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SSI Applications Manual - Earthing and Bonding of Solid State Interlocking Equipment

Endorsement, Authorisation and Issue Record

For endorsement, authorisation and issue record of this document, please refer to the SSI Applications Manual Contents, NR/SP/SIG/17002.

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Issue record

Issue	Date	Comments
2	Jun 2002	Radio mast requirements added
3	Jun 2008	ISPU added and CPC power supplies
4	March 2011	ISPUs non-coincident to have DLIT on other link

Compliance

This Network Rail Company Standard is mandatory and must be complied with by Network Rail/Contractors from 04/06/2011.

When this Company Standard is implemented, it is permissible for all projects, which have formally completed GRIP Level 4, to continue to comply with the Issue of any relevant Network Rail Standards current when GRIP Level 4 was reached and not to comply with requirements contained herein unless the Head of Signal Engineering has stipulated otherwise in the accompanying Briefing Note.

Where the Head of Signal Engineering has specified that all projects will comply with the requirements, specific authority not to comply can be sought in the usual manner using the appropriate non-compliance authority processes described in Network Rail Standard, [NR/SP/STP/045](#) Managing the Process for Non-compliance Authority (formerly RT/LS/P/045).

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1 Purpose

This system specification defines the special requirements in design, manufacture, installation and maintenance that are essential for providing a safe earthing and bonding system for Solid State Interlocking (SSI) installations. Such a system must:

- ensure fast and efficient operation of protective equipment in the case of earth faults which might otherwise be undetected;
- protect against danger due to installation metalwork being maintained at a dangerous potential relative to earth;
- minimise the effects of interference from electrical surges such as switching transients, flashovers from the traction supply and lightning strikes on the SSI Equipment.

2 Scope

This standard applies only to the earthing and bonding of SSI installations on Network Rail Infrastructure. It applies to all new schemes and should be considered as part of any alteration to existing installations. Care must be taken when installing other types of equipment at SSI locations to ensure that the installation of that equipment does not compromise the provisions of this standard.

3 References

See Appendix B.

4 Definitions

See Appendix A.

5 General

The primary function of any earthing system is to protect personnel from injury under fault conditions. This requires that all exposed metalwork is maintained at a potential near to the ground earth and that sufficient current can flow through protection devices to enable the source to be quickly and automatically disconnected.

Semiconductor devices, however, also require that electromagnetic interference (EMI) and fault voltage/current spikes including lightning and traction faults, are suppressed quickly before either physical damage or malfunction occurs.

SSI installations require special earth protection. With care the earth system installed including surge protection, can protect the equipment from damage. Special attention should be given to ensure that the system can protect against high frequency spikes. A key requirement is that earth leads are kept as short and straight as possible and that the system is designed such that hazardous differential ground

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voltages do not appear between equipment connected to the same or different earth points when a fault occurs.

'Signalling & Operational Telecommunications Design: Technical Guidance' (reference B4) requirement D2:8 requires that surge arrestors on safety critical circuits should not be earthed, unless the equipment has been specifically designed to resist dangers from multiple earth faults. Coded circuits, such as SSI datalinks, are protected against such earths, therefore SSI SPUs and ISPUs shall be earthed.

The requirements are specified in such a way that their implementation can be inspected and a certificate of compliance issued for each earth system. An example certificate is shown in Appendix F which should also include the retest interval. This interval should reflect the site conditions e.g. lightning prone, poor/good ground, strategic importance. An example retest record card is attached as Appendix G.

It is important when installing an earth system to provide one main earth and connect all equipment to one main earth termination (MET). Other earth systems that may be present shall also be bonded to the MET. The only exception to this is where there are test earths for earth leakage detectors (see reference B3). This requirement is to eliminate earth loop currents, and to ensure that current spikes due to the operation of surge protection units do not produce large voltage differences within the system. Example layouts are shown in Appendix D and Appendix E (Figures 3 to 6).

All SSI trackside locations must be provided with an earth connection in accordance with either Section 6.1 or 6.2, as should non-SSI location cases adjacent to SSI cases.

Tall earthed structures such as radio masts, and SSI equipment, should not generally be erected within 50m of each other. This is to reduce the risk of large earth currents circulating within the SSI earth system as a result of a lightning strike. However, this distance may be reduced for GSM-R sites, but only where 50m separation cannot physically be achieved, and provided that the earthing of the mast is in accordance with 'Radio Mast Lightning Protection and Earthing System' (reference B12), which requires that the earth resistance for telecoms masts should be as low as reasonably practicable, and no more than 10Ω. If installed in close proximity, the telecoms mast should ideally have a lower earth resistance than the SSI equipment.

