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Rail Industry Standard for Low Voltage Power Supplies in Electrified Areas

Synopsis
This document includes requirements for earthing, bonding and the control of traction currents in low voltage power supplies in areas of the GB mainline network electrified at either 25 kV AC or 750 V DC third rail.

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This document will be updated when necessary by distribution of a complete replacement.

Superseded Documents

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Part 1 Purpose and Introduction

1.1 Purpose

1.1.1 This document is a standard on low voltage power supplies in areas of the GB mainline network electrified at either 25 kV AC or 750 V DC third rail, for members of RSSB to use if they so choose.

1.1.2 This document includes requirements and guidance for the management of earthing and bonding to avoid hazardous voltages, and for the management of segregation to control stray currents and minimise current transfer between different electrical power supply systems.

1.1.3 These requirements are additional to those normally required for low voltage (LV) power supplies (for example, compliance with BS 7671) and are needed to avoid hazardous touch voltages arising from the presence of differences in two independent power supply systems (LV power supplies and traction power supplies) while effectively managing fault and stray currents.

1.1.4 This document excludes power supplies to signalling and telecommunications (S&T) equipment, for which specific earthing and bonding arrangements are made.

1.1.5 This document excludes installations which do not form part of the mainline railway, such as traction substations.

1.2 Introduction to low voltage power supplies for electrified areas

1.2.1 Infrastructure managers (IMs) need to co-operate to design, install and maintain LV electrical installations such that the earthing, bonding and segregation arrangements are not compromised.

1.3 Application of this document

1.3.1 A member of RSSB may choose to adopt all or part of this document through internal procedures or contract conditions. Where this is the case the member of RSSB will specify the nature and extent of application.

1.3.2 Therefore compliance requirements and dates have not been specified since these will be the subject of internal procedures or contract conditions.

1.3.3 The Standards Manual and the Railway Group Standards (RGS) Code do not currently provide a formal process for deviating from a Rail Industry Standard (RIS). However, a member of RSSB, having adopted a RIS and wishing to deviate from its requirements, may request a Standards Committee to provide opinions and comments on their proposed alternative to the requirement in the RIS. Requests for opinions and comments should be submitted to RSSB by e-mail to proposals.deviation@rssb.co.uk. When formulating a request, consideration should be given to the advice set out in the ‘Guidance to applicants and members of Standards Committee on deviation applications’, available from RSSB’s website.

1.4 Health and safety responsibilities

1.4.1 Users of documents published by RSSB are reminded of the need to consider their own responsibilities to ensure health and safety at work and their own duties under health and safety legislation. RSSB does not warrant that compliance with all or any documents published by RSSB is sufficient in itself to ensure safe systems of work or operation or to satisfy such responsibilities or duties.
1.5 Structure of this document

1.5.1 This document sets out a series of requirements that are sequentially numbered.

1.5.2 This document also sets out the rationale for the requirement. The rationale explains why the requirement is needed and its purpose. Rationale clauses are prefixed by the letter ‘G’.

1.5.3 Where relevant, guidance supporting the requirement is also set out in this document by a series of sequentially numbered clauses and is identified by the letter ‘G’.

1.6 Approval and Authorisation

1.6.1 The content of this document was approved by Energy Standards Committee on 12 January 2017.

1.6.2 This document was authorised by RSSB on 27 January 2017.
Part 2 Earthing and Bonding Requirements

2.1 General earthing and bonding requirements

2.1.1 Touch voltages

2.1.1.1 Where it is possible for a person to simultaneously touch exposed conductive parts that are connected to the equipotential bonding system of an LV electrical installation and the exposed conductive parts connected to the equipotential bonding system of an electric traction system or rail mounted vehicle, the LV electrical installation shall be designed to ensure these touch voltage values do not exceed those specified in clause 9 of BS EN 50122-1:2011+A.2:2016.

Rationale

G 2.1.1.2 This requirement helps mitigate the risk from indirect electric shock by establishing the limit for the maximum permissible touch voltage values according to European Standards applicable to the railway sector.

G 2.1.1.3 Implementing this requirement helps to support compliance with Regulations 3 and 8 of The Electricity at Work Regulations 1989.

