time-varying Electric Field, Magnetic Field and Electromagnetic Field” announced by the Environmental Protection Administration of the Executive Yuan, and the measurement method adopts EN50500 or the standards of the same level.	N/A	This requirement will be covered as part of Commissioning Test / EMC Test Procedure
12	8.9.4-(7)	The main transformer should pay special attention to the surge current activated by the vacuum circuit breaker closing. The DC component of a vacuum circuit breaker should not exceed 2.6 amps after it is closed for 1 second.	C	Refer to Section 10
13	Appendix G3.10	Type test for ATP onboard equipment, communication system and equipment, locomotive control and monitoring system, noise and vibration, EM waves and EMC should be carried out according to the approved test plan(including the increased items after contract variation).	C	TISS will carry out the EM waves test. Refer to Section 7 for detail test procedure. Regarding EMC test, refer to Factory Test Procedure for EMC Test [ECS-QA-E7-TP- 0081].

(*) C.=Complete Comply, C.C.=Comply with Comments, N.C.= Not Comply, N.A.= Not Applicable

5. Test Schedule

TISS and Tenco will perform Radiated EMI Testing and Conducted EMI Testing at the TRA Depot Track. F

Figure 5-1 shows TISS's planned EMI factory field test activities.

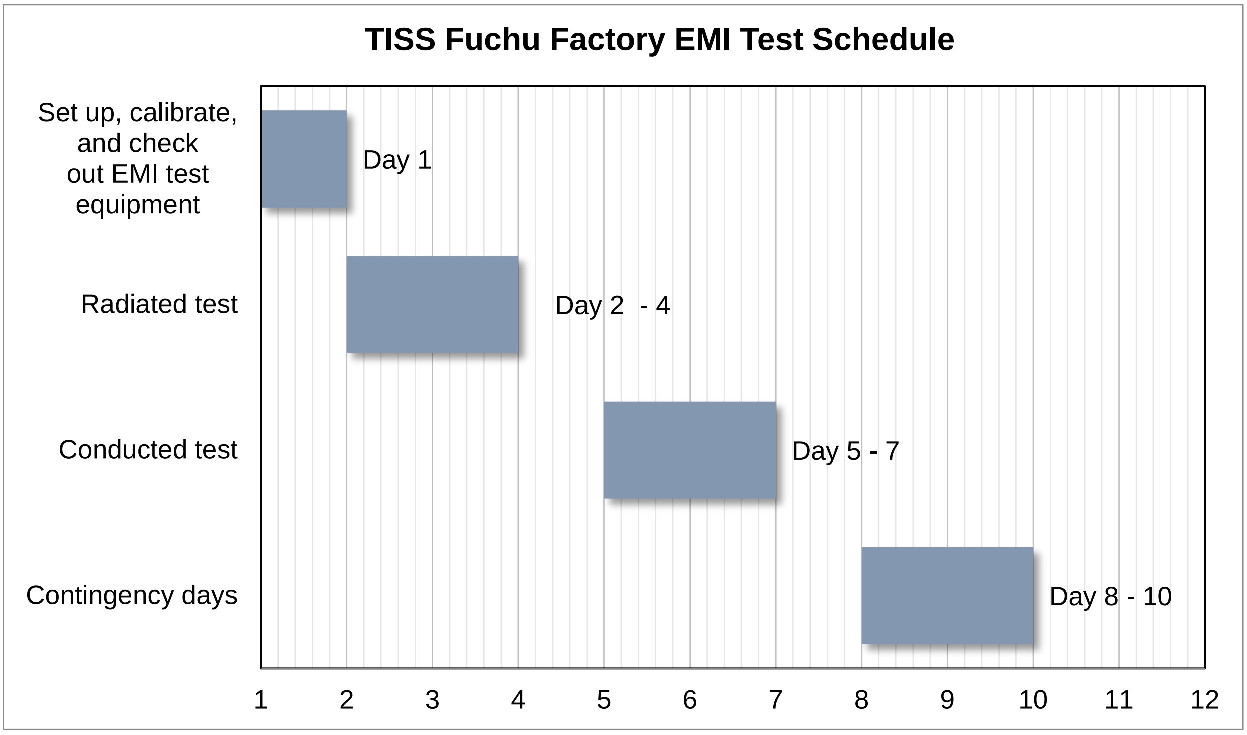


Figure 5-1 Test Schedule (Tentative)

The filming plan the these tests are as follows;

Table 5-1 Test Process Filming Target

No.	Target	Test Item	Test Schedule
1	One Locomotive of first lot	Radiated Emissions Test	To be announced separately.
2		Conducted Emissions Test	
3		DC Return Current Test	
4		Onboard magnetic field test	

6. Train Configuration Under Test

6.1. Train Consist and Loading

F

ISS and Tenco will perform the CETT on a single Electric Locomotive at available load, on the TRA Depot Test Track.

6.2. Configuration

TISS and Tenco will record the Electric Locomotive configuration including software revision level and parameter configurations for any systems relevant to EMI as part of the test record for both RET and CET, using the forms in Attachment 1.

7. TRA Depot Track

F

TISS and Tenco will perform the following tests on a suitable section of TRA Depot track:

- Low-speed CET
- Low-speed Onboard MFT

The TRA Depot Test Track should have the following characteristics:

- The test track should be a straight or widely curved level section of track
- The tests will be performed at the highest safe speed as close as possible to the track section speed limit
- The CET measurements will be made with current measurement devices at a traction power return bond at a traction power substation and onboard an Electric Locomotive. The CET track section should include the substation, and should preferably permit acceleration both toward and away from the substation feed point.

For all CETT, TISS and Tenco request that TRA:

- Provide shop access to install suitable current sensors on the Electric Locomotive under test, and space onboard the Electric Locomotive for the test instruments. The current sensors will be installed on the traction power return side of the Electric Locomotive main transformer, or on a suitable 25 kV insulated feeder cable on the roof of the Electric Locomotive.
- Provide access to the track, the Electric Locomotive, traction power, crew, communications, all necessary safety protection, security as needed, and operations support.

Provide radio or other suitable communications for the test staff, Central Control, and other TRA staff, on a channel that will not interfere with TRA train operations.

RET requirements:

1) For the RET, per EN 50121-3-1, the test track should allow operation by trains at speeds up to 40 km/h, and the test area should be distant from high tension lines, substations, power generating stations, and other sources of broadband emissions other than the Electric Locomotive under test.

   The RET Measurement Point (MP) should be:

   - 10 m from the centerline of the track under test. If obstructions prevent measurement at 10 m, an alternative MP can be 30 m or 15 m from the track centerline using limits adjusted for the increased distance.
   - “Free space” per EN 50121-3-1. There should be no trees, walls, bridges, tunnels or vehicles close to the MP.
   - There should be no fence or other significant metal structure above the rail level between the MP and the Electric Locomotive, or immediately behind or to the sides of the MP.
   - The antenna mounting point should allow easy setup of the antenna 2 m above the rail head level.

8. Radiated Emissions Test (Test ID 1)

8.1. Radiated Emissions Test Equipment Configuration

Figure 8-1 shows the RET test equipment setup.

The test antenna will be placed 10 m from the centerline of the track under test, per EN 50121-3-1 and 2 m above the railhead. If the layout of the test track does not permit testing at a lateral distance of 10 m, limits will be recalculated to match the actual lateral distance. The method for recalculating the limits follows.

Limits can be converted to an equivalent 10 m value by using the following formula, per EN 50121-3-1 Annex B reference to EN 50121-2:

$$E10 = Ex + n * 20 * \log10 (D / 10)$$

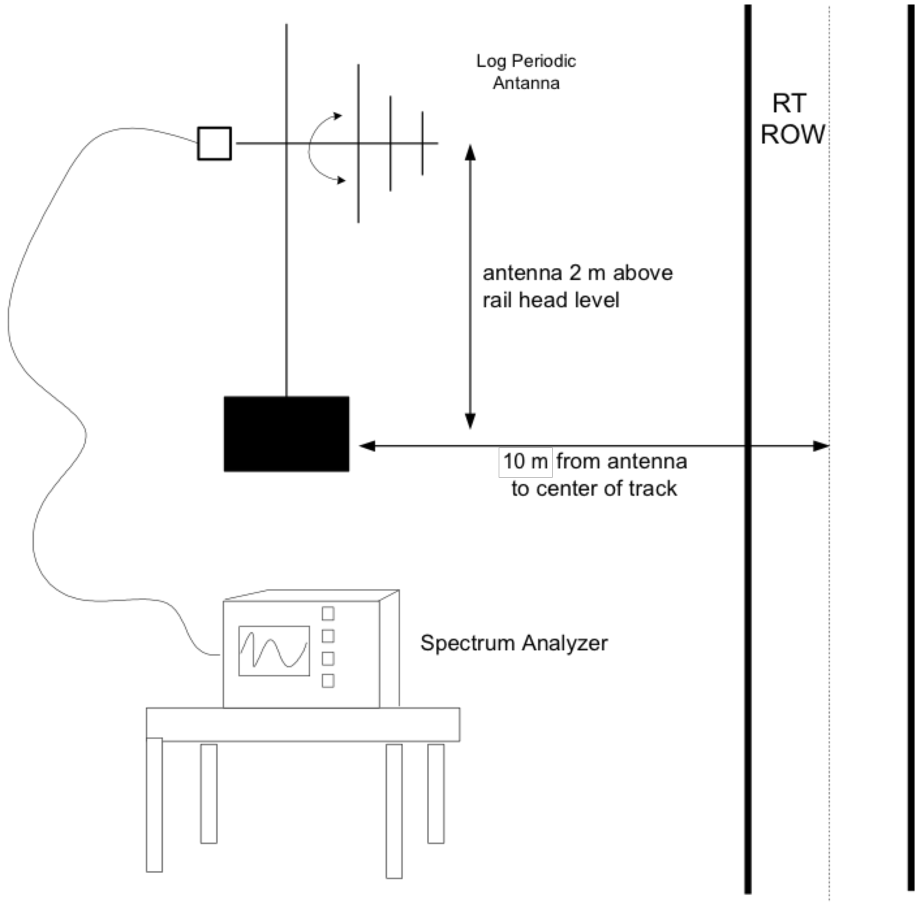
where E10 is the value at 10 m

Ex is the measured value at D m

n is a factor taken from the Table 8-1 below.

Table 8-1 Antenna Adjustment Conversion Factor *n*

Frequency Range	*n*
150 kHz to 400 kHz	1.8
400 kHz to 1.6 MHz	1.65
1.6 MHz to 110 MHz	1.2
110 MHz to 1 GHz	1.0



F

Figure 8-1 Radiated Emissions Test Configuration

8.1.1. Test Equipment

Table 8-2 lists the Radiated EMI Factory Field Test equipment.