6 Trackside Earthing

6.1 Earth Connection in 25kV Traction Area

In 25kV traction areas location cases and REBs shall not be installed within 2.5 metres of an electrification structure or within 2.5m of any metal structure bonded to the traction system earth for personnel 'touch potential' protection. This requirement shall include metal platforms and handrails. The risks associated with the overhead line equipment (OLE) proximity need to be assessed for each site. Providing this requirement is satisfied then the Fast Transient Earth (FTE) protection should be provided as described in Section

6.2. However the electrodes must not be installed within 100m of Electricity Board sub-stations or within 50m of track sectioning cabins.

If the above requirement cannot be met due to the proximity of a structure, it may be acceptable to mitigate touch potential risks by providing a separation barrier of non conducting fencing to protect personnel from potential dangerous voltages. A full risk assessment should be undertaken by the project before this solution is adopted.

Where it is physically impossible to maintain 2.5 metres separation or the risks associated with the OLE are unacceptable, the MET should be bonded to the traction system earth in accordance with the requirements of 'Design of Earthing & Bonding Systems for 25kV AC Electrified Lines' (ref B11). In this event a separate earth electrode system must not be provided. However it should be noted that as a result of direct coupling to the traction earth system there may be an increase in traction related interference. To mitigate against this additional data link line isolation transformers (DLIT) may be necessary subject to the constraints of Section 13.1.

6.2 Fast Transient Earth Electrode System

Where the MET is not bonded to the traction system earth, a Fast Transient Earth (FTE) system shall be provided to protect the SSI equipment. The FTE is also required to act as the safety earth to provide protection to personnel from rises in electrical potential of the housing in relation to ground. This is important at sites where the supports or anchors of the housing may provide a poor earth such as on viaducts or embankments.

The earth system shall be such that any exposed metalwork made live by either the first or second earth fault cannot attain the maximum permissible touch and accessible voltage stated in EN 50122-1 (also stated in ref. B11). This requires such metalwork to be connected to an earth electrode system of a sufficiently low resistance via a conductor of a size capable of carrying the worst case fault current.

The minimum requirement for an FTE Earth Electrode System is an Earth Electrode installed immediately adjacent to the Master Location Case, REB or Equipment Room, ideally consisting of three copper or copper clad steel earth rods connected vertically and driven in as far as possible. The top of the Earth Electrode shall be covered by a concrete inspection pit fitted with a removable lid marked 'Earth'. In areas of high vandalism the FTE may be positioned under the base of the master location case thus obviating the need for an inspection pit.

The d.c. resistance to earth should be 10 Ω or less, and preferably no more than 1 Ω at REBs and Equipment Rooms. To achieve this, the provision of additional earth rods may be necessary. Once the minimum 10 Ω value has been achieved at Location cases, further earth rods should only be considered if a lower value is specifically required for reasons such as clearance of power

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supply faults, in such cases the lower value shall be stated on the drawing showing the MET. Section 14 gives details regarding the construction of an earth electrode system.

The route of the bonding cable from the MET to the master electrode shall be as direct as possible with no sharp bends and it must not be coiled. The cable should be protected from accidental damage and not present a tripping hazard. The termination at the master electrode shall bear a label indelibly marked with the legend 'Safety Earth Connection - Do Not Remove'.

6.3 Earth Leakage Detector Earth Electrode

The provision of more than one earth is not normally recommended at a single location or Equipment Room, the exception to this is when an earth leakage detector is provided and a separate earth rod is required for reference. In these circumstances the test earth rod(s) shall be a minimum of 2m away from the main earth electrode system with exposed surfaces insulated.

7 Location Cases

7.1 Earth Terminals

Every location case shall be provided with an external and internal case earth terminal. These terminals shall be electrically connected through the joint fixing each terminal to the case shroud. The internal and external case earth terminals shall be mounted as near as practical, consistent with accessibility, to the base of the case.

Each location case housing SSI equipment shall have a copper earth busbar to facilitate earthing of equipment. It shall be sufficiently long to run from the internal earth terminal to the highest equipment row position, between the front and rear uprights of the inner frame running vertically, adjacent to that side of the case containing the internal case earth terminal. The case earth busbar shall be adequately supported along its length with sufficient connection points to enable equipment on each row to have short earth bonds.