Guidance


2.1.2 Circuit protective conductor

2.1.2.1 Metallic conduit, trunking and cable trays shall not be used as an LV circuit protective conductor (CPC) where high load or fault current associated with electric traction systems can adversely affect the integrity of this circuit protective conductor.

Rationale

G 2.1.2.2 If an LV CPC uses metallic conduit, trunking and cable trays, the fault and load currents in the traction return system can flow via the LV CPC and cause overheating and loss of CPC integrity. This can give rise to fire risk and, if the LV CPC integrity is lost, can result in an increased risk from indirect electric shock hazard. Avoiding metallic conduit, trunking and cable trays within the CPC for the LV electrical equipment avoids traction current flowing via these unsuitable metallic parts.

G 2.1.2.3 Implementing this requirement helps to support compliance with Regulations 3, 5 and 8 of The Electricity at Work Regulations 1989.

Guidance

G 2.1.2.4 Guidance is given in Appendix A Guidance on Low Voltage Power Supplies in Electrified Areas on page 13.
2.2 Earthing and bonding requirements for low voltage electrical installations in AC electrified line areas

2.2.1 Low voltage electrical equipment directly bonded to the traction return circuit

2.2.1.1 Where LV electrical equipment is either in contact with a conductive structure directly bonded to the traction return circuit, or is directly bonded to the traction return circuit, the LV electrical equipment CPC and any other earthed conductor (for example, screen wire or armouring) shall not be connected to the LV electrical equipment if high load or fault current associated with electric traction systems can adversely affect these conductors or the associated equipment.

Rationale

G 2.2.1.2 If an LV CPC and other conductors are connected to the LV electrical equipment, fault and load currents from the traction system can flow via these conductors. These traction system currents can cause overheating and loss of conductor integrity. This current flow can give rise to fire hazard. In addition, if LV conductor integrity is lost, this can result in an increased risk of indirect electric shock hazard. By not connecting these conductors to the LV electrical equipment, it avoids the risk of traction system currents flowing via these conductors.

G 2.2.1.3 Implementing this requirement helps to support compliance with Regulations 3, 5 and 8 of The Electricity at Work Regulations 1989.

Guidance

G 2.2.1.4 Guidance is given in Appendix A Guidance on Low Voltage Power Supplies in Electrified Areas on page 13.

2.2.2 Low voltage electrical equipment indirectly bonded to the traction return circuit

2.2.2.1 The LV electrical equipment and CPC shall be rated to carry the maximum expected traction fault current likely to be conducted by the CPC, unless there is no possibility of carrying this current.

Rationale

G 2.2.2.2 If LV electrical equipment and the CPC carries fault currents from the traction return system, it can cause overheating and loss of CPC integrity if it is not rated for this condition. This can give rise to fire risk and, if LV CPC integrity is lost, there can also be an increased risk from indirect electric shock. Correct rating of the CPC avoids these problems.

G 2.2.2.3 Implementing this requirement helps to support compliance with Regulations 3, 5 and 8 of The Electricity at Work Regulations 1989.

Guidance

G 2.2.2.4 Guidance is given in Appendix A Guidance on Low Voltage Power Supplies in Electrified Areas on page 13.

2.2.3 Main earth and the traction return circuit

2.2.3.1 Where indirect bonding is used, a bond between the LV electrical installation supply main earth and the traction return circuit shall be provided.
Rationale

G 2.2.3.2 The bond between the LV electrical installation supply main earth and the traction return circuit provides a path for the traction fault current to be returned to its source.

Guidance

G 2.2.3.3 Guidance is given in Appendix A Guidance on Low Voltage Power Supplies in Electrified Areas on page 13.

2.2.4 Utility services and LV electrical installation bonding

2.2.4.1 Where the LV electrical installation is bonded to an electric traction system, the bonding and segregation arrangement of the utility services (for example gas, water etc) shall avoid, under operating and fault conditions, the hazards arising from:

a) Touch voltages between the utility services and the electric traction systems, and
b) The transfer of current between the electric traction systems and the utility services.

Rationale

G 2.2.4.2 The correct bonding or segregation of the utility services from the electric traction systems mitigates the indirect electric shock hazard and risk from excessive current transfer via the utility services.

G 2.2.4.3 If a utility service carries excessive currents originating from the electric traction systems, it can cause overheating and give rise to fire risk. Implementing this requirement mitigates these risks.