Table 8-2 Radiated Emissions Test Equipment List

No.	Item	Purpose
1	RF Spectrum Analyzer, Keysight N9010B-503-P03-EDP, 10 Hz to 3.6 GHz	For measuring EMI field intensity between 10 Hz and 3.6 GHz.
2	HP 5L Printer, or equivalent, with A4 size paper	For plotting emission spectra. Compatible with spectrum analyzer.
3	Keyboard, and mouse	For entering test configuration data onto test instrument screen before plotting.
4	A.H Systems SAS-550-1B: Active Monopole Antenna or equivalent, 9 kHz to 60 MHz	Calibrated antenna for Bands 1 – 4
5	A.H. Systems SAS-521F-7: Bilogical Antenna or equivalent, 25 MHz to 7 GHz	Calibrated antenna for Bands 5 –6
6	Adjustable Antenna Tripod	To support antennas
7	Laptop computer	For control of printer and storage of test data results
8	AC Power Source 100 VAC-50 Hz	AC power source for the Monopole antennas and the signal analyzer.
9	Table/Desk, Chairs, and Tent	Workspace for wayside measurement.
10	Lighting	Visibility at workspace, if testing at night
11	Handheld Radios/transceivers	Communication between locomotive driver and wayside test team
12	Isolation transformer 100 VAC-50 Hz, 1kVA	To provide AC power and eliminate ground current loops.

※The test equipment items are provisionally listed

The following subsections describe the major test equipment items.

RF Spectrum Analyzer

The Keysight N9010B-503-P03-EDP RF Spectrum Analyzer measures intensity of the Radio Frequency (RF) field over a frequency range of 10 Hz to 3.6 GHz. The spectrum analyzer:

- Measures and documents the field intensity received from calibrated antennas.
- Converts received signals from calibrated antennas into standard dBμV/m units.
- Applies conversion factors to convert measurements into dBμV/m units.
- Stores system configuration including antenna factors and cable losses.
- Has amplitude accuracy better than ± 0.8 dB, adequate for the task
- Displays Limit Lines to indicate EMCCP specification limits.

The spectrum analyzer will be connected to a laptop or PC via router for data acquisition, storage, and printing.

The test team will use standard techniques to assure calibration of the impulse bandwidth of the spectrum analyzers. For spectrum analyzers whose intermediate frequency (IF) stages have Gaussian passbands, such as the Keysight spectrum analyzer used here, the impulse bandwidth is 1.4 times the resolution bandwidth (-3 dB bandwidth), and is approximately equal to the -6 dB IF bandwidth.

Antennas

TISS and Tenco will mount antennas on a tripod with the antenna base plate 2 meters above rail head level. The tests will orient the antennas as follows:

Active Monopole Antenna: The Active Monopole Antenna covers the frequency range from 9 kHz to 60 MHz. This antenna is oriented vertically for measurements.

Bilogical Antenna: The Bilogical Antenna is a wide operating range antenna which covers the frequency range of 25 MHz to 1 GHz. The name “bilogical” indicates that the antenna combines the characteristics and response of a biconical and log periodic antenna. For measurements, this antenna is oriented vertically, with its axis perpendicular to the ground, and with the antenna oriented horizontally, with the antenna axis parallel to the Electric Locomotive’s path.

Calibrated antennas receive and convert RF field intensities into electrical signals with a known conversion antenna factor. These antenna factors are provided by the antenna supplier, and are entered into the spectrum analyzer so the spectrum analyzer can display received signals in units of the corresponding electrical field intensity.

8.1.2. Test Bands

TISS and Tenco will perform broadband emission measurements from 150 kHz to 1 GHz using active monopole and bilogical antennas for horizontal and vertical electric fields as appropriate.

TISS and Tenco will divide the measurement band into six smaller test bands, listed in

Table 8-3.

TISS and Tenco will use the active monopole antenna to cover the range from 150 kHz - 30 MHz, in four measurement sub-bands. TISS will measure with the active monopole oriented vertically.

TISS and Tenco will use the bilogical antenna to cover the range from 30 MHz to 1 GHz, with both horizontal and vertical orientation.

For the RET, per EN 50121-3-1, Figure 1, the specified spectrum analyzer resolution bandwidths are:

- 9 kHz for measurements between 150 kHz and 30 MHz
- 120 kHz for measurements above 30 MHz

Table 8-3 Radiated Emissions Test Bands

ID	Frequency Range	Antenna	Ant Orientation	Resolution Bandwidth
B1	150 kHz – 650 kHz	Active Monopole	Vertical	9 kHz
B2	500 kHz – 3 MHz	Active Monopole	Vertical	9 kHz
B3	2.5 MHz – 7.5 MHz	Active Monopole	Vertical	9 kHz
B4	5 MHz – 30 MHz	Active Monopole	Vertical	9 kHz
B5h	30 MHz – 330 MHz	Bilogical	Horizontal	120 kHz
B5v	30 MHz – 330 MHz	Bilogical	Vertical	120 kHz
B6h	300 MHz – 1 GHz	Bilogical	Horizontal	120 kHz
B6v	300 MHz – 1 GHz	Bilogical	Vertical	120 kHz

8.2. Radiated Emissions Test Runs

TISS and Tenco will perform the Radiated Emissions Factory Test using appropriate combinations of low, medium, and high tractive effort; in powering and regenerative brake modes; in forward and reverse directions; in addition to stationary and coasting test runs; with a single Electric Locomotive, at available line voltage. TISS will select combinations of test conditions to identify the worst-case emissions.

TISS and Tenco will measure radiated electric field emissions following EN 50121-3-1.

TISS and Tenco will perform sufficient ambient electric field measurements to identify worst-case emissions for normal conditions. TISS and Tenco will perform measurements of worst-case conditions to confirm that worst-case emissions when the Electric Locomotive is powering, regenerative braking, or coasting are similar to stationary emissions.

For all test runs, TISS and Tenco will maintain a test log per the requirements of FETP Section 11, providing the test type, Electric Locomotive configuration, run description, comments for each run, and other relevant information.

8.2.1. Test Variables

TISS and Tenco will perform test runs for the Electric Locomotive configurations and operating modes described below. TISS will evaluate results during the first series of test runs to determine the modes and conditions under which the Electric Locomotive produces its worst-case emissions. Further tests will focus on worst-case modes and conditions.

Direction: TISS and Tenco will perform test runs in forward and reverse directions to confirm emissions are similar in both directions. If direction has no effect on emissions, tests will be performed in either direction, as convenient.

TISS and Tenco will plan to test R4 (train powering (see Ch. 8.2.2)) in the forward and reverse direction in the most common emission bands of B1 - B4 before making the determination if direction matters for radiated emission levels.

The test team will determine that direction has no effect on the RE measurement if the forward/reverse measurements are within the typical RE measurement error/repeatability margin of 6 dB in the forward and reverse direction for each band. If the measurement levels change more than 6 dB, Tenco will re-measure ambient RE levels to confirm if the change was caused by direction or by an ambient level change.

Operating Modes: TISS and Tenco will perform tests using the full range of operating modes and speeds.

Speed: TISS and Tenco will perform test runs with the Electric Locomotive standing, accelerating, and braking at speeds of 40-60 km/h.

F

Auxiliaries: In general, peak emissions from the auxiliaries occur when the Low Voltage Power Supply (LVPS) inverter or Heating, Ventilation, and Air Conditioning (VAC) compressor runs near full power. RET will be performed using appropriate auxiliary power load conditions. To the extent compatible with the Electric Locomotive crew comfort, TISS and Tenco will perform most test runs with locomotive auxiliaries on and VAC running at maximum power. TISS and Tenco will perform three R2 test runs with the Electric Locomotive standing to determine Auxiliary Power Converter emission dependence on load: One run with all Auxiliary loads shutoff except essential loads, one run with all auxiliary loads and VAC operating normally, and one run with VAC running at maximum power.

Line Voltage: TISS and Tenco will perform all tests at available line voltage at the Mainline Test Track, and will record the line voltage in the test log.

As noted above, TISS and Tenco will test the possible operating ranges, modes, and combinations to identify worst cases. From among those tests, TISS and Tenco will select, further test, and document conditions for worst-case emissions.

8.2.2. Test Run Types

TISS and Tenco will perform the RET with a single Electric Locomotive.

The test setup for data collection is described above in this Factory FETP section 8.1.

TISS and Tenco will perform the following types of test runs, measuring radiated fields under different operating modes of the Electric Locomotive as appropriate.

The chapter 8.3.2 of EL68-EMC-TP-3001 document “Commissioning Test / Function Test Procedure for EMC Test” takes over this chapter due to the test will be carried out in Taiwan.

R0: Calibration, Receiver Sensitivity and Spurious Response Levels

Each time the test equipment is set up, perform this spectrum analyzer calibration to establish the noise baseline.

Adjust the receiver sensitivity following the manufacturer’s adjustment procedure, using the built-in calibration signal of the spectrum analyzer.

Install the receiver and equipment at the test site. Attach a matched termination to the receiver’s antenna input terminal. Accelerate the Electric Locomotive past the test setup with the pantograph up with 33% effort to a speed of 16kph.

Observe and record the receiver output levels across the entire frequency range. Label data “With Antenna Terminal Terminated.” Note any spurious receiver response.

R1: Ambient

With the Electric Locomotive standing at least 10 m away (Refer to Ch.6.3.3 on EN50121-3-1) from the antenna and the locomotive with pantograph has been fully lowered condition, measure and record emission levels at all frequency sub-bands and antenna polarizations from 150 kHz to 1 GHz, per Table 8-3.

R2: Train Standing

With the Electric Locomotive standing and locomotive centerline is aligned with the antenna with auxiliaries and VAC depends on actual testing environment, HEP with no load condition, measure and record emission levels at all frequency sub-bands and antenna polarizations from 150 kHz to 1 GHz, per Table 8-3.

R3: Train Coasting

With the Electric Locomotive coasting at low speed (10kph) past the test setup and auxiliaries and VAC on at appropriate power load conditions, HEP with no load condition, measure and record emission levels at all frequency sub-bands and antenna polarizations from 150 kHz to 1 GHz, per Table 8-3

R4: Train Powering F

With the Electric Locomotive powering at varying efforts past the test setup and auxiliaries and VAC on at appropriate power load conditions, HEP with no load condition, measure and record emission levels at all frequency sub-bands and antenna polarizations from 150 kHz to 1 GHz, per Table 8-3.

R5: Train Regenerative Braking F

With the Electric Locomotive braking at varying efforts past the test setup and auxiliaries and VAC on at appropriate power load conditions, HEP with no load condition, measure and record emission levels at all frequency sub-bands and antenna polarizations from 150 kHz to 1 GHz, per Table 8-3.

8.2.3. Test Run List

Table 8-4 below lists the Train and Test Configurations used for the varying test run types listed above in section 8.2.2 of this Factory FETP.

TISS and Tenco will perform the tests on the following list in an order which makes efficient use of track and Electric Locomotive time and staff availability. Some tests may be performed multiple times to establish the identity of any narrow band emissions from 150 kHz to 1 GHz.

