



TECHNICAL DIRECTORATE

TECHNICAL PAPER

Results of the Electrical and EMC Testing of the PES Prototype

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Abbreviations

AEW	Aerial Earth Wire
CCTV	Closed Circuit Television
CIS	Customer Information System
CMS	Cable Management System
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
HV	High Voltage (>1000v)
LED	Light Emitting Diode
PA/VA	Public Address / Voice Announcement
PES	Platform Edge Screen
PSD	Platform Screen Door
TEW	Traction Earth Wire
OHLE	Over Head Line Equipment
ITP	Inspection Test Plan
DOO	Driver Only Operation Camera

Abstract

Background:

Crossrail has recently conducted a series of Electrical and (EMC) tests on a prototype Station Platform PES and PSD which also included the following electrical and electronic operational services;

- Loudspeaker based PA/VA
- CIS Screens (parallel to PSD)
- CCTV & DOO cameras
- Lighting Incorporating Dali Control
- Illuminated Signage
- Cable management system
- Platform Leaky feeder
- PSDs
- Fire Detection (mounted in the crown of the tunnel)

The series of tests was designed to assure the various aspects of the platform design, including operability, maintainability and safety, and demonstrate the level achieved. The criteria for the electrical and EMC tests to be performed on the prototype will be based on a pass/fail result and be in conjunction with specific inspection test plans (ITP).

1 Introduction

The test scope is intended to determine induced voltages in various conductors when traction current is flowing in the OHLE and Monitor the performance of selected electrical and electronic systems, assets to demonstrate confidence in the design principles. There will also be 'non-induced' accessible voltages in normal, degraded and fault conditions. These cannot be simulated in the mock-up tests and will be tested during C610 testing and commissioning and live (train running) testing along with the testing of the 'as built' M&E and systems assets prior to Station Handover and the off site testing of individual system components as required by the Crossrail EMC Plan Scope

2 Scope

The test specification was set out in Crossrail's Technical paper "Electrical and EMC Testing of Station Platform PES and PSD Prototype" document No. CRL1-XRL-E-RSP-CRG03-50001.