G 2.2.4.4 Implementing this requirement helps to support compliance with Regulations 3 and 8 of The Electricity at Work Regulations 1989.

Guidance

G 2.2.4.5 Guidance is given in Appendix A Guidance on Low Voltage Power Supplies in Electrified Areas on page 13.

2.3 Earthing and bonding requirements for low voltage electrical installations in DC electrified line areas

2.3.1 Protection against DC stray current - socket outlet

2.3.1.1 Where a socket outlet is located such that a portable electrical appliance can be used on or near an object in contact with the running rail or other exposed conductive parts of the electric traction return circuit, the design of the LV electrical installation shall prevent the adverse effects of DC stray current flowing in the LV CPC.

Rationale

G 2.3.1.2 If LV installations are not designed to prevent the adverse effects of DC stray currents in the CPC, this can cause overheating and loss of conductor integrity. This DC stray current can give rise to increased risk from fire hazard and, if CPC integrity is lost, there can be an indirect electric shock hazard. Correct design of the LV installation avoids these problems.

G 2.3.1.3 Implementing this requirement helps to support compliance with Regulations 3, 5 and 8 of The Electricity at Work Regulations 1989.
 Guidance

G 2.3.1.4 Guidance is given in Appendix A Guidance on Low Voltage Power Supplies in Electrified Areas on page 13.

2.3.2 Protection against DC stray current - neutral conductor

2.3.2.1 The LV electrical installation shall be designed to prevent the adverse effects of DC stray current entering the neutral conductor of any other equipment or electrical distribution system because of faults between the CPC and neutral conductors.

Rationale

G 2.3.2.2 If LV electrical installations are not designed to prevent DC stray current flowing via LV conductors and equipment (due to earth faults between the CPC and neutral conductors), this can result in fire risk due to the conductor or equipment overheating or loss of CPC conductor integrity, which gives increased risk from indirect electric shock.

 Guidance

G 2.3.2.3 Guidance is given in Appendix A Guidance on Low Voltage Power Supplies in Electrified Areas on page 13.

2.3.3 Protection against DC stray current - detection system

2.3.3.1 The detection system of earth proving devices shall be protected against the adverse effects of DC stray current.

Rationale

G 2.3.3.2 If these devices are not protected against the adverse effects of DC stray current, this can interfere with their correct functioning.

G 2.3.3.3 This can give rise to a risk from indirect electric shock hazard due to incorrect operation, that is, the detection system fails to detect a fault condition or falsely operates.

 Guidance

G 2.3.3.4 Guidance is given in Appendix A Guidance on Low Voltage Power Supplies in Electrified Areas on page 13.

2.3.4 Protection against stray DC current - list of approved RCDs

2.3.4.1 Network Rail maintains a list of approved residual current devices (RCDs) that are immune up to declared levels of DC leakage and shall make this list available to others on request.

Rationale

G 2.3.4.2 In DC electrified line areas, DC leakage can affect the operation of the RCD used to provide additional protection against direct contact electric shock. A list provides an opportunity for the efficient identification of those RCDs with suitable characteristics for use in DC electrified lines areas.

 Guidance

G 2.3.4.3 Guidance is given in Appendix A Guidance on Low Voltage Power Supplies in Electrified Areas on page 13.
Part 3 Other Requirements

3.1 Segregation

3.1.1 Segregation

3.1.1.1 The electric traction system and its high voltage (HV) system shall be segregated from low voltage (LV) systems in order to avoid extraneous connections.

Rationale

G 3.1.1.2 If an LV system is not correctly segregated from HV systems and electric traction systems, current from these systems flowing into the LV system can cause overheating and loss of circuit and electrical protection integrity. This current flow can give rise to fire risk and, if part of the LV earth and CPC integrity is lost, there can be an indirect electric shock hazard. Correct design of the segregation avoids these risks.

G 3.1.1.3 Implementing this requirement helps to support compliance with Regulations 3, 5 and 8 of The Electricity at Work Regulations 1989.

Guidance

Part 4 Temporary Low Voltage Electrical Installations

4.1 Temporary installations

4.1.1 Temporary installations

4.1.1.1 Temporary LV electrical installations shall comply with the arrangements set out in Part 2 and Part 3.

4.1.1.2 Temporary LV electrical installations shall not affect existing permanent earthing, bonding and segregation arrangements.