F

Table 8-4 Radiated Emissions Test Run List

Band	Measurement Range	Resolution Bandwidth	Antenna	E-field	Test ID	Operating Activity	Description	Criteria
B1	150 kHz to 650 kHz	9 kHz	Active Monopole	Vertical	R1	No Traction	Ambient	R1: Only for measure ment R2: Refer to Table 8-5 and Figure 8-2 R3, R4 and R5: Refer to Table 8-6 and Figure 8-3
					R2		Standing	
					R3	Start from 0 km/h. Coasting at 10 km/h	Coasting	
					R4	Start from 0 km/h. Acceleration to 50 km/h	Powering	
					R5	Approach at 50 km/h. Brake to 0 km/h	Braking	
B2	500 kHz to 3 MHz	9 kHz	Active Monopole	Vertical	R1	No Traction	Ambient	
					R2		Standing	
					R3	Start from 0 km/h. Coasting at 10 km/h	Coasting	
					R4	Start from 0 km/h. Acceleration to 50 km/h	Powering	
					R5	Approach at 50 km/h. Brake to 0 km/h	Braking	
B3	2.5 MHz to 7.5 MHz	9 kHz	Active Monopole	Vertical	R1	No Traction	Ambient	
					R2		Standing	
					R3	Start from 0 km/h. Coasting at 10 km/h	Coasting	
					R4	Start from 0 km/h. Acceleration to 50 km/h	Powering	
					R5	Approach at 50 km/h. Brake to 0 km/h	Braking	
B4	5 MHz to	9 kHz	Active Monopole	Vertical	R1	No Traction	Ambient	
					R2		Standing	

Band	Measurement Range	Resolution Bandwidth	Antenna	E-field	Test ID	Operating Activity	Description	Criteria
	30 MHz				R3	Start from 0 km/h. Coasting at 10 km/h	Coasting	
					R4	Start from 0 km/h. Acceleration to 50 km/h	Powering	
					R5	Approach at 50 km/h. Brake to 0 km/h	Braking	
B5h	30 MHz to 330 MHz	120 kHz	Bilogical	Horizontal	R1	No Traction	Ambient	
					R2		Standing	
					R3	Start from 0 km/h. Coasting at 10 km/h	Coasting	
					R4	Start from 0 km/h. Acceleration to 50 km/h	Powering	
					R5	Approach at 50 km/h. Brake to 0 km/h	Braking	
B5v	30 MHz to 330 MHz	120 kHz	Bilogical	Vertical	R1	No Traction	Ambient	
					R2		Standing	
					R3	Start from 0 km/h. Coasting at 10 km/h	Coasting	
					R4	Start from 0 km/h. Acceleration to 50 km/h	Powering	
					R5	Approach at 50 km/h. Brake to 0 km/h	Braking	
B6h	300 MHz to 1 GHz	120 kHz	Bilogical	Horizontal	R1	No Traction	Ambient	
					R2		Standing	
					R3	Start from 0 km/h. Coasting at 10 km/h	Coasting	

Band	Measurement Range	Resolution Bandwidth	Antenna	E-field	Test ID	Operating Activity	Description	Criteria
					R4	Start from 0 km/h. Acceleration to 50 km/h	Powering	
					R5	Approach at 50 km/h. Brake to 0 km/h	Braking	
B6v	300 MHz to 1 GHz	120 kHz	Bilogical	Vertical	R1	No Traction	Ambient	
					R2		Standing	
					R3	Start from 0 km/h. Coasting at 10 km/h	Coasting	
					R4	Start from 0 km/h. Acceleration to 50 km/h	Powering	
					R5	Approach at 50 km/h. Brake to 0 km/h	Braking	

8.3. Radiated Emissions Test Methods

8.3.1. Test Steps

TISS and Tenco will document correct operation for all instruments.

RET measurements will be made using the peak hold averaging mode on the spectrum analyzer while the Electric Locomotive passes the test location or while ambient measurements are being made.

The test staff can use Min/Max Hold or Quasi-peak detector functions to distinguish broadband and narrowband emissions and continuous versus discontinuous emissions.

For each frequency sub-band, TISS and Tenco will test the locomotive for the following test operating conditions:

R0	Calibration
R1	Ambient
R2	Electric Locomotive standing at Measurement Point
R3	Electric Locomotive coasting past Measurement point
R4	Electric Locomotive powering past Measurement point
R5	Electric Locomotive Regenerative braking past Measurement point

TISS and Tenco will frequently repeat the ambient measurement R1 to document variations in the radiated ambient.

If Tenco finds that the ambient noise is close to or higher than the Table 8-5 RE criteria, Tenco will find proper ambient noise location, and place the antenna. Then, carry out the RE tests. TISS and Tenco will evaluate the RE field levels as described in Section 8.3.2 below. F

8.3.2. Pass / Fail Criterion

The objective of the Radiated Emissions Factory Test is to demonstrate that the worst- case Electric Locomotive RE do not exceed TRA limits in section 5.1.2 of the EMCCP.

Worst-case emissions due to operation of an Electric Locomotive must not exceed the greater of the TRA ambient electric field and, the TRA radiated emission limits.

TISS and Tenco will demonstrate that Electric Locomotive worst-case radiated emissions are acceptable by performing and documenting a Radiated EMI Test per EN 50121-3-1.

TISS and Tenco must also demonstrate that the Electric Locomotive does not contribute above the ambient limits, by measuring ambient environment and comparing it to Electric Locomotive emissions. Worst-case emissions due to operation of the Electric Locomotive measured with a suitable antenna and spectrum analyzer must not exceed the greater of the Fuchu Factory ambient and the specified amplitude in the specified frequency ranges, either for a duration or with a repetition interval significant for nearby equipment.

The duration and repetition frequency are only relevant for train signaling systems that use AC track circuits.

The only criteria that would permit an emission to be higher than the EN50121 or Ambient background criteria if the emission was due to a transient event, such as a pantograph bounce or section break.

To identify broadband Electric Locomotive emission levels observed at a particular frequency and polarization as distinct Electric Locomotive emissions, the emission levels must exceed the corresponding observed ambient broadband level by 10 dB or more. The frequency in question must be at least twice the impulse bandwidth from any ambient narrowband signal producing receiver output greater than the observed broadband emission levels. If a questionable signal is found that would be excluded under these criteria, TISS and Tenco will retest it later under similar conditions in an attempt to find a lower ambient condition and determine whether the signal is actually ambient or an Electric Locomotive emission.

TISS and Tenco will compare the results of Electric Locomotive RE against the specified radiated emission limits. If the test results show that the Electric Locomotive's radiated emissions are less than the corresponding limits, the locomotive passes the test.

TS 6.5.3 (1) requires that radiated emissions comply with emission limits in IEC62236, EN 50121 or equivalent specifications.

EN 50121-3-1 specifies Electric Locomotive radiated emission limits in H field (dBuA/m) from 150 kHz to 30 MHz, and E field (dBuV/m) from 30 MHz to 1 GHz. This FETP converts the H field limits to E field limits, and provides the limits in E field only, shown below in Table 8-5 and Table 8-6 shows the radiated emission limits for a stationary Electric Locomotive.

The RE limits were calculated by converting the H field limit (150 kHz – 30 MHz) to E field values, using the following equation:

Limit-E-Field = Limit-H-Field + 20*log(Z-Free-Space)

Z-Free-Space is the same as “impedance of free space wave” in EN50121-2 Ch.9.7 and hereafter Z0). Z0=377 Ω (See Note)

The value for Table 8-5 E-Field Limit(dBµV/m) is calculated by above formula which is referred to EN50121-2 Annex A Ch.A.7 with Z0=377Ω

Note

Z0 is calculated by below formula
$Z0=\mu 0 * C$
$\mu 0$: permiability in free space ≒12.566x10-7 H/m
C : Light speed in free space ≒300,000 km/S
So Z0＝12.566x10-7 H/m x 300,000 km/S≒377Ω

Table 8-5 EN50121-3-1 Electric Locomotive RE Limit at 10 m – Stopped Train

Frequency (MHz)	E-Field Limit (dBµV/m)	Remarks
0.15	106.5	H field limits to E field limits conversion
30	56.5	H field limits to E field limits conversion
30	60	E field limit as per EN 50121-3-1
1000	50	E field limit as per EN 50121-3-1

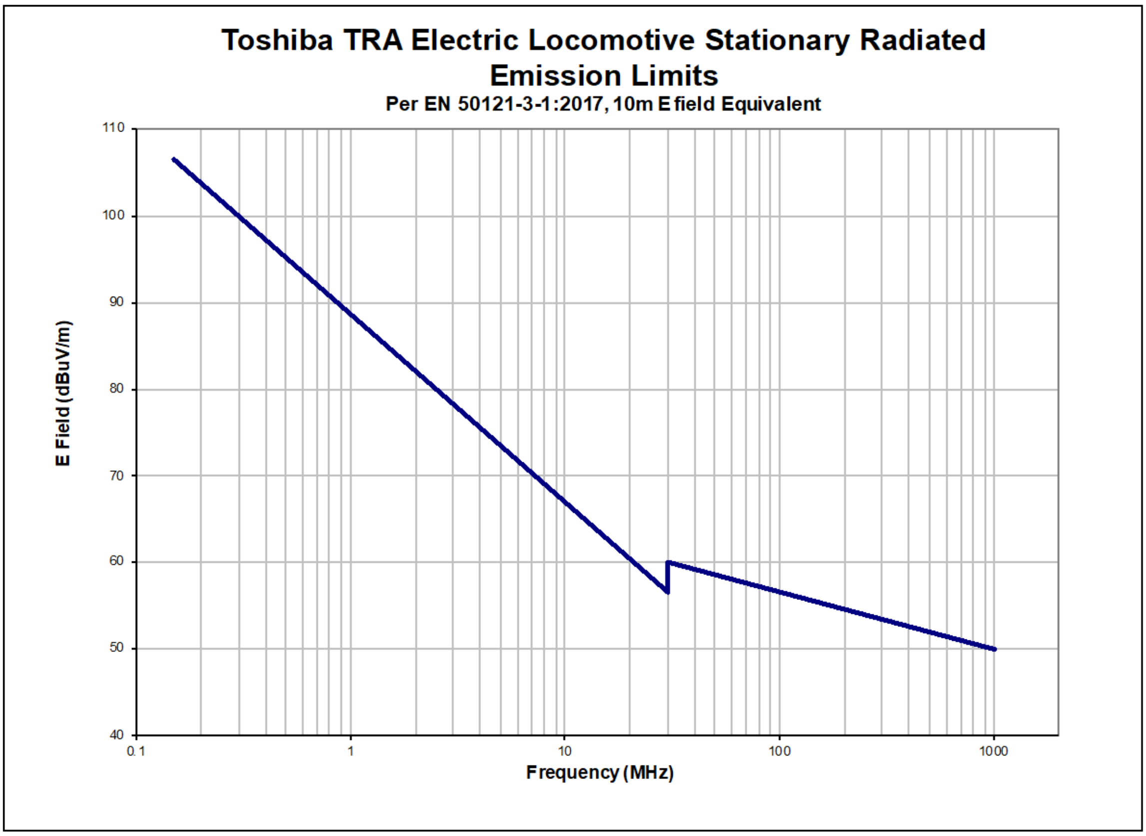


Figure 8-2 EN50121-3-1 Electric Locomotive RE Limit at 10 m - Stopped Train

The limits are defined as quasi-peak values and the bandwidths are those used in EN 55016-1-1:

Frequencies from 150 kHz to 30 MHz	9 kHz (bw 1)
Frequencies above 30 MHz	120 kHz (bw 2)

Table 8-6 and Figure 8-3 shows the RE limits for a slowly moving Electric Locomotive. The slow-moving test is designed to minimize the potential broadband emissions caused by poor contact between the locomotive pantograph and the Overhead Contact System (OCS).