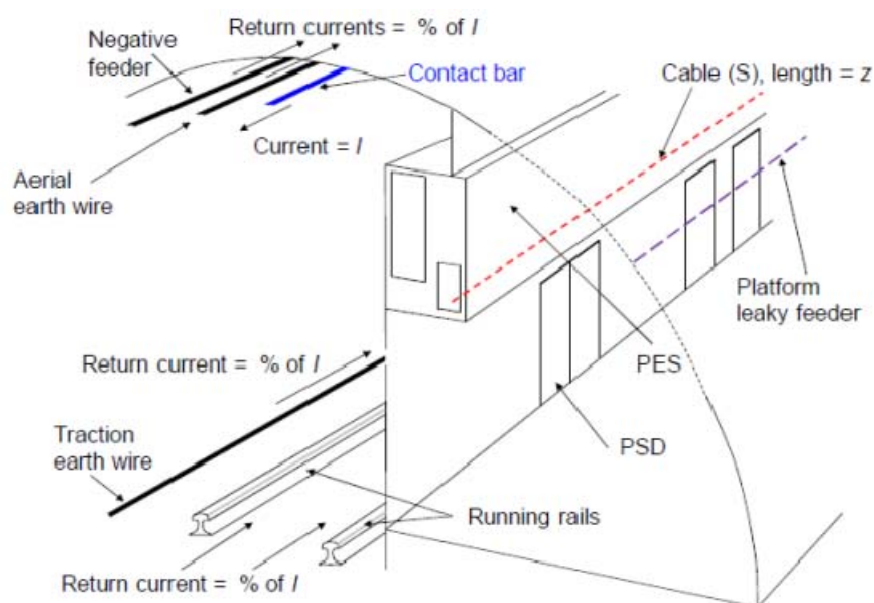
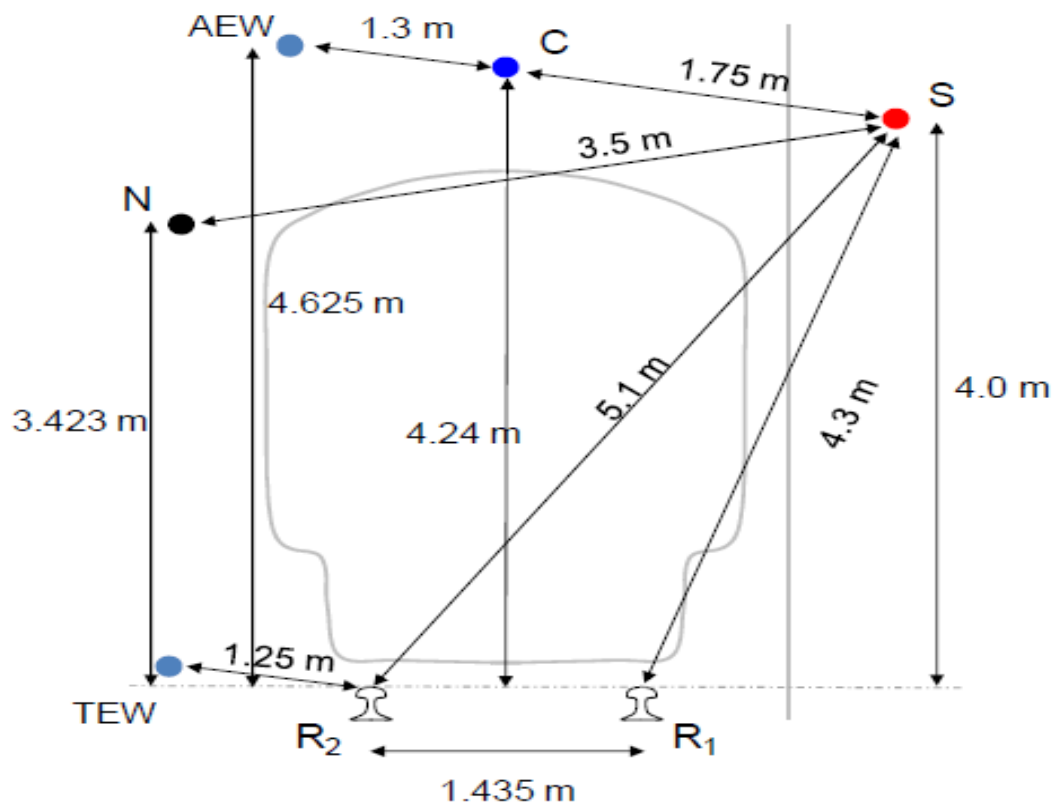


Figure 1 Schematic of PES/PSD prototype

2.1 Electrical Layout

Figure 1 above shows a schematic of the station platform PSD/PES prototype. The platform section is approximately 10.5 m long. Note that for clarity of the electrical layout, various parts of the design are not shown in Figure 1 including the solid L-shaped barrier which forms part of the extract plenum. The station earthing system (Appendix B) is electrically isolated from the traction earthing system, except for one connection to the station earth bar, meaning the PSD which is at traction earth potential is physically isolated from the PES which is at station earth potential.

As far as the electrical tests are concerned it is only necessary to place conductors of the appropriate rating in the correct geometrical relationship to the platform and PSD. The conductor representing the contact bar (OHLE) is supported by an insulating structure which can withstand a steady state voltage of > c. 35 kV rms 50 Hz arc, the general test arrangement is shown in appendix B.