Rationale

G 4.1.1.3 Hazards arising from temporary installations need to be addressed in the same way as for permanent installations.

G 4.1.1.4 Implementing this requirement helps to support compliance with Regulation 3 of The Electricity at Work Regulations 1989.

Guidance

G 4.1.1.5 Guidance is given in Appendix A Guidance on Low Voltage Power Supplies in Electrified Areas on page 13.
Appendices

Appendix A  Guidance on Low Voltage Power Supplies in Electrified Areas

A.1 Consultation with affected parties

A.1.1 Before making any change to an LV electrical installation, it is advisable to consult with any other party which could be affected to establish that the design, installation, testing and maintenance of the LV electrical installation maintains the necessary bonding and segregation arrangements associated with the HV and electric traction systems, so that touch voltages limits between the LV system and other systems are not exceeded.

A.2 General guidance for earthing requirements

A.2.1 In addition to the guidance in this appendix, clauses 6.2, 6.3 and 7 of BS EN 50122-1:2011+A.2:2016 give information, and requirements relating to touch voltage, and the transfer of voltages and currents.

A.2.2 In determining the arrangement of the earthing system for the railway LV equipment, the following aspects are considered:

a) The distribution network operator’s (DNO’s) LV supply earthing arrangements (existing or proposed), and
b) If the DNO will permit a direct connection between their LV earthing system and the earthing system for the railway LV equipment in electrified areas.

A.2.3 The transfer of voltage potentials and currents between the railway systems and the DNO is influenced by the arrangements employed by both parties. The arrangements employed on the railway need to be compatible with the DNO installation to avoid incompatibility and possible safety risk. Early dialogue with the DNO is beneficial.

A.2.4 In some situations the DNO can require lower touch voltage limits than those specified in BS EN 50122-1:2011+A.2:2016. For further information, see clause 6.2.1.2 of Engineering Recommendation G12 Issue 4 (2013).

A.2.5 EMC requirements can also impinge on the earthing and bonding arrangements.

A.3 Earthing requirements for low voltage electrical installations in DC electrified line areas

A.3.1 General earthing requirements for low voltage electrical installations in DC electrified lines areas

A.3.1.1 The conductor rail is energised at a nominal voltage of 750 V DC. Electric trains draw power from the conductor rail with current returning to the substation via the running rails. The running rails are not deliberately earthed but are allowed to ‘float’ electrically about true earth.

A.3.1.2 Information regarding the short-circuit fault current levels, which can be present in the conductor rail system of the GB mainline railway, is set out in GLRT1212.

A.3.1.3 As a result of the high-traction current levels and corresponding volt-drop, the running rails can rise to some tens of volts above true earth. Also, because the running rails are not electrically insulated from the ground, the track ballast, surrounding area and the conductive framework of buildings nearby take up a DC voltage between true earth and the running rail potential.

A.3.2 Protection against DC stray current – socket outlets for portable electrical appliances

A.3.2.1 When an earthed portable electrical appliance makes contact with a running rail or conductive object at running rail potential, DC current can flow dependent upon the actual voltage and circuit parameters. In the case of an earthed portable electrical appliance, this current flows in the CPC. Overheating and loss of CPC integrity is possible in the lead of the portable electrical appliance and possibly
the CPC of the electrical distribution system. Long-term uncontrolled DC stray current can cause corrosion in adjacent metalwork. An arc can be produced when contact between the electrical appliance and the running rail or conductive object at running rail potential occurs.

A.3.2.2 Special precautions are applied where any socket outlet, within 30 m of a running rail at traction potential, can provide power to a portable electrical appliance to be used on or about an object in contact with the running rail. Where earthed portable appliances can come into contact with the running rail or conductive object in connection at running rail potential, precautions are employed to ensure DC leakage current flow is prevented or reduced, so as not to impair the effectiveness of the appliance earth conductor or supply earth conductors. Techniques to limit or control DC leakage might include one or more of the following:

a) Ensure the earthing path has a sufficiently high resistance, for example provide additional resistance but without prejudicing safe disconnection times, to ensure the magnitude of the DC stray current flow is not significant.

b) Prevent DC stray current flow by inserting a suitable device such as a capacitor, with a discharge resistor in parallel, within the earth path of the supply but ensuring that the protection for AC faults remains effective.

c) Use of RCDs and multi-pole protection to detect and disconnect the appliance (phase and neutral circuits).

