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Electrical Equipment Code

Prishtina

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0 Preface to this version of the Electrical Equipment Code

0.1.1.1 This version is intended as final taking account of the comments received on the drafts that were prepared for review within KOSTT and by other interested parties to allow the development of a final draft to be presented to the steering group.

0.1.1.2 In a few places in this version, there still appears [xx] in place of figures. At these points, either figures specific to the KOSTT network are required or information of particular equipment used by KOSTT or KEK Networks. Attention is drawn to the areas where responses are still required by KOSTT in the paper entitled “Analysis of Comments on the Sixth Draft of the Electrical Equipment Code”

1 Introduction

1.1.1.1 This **electrical equipment code** sets out the requirements for equipment forming part of the network of the **TSMO** and for equipment of **system users** at the point of **connection** with the network of the **TSMO**. It relates to equipment operating at nominal voltages of 110kV, 220kV and 400kV forming part of the main system of the **TSMO** and, where appropriate, to equipment connected to tertiary windings of main transformers at a nominal voltage of 10kV or 6.3kV.

1.1.1.2 Where it refers specifically to the network of the **TSMO**, it defines the ratings and general requirements for plant, equipment and apparatus to be connected to the **TSMO** network by, or on behalf of, the **TSMO**, taking account of the characteristics of the network in the area that the equipment is to be connected.

1.1.1.3 Where it refers to equipment of **system users**, it defines the general requirements for plant, equipment and apparatus at the **connection point** between the networks of the **system user** and of the **TSMO** and the range of equipment ratings used by the **TSMO** that will be used at the **connection point** as defined in the **connection agreement**.

1.1.1.4 In general, ratings are selected from the range of values given in the appropriate IEC documentation and will be applied throughout the **TSMO** network. Where absolutely necessary, other ratings may be specified or agreed by **TSMO** where interconnection is required with parts of the network that were constructed to older specifications that are incompatible with current standards. Where this occurs, equipment ratings will be specified on a site specific basis only, preferably utilising another IEC value or design arrangement that is compatible with the safety and security levels utilised by the **TSMO** for its network and to ensure compliance with the requirements of the **UCTE**.

1.1.1.5 **System users** must utilise the same equipment standards at the **connection point** and are encouraged to adopt the same equipment standards as the **TSMO** throughout their network to ensure stability of the main **transmission system**.

1.1.1.6 In accordance with the **law on energy**, the **transmission system operator** is responsible for the administration of all technical codes for electricity including this **electrical equipment code** and they are subject to the approval of the **regulator** prior to their implementation.

2 Glossary and Definitions

2.1.1.1 In this **electrical equipment code**, the following definitions apply:

Term	Acronym	Definition
Code of Practice for Access to Land and/or Property		The code by that name, developed by **TSMO** and approved by the **ERO**, detailing the arrangements by which **TSMO** shall take access to land or property not in its ownership or control when so required for the purposes of construction, modification, operation or maintenance of the **transmission system**.
Connection		The interconnection of two **systems**.
Connection Agreement		A bilateral agreement between a **network operator** and a **user** that details the conditions for **connection** to the **network**.
Connection Point		The agreed point of **supply** established between a **network operator** and another **party**.
Electrical Standards Code		The code by that name, developed by **TSMO** and approved by the **ERO**, detailing the applicable electrical standards for the **transmission system** operated by **TSMO**.
Energize		To apply voltage to an electrical installation by closing the final switch or inserting a cut-out fuse. Energized, energization etc shall be construed accordingly.
Energy Regulatory Office	**ERO**	Is the independent regulatory body established by the **Law on the Energy Regulator**.
Force Majeure		is in relation to any **Party** any event or circumstances beyond the reasonable control of such **Party** and which results in or causes the failure of that **Party** to perform any of its obligations under the this **metering code** including, but not solely limited to any one or more of the following acts: Acts or restraints of governments or public authorities; war, resolution, riot or civil commotion; strikes, lock-outs or other industrial action; blockage or embargo; failure of supplies of power, fuel, transport, equipment or other goods or services; damage to the premises or storage facilities by explosion, fire, corrosion, ionizing radiation, radioactive contamination, flood, natural disaster, or negligent act of others or accident; and breakdown or failure of equipment whether of the **Party's** or others
Generating Unit		a physical unit located within Kosovo for the production of electricity operated by a **Generator.**