Table 8-6 EN50121-3-1 Electric Locomotive RE Limit at 10 m – Slow Moving Train

Frequency (MHz)	E-Field Limit (dBµV/m	Remarks
0.15	121.5	H field limits to E field limits conversion
30	71.5	H field limits to E field limits conversion
30	90	E field limit as per EN 50121-3-1
1000	65	E field limit as per EN 50121-3-1

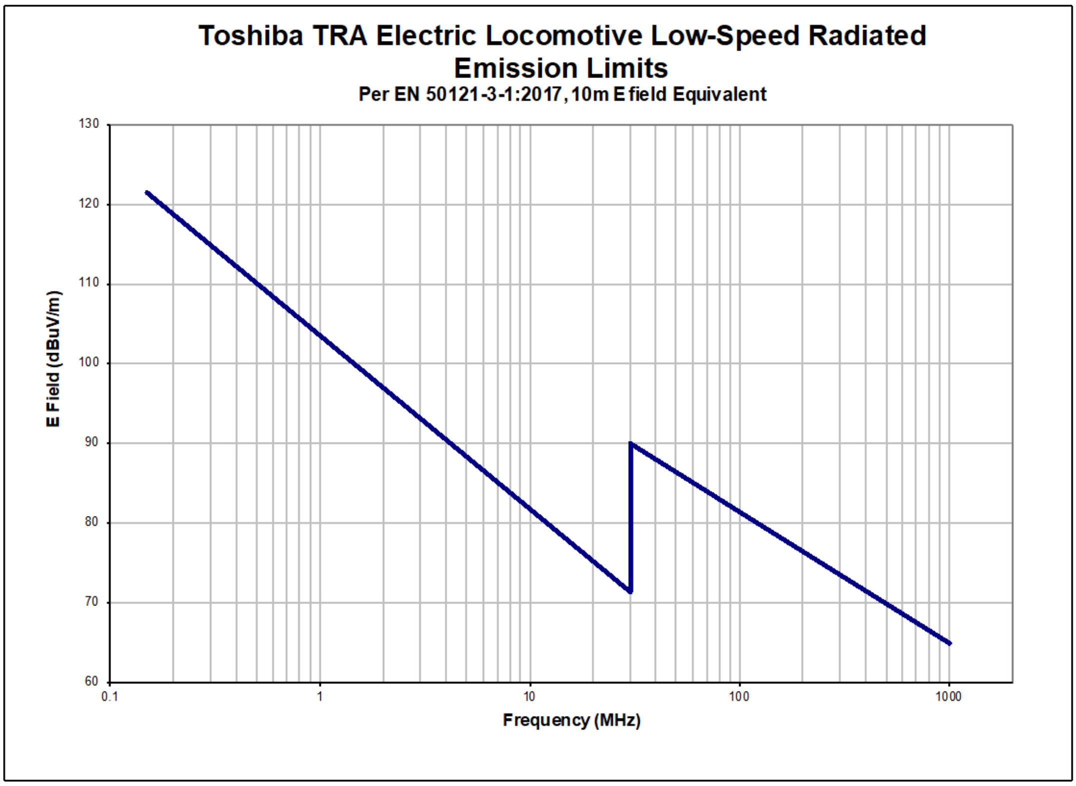


Figure 8-3 EN50121-3-1 Electric Locomotive RE Limit at 10 m – Slow Moving Train

TISS and Tenco will perform the RET on one Electric Locomotive of first lot at the TRA Depot Track.

TISS and Tenco will perform the radiated emission tests per IEC 62236 or EN 50121-3-1, and confirm Electric Locomotive compliance with the standard limits.

8.3.3. Test Run Instructions

TISS and Tenco will perform the following test instructions when measuring radiated emissions with the Electric Locomotive:

1. Slowly move the Electric Locomotive past the measurement point to find any potential worst-case emissions.
2. Run each test type for each band, as shown in Table 8-4.
3. Repeat test runs with worst-case results across the variables described in section 8.2.1.

The test set up for data collection is described in FETP section 8.1.

8.3.4. Test Repetitions

Tenco and TISS will perform sufficient test runs for the principal test features to ensure that results are consistent under similar test conditions.

If RE in some test indicates strongly that another later test will not produce greater levels of interference, the later test need not be performed, or can be modified. Tenco and TISS will record the justification for not performing the test on the appropriate form.

Some tests may be performed multiple times to establish the identity of any narrow band emissions from 150 kHz to 1 GHz .

8.3.5. Field Reduction of Data

TISS and Tenco will set up the spectrum analyzer to account for antenna factors, calibration factors, gain, and conversion units so that the emission amplitudes are recorded in dBμV/m. The test team will plot or print the spectrum analyzer data on completion of each frequency test run, annotating the test results as appropriate.

Data for Electric Locomotive emissions and ambient levels will be regarded as invalid at frequencies at which the receiver accuracy is affected adversely by spurious response or lack of sufficient receiver sensitivity.

Conducted Emissions Test (Test ID 2)

9.1. Conducted Emissions Test Equipment Configuration

Figure 9-1 shows the typical test equipment setup for the Conducted EMI Factory Test, per the EN standard. Figure 9-1 includes a DC current sensor for the DC Current Test, described in Section 10 of this FETP. The FFT Analyzer is connected to an AC current sensor monitoring the pantograph main circuit feed. Figure 9-2 shows an annotated schematic of the locomotive high voltage traction circuit, to show the location of the sensors.