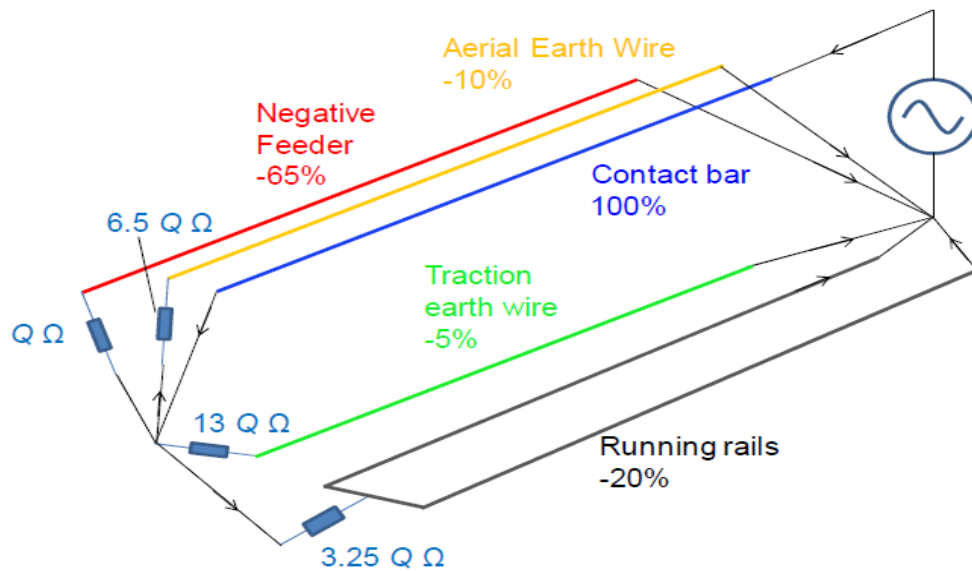
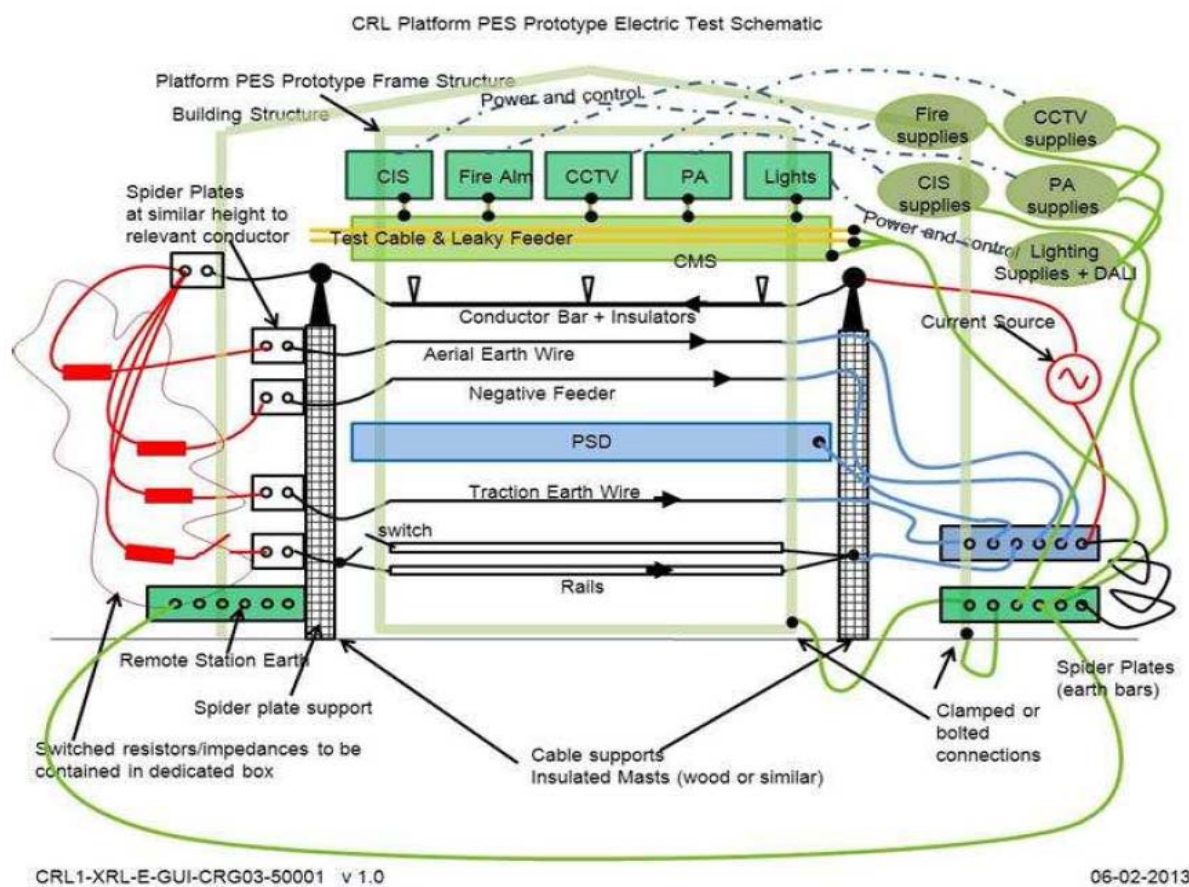