Term	Acronym	Definition
Generator		an electricity enterprise with a generation **licence** or a natural or legal person exempt from holding a **licence** in accordance with the **Law on the Energy Regulator** who engages in the activity of owning, controlling, or operating **generating units** and who generates electricity.
Law on Energy		Is law number 2004/8 approved by the Assembly of Kosovo and promulgated by regulation UNMIK/REG/2004/21.
Law on the Energy Regulator		Is law number 2004/9 approved by the Assembly of Kosovo and promulgated by regulation UNMIK/REG/2004/20.
Law on Electricity		Is law number 2004/10 approved by the Assembly of Kosovo and promulgated by regulation UNMIK/REG/2004/22.
Licence		an authorization issued by the **Energy Regulatory Office** that allows the holder to perform an activity in the energy sector for which a **Licence** is required according to its provisions as established by the **Law on the Energy Regulator**
Metering Code		is the code of that name, which has been prepared by the **Transmission System Operator** and approved by the **Energy Regulatory Office** as established by Article 38.7 of the **Law on Electricity**
Operational Codes Governance Committee	OCGC	The committee established in accordance with the provisions of the rule on governance procedures **for technical/operational codes** to oversee the operation of technical and operational codes.
Party		The **TSMO** or any **system user** affected by the operation of this code.
Reasonable and Prudent Operator		An operator of an electricity undertaking seeking in good faith to perform its obligations and, in the conduct of its undertaking, exercising that degree of skill, diligence, prudence and foresight which could reasonably be expected from a skilled and experienced operator with sufficient financial resources complying with the relevant law Licences, **market rules** and **technical codes** – including this **electrical equipment code** – and any reference to the standard of a **Reasonable and Prudent** Operator shall be a reference to such degree of skill, diligence, prudence and foresight as aforesaid.
Regulator		Is the Energy Regulatory Office (ERO), the independent regulatory body established by the **Law on the Energy Regulator**.
Rule on Dispute Settlement Procedures		A rule on dispute settlement procedure established by **regulator** in accordance with article 17.1 of the **law on the energy regulator** for the resolution of disputes in the power market.
Rule on Governance Procedures for Technical/Operational Code		A **rule on governance procedures** for technical and operational codes issued by the regulator in accordance with article 9.1(f) of the **law on the energy regulator.**

Term	Acronym	Definition
System User		A **system user** is a natural or legal person who uses the transmission network of the **TSMO** including: large consumers whose equipment is connected to the **transmission network**, **generators** whose equipment is connected to the **transmission network** or is eligible to trade in the wholesale market, other **transmission system operators** whose networks interconnect with that of KEK, **distribution network operators** whose networks interconnect with TSMO, and electricity **customers**.
Transmission		Activities pertaining to a **transmission network** including the conveyance of electricity, and providing a physical connection to it.
Transmission System Operator	**TSMO**	the operator of the transmission network in Kosovo licensed by the **Regulator** as **Transmission System Operator** on 4 October 2006.
Transmission System		The electricity network owned or operated by **TSMO** or, where the context requires, by the TSO in an adjoining state.
Union for the Co-ordination of Transmission of Electricity	**UCTE**	is the association of **transmission system operators** in continental Europe which co-ordinates the operational activities of **transmission system operators** in member countries.

2.1.1.2 In addition to special meanings contained in the Glossary and Definitions above, within this document certain words and phrases have the following meanings:

- References to the masculine shall include the feminine and references in the singular shall include references in the plural and *vice versa*,
- Where this **electrical equipment code** specifies written information or written confirmation to be given then any other suitable means of electronic transfer that enables the recipient to retain the information – such as electronic mail or FAX - fulfils this requirement,
- Except where explicitly stated otherwise all references to section shall be a reference to a section in this **electrical equipment code**,
- Any reference to a law or regulation shall be a reference to that law or regulation applicable in Kosovo or, following the replacement of that law or regulation the new law or regulation from the date it comes into force.

3 Service Conditions

3.1 General

3.1.1.1 Plant, equipment and apparatus will be suitable for operation under the following normal and special service conditions.