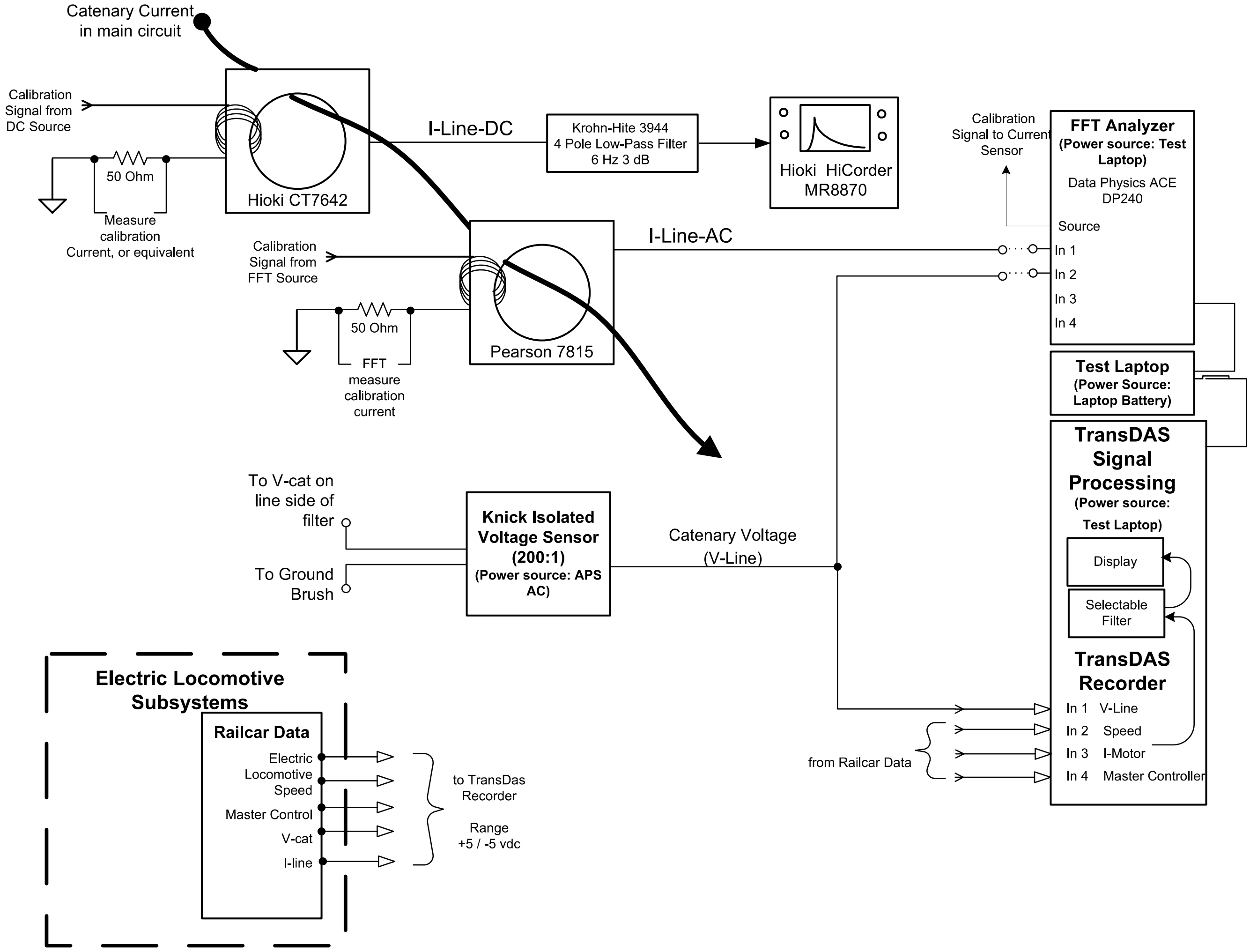


Figure 9-1 Conducted EMI Test Configuration

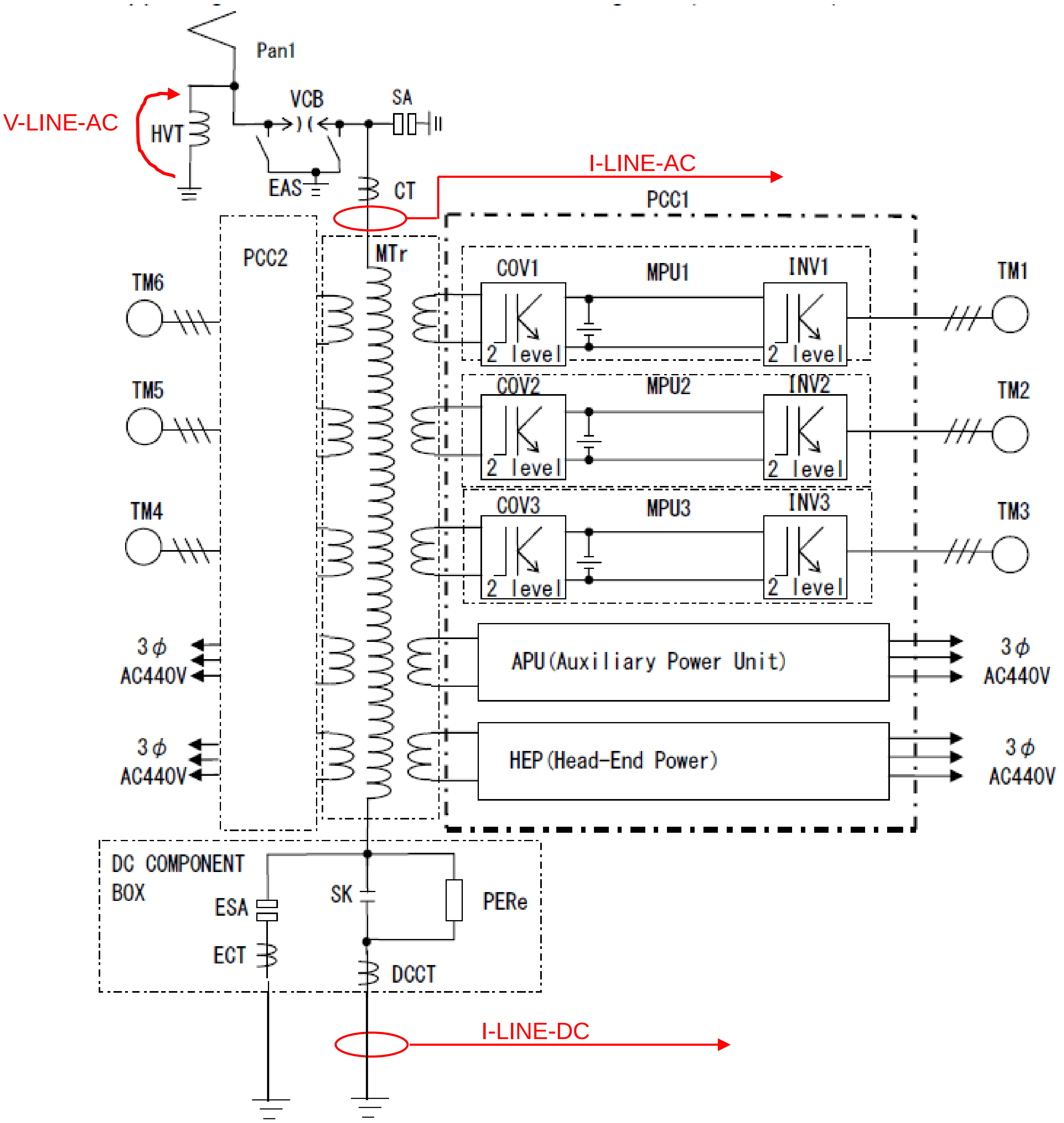


Figure 9-2 Conducted EMI Test Sensor Locations

9.1.1. Test Equipment

Table 9-1 lists the CET equipment.

Table 9-1 CET Equipment List

No.	Item	Purpose
1	Four Channel FFT Dynamic Signal Analyzer and Digital Data Recorder, Data Physics ACE DP240 or equivalent.	For measuring and recording emission signals, typically FFT spectra.
2	Printer, Brother MFC-J870DW, HP930 Deskjet Printer, or equivalent.	For plotting emission spectra.
3	Hioki CT7642 AC/DC Current Probe	For monitoring DC current component
4	Pearson 7815 AC Current Probe	For measuring AC current components.
5	Tenco TransDAS Data Acquisition Computer or Strip Chart Recorder	For capturing and printing stripchart-type time-based records of locomotive performance, and for monitoring selected AC components.
6	110 Vac Isolation Transformer	To provide AC power and eliminate ground current loops.
7	Digital Voltmeter	For monitoring AC and DC voltages.
8	Uninterruptible Power Supply	To provide instrument AC power when the APU is not running.
9	Krohn-Hite 3944 Low Pass Filter	Channel 1 to filter out AC components. Channel 2 to amplify 60 Hz component and suppress higher harmonics.
10	Hioki MR8870 2-channel Memory HiCorder. Digital Oscilloscope/Recorder	For measuring and recording DC and AC components of line current.
11	Laptop computer	For control of printer and storage of test data results

※The test equipment items are provisionally listed.

TISS and Tenco will measure the following CET signals with the DP240 and TransDAS, as described in sub-sections Dynamic Signal Analyzer and TransDAS below:

- I-Line-AC
- V-Line

TISS and Tenco will measure the following signals with a TransDAS real-time data acquisition and display system:

- Speed
- Master Controller

TISS will measure I-Line-DC for the DC Return Current Test, described in Section 10 of this FETP.

Dynamic Signal Analyzer

A Data Physics Dynamic Signal Analyzer Model DP240 (FFT Analyzer) performs the following tasks:

- Measures and documents the transfer function for CET equipment, from input signal to output signal
- Provides a sweep signal necessary to determine transducer or connection transfer function
- Monitors signals in the frequency domain, including peak hold function
- Monitors signals in their frequency and time domain using the waterfall 3-D display function
- Provides and documents conversion of measured signals into engineering units
- Provides hard copy of crucial test information such as instantaneous Electric Locomotive emission levels, or snapshots of events
- Records data to laptop, enabling later playback and post processing.

TransDAS

TransDAS is a PC-based data acquisition system which uses the LabVIEW software development and operating environment. A high-speed data acquisition board inside the TransDAS PC samples each input signal 51,200 times per second and digitizes the result. TransDAS stores the results in memory and calculates the quantities of interest for the test. TransDAS provides stripchart-type displays of selected variables versus time, with selectable scaling and labeling.

TransDAS also includes outputs which can be programmed to generate outputs proportional to computed or processed variables, as well as sinusoid or other selected waveforms.
A Strip Chart Recorder (SR) and Printer can perform similar input monitoring and display functions, and may be used instead of TransDAS.
For this project, TransDAS or the SR will monitor, record and print out all sensor and status outputs in annotated stripchart format. These outputs include I-line, power/brake command, speed, OCS voltage.

Current Transducers

Current transducers (CT’s) monitor AC and DC current in the OCS feed on one locomotive.

Hioki CT7642: The Hioki model CT7642 Clamp on AC/DC current probe has a current range of 2000 A AC or DC. It measures current from 0 A up to 2300 A AC or DC with 2% reading accuracy. For the CET, it measures I-line DC, the OCS current feeding the test Electric Locomotive. The Hioki CT7642 has an output of 0.1 mV/A and a frequency range of DC to 15 kHz at low line currents.

Pearson 7815: The Pearson 7815 is a passive clamp-on current transformer with a sensitivity of 10 mV/A. It handles an RMS current of 400 A and a peak current of 50,000 A. Its 3 dB frequency response is from 1.5 Hz to 2 MHz. It has an output impedance of 50 ohm. For the CET, it measures I-line AC, the OCS current feeding the test Electric Locomotive.

The Pearson 7815 has an output sensitivity of 10 mV/A. It has a frequency range of 1.5 Hz to 2 MHz. Because the current sensor does not respond to DC current, it can be set to a more sensitive range. In the sensitive range, the current sensor provides a measurement with better dynamic range and signal-to-noise ratio.

TISS and Tenco will install the Hioki 7642 and the Pearson 7815 current transducers on OCS main circuit feed.

Low Pass Filter

The Krohn-Hite 3944 is a 4-channel Butterworth/Bessel filter, which provides adjustable high and low pass filters, with 4 pole, and 24 dB/octave attenuation. The Krohn-Hite 3944 also provides up to 20 dB gain on the input, and 20 dB on the output. The test team will use Channel 1 to block components measured by the Hioki CT6742 above 6 Hz, and Channel 2 to condition the AC component for recording. The Krohn-Hite 3944 will be used for the DC Return Current Test, described in Section 10.

Digital Oscilloscope/Recorder

The Hioki MR8870 HiCorder is a 2 channel hand held, battery powered, digital oscilloscope/recorder with sampling rate of 10^6 samples (1 Mega-sample) per second, capable of storing up to 3 min of waveform at 10 kHz sampling rate. The Test team will use the Hioki MR8870 to observe and record AC and DC current levels for the DC Return Current Test, described in Section 10.

9.1.2. Calibration

The Hioki and Pearson CT require calibration. A typical calibration arrangement is to install a 10-turn calibration coil on the CT's. TISS and Tenco will use an AC sweep from the DP240 into a known resistor to provide a calibration current of known amplitude into the CT's. Confirm the calibration of the Pearson. For example, a 1.0 V p-p AC voltage across a 50 ohm resistor provides about a 20 mA p-p current into a calibration coil for the Pearson, which has a 10 mV/A range. With 10 turns on the Pearson, the calibration signal is 0.2 A equivalent or 2 mV p-p at the Pearson output. TISS and Tenco will observe the calibration signal and Pearson output signal with the DP240, using a transfer function to compare the signals.

The test team will also calibrate the Hioki CT 7642 and Krohn-Hite filter by running DC current through the test loop. With the Krohn-Hite 3944 set for 20 dB gain on the input, and 20 dB gain on the output, a 5 VDC input will provide 1 A effective calibration current, and 10 mV input to the Hioki MR8870 HiCorder.

9.2. Conducted Emissions Test Runs

TISS and Tenco will perform tests to determine the modes and conditions under which the Electric Locomotive makes its worst-case CE, considering powering, regenerative braking, and auxiliaries. Typically, the worst-case CE occurs when the Electric Locomotive is operating at maximum power, with one Auxiliary Power Unit (APU) or Head End Power (HEP) Converter-Inverter (CI) off line

TISS and Tenco will measure harmonic components of the main circuit current.

TISS and Tenco will perform sufficient test runs to identify worst-case CE for normal operating conditions; and in combinations of applicable operating modes, speeds, and failure conditions.

TISS and Tenco will record test data so that test artifact events caused by Electric Locomotive starting, pantograph bounce, OCS wire gaps, and startup of a regeneration load Electric Locomotive can be distinguished from events caused by the Electric Locomotive under test, such as mode transition and regeneration variation.

For all test runs, TISS and Tenco will maintain a test log per the requirements of Section 11 of this FETP, providing the test type, Electric Locomotive configuration, run description, comments for each run, and other relevant information.

9.2.1. Test Variables

TISS and Tenco will perform test runs for the Electric Locomotive configurations and operating modes described below. Tenco will evaluate results during the first series of test runs to determine the modes and conditions under which the Electric Locomotive makes its worst-case emissions, considering powering, regenerative braking, speed, and number of active converter-inverters. Further tests will focus on worst-case modes and conditions.

The configurations and operating modes below show potential test runs that Tenco will perform, as available during the Factory CET.

Length and Loading:

TISS and Tenco will perform all test runs on a single Electric Locomotive.

The Electric Locomotive will only be loaded with test equipment and test personnel. Electric Locomotive CE will be measured at the main circuit feed to the OCS to include both APU/HEP and Traction Emissions. Tenco will make initial runs with the Electric Locomotive standing to measure APU/HEP and Battery Charger emissions only.