Figure 3 Current test set up.



2.1 Test Criteria

1. Fire Alarm Detection Control Test

Reference (ITP CRL1-XRL-E-ITP-CR001_6-50001, revision 2.0 Fire Section 5.1)

Before the OHLE power was energised, the beam detectors were tested to establish that the system was operational. A specialised optical filter was used to interrupt the beam between the detectors. The fire alarm panel was visually monitored while a 'fire' signal was received, and the panel was then appropriately reset.

2. Current Tests

Reference (ITP CRL1-XRL-E-ITP-CR001-6-50001 Section 4.1a, b, c)

Injected an AC current of 100A, 150A and 200Amps into the contact feeder bar with return current distribution as following (See Figure 3):

- I. -25kV Feeder = 65%
- II. Two running rails = 20% (10% in each rail)
- III. Aerial earth wire = 10%
- IV. Traction Earth Wire = 5%

(Action to Monitor: lights, signs and audio and life safety system for effects).

3. EMC Test (Arc)

Reference (ITP CRL1-XRL-E-ITP-CR001-6-50001 Section 4.2)

An arc discharge to the feeder contact bar with a current of 100Amp AC and a discharge gap of 1mm. (Action to Monitor: lights, signs and audio and life safety system for effects).

4. Fire Alarm

Reference (ITP CRL1-XRL-E-ITP-CR001_6-50001, revision 2.0 Fire Sections 5.3, 5.4)

Tests on the smoke and fire were simulated and activation time was recorded, the panel was reset and re armed after each activation.

5. Current Tests (Sweep Frequency)

Reference (ITP CRL1-XRL-E-ITP-CR001-6-50001 Section 4.1d)

An injection of 1Amp AC with a swept frequency range of 10Hz to 6 kHz. (Action Monitor: audio and life safety system for effects)

6. Magnetic Field Test

Reference (ITP CRL1-XRL-E-ITP-CR001-6-50001 Section 4.3)

A survey of the magnetic field was carried out using the Hurst Gauss meter. For this test the current was set to 200A and the AC magnetic field at the platform screen was measured the

instrument displayed a background signal of 2.5 μ T. Then once inserted in its calibration capsule and it registered 0.0 μ T.

2.2 Standards to be applied

- The maximum permissible induced voltage limit specified in BS EN 50122-1
- Draft Baseline Report of the ICNIRP European Environment and Health Strategy (COM 2003)338 final) Directive (Sept 2012) States; Magnetic Fields in any public area permissible limit is 1000Mt.

3 Results

The test results were described and set out in Cobham Technical paper “Electrical and EMC Testing of a Mock-up Station Platform with Monitoring of the PES and PSD” document no. CUL/LT-0725.