A.3.2.3 Where the neutral conductor is earthed special precautions are used at the supply point, and neutral to earth faults can remain undetected and, if unchecked, cause unacceptably high stray traction current to flow through the neutral conductor system. Precautions will be dependent upon the specifics of the application, but might include the use of RCDs and multi-pole protection to detect and disconnect the portable appliance (phase and neutral circuits) if inadmissible stray current flows.

A.3.2.4 For a supply with a nominal voltage of 400 V 3 phase, there should be no neutral provided at the socket outlet. Any neutral necessary for control circuits should be derived from an isolating transformer mounted on the appliance.

A.3.2.5 For a supply with a nominal voltage of 110 V or 230 V, the supply should be derived from an isolating transformer, with a centre tap connected to an earthing arrangement.

A.4 Earthing requirements for low voltage electrical installations in AC electrified line areas

A.4.1 General earthing requirements for low voltage electrical installations in AC electrified lines areas

A.4.1.1 The overhead contact line (OCL) is energised at a nominal voltage of 25000 V. Electric trains draw power from the OCL with current returning to the feeder station via the running rails and, depending upon the system design, other conductors such as return conductors, aerial circuit protective conductor or autofeeder conductors. Each overhead contact line support mast is bonded to the traction return circuit and provides an earth path through the mast foundation.

A.4.1.2 Information regarding the short-circuit fault current levels, which can be present in the overhead contact line of the Great Britain (GB) mainline railway, is set out in GLRT1210.

A.4.1.3 Equipotential bonding is used where it is possible to simultaneously touch exposed conductive parts and the running rails, trains or other conductive objects connected to the traction return circuit. These limit touch voltages to values not exceeding those specified in BS EN 50122-1:2011+A.2:2016.

A.4.2 Low voltage electrical equipment directly bonded to the traction return circuit

A.4.2.1 The creation of parallel paths for traction current can be avoided by not connecting the LV electrical installation supply circuit protective conductor, cable armouring and other earthed metallic conductors to the LV electrical equipment (see figure below for a typical arrangement) when the LV electrical equipment is either directly bonded to the traction return circuit, or is in contact with a conductive structure having a direct bond to the traction return circuit.
A.4.2.2 Separation can be achieved by ‘gapping’ the supply cable armouring, by either:

a) The use of an insulated gland, or
b) Cutting back the cable armouring to a maximum distance of 300 mm from the equipment entry point.

A.4.2.3 In both cases, heavy-duty heat-shrink sleeving, or equivalent, can be applied to cover the gland or the cut-back section and 150 mm of the cable outer sheath, and terminate any other earthed metallic conductor and additional circuit protective conductor before it reaches the equipment.
A.4.2.4 A suitable permanent warning label is installed, securely attached to the cable at the gapping location, which identifies that the cable has been ‘gapped’ and is not to be bridged. The preferred warning label wording (black text on yellow background) is "Caution: cable gapped (see Rail Industry Standard RIS-1855-ENE). Do not bridge this gap".

A.4.2.5 A bond might be required between the traction return circuit and the LV electrical installation supply main earth to provide earth fault protection for the equipment and / or minimise touch voltages. This bond between the traction return circuit and the LV electrical installation should not be fitted at feeder stations because of the high level of traction currents which can flow via the bond into the LV supply network. The type and rating of this bond should be agreed with the IM responsible for the traction system, and the DNO.

A.4.2.6 The LV electrical protection arrangement for gapped circuits needs to be carefully considered because of the discontinuity of the LV circuit protective conductor. The characteristics of the traction system return circuit and its earthing arrangements can allow conduction of the LV fault current via the traction return system. In some cases, use of this path can be adequate for LV electrical protection even if a bond in accordance with A.2.2.5 is not fitted, subject to the requisite earth loop impedance being achieved. Provision of appropriate RCD protection might be beneficial.