Direction:

TISS and Tenco will perform test runs in forward and reverse directions on the test block.

Operating Modes:

TISS and Tenco will test presumed worst-case operating modes, in forward and reverse direction with low level of auxiliary power, HEP with no load condition, including appropriate combinations of:

- Maximum, medium, and minimum tractive effort
- Maximum, medium, and minimum regenerative braking effort
- Brakes in emergency; slip-slide

Speed:

TISS and Tenco will run the Electric Locomotive up to the highest safe speed as close as possible to the track section speed limit. F

Location: F

TISS and Tenco will perform low-speed CET at the TRA Depot Test Track .

Converter-Inverters:

TISS and Tenco will perform tests with the following conditions:

- Nominal: 6 MPU’s active, 2 APU’s active, 2 HEP`s active
- 1 MPU is failed: 5 MPU’s active, 2 APU’s active, 2 HEP`s active
- 1 APU is failed: 6 MPU’s active, 1 APU’s active, 2 HEP`s active
- 1 MPU and 1 APU are failed: 5 MPU’s active, 1 APU’s active, 2 HEP`s active

The test log will record the number of converter-inverters used in each test. If select measurements are shown to be identical for different configurations with worst-case conditions, TISS and Tenco will skip select runs. TISS and Tenco will choose a test run order to minimize the configuration changes between each run, for efficient use of test time.

Line Voltage:

TISS and Tenco will perform all tests at available line voltage and will record the line voltage in the test log . F

Failure Conditions:

TISS and Tenco will test the Electric Locomotive with possible failure conditions active. TISS and Tenco will test relevant combinations of annunciated failures.

Mode Transitions:

TISS and Tenco will perform tests measuring emissions during transition between modes (powering-coasting-powering, powering-coast-braking-coasting, etc.). To prevent multiple simultaneous Electric Locomotive response events, Tenco will allow the Electric Locomotive to coast for one second in the transition period between modes.

As noted above, TISS and Tenco will test the possible operating ranges, modes, and combinations to identify worst cases. From among those tests, TISS and Tenco will select, further test, and document conditions for Powering and Regenerative Braking worst-case emissions.

If a set of tests show that some variations or test runs are not necessary, TISS and Tenco will document the reason.

9.2.2. Test Run Types

TISS and Tenco will perform the CET with a single Electric Locomotive.

The test setup for data collection is described above in this FETP section 9.1.

TISS and Tenco will perform the following types of test runs, measuring CE under different operating modes of the Electric Locomotive, as appropriate.

TISS will perform the CET using appropriate combinations of minimum, medium, and maximum tractive effort; in powering and regenerative brake modes; in forward and reverse directions; on a single Electric Locomotive; with minimum, medium, and maximum levels of auxiliary power usage; at available line voltage

TISS and Tenco will perform sufficient test runs to identify worst-case conditions for normal, abnormal, and failed operating conditions; and in the full range and combinations of applicable operating modes, speeds, and failure conditions.

Further information regarding the types of test runs can be found in section 9.2.3 below.

9.2.3. Test Run List

TISS and Tenco will perform: F

- Low-speed CET at the TRA Depot Test Track.

Table 9-2 below lists the CE Test Run types on the TRA Depot Track

TISS and Tenco will perform the tests on the following list in an order which makes efficient use of track and Electric Locomotive time and staff availability.

F

Table 9-2 CE Test Runs

Electric Locomotive Conducted Emission Test Runs					
Prop. State	Type	Operating Activity	Mode	Speed (kph)	Purpose/Special Conditions
Concurrent with Factory Test Runs					
Regenerative Brake	C1a	Approach at 50 km/h. Max Brake to 0 km/h	Max Brake	50 – 0	Nominal: 6/6 MPU’s active, 2/2 APU’s active 2/2 HEP`s active
	C1b				1 MPU Fail Case: 5/6 MPU’s active, 2/2 APU’s active 2/2 HEP`s active
	C1c				1 APU Fail Case: 6/6 MPU’s active, 1/2 APU’s active 2/2 HEP`s active
	C1d				1 MPU and 1 APU Fail Case: 5/6 MPU’s active, 1/2 APU’s active 2/2 HEP`s active
	C2a	Approach at 30 km/h 50% Brake to 0 km/h	50% Brake	30 – 0	Nominal: 6/6 MPU’s active, 2/2 APU’s active 2/2 HEP`s active
	C2b				1 MPU Fail Case: 5/6 MPU’s active, 2/2 APU’s active 2/2 HEP`s active
	C2c				1 APU Fail Case: 6/6 MPU’s active, 1/2 APU’s active 2/2 HEP`s active
	C2d				1 MPU and 1 APU Fail Case: 5/6 MPU’s active, 1/2 APU’s active 2/2 HEP`s active
	C3a	Approach at 20 km/h Min Brake to 0 km/h	Min Brake	20 – 0	Nominal: 6/6 MPU’s active, 2/2 APU’s active 2/2 HEP`s active
	C3b				1 MPU Fail Case: 5/6 MPU’s active, 2/2 APU’s active 2/2 HEP`s active
	C3c				1 APU Fail Case: 6/6 MPU’s active, 1/2 APU’s active 2/2 HEP`s active

Electric Locomotive Conducted Emission Test Runs					
Prop. State	Type	Operating Activity	Mode	Speed (kph)	Purpose/Special Conditions
	C3d				1 MPU and 1 APU Fail Case: 5/6 MPU's active, 1/2 APU's active 2/2 HEP`s active
	C4	Slide Controlled Emergency Brake from 20 km/h	Emergency Brake	20	Worst Case configuration from C1 – C3
Powering Acceleration Runs during Performance Test	C5a	Start from 0 km/h. Max Acceleration to 40 km/h	Max Accel	0 – 40	Nominal: 6/6 MPU's active, 2/2 APU's active 2/2 HEP`s active
	C5b				1 MPU Fail Case: 5/6 MPU's active, 2/2 APU's active 2/2 HEP`s active
	C5c				1 APU Fail Case: 6/6 MPU's active, 1/2 APU's active 2/2 HEP`s active
	C5d				1 MPU and 1 APU Fail Case: 5/6 MPU's active, 1/2 APU's active 2/2 HEP`s active
	C6a	Start from 0 km/h. Med Acceleration to 30 km/h	50% Accel	0 – 30	Nominal: 6/6 MPU's active, 2/2 APU's active 2/2 HEP`s active
	C6b				1 MPU Fail Case: 5/6 MPU's active, 2/2 APU's active 2/2 HEP`s active
	C6c				1 APU Fail Case: 6/6 MPU's active, 1/2 APU's active 2/2 HEP`s active
	C6d				1 MPU and 1 APU Fail Case: 5/6 MPU's active, 1/2 APU's active 2/2 HEP`s active
	C7a	Start from 0 km/h. Min Acceleration to 20 km/h	Min Accel	0 – 20	Nominal: 6/6 MPU's active, 2/2 APU's active 2/2 HEP`s active
	C7b				1 MPU Fail Case: 5/6 MPU's active, 2/2 APU's active 2/2 HEP`s active

Electric Locomotive Conducted Emission Test Runs					
Prop. State	Type	Operating Activity	Mode	Speed (kph)	Purpose/Special Conditions
	C7c				1 APU Fail Case: 6/6 MPU's active, 1/2 APU's active 2/2 HEP`s active
	C7d				1 MPU and 1 APU Fail Case: 5/6 MPU's active, 1/2 APU's active 2/2 HEP`s active

(*Note 1): The speed condition and master controller position may change during the test due to test track restriction, driver operation and safety considerations.

9.2.4. Test Run Notes

The following Master Controller positions are available on the Electric Locomotive. Tenco and TISS will use the appropriate ones per the test run requirements:

- Full Service Braking by operating the automatic brake handle of EBV to the appropriate position, set the reverser to "電軔" position and by moving the master controller handle towards the driver side.
- Maximum Powering by setting the reverser to "F" position and moving the master controller handle towards the driver side
- Coasting position by moving master controller handle to "OFF" position.

Moving the Manual Controller between Min Power and Max Power causes a linear increase in tractive effort. Moving the Manual Controller from Min Brake to Full-Service Brake causes a linear increase in braking effort. F

9.3. Conducted Emissions Test Methods

9.3.1. Test Steps

TISS and Tenco will operate the Electric Locomotive per the test runs listed in section 9.2 The test setup in Figure 9-1 monitors the OCS current on board the Electric Locomotive under test.

Tenco will follow these steps for the CET:

1. Set up the test equipment per Figure 9-1. Confirm that the Pearson 7815 AC Current Sensor is not susceptible to pick up from currents outside its measurement window. Connect the Pearson 7815 to the TransDAS and the FFT Analyzer. Record the test equipment configuration.
2. Use a test signal to calibrate the Pearson 7815 output as displayed by the TransDAS and the FFT Analyzer. Record the end-to-end frequency response of the Pearson 7815 when used with the TransDAS and FFT Analyzer.
3. Set the FFT analyzer frequency resolution high enough to capture sweeping inverter harmonics. TISS and Tenco will use 3 different frequency resolutions during the test, shown in Table 9-3. TISS and Tenco will generally use frequency resolution #1 to perform most test runs, frequency resolution #2 to check the amplitude of fixed harmonics, and frequency resolution #3 to record emissions across the entire audio frequency range, and to check worst-case emissions.

Table 9-3 FFT Settings

FFT Analyzer Frequency Resolution Settings		
ID	**Frequency Range**	**Resolution Lines**
1	0 – 1.6 kHz	400
2	0 – 800 Hz	400
3	0 – 25.6 kHz	3200

F

4. Set up the Electric Locomotive for running on the test section, with all equipment energized as indicated in the test list.
5. Record Electric Locomotive general configuration; MPU software configuration; APU/HEP software configuration; Electric Locomotive loading condition; any simulated signals; and test track layout.
6. Record TPSS (Traction Power Substation) locations and track number. Confirm calibration of sensors and equipment.
7. Measure Electric Locomotive CE for the listed test runs. Note in the test log the number of converter-inverters used for the test and the consist length and makeup.
    a. Display and record CE with the DP240 FFT analyzer. Use TransDAS to document the acceleration / deceleration cycle and other Electric Locomotive signal measurements including speed, mode and status. Confirm peak emissions do not exceed maximum settings for the AC current sensor.

b. Determine worst-case CE from each run, compare psophometric current calculated from the measured data with limits specified in 9.3.2. Repeat tests as necessary to highlight frequencies where CE is close to or above the scaled CE limits. Determine whether each run type conforms to limits. Determine whether run is a worst-case run for later repetition. Record data and results.

Check that all run types have been performed, and that compliance has been checked for each frequency range for each run type.

9.3.2. Pass / Fail Criterion

The objective of the Conducted Emissions Factory Test is to demonstrate that the worst-case Electric Locomotive CE meet TRA's requirements for psophometric current.

TISS and Tenco will demonstrate that the Electric Locomotive worst-case CE are acceptable by performing and documenting a Conducted EMI Test per EN 50121-3-1.