I. Fire Alarm Detection Control Test

The panel was visually checked reset then armed to its operational state operational, in line with Crossrail Document CRL1-PDP-Z-RGN-CRG02-50002, revision 2.0 and ITP CRL1-XRL-E-ITP-CR001_6-50001. A **PASS** was recorded.

II. Current Tests

Reference (ITP CRL1-XRL-E-ITP-CR001-6-50001 Section 4.1a, b, c)

Table 2 lists the relevant position on the station, the RMS induced voltages and the scaled voltage for the actual station with a traction current of 1000Amps. The Crossrail maximum allowable station voltage is 60V in compliance with BS EN 50122-1. Figures 1 shows typical measured voltages (PSD) the black traces are a 30 point moving average in order to assist in the measurement of the mean value through noise on the signal. Results detailed in Table 2 show readings on the PSD with an current injection of 152 Amps yielding a scaled result of 129mV once scaled to the station equalling 9.7 V this is achieved utilising a calculation $(6.7 \times (120/10.5) \times V)$ as described in CRL1-XRL-E-RSP-CRG03-50001v4 section 4.1. The recorded results detailed in Table 2, were all well below the limits and a **PASS** was recorded.

Injected Current [A]	Voltage RMS [mV]	Scaled to Station [V]	I Maximum station voltage [V]	Pass / Fail
PSD				
100	18.38	2.1	60	PASS
150	27.93	2.1	60	PASS
200	32.88	1.9	60	PASS
PSD with -25kV released				
152	129	9.7	60	PASS
PSD with -25kV released and station earth removed				
145	76	6	60	PASS
CMS				
100	5.3	1.2	60	PASS
150	8.13	1.2	60	PASS
200	10.25	1.1	60	PASS
Test cable in CMS				
100	2.65	0.1	60	PASS
150	4.07	0.1	60	PASS
200	5.87	0.1	60	PASS
Leaky Feeder				
100	1.63	0.4	60	PASS
150	2.3	0.3	60	PASS
200	3.36	0.4	60	PASS

Table 2

III. EMC Test (Arc)

Reference (ITP CRL1-XRL-E-ITP-CR001-6-50001 Section 4.2)

A 100A arc test was carried out, and for this test the lighting, life safety system and CIS system were monitored by visual inspection and the sound system by listening for glitches/tones/noise associated with the arcing. The arc current was monitored via the current shunt. The injected current ranged from 80A to 110A, which was dependent on the arc and the electrode separation (arc length). No noise or distortion was recorded or visually noted and a **PASS** was logged.

IV. Fire Alarm

Reference (ITP CRL1-XRL-E-ITP-CR001_6-50002, revision 2.0, revision 2.0 Sections 5.3, 5.4)

Tests on the smoke detection and fire alarm system were carried out at 200 amps AC. The current was injected for a period of approximately 5 minutes. During this time the beams were interrupted in the above manner and the system was demonstrated to work satisfactorily. Visual inspections of the lighting and signs were also observed during the period and shown to be functioning satisfactorily. A **PASS** was recorded.

V. Current Tests (Sweep Frequency)

Reference (ITP CRL1-XRL-E-ITP-CR001-6-50001 Section 4.1d)

For this test personnel monitored the sound audio system, lighting and life safety systems while the frequency was swept from 8Hz to 6.2 kHz and back to 8Hz, the increase in frequency was over a period of 25 seconds, while the reduction in frequency was over a period of 4 minutes. The injected current was monitored with the Pearson current probe. At the lower frequency the current (below amplifier lower frequency band 20Hz) was 1.18Amps RMS; across the remainder of the band 2.2 RMS Amps (1 Amp test level). The frequency sweep was carried out a number of times (minimum 4). A **PASS** was recorded

VI. Magnetic Field Test

Reference (ITP CRL1-XRL-E-ITP-CR001-6-50001 Section 4.3)

A survey of the magnetic field was carried out using the Hurst Gauss meter. For this test the current was set to 200A and the AC magnetic field at the platform screen was measured. The instrument displayed a background signal at 2.5μT. The instrument when inserted in its calibration capsule registered 0.0μT. There was no measurable signal above that of background that could be attributed to the 200A injected current.