A.4.3 Low voltage electrical equipment indirectly bonded to the traction return circuit

A.4.3.1 When the LV electrical equipment needs to be bonded to the traction return to ensure safety during traction fault conditions or to control touch voltages and it is not in contact with any metalwork which is connected to the traction return circuit, indirect bonding can be used. See figure below for a typical arrangement using indirect bonding.
A.4.3.2 Where LV electrical equipment is not directly bonded to the traction return circuit, the LV electrical equipment CPC is connected to the LV electrical equipment.

A.4.3.3 Where the LV electrical equipment is at risk from traction system faults, for example by flashover or conductor breakage, the LV circuit protective conductor provides a fault path which is completed by a bond between the LV electrical installation supply main earth and the traction return circuit. When assessing the

Figure 2: Low voltage electrical equipment indirectly bonded to the AC traction return circuit
risk to LV electrical equipment resulting from contact line conductor breakage or current collector failure, the LV equipment’s location in relation to the overhead contact line zone and pantograph zone is considered. These zones are described in BS EN 50122-1:2011+A.2:2016 and the national parameters for the GB mainline network are set out in GLRT1210.

A.4.3.4 Where LV electrical equipment is in the vicinity of other traction system aerial conductors, for example auto-feeder conductors, and where conductor breakage might cause damage to the LV equipment, advice should be sought from the IM regarding this risk.

A.4.3.5 Where the LV electrical equipment is at risk from traction system faults, for example by flashover or conductor breakage, or breakage of other traction system aerial conductors, for example auto-feeder conductors, the cable termination arrangements on LV equipment can result in the transfer of traction system fault current when cable armour / metallic screens are present. Therefore, cable terminations are used to avoid creating an extraneous path for these fault currents.

A.4.3.6 Where the LV equipment is not directly at risk from traction system faults, the bond between the LV supply main earth and the traction supply is used to control touch voltages between the LV equipment and exposed conductive parts connected to the traction return system. The type and rating of this bond is agreed with the IM responsible for the traction system.

A.4.3.7 A suitable permanent warning label is securely attached to the bond identifying that the traction return circuit is connected to the LV supply main earth and that care needs to be taken when disconnection is required.

A.4.4 Non-electrified sidings in an electrified area

A.4.4.1 Non-electrified sidings in an electrified area are treated as electrified lines unless fitted with insulated rail joints. When fitted, these joints effectively separate the rails in the siding from those adjacent rails which form part of the traction return circuit.

A.5 Interlocking of independent LV power supplies

A.5.1 Interlocking of power supplies is provided where it is necessary to prevent paralleling of independent LV electrical power sources.
### Definitions

**Circuit protective conductor (CPC)**
A circuit protective conductor is a protective conductor connecting exposed-conductive-parts of equipment to the main earthing terminal.

**Electrical installation**
Assembly of associated electric equipment having co-ordinated characteristics to fulfil specific purposes. *IEV826-10-01*

**High voltage (HV)**
High voltage is the set of voltage levels in excess of low voltage. *IEV601-01-27*

**Low voltage (LV)**
A set of voltage levels used for the distribution of electricity and whose upper limit is generally accepted to be 1000 V for AC and 1500 V for DC. *IEV601-01-26 modified*

**Nominal voltage**
Value of the voltage by which the electrical installation or part of the electrical installation is designated and identified. *IEV-826-11-01*

**Temporary installation**
An installation that is not intended to become a fixed installation, regardless of the length of time.

**Touch voltage**
Voltage between conductive parts when touched simultaneously by a person or animal. *IEV826-11-0*

**Traction return circuit**
All conductors which form the intended path for the traction return current and the current under fault conditions. *IEV 811-35-01*

*Note:* The conductors may be for example running rails; return conductor rails; return conductors; return cables.
References

The Catalogue of Railway Group Standards gives the current issue number and status of documents published by RSSB. This information is also available from http://www.rssb.co.uk/railway-group-standards.co.uk.

RGSC 01  Railway Group Standards Code
RGSC 02  Standards Manual

Documents referenced in the text

Railway Group Standards

GLRT1210  AC Energy Subsystem and Interfaces to Rolling Stock Subsystem
GLRT1212  DC Conductor Rail Energy Subsystem and Interfaces to Rolling Stock Subsystem

Other References

BS 7671  Wiring Regulations
ENA document Engineering Recommendation G12 Issue 4  Requirements for the Application of Protective Multiple to Low Voltage Networks
HSR25  The Electricity at Work Regulations 1989