The internal case earth terminal shall be directly connected to the case earth busbar with provision for disconnection to facilitate earth resistance testing.

In a single case location the external case earth terminal (MET) shall be connected to the earth electrode system or to the traction system earth as appropriate

7.2 Bonding of Connected Metalwork

All internal metalwork which forms part of the location case (e.g. mounting rails, cable supports, etc.) and all moveable parts of the case (e.g. doors) shall be electrically bonded to the case shroud. Metalwork that is welded or riveted together has adequate earth continuity between its parts. Flexible cable shall

be used where movement is necessary (such as case doors). The resistance between any metal part and the MET shall not exceed 1 Ω .

7.3 Multiple Case Locations

A group of Location Cases in close proximity may be treated as Multiple Case Locations provided that the distance between extremities of the group is not more than a few yards. Location Cases that are mounted on a structure that may itself provide some earthing, such as a steel platform, should be treated as Multiple Case Locations to avoid earth loops. Location Cases more than a few yards apart and not sharing the same mounting should not be treated as Multiple Case Locations.

The earthing arrangements for the Master Location Case shall be as described in Section 7.1 above, with the external case earth terminal designated the MET. See Appendix D, Figure 3.

A bonding cable shall be fitted to connect the MET of the Master Location Case to the external case earth terminal of each Slave Location Case. The interconnection bonds shall not form a loop via earth and shall follow a direct route with no sharp bends or coils. See Appendix E, Figure 4.

Where screened twisted pair cables connect a DLM in one case to a TFM in another case, the screen shall be connected to earth at the DLM end only.

The earthing arrangements for a Slave Location Case shall be the same as for a Master Location Case but without its own direct connection to the Earth Electrode System or to the traction system earth. See Appendix E, Figure 4.

7.4 Resistance of Earth Bonds

The resistance measured between any earth terminal in either the slave or master location case and the master earth electrode or traction return connection point shall not exceed 1 Ω .

7.5 Earth Leakage Testing

This is accomplished by manual busbar earth testing, as described in the relevant SMS (Ref. B14).

8 Equipment Rooms

Where trackside equipment is housed in an Equipment Room including REBs, the following shall apply:

8.1 Earth Busbar

Each equipment room shall be provided with a main earth terminal (MET) which shall be electrically bonded to a main earth busbar. This equipment room earth busbar shall be located on the wall or frame which houses the surge protection

units on incoming circuits. The equipment room earth busbar shall be bonded to the Earth Electrode System or traction bond according to Sections 6.1 and 6.2. The interconnection bonds shall not form a loop and should follow a direct route with no sharp bends or coils.

The equipment room earth busbar shall be provided with sufficient terminals to enable connection to all equipment within the room. It must be possible to disconnect earth connections to allow the installation to be tested.

Each rack of equipment shall have a rack earth busbar. All rack earth busbars shall be bonded together. The “master rack” shall be bonded to the Equipment Room earth busbar. The surge protection units are to be mounted adjacent to the Equipment Room earth busbar, and as near as possible to any incoming lines to which they are connected. See Appendix E, Figure 5.

8.2 Other Earth Systems

All earth systems applicable to the Equipment Room shall be bonded to the MET. Note that local electricity board incoming earths are isolated in electrified areas, before entering the Equipment Room.

8.3 Bonding of Metalwork

All metalwork within the equipment room, and any metal building framework, shall be bonded to the rack earth busbar or Equipment Room earth busbar.

8.4 Resistance of Earth Bonds

The resistance measured from exposed metalwork and the rack earth busbar to the Earth Electrode System or traction return connection point shall not exceed 1 Ω .

8.5 Earth Leakage Testing

This shall be accomplished by a device that continuously monitors, and has a latched fault indication that is displayed when a pre-set threshold is exceeded. Each supply provided by the equipment room to external equipment shall be fitted with its own earth leakage detector. Monitoring of earth leakage detectors is as described in the relevant SMS (Ref. B14).

9 Control Centres

Where SSI equipment is housed in a control centre equipment room, the following shall apply:

9.1 Earthing Arrangements

The earthing arrangements shall be as specified in Sections 8.1, 8.2 and 8.3, except that the equipment room earth busbars shall be bonded to the control centre main earth. See Appendix E, Figure 6.