3.2 Normal Current Ratings of Equipment

3.2.1.1 Unless otherwise stated, the normal current ratings of all equipment to be connected to the TSMO network shall be:

Nominal Sysyem Voltage (kV)	Maximum Normal Current (A)	Short Circuit Current (kA)	Fault Duration (S)
400	2500	40	3
220	3150	40	3
110	3150	40	3
10	2500	[31.5]	3
6.3	2500	[31.5]	3

3.3 Normal Service Conditions

3.3.1.1 Controlgear and other equipment housed outdoors in association with high or medium voltage plant shall have a degree of protection of at least IP 54 as defined in IEC 60529.

3.3.1.2 Controlgear and other equipment housed outdoors in association with high or medium voltage plant shall have a degree of protection of at least IP 41 as defined in IEC 60529.

3.3.1.3 All plant, equipment and apparatus shall have a degree of protection of at least IP2X under normal operating conditions which, for the purposes of this document shall include, for example, local operation of equipment with cabinet doors open.

3.3.1.4 Normal service conditions, as defined in IEC 60694, are applicable. Where a choice exists in IEC 60694, the following selection of values has been made, and together with the fixed values in IEC 60694 are the values required by the TSMO.

3.3.2 Indoor Plant

3.3.2.1 Temperature class minus 5 indoor.

3.3.3 Outdoor Plant

3.3.3.1 The following air temperatures apply:-

- Maximum ambient temperature 40C
- Maximum daily average ambient temperature 30C
- Annual average ambient temperature 20C
- Minimum ambient temperature -30C

3.3.3.2 The maximum wind (gust) velocity is 50 metres per second.

3.3.3.3 The humidity is low in summer and high in winter.

3.3.3.4 Atmospheric pollution

- In Kosovo, pollution is generally medium.
- In certain places pollution is heavy or very heavy and, if this applies, it will be stated in the tender documentation.

3.3.3.5 Ice Coating Class 20 mm.

3.3.3.6 Seismic activity between VII and VIII on the Modified Mercalli Intensity Scale, is likely to be encountered in Kosovo. All civil works must be constructed with this level of seismic activity considered in the design works. Any supplier proposing to provide electromechanical equipment shall demonstrate that it is designed to resist earthquake loadings resulting from accelerations specified in a location specific report from a recognised seismic institute.

3.3.4 Protection and Control Equipment Operating Environments

3.3.4.1 The operating environment for Equipment, such as control and protection, is categorized in the following table. Equipment shall be suitable for operation in its intended environment including the ability to maintain critical functions in the event of failure of environmental control facilities such as air conditioning.

Class	Siting Conditions	Class according to IEC 60654-1	Ambient Temperature Range	Relative Humidity Limits
1	Rooms having a closely controlled environment	A1	+18 to +27℃	20 to 75%
2	Control rooms and Equipment rooms not fully air conditioned	B3	-5 to +55℃	5 to 95%
3	Plant areas, rooms and block houses away from high temperature plant and subject to greater extremes than Class 2	N/A	-5 to +40℃	5 to 95%
4	Outdoors	C2	-30 to +40℃	10 to 100%

The ambient temperature maxima assume negligible solar gain and negligible localised temperature excursions i.e. adequate ventilation. The validity of these assumptions must be considered, and confirmed, at the application stage.

For ventilated Equipment the ambient temperature is defined as being the free air temperature existing at a point level with the top of the Equipment.

3.3.5 Fault Clearance

3.3.5.1 Plant and Equipment shall be suitable for operation under the following conditions:

Nominal Voltage (kV)	Target fault interruption time of main in-feeding circuit (ms)	Target total fault clearance time (all infeeds) (ms)	Target backup clearance time (ms)
400	85	145	500

Nominal Voltage (kV)	Target fault interruption time of main in-feeding circuit (ms)	Target total fault clearance time (all infeeds) (ms)	Target backup clearance time (ms)
220	100	250	
110	140	250	
10 or 6.3	75	n/a	n/a

3.3.5.2 In the event of a circuit-breaker failure, circuit-breaker fail protection shall trip all necessary adjacent circuit-breakers that supply a fault infeed within a target fault clearance time less than 300 mS.

3.3.6 Multi-pole Opening/Tripping and Auto-reclosing

3.3.6.1 Plant and equipment shall be suitable for simultaneous three-phase opening/tripping and simultaneous three-phase auto-reclosing on overhead line feeder circuits.

3.3.7 Special Service Conditions

3