TISS and Tenco will perform the Conducted Emissions Factory Test by connecting AC current sensors to the Electric Locomotive onboard traction feeder cables or traction return cables. TISS and Tenco will record the current for a single electric locomotive, and evaluate the measured current against the psophometric current limits specified in this FETP. During the test, TISS will measure and record other Electric Locomotive parameters including operator command and Electric Locomotive speed, mode, and status.

The TRA lines on which the Electric Locomotives will run use only DC track circuits. There are no audio frequency track circuits in use on the TRA lines. TRA presently operates EMU800 trains with identical Traction converter-inverter (CI) equipment, and with similar APU equipment, with no conducted or inductive interference problems. Accordingly, TRA did not apply conducted or inductive emission limits to protect track circuits.

TRA defines Electric Locomotive CE limits in TS 6.4 (4) which requires that the “interference noise current (Psophometric Weighted) of the maximum horsepower output of the locomotive and 25kV electric line voltage shall not be more than 10A maximum; the maximum interference value within 10% variation of the running speed is also not to exceed 12A.

During the design stage, TISS and Tenco will calculate Electric Locomotive psophometric current Ipso using simulated converter and APU 60 Hz conducted emissions. During factory testing, TISS and Tenco will calculate Ipso using MPU, APU and HEP conducted emissions measured per IEC62236 or EN 50121-3-1.

TISS will calculate Ipso:

$$I_{pso} = (1/P800) \times \sqrt{ \{ \sum (Pf \times If)2 \} }$$

Where:

- Ipso is the psophometric current

- If is the current component at frequency f in the traction current
- P800 is the psophometric weighting factor at a frequency of 800 Hz
- Pf is the psophometric weighting at other frequencies.

The weighting factor at 800 Hz, P800, has a value of 1.

The values of Pf are specified in ITU-T O.41, "Protection of telecommunications against harmful effects from electrical power and electrified railway lines." The calculation applies the weighting factor to each the current at each harmonic in proportion to its disturbing effect relative to 800 Hz.

Figure 9-3 shows the Table 1/O.41 of ITU-T O.41 weighting values.

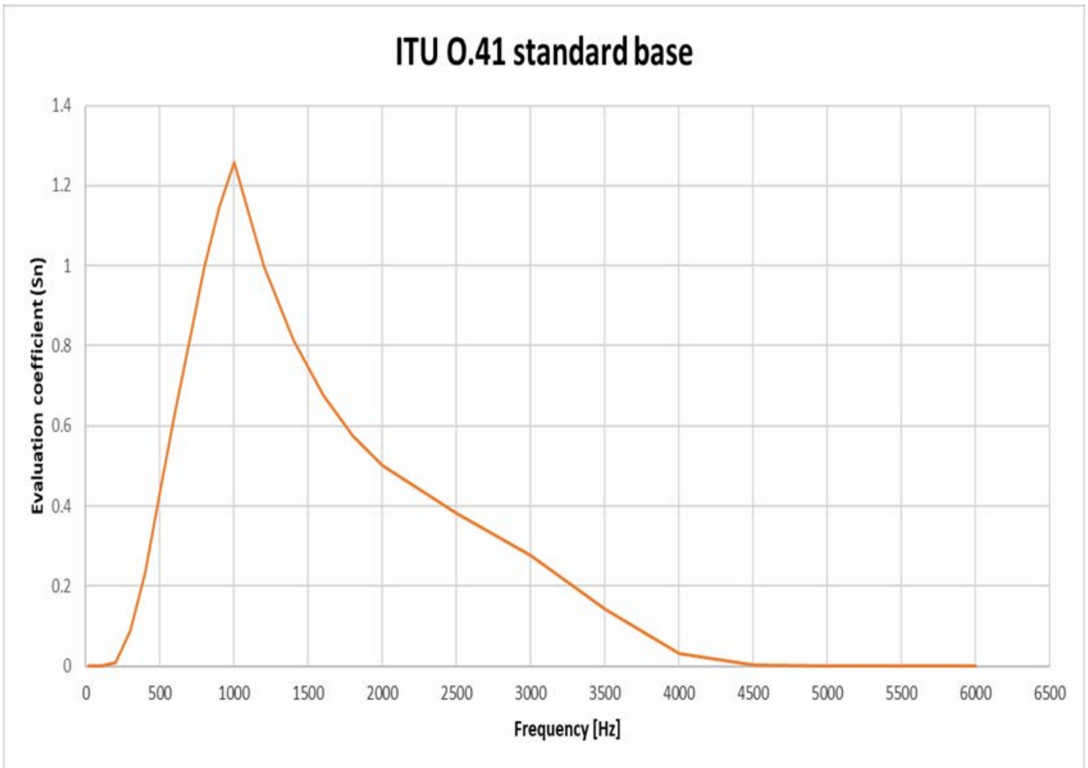


Figure 9-3 Psophometric Weighting Factor

Below are the maximum load conditions at power and regenerative braking.

1. Traction Power for 6 traction motors:

   DC link power 733 kW, while Locomotive was powering at 62kph (added resistive load at powering)

   DC link power 573kW, while Locomotive was regenerative braking at 73kph (added DC current source at regenerative Braking)
2. Auxiliary Power Unit 1 (APU1) for Locomotive: 130kVA
3. Auxiliary Power Unit 2 (APU2) for Locomotive: 100kVA

4. Head End Power for Passenger Car (2 units total): 450kVA

TISS will perform conducted emissions tests on one Electric Locomotive of first lot at the TRA Depot Track. F

TISS will perform the conducted emission tests per IEC62236 or EN50121-3-1, and confirm compliance with TRA psophometric current limits.

9.3.3. Test Run Instructions

TISS will perform the following test instructions when measuring conducted emissions with the Electric Locomotive:

1. Run each test type, as shown in Table 9-2
2. Repeat test runs with worst-case results across the variables described in section 9.2.1

The test set up for data collection is described above in 9.1 of this FETP.

9.3.4. Test Repetitions

TISS will make sufficient runs of the most significant conditions to ensure that results are consistent under similar test conditions.

If data in some test indicates strongly that another later test will not produce greater levels of interference, the later test need not be performed, or can be modified. Record the justification for not performing the test on the appropriate form.

9.3.5. Measurement of Emissions

The TRA specification referenced standards define quantitative limits for conducted emissions. These emission levels are expressed as if all the emissions in question are narrowband emissions, that is, signals with a discrete and stable frequency. Narrowband emissions are characteristic of inverters with a fixed operating frequency, such as auxiliary power converter inverters.

The principal source of inductive and conducted emissions on the Electric Locomotive is the Traction converter inverter. The Electric Locomotive Traction converter inverter, like similar equipment, uses pulse width modulation (PWM) to generate a precisely controlled current waveform synchronized to the line voltage. The resulting PWM frequency emissions under most usual operating conditions have a narrowband quality. Another important source of EMI is impulses, such as caused by Traction Power Substation (TPSS), from stray magnetic flux near current sensors, contactor closure, gap arcing, pantograph bounce, or mode change.

Overall, the emissions and impulses which result from traction converter inverter operation tend to be more broadband rather than narrowband.

The appropriate emission limit and measurement method for sweeping or broadband signals is to measure signal strength in a frequency band of a selected width using measurement units of Volts rms, by setting the dynamic signal analyzer so its frequency line spacing matches the selected frequency bandwidth. TISS will choose the dynamic signal analyzer measurement bandwidth to match the receiver bandwidth for the track signal equipment used in the frequency range under test.

For narrowband emissions, the dynamic signal analyzer frequency line spacing can be set to any convenient value consistent with measuring the performance of the equipment under test. Measurement units are volts rms.

9.3.6. Field Reduction of Data

TISS will set up the signal analyzer to account for equipment factors, calibration factors, gain, and conversion units so that the emission amplitudes are recorded in units of current. The test team will plot or print the signal analyzer data on completion of each test run, annotating the test results as appropriate.

Data for Electric Locomotive emissions and ambient levels will be regarded as invalid at frequencies at which the receiver accuracy is affected adversely by spurious response or lack of sufficient receiver sensitivity.

10. DC Return Current Test (Test ID 3)

10.1. DC Return Current Test Equipment Configuration

Per TRA specification Section 8.9.4 (7), the test team will measure the surge current generated on the main transformer after closing the Electric Locomotive Vacuum Circuit Breaker (VCB). The TRA specification requires the DC component of Line current in the traction circuit to not exceed 2.6 A after the VCB is closed for 1 s.

As described in Section 9.3.2, the TRA lines on which the Electric Locomotives will run use DC track circuits. TISS will perform a DC Return Current Test (DCRCT), to:

- Demonstrate there is no sustained DC current in the Main Transformer after the VCB is closed.
- Prevent any over-limit DC current to flow in the return rails that could interfere with TRA track circuits.

Figure 9-2 in Section 9.1, shows that the 25 kV overhead line power is collected with a pantograph on the locomotive roof, and drawn to the main transformer via the VCB. Figure 9-2 also shows the location of the DC current transducer in the traction circuit for the DCRCT.

Figure 10-1 shows the DC current sensor setup for the DCRCT. TISS will perform this test on one locomotive of first lot, before TISS delivers it to TRA.

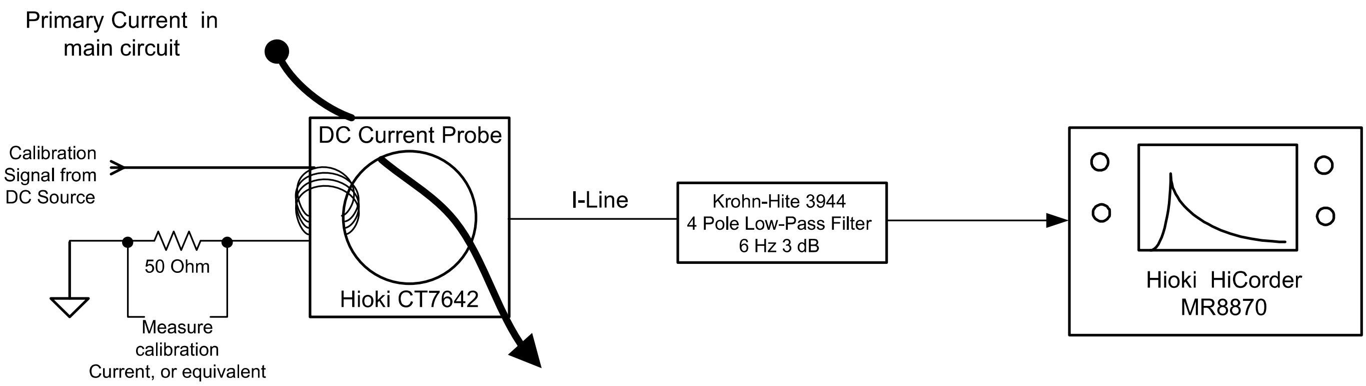


Figure 10-1 DC Return Current Test Configuration

10.1.1. Test Equipment

Table 10-1 lists the test equipment used for measuring the DC component of the Line current.

Table 10-1 DC Return Current Test Equipment List

No.	Item	Purpose
1	Hioki CT7642 AC/DC Current Probe	For monitoring DC return current component
2	Krohn-Hite 3944 Low Pass Filter	Channel 1 to filter out AC components. Channel 2 to amplify 60 Hz component and suppress higher harmonics.
3	Hioki MR8870 2-channel Memory HiCorder. Digital Oscilloscope/Recorder	For measuring and recording DC and AC components of line current.
4	Printer, Brother MFC-J870DW, HP930 Deskjet Printer, or equivalent.	For plotting DC return current spectra.

TISS will measure the DC component of the line current with the Hioki 7642 DC current transducer, the Krohn-Hite 3944 4-pole low pass filter, and record with the Hioki MR8870 HiCorder.

The test equipment is described in Section 9.1.1. The test team will calibrate the Hioki 7642 current transducer combined with the Krohn-Hite filter, as described in Section 9.1.2.

10.2. DC Return Current Test Methods

10.2.1. Test Steps

TISS will follow these steps for the DCRCRT:

1. Set up the test equipment per Figure 10-1.
    a. Confirm that the Hioki CT7642 is not susceptible to pickup from currents outside the CT clamp
    b. Connect the Hioki 7642 output to the Krohn-Hite filter inputs on Channels 1 and 2
    c. Set the Krohn-Hite filter Channel 1 to 6 Hz, 3 dB point, Butterworth filter with 24 dB attenuation per octave, 20 dB input gain 20 dB output gain
    d. Set the Krohn-Hite filter Channel 2 to 3 kHz, 3 dB point, and 20 dB output gain
    e. Connect respectively the Krohn-Hite filter output Channel 1 and 2 to the Hioki MR8870 HiCorder input Channel 1 and 2
    f. Set the Hioki MR8870 HiCorder to 10 ms/div on the time scale, and 10 mV per division on both channels

2. As described in Section 9.1.2, use a DC test signal to calibrate the Hioki CT7642, the Krohn-Hite filter, and display it on the Hioki MR8870 Channel 1. Repeat this step with a 60 Hz AC test signal on the Hioki MR8870 Channel 2.
3. Set the Electric Locomotive in standstill position on the test track, with the VCB open.
4. Record Electric Locomotive general configuration; Traction software configuration; APU and HEP software configuration; Electric Locomotive loading condition; any simulated signals; and test track layout. HEP will be operated with no load condition.
5. Record TPSS (Traction Power Substation) locations and track number. Confirm calibration of sensors and equipment.
6. Turn ON the VAC and Blower equipment, and perform the following:
    a. Make sure all conditions are met to close VCB.
    b. Start recording on the Hioki MR8870 HiCorder
    c. Close VCB
    d. Continue recording for 30 s
    e. Open VCB
    f. Stop recording, save data and results
7. The VCB closing time will be determined by the sudden rise in 60 Hz current on Channel 2 of the Hioki MR8870 recording.

10.2.2. Pass / Fail Criterion

Per TRA specification Section 8.9.4 (7), the objective of the DCRCT is to demonstrate that the DC return current does not exceed 2.6 A, after the VCB is closed for 1.0 s.

If the DC return current is lower than the limit after the elapsed time, the locomotive passes the test.

11. Test Data Collection

TISS will collect and maintain data from the RET and CET, including for test equipment calibration, test set-up calibration, and each test run. Sample forms are shown in Attachment 1.

11.1. Equipment Calibration

TISS will record calibration data for each major test equipment item. Calibration data will include:

- Test Equipment Item
- Provided By (TISS or Tenco)
- Manufacturer, Model, and Serial Number
- Calibration Date and Calibration Source and Reference Number
- Notes

11.2. Test Setup

TISS will document correct operation for all instruments. TISS will confirm and document accuracy of the spectrum analyzer. TISS will record the test track setup.

11.3. Test Run Log

TISS will maintain a test run log, recording the following for each test run:

- Date and Time
- Performed By
- Location
- Electric Locomotive Configuration
- Run #
- Test Type, including operating mode
- Run Description, including speed and direction or from/to
- Test Configuration Data, such as frequency range
- Summary Results
- Notes

See the Test Run Log and Directory of Test Run forms in Attachment 1.

12. Onboard Magnetic Field Measurement Test (Test ID 4)

12.1. Instrument for the test

Table 12-1 shows instrument for the test.

Table 12-1 Instrument for the Test

Item	Instrument	Type	Quantity	Manufacturer	Remarks
1	Three Axis Vector/Magnitude Gaussmeter, with probe	VGM	1	AlphaLab	For measuring magnetic field

Note; Instrument for the test is subject to change depending on circumstances.
Detail information of test instruments for each test is submitted in each test report.

12.2. Test Condition and Preparation

This test will be conducted on the TRA main line.

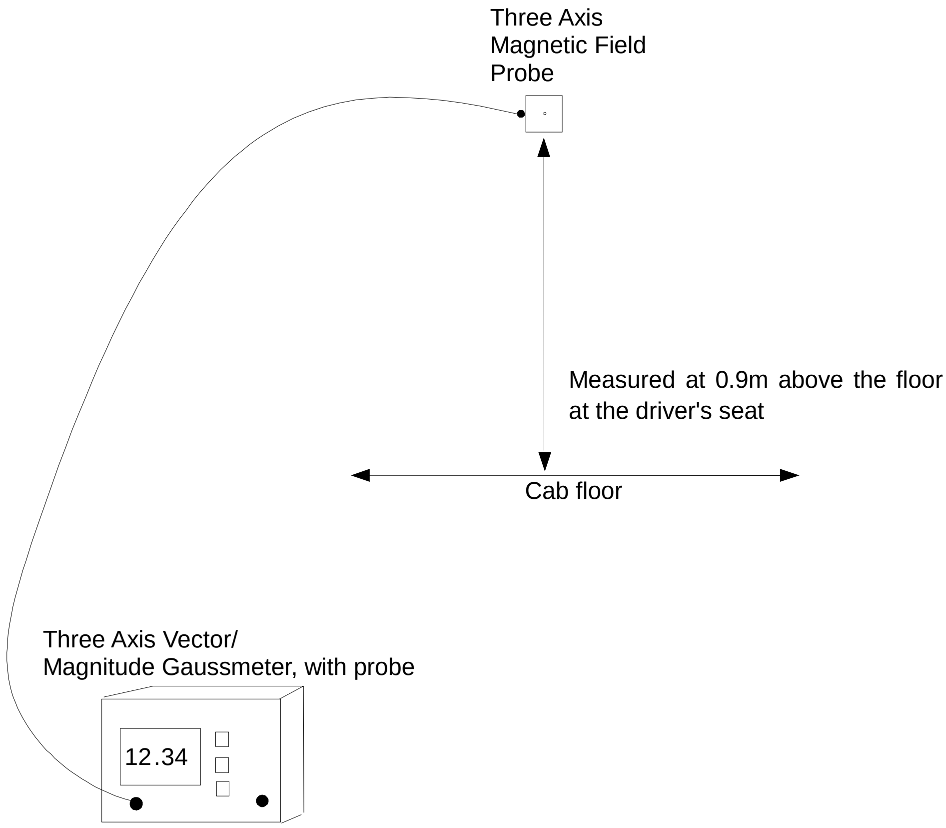


Figure 12-1 Onboard Magnetic Field measurement test Configuration

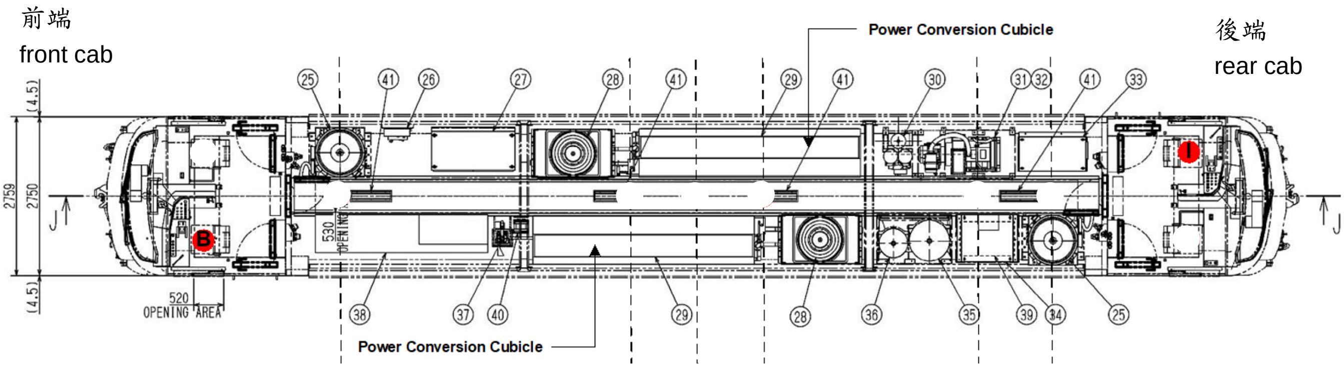


Figure 12-2 Onboard Magnetic Field measurement test Locations

Figure 12-2 shows the measurement points which are selected in the locomotive. The measurement point “B” is located at driver seat in front cab, and the measurement point “I” is located at driver seat in rear cab.

12.3. Test Procedures

Test procedures are as show in Table 12-2.

Table 12-2 Test Procedure of Onboard Magnetic Field measurement

Test ID		Item	Verification	Remarks
		Operate Method	Description	
4	1	Accelerate from 0km/h to 130km/h at maximum acceleration.	Magnetic field level at maximum acceleration on the front driver's side Record. (B)	
4	2	From 130km/h, it stops at 0km/h with maximum deceleration by dynamic braking.	Magnetic field level at maximum deceleration on the front driver's side Record. (B)	
4	3	Accelerate from 0km/h to 130km/h at maximum acceleration.	Magnetic field level at maximum acceleration on the rear driver's side Record. (I)	
4	4	From 130km/h, it stops at 0km/h with maximum deceleration by dynamic braking.	Magnetic field level at maximum deceleration on the rear driver's side Record. (I)	

12.4. Test Criteria

Acceptance criteria is as shown in Table 12-3.

Table 12-3 Test criteria

Test ID		Measured value, mG		Criteria	Pass/Fail
4	1	X		Less than 833mG	□Pass □Fail
		Y			□Pass □Fail
		Z			□Pass □Fail
4	2	X		Less than 833mG	□Pass □Fail
		Y			□Pass □Fail
		Z			□Pass □Fail
4	3	X		Less than 833mG	□Pass □Fail
		Y			□Pass □Fail
		Z			□Pass □Fail
4	4	X		Less than 833mG	□Pass □Fail
		Y			□Pass □Fail
		Z			□Pass □Fail

Note: Less than 833mG per IEEE Std C95.1.

Attachment:

1. Format of Factory Test Report for EMC Test

(ECS-QA-E7-TR-0081 Rev.1, Total 16 pages)

Attachment 1

Format of Factory Test Report for EMC Test

(ECS-QA-E7-TR-0081 Rev.1, Total 16 pages)