In these test where the AT return feeder is not in circuit is an extremely onerous test as in practice some current would flow in the negative feeder even if one or two ATs were out of service. In the event the negative AT Feeder Transformer was faulty the traction power system would be fed from a healthy transformer at the other end.

When the station earth – traction earth connection is removed during the test above, the traction system now floats relative to the station system, and the centre of the traction system in contact with the ground, i.e. the centre of the rails, adopts the potential of station earth. This accounts for the approximate halving of the measured induced voltage. It should be noted that this test scenario is extremely unlikely ever to occur, namely no return current in the negative feeder and an unconnected station to traction earth bond. Scaling the 2.5μT @ 200 Amps up to 1000 Amps yields 12.5μT which is well below limits and in line with the **PASS** criterion.

4 Conclusion

Having witnessed and satisfied each test conducted in accordance with each of the Inspection Test Plans (ITP) and satisfied the criteria in Cross rail's Technical paper "Electrical and EMC Testing of Station Platform PES and PSD Prototype" document no. CRL1-XRL-E-RSP-CRG03-5000, in line with prevailing standards and specifications. All recorded results were within the defined limits and parameters, ensuring safety standards for all parties remain paramount and induced voltages relating to traction power remain negligible. The witness team did sign the ITPs for verification of correct demonstration and procedure of test criteria in their presence, therefore a **PASS** result on all tests was recorded.

5 Referenced Documentation

C100 Electrical and EMC Testing of the Station Platform PES and PSD Prototype, document reference CRL1-XLR-E-RSP-CRG03-50001

Crossrail ITP report titled "Platform PES Prototype- Electrical & EMC Testing", document reference: CRL1-XRL-E-ITP-CR001-6-50001, revision 2.0

Crossrail ITP report titled “Fire Alarm and Detection- Access and Maintenance Testing”, document reference: CRL1-XRL-E-ITP-CR001_6-50001, revision 2.0

Crossrail ITP report titled “Fire Alarm and Detection- Electrical & EMC Testing”, document reference: CRL1-XRL-E-ITP-CR001_6-50002, revision 2.0

C124 Earthing and Bonding Strategy, document reference: C124-MMD-O8-XST-CR001-00002, Rev 6.0

C124 Generic Earthing System Design Philosophy, document reference: C124-MMD-E-RAN-CR001-00003, Rev 2.0

C124 EMC Specification, document reference: C124-MMD-E-RSP-CR001-00001, Rev 2.0

C124 Magnetic Field Study, document reference: C124-MMD-E-RST-CR001-00006, Rev 1.0

C100 RIBA Stage F1 Constructability, Access & Maintenance Report, document reference C100-ATK-K2-TSY-CRG02-00001, revision 2.0

Crossrail report titled “Safe Maintenance of Systems in Proximity to Overhead Line Equipment (OHLE)”, document reference CRL1-PDP-Z-RGN-CRG02-50001 revision 1.0

Crossrail report titled “Area above PSD HAZID Report”, document reference: CRL1-PDP-Z7-RGN-CRG03-50002, version 1.0

Crossrail report titled “Review of Underground Station Platform Fire Safety”, document reference: CRL1-PDP-Z-RGN-CRG02-50002, revision 2.0

Crossrail report titled “Platform Cross Section Design Development Report”, document reference: CRL1-PDP-Z-RAE-CRG02-00002, revision 1.

Crossrail report titled “Platform Edge Screen (PES) Systems Safety, Constructability, Functionality and Maintainability Report”, document reference: “CRL1-XRL-E-RGN—CR001_Z-6-50001, revision 1.0

Specification, document reference: EN 50122-1 (Earthing, Bonding and the Return Circuit)

Specification, document reference: ICNIRP statement - 2003