

Category 1 Standard

S1109 Switchgear and Ancillary Equipment

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1 Purpose

- 1.1 The purpose of this Standard is to define the requirements for AC and DC switchgear and associated equipment.

2 Scope

- 2.1 This Standard applies to switchgear and ancillary equipment for which the Power Engineer has jurisdiction, as follows:

- a) AC switchgear;
- b) DC traction switchgear;
- c) DC shore supply switchgear;

- 2.2 This Standard replaces the Standards listed below:

Old Standard	Applicable Section of New Standard
E4260 A2	Section 3.1 - General
E4013 A2, E4102 A2, E4260 A2 & EME-SP-01-002 A3	Section 3.2 - General
E4050 A2	Section 3.3 – AC Switchgear
EME-SP-01-002 A3	Sub-Section 3.4.1 – DC Traction Switchgear
PEE-SPE-12-043 A2	Sub-Section 3.4.2 – DC Overhead Trolley Switchgear
PEE-STD-04-013 A2 & PEE-STD-04-014 A2	Section 3.6 – Switchgear Maintenance
PEE-STD-01-009-A2	

- 2.3 Sections 3.2 to 3.6 do not apply to the Power Services Contractor.

- 2.4 This Standard supports the following LU Policies

Number	Title	Version
1-01102-001	Health, Safety and Environment	A2
1-01101-004	Service Operations	A1

3 Requirements

3.1 General requirements for Switchgear – Part 1

- 3.1.1 Design and construction

- 3.1.1.1 Switchgear shall be divided into cubicles or compartments to ensure safe access to perform routine first line inspection and maintenance without risk of contact with live parts.

- 3.1.1.2 Main circuit breakers, contactors, isolators, fuse-switches and other direct acting functional switching devices shall be partitioned so that each unit is isolated by earthed metal or rigid insulation from all other circuits and busbars.

- 3.1.1.3 Busbars shall be totally enclosed.



- 3.1.1.4 Adequate space within compartments shall be provided for any reasonably foreseeable adjustment, operation, maintenance or any other works to be performed. .
- 3.1.1.5 Access to compartments containing functional switching devices with a nominal voltage in excess of 110V AC or DC between circuit conductors and in the case of AC in excess of 55V between conductors and earth shall be by means of an interlocked door, or in the case of circuit breakers fitted with integral front panels, by removal of the complete switchgear unit.
- 3.1.1.6 Access to normally live parts on a withdrawable switching device shall not be possible unless the device is fully isolated.
- 3.1.1.7 Automatic padlockable safety shutters shall be provided for each circuit or busbar connection on switchgear with withdrawable switching devices.
- 3.1.1.8 Access to normally live parts on fixed functional switching devices shall be shrouded so that when the cover of the switch is open there are no live parts exposed.
- 3.1.1.9 When fixed switches are open the gap between the moving and fixed contacts shall be clearly visible or reliably indicated.
- 3.1.1.10 Fixed fuse switches shall completely isolate the fuses from both supply and load when in the open position, allowing safe replacement of fuses when the busbars are live.
- 3.1.1.11 Interlocking shall prevent incorrect operational and switching sequences of switchgear and prevent possible resultant injury to personnel.
- 3.1.1.12 All interlocks shall be affected by mechanical means, where practicable, and shall be of a robust design, clearly labelled, safe and simple to operate.
- 3.1.1.13 Interlocking shall be provided to prevent impermissible power system configurations where this provision is necessary, given the procedural environment and the level of competence of operators. The competence of operators and the procedures for operation of high voltage switchgear are such that interlocking to prevent impermissible power system configurations shall not be provided.
- 3.1.1.14 Earth bars shall be provided and provision shall be made for the bonding of gland plates.
- 3.1.1.15 Unless otherwise stated all discrete parts of Switchgear shall be fitted with an earthing stud to which the framework of the cubicle shall be bonded.
- 3.1.1.16 Labelling shall be in accordance with LU Standard S1004.
- 3.1.2 Verification
 - 3.1.2.1 The requirements of this Standard shall be verified by:
 - a) sample tests of the Switchgear in service;
 - b) audit of design review and verification documentation.
- 3.1.3 Documentation
 - 3.1.3.1 All relevant documentation and test data shall be accurate, stored securely, and available for audit.
 - 3.1.3.2 All documentation shall be kept for the life of the asset.
 - 3.1.3.3 All documentation and equipment records shall comply with LU standard 1-119 .Power Asset Records and Reporting

3.2 General requirements for Switchgear – Part 2

- 3.2.1 All switchgear shall be designed, manufactured, installed and operated in such a way that its correct usage shall not cause danger or injury.
- 3.2.2 Design and construction
- 3.2.2.1 Switchgear shall safely connect and disconnect electrical systems and loads within its designed rating.
- 3.2.2.2 Switchgear shall operate without causing danger or injury when connected into the system and installed in an environment as defined in Clause 3.2.3 below, taking into account the following:
- a) rated voltage;
 - b) rated insulation levels;
 - c) rated frequency;
 - d) rated normal current;
 - e) rated short-time withstand current;
 - f) rated peak withstand current;
 - g) rated duration of through faults;
 - h) rated symmetrical and asymmetrical fault making current;
 - i) rated fault breaking current;
 - j) levels of harmonics present within electrical systems within a traction environment.
- 3.2.3 Environment
- 3.2.3.1 Switchgear shall be suitable for operation in all environments to which it may be exposed, taking particular cognisance of the conditions stated below and those contained in BS EN 50125:
- a) Wide temperature variations are liable to occur daily because of cyclic loading;
 - b) Dust levels of 2 mg per metre cubed, comprising 55% metallic iron or iron oxide, 10% carbon, 21% silica plus fibrous particles may occur;
 - c) Effects of solar radiation.
- 3.2.3.2 Where switchgear is to be installed in the vicinity of areas provided with flooding systems employing gaseous or aqueous extinguishant the construction, materials and performance shall not be adversely affected by discharge of such systems and no degradation occurs subsequent to discharge.

Note: Switchgear may be installed in the vicinity of road or rail traffic and will be subjected to vibration. Historically the amplitude of vibration has been taken as 0.125 mm, at any frequency from 3 Hz to 50 Hz.
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3.2.4 Supply characteristics

The switchgear shall be compatible with the supply network into which it is to be connected taking cognisance of its characteristics under all credible operating modes.



Note:	Further information regarding the supply networks are contained in LU Standards 1-105 and 1-100
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3.2.5 Materials

3.2.5.1 All materials, components, finishes and assemblies shall, where applicable, comply with LU Standard 1-085.

3.2.5.2 Materials shall be suitable for their required duty and shall maintain their required performance for their intended life.

3.2.6 Service Life

The service life of switchgear shall be 40 years minimum and shall be designed to provide the full rated performance throughout its lifetime.

3.2.7 Ingress protection

3.2.7.1 For indoor switchgear:

a) The degree of protection shall be a minimum of IP32 where ventilation is required for heat dissipation or IP52 where ventilation is not required except as required by Clause (c) below;

b) The degree of protection shall be a minimum of IP41 for safety shutters and compartments where apertures are required for operating handles and similar devices;

c) All other compartments and parts of the enclosure shall be protected to a minimum of IP52 with the exception of ventilation grilles fitted to DC switchgear above the arc chute. For this exception IP30 or higher shall be permitted;

d) Where the purpose of the enclosure is to permit the use of materials not compliant with Clause 3.2.5 of this document, the degree of protection shall be IP65.

3.2.7.2 For outdoor switchgear

a. The degree of protection shall be IP44 where ventilation is required for heat dissipation or IP54 where ventilation is not required;

Where the purpose of the enclosure is to permit the use of materials not compliant with Clause 3.2.5 of this Standard, the degree of protection shall be IP65.

3.2.7.3 Holes for condensate draining must be positioned so as to maintain the degree of protection against contact with live parts.

3.2.7.4 Degrees of protection shall not be reduced at cable entries or ventilation positions.

3.2.8 Electrical clearances

3.2.8.1 Electrical clearances shall be provided between all uninsulated current carrying parts and parts operating at different potentials, polarities or phases.

3.2.8.2 Electrical clearances shall be provided between uninsulated current carrying parts and exposed-conductive-parts or extraneous-conductive-parts, to prevent accidental bridging.

3.2.8.3 Switchgear shall be constructed with the required insulation dielectric strength or clearance spacing between live or circuit conductors and exposed or extraneous parts to prevent danger from indirect contact or fault currents.

3.2.8.4 All functional switching devices shall have the required clearance between the open contacts to prevent any possibility of electrical breakdown between open contacts.



- 3.2.8.5 Where fitted, detection equipment associated with earth/frame leakage protection schemes shall be prevented from being accidentally by-passed.
- 3.2.8.6 There shall be a minimum clearance of 50mm between all parts rated for 800V and all earthed metal work.
- 3.2.9 Isolation and maintenance
- 3.2.9.1 So far as reasonably practicable, switchgear shall be designed to reduce the need for maintenance during the life of the Switchgear.
- 3.2.9.2 Switchgear shall be designed to facilitate maintenance procedures as recommended in BS 6423 or BS 6626.
- 3.2.9.3 It shall be possible to safely inspect, maintain, clean and repair switchgear by correct procedures with the minimum necessary disruption to normal switchgear service.
- 3.2.9.4 All consumable shall be easy to replace.
- 3.2.9.5 It shall be possible to isolate and then safely maintain and adjust any switchgear feeders and associated protective and control devices without isolating the switchboard or other feeders.
- 3.2.9.6 Facilities shall be provided to lock switchgear to provide for secure isolation and safe working.
- 3.2.10 Power and control cabling
- 3.2.10.1 Switchgear shall be provided with suitable connections that will accept cable lug terminations.
- 3.2.10.2 The temperature rise at such connections shall not exceed the upper operating limit for the cable being used.
- 3.2.10.3 Adequate access shall be provided for installation and termination of cables allowing for any restrictions imposed by the location of Switchgear on site.
- 3.2.10.4 It shall be possible to safely terminate or disconnect external power and control cables without isolating the switchboard or any unaffected feeders.
- 3.2.10.5 All terminals, which are intended for the termination of external cables, shall be so arranged and segregated that the termination of a cable to any circuit switch can be carried out safely without any danger of touching live parts.
- 3.2.11 Self-diagnosis
- 3.2.11.1 Self-diagnostic features should be incorporated to indicate the need for maintenance, rather than relying on a fixed interval maintenance regime, if reasonably practicable.
- 3.2.11.2 It shall be possible for maintenance staff to inspect any diagnostic devices, where provided, without dismantling of Switchgear.

Note: For example wear indication may be provided on the switch mechanisms.
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3.2.12 Minimisation of downtime

Components and sub-assemblies shall be modular in construction, so that defective items can be replaced with a minimum of site work. The need for calibration of devices on site shall be minimised.

3.2.13 Form of Switchgear



- 3.2.13.1 The front of the switchboards shall be flush and shall reflect the electrical configuration of all circuits.
- 3.2.13.2 Instruments, relays and control equipment shall operate at 110V or below AC or DC between conductors and 55V or less between conductors and earth in the case of AC. Compartments containing these devices shall not contain any terminals or equipment operating at higher voltages.
- 3.2.13.3 Any terminals, auxiliary equipment or devices operating at a higher voltage shall be contained in separate compartments with covers (This may be an enclosed area within the compartment for equipment operating at up to 110V ac or dc).
- 3.2.13.4 Main cable terminations shall be contained in segregated compartments.
- 3.2.13.5 Segregated trunking shall be provided for auxiliary wiring.
- 3.2.13.6 Provision shall be made for securing cables.
- 3.2.14 Switchgear enclosures
- 3.2.14.1 Switchboards shall be capable of delivery in transport units not exceeding 2250mm in height, width or depth.
- 3.2.14.2 No exposed part of the Switchgear shall attain a temperature in excess of 60 °C when the Switchgear is operating at or below rated duty at the maximum rated ambient temperature.
- 3.2.14.3 No component such as a switch handle or any other device shall protrude by more than 75 mm beyond the main body of the Switchgear. Skids or similar members shall not protrude by more than 75 mm.
- 3.2.14.4 Enclosures shall be designed to remain vertically stable when upright and then tilted over by an angle of 30 ° from the vertical in any direction.
- 3.2.14.5 Designated lifting points suitable for the attachment of shackles shall be provided and painted bright yellow. Removable lifting lugs or eyes shall have secure provision made for them within the Switchgear. If special equipment is required a label giving instructions shall be fixed on the Switchgear.
- 3.2.14.6 Switchgear enclosures shall have sufficient inherent strength to be lifted and manoeuvred into position by any reasonable method including the use of rollers.
- 3.2.15 Access
- 3.2.15.1 Access to compartments shall be by means of the following:
- a) to compartments containing functional switching devices with a nominal voltage in excess of 110V AC or DC between circuit conductors and in the case of AC in excess of 55V between conductors and earth shall be by means of an interlocked door, or in the case of circuit breakers fitted with integral front panels, by removal of the complete switchgear unit;
 - b) to auxiliary equipment compartments by means of a hinged door with tool operated, self retaining fastenings;
 - c) to all other compartments, by means of removable panels with tool operated, self retaining fastenings;
 - d) access to auxiliary equipment compartments of overhead trolley circuit breakers containing equipment operating at or below 240V ac or dc, shall be by means of a hinged door with hand operated catch and padlocking facility.



3.2.15.2 Any removable panels shall have a weight and size that permits easy handling by one person, the number and type of fastenings shall be such that panels can be removed and refitted within a reasonable duration.

3.2.15.3 Withdrawable switching devices

- a) Shutters shall operate when the switching device is withdrawn to provide segregation between the switchgear compartment and any other compartment, which contains live parts.
- b) Shutters shall operate automatically and positively, being actuated by the movement of the switchgear truck or carriage.
- c) It shall be possible to open the shutters manually to gain access to the circuit or busbar chambers after which they shall also close automatically when released.
- d) When operated manually it shall be possible to open and close each shutter independently of the other.

3.2.15.4 Where Switchgear is to be installed against a wall or partition precluding rear access, all parts which require maintenance or inspection, shall be accessible from the front of the switchboard and access for main cable termination shall be possible via the front of the switchboard.

3.2.16 Safety interlocking

3.2.16.1 In addition to interlocking as required by BS EN 60439 interlocks shall be provided to prevent the switchgear:

- a) being closed without auxiliary circuits being connected;
- b) being closed with any associated door open;
- c) having any associated door opened unless the switchgear is in the test or disconnected position.

and in addition for withdrawable switchgear only measures shall be provided to prevent;

- d) being transferred to the connected position with the shutters locked;
- e) plugging in a switching device while in the closed position;
- f) withdrawing a switching device while in the closed position;

3.2.16.2 Interlocks shall be such that invalid operations are blocked and do not result in tripping of a switching device, which is in the test or disconnected position.

3.2.16.3 Interlocking shall be provided such that it is impossible to configure the switchgear in a manner which would cause its fault or other current ratings to be exceeded.

3.2.16.4 Interlock keys shall be of the captive type for any interlock functions.

3.2.17 General requirements for switchgear closing mechanisms

3.2.17.1 Closing mechanisms shall be of the dependent or independent power closing type.

3.2.17.2 The mechanisms shall operate at a voltage no greater than 110V AC.

3.2.17.3 Following the closing operation the switchgear shall not require any electrical supply (whether derived from the main circuit or control supplies) to remain closed.

3.2.18 Manual closing

3.2.18.1 Provision shall be made to close the switchgears manually for maintenance and test purposes or in the event of loss of closing supply.

3.2.18.3 Such closing facilities shall preferably be of the independent manual type, and shall permit closing of the breakers at rated fault level.

3.2.18.4 If dependent manual closing is offered the closing shall only be possible in the disconnected and test positions.

3.2.19 Local indications

3.2.19.1 Indications shall be provided on Switchgear to show the status of circuit breakers, devices and alarm conditions in accordance with BS EN 60947.

3.2.19.2 Remote status indication wiring shall be brought out in parallel to terminal blocks, which may be used to provide electrical indication facilities.

3.2.19.3 Local indication of opened or closed

a) A mechanical indicating device which is positively driven in both directions shall be provided at the switching device or isolator position to show if the switching device or isolator is open or closed.

b) The indication shall be clearly visible without the need to open any door.

c) The open and the closed indication shall be in accordance with BS EN 60947.

3.2.19.4 Stored energy mechanisms

a) If a stored energy closing mechanism is used visual mechanical indication shall be provided to show the state of the closing spring or other stored energy device.

b) This indication shall be in accordance with BS EN 60947. and shall be visible with the switching device in the service position.

3.2.20 Auxiliary switches

Auxiliary switches shall be provided as required for circuit breaker or isolator operation and also for indication.

3.2.21 Local and remote controls

3.2.21.1 Rotary switches with padlockable barrels shall be fitted where changes of state are required using local electrical control supplies.

3.2.21.2 Switchgear trip and close switches shall be of the 3 position type. They shall be marked 'Trip-Neutral-Close' with the trip and close positions fitted with a spring return to the neutral position on release of the switch by the operator.

Note: These requirements are more readily applicable to HV switchgear and concessions may therefore be granted for LV equipment.

3.2.21.3 'Local and Remote' selection switches shall be fitted to select remote operation under SCADA control or local operation using controls mounted on the Switchgear. These switches shall have an extra pair of contacts closed in the local position, wired to terminals to provide a remote indication that local control has been selected.

3.2.22 Remote control, indication and monitoring

- 3.2.22.1 Substation and switchroom equipment shall be provided with all necessary controls and indication to interface to a SCADA remote control and monitoring system. Control power supplies shall conform to the requirements of Clauses 3.2.34 and 3.2.35 of this document.
- 3.2.22.2 An interposing relay shall be fitted for all operations requiring a change of state signal initiated from the SCADA system. This shall accept a 50V DC pulse between 0.3 and 5 seconds in duration from the SCADA system.
- 3.2.22.3 Interposing relays shall have a burden not exceeding 5 VA at 50V DC. Voltage spikes caused by opening of interposing relay coil circuits shall be limited to 150% of nominal voltage.
- 3.2.22.4 Volt-free contacts rated for 70 V 1A inductive or resistive shall be provided for all equipment modes required to be scanned by the SCADA equipment for remote indication.
- 3.2.22.5 Where required interface devices shall be provided for remote indication of analogue quantities and for remote metering. Unless otherwise specified, devices for indication of quantities such as voltage and current shall provide output of 4 mA to 20 mA corresponding to full-scale indication of the quantity monitored, feeding into an impedance of up to 500 ohms.
- 3.2.22.6 Electrical isolation capable of withstanding the power circuit insulation test voltage shall be incorporated between the power circuit and the output circuit.
- 3.2.23 Switchgear wiring
- 3.2.23.1 All wiring shall be adequate for the duty concerned. Due regard shall be taken of grouping effects especially where multi-core cables are employed. Allowance must be made for voltage drop and loop impedances for correct and safe operation of protection, indication and control devices.
- 3.2.23.2 Solenoid and similar devices shall be wired with cable sufficiently rated for continuous operation if a malfunction occurs.
- 3.2.23.3 Any wiring connected to the 630 V DC system shall be certified to withstand a 4 kV DC voltage withstand test for 1 minute.
- 3.2.23.4 All wiring shall be supported and shall be installed to give accessibility of cores/wires and their terminations, clear identification of circuits, neatness and spacing in cubicles and on panels and shall not restrict access to apparatus for testing and maintenance.
- 3.2.24 Electrical protection
- Switchboards shall incorporate all necessary protection, control and monitoring equipment.
- 3.2.25 Surface protection and finishing
- 3.2.25.1 All parts of Switchgear shall be effectively protected against corrosion and deterioration, taking into account the environment in which it will operate and the intended usage, see BS EN 50123-6.
- 3.2.25.2 Internal surfaces of chambers which are filled with oil, synthetic liquid, or sealed gas shall be cleaned by shot blasting, or by other approved methods, and shall be finished with a protective coat of paint or varnish compatible with the medium used in the chamber.



3.2.26 Floor mounting

Switchgear intended for floor mounting shall be suitable for installation on a concrete or screeded floor which may vary in level by +/-5 mm in 3000 mm.

3.2.27 Not Used

3.2.28 Electromagnetic compatibility

3.2.28.1 Power supply equipment shall not cause low frequency disturbances that are conducted through the power system that cause damage, malfunctions or deterioration of performance in other equipment.

3.2.28.2 Power supply equipment shall not cause unacceptable interference to other elements of the system or to other interfacing systems.

3.2.28.3 Switchgear shall comply with LU Standard 1-122 Electromagnetic Compatibility (EMC) and shall not cause interference to LU communications, SCADA or signalling systems.

3.2.29 Interchangeability

3.2.29.1 All items of the same type and rating supplied by the same manufacturer shall be interchangeable. This requirement applies both to withdrawable and demountable devices such as circuit breakers and to fixed devices such as instruments.

3.2.29.2 Withdrawable and demountable items which are superficially similar but which are not intended to be interchangeable shall have interchangeability inhibited, e.g. by fouling pins on similarly rated circuit breaker trucks which have different control or protection devices.

3.2.30 Extensibility

Any Switchgear, which comprises an assembly of similar modules, shall be constructed such that further similar modules can be added at either end.

3.2.31 Switchgear Earthing and bonding

3.2.31.1 All Switchgear intended to have protection against indirect contact by earthed equipotential bonding and automatic disconnection of supply, shall have all exposed-conductive-parts solidly connected to its own common main earthing terminal or earth bar by equipotential bonding conductors. Bonding conductors shall be provided where fixed, solid, negligible impedance contact cannot be assured at all times.

3.2.31.2 All Switchgear simultaneously-accessible-exposed and extraneous-conductive-parts shall be bonded together by equipotential bonding conductors.

3.2.31.3 Bonding conductors shall be rated to carry the prospective fault currents for 3 seconds and to limit potential differences under fault conditions to safe levels taking into account the expected duration of any fault.

3.2.32 Neutral or referenced conductors

No device which may become an open circuit or give rise to high impedance shall be connected in any neutral or other referenced conductor, except that bolted links or links which are switched together with the related circuit conductors may be used. This shall not interrupt the protective conductor. Switched links shall be arranged such that the referenced conductor is broken after and made before the related circuit conductor.

3.2.34 DC auxiliary supplies

Equipment shall be compatible with the available supplies.



New switchboards shall be designed to operate from a 110V battery for closing, tripping, indication and remote control functions.

Note: In some locations a 110 V battery is used for closing and a 48 V battery for tripping, protection relays, indication and remote control.

3.2.35 Operational limits

3.2.35.1 All equipment must operate within specification at the voltage tolerances as defined in BS EN 60694:1997, with the exception of the upper limit for solenoid operation, which shall be 110% not 105%. The limits shall apply to 110V DC supplies for all control functions and to 48V DC supplies at equipment terminals for switch tripping, protective relays, indication and remote control systems.

3.2.35.2 All equipment shall operate within specification even where subjected to occasional over voltages due to boost charging of batteries.

Note: Typically these limits are 143 V DC for the 110 V batteries and 63 V DC for the 48 V batteries, both measured at the battery terminals unless otherwise specified.

3.2.36 Handling

3.2.36.1 Means shall be provided so that one person can safely operate Switchgear including isolation, transfer earthing and inter-changing of withdrawable switchgear trucks or demountable switchgear. If necessary, mechanical handling devices shall be provided.

3.2.36.2 It shall be possible to operate any handle or lever with a force of no greater than 150 Newtons.

Note: Guidance on manual handling risk assessment can be obtained in the Manual Handling Operations Regulations 1992 (as amended) when making these assessments.

3.2.37 Locking facilities

3.2.37.1 All keys and locks shall be provided as necessary to fulfil the requirements of this Standard.

3.2.37.2 Locking facilities shall be provided to secure all doors, switches and devices.

3.2.37.3 The same key shall operate all locks supplied for the same function on any complete item of Switchgear.

3.2.37.4 It shall not be possible to open any lock with the key supplied for any other equipment at the same site nor to open a lock having a different function on the same equipment.

3.2.38 Diagrammatic representation of switchboard main circuits

3.2.38.1 The front panels of switchboards shall have a diagrammatic representation to indicate the arrangement and function of the main circuits. Such markings shall be indelibly marked.

Note: Typically lines of at least 12 mm thick with lettering at least 24 mm high are used.

3.2.38.2 The markings shall clearly identify switches by their physical location and indicate the relative electrical connections, especially the allocation of circuits to busbar sections and the position of bus section and bus coupler switches.

3.2.38.3 The diagrammatic representation shall be coloured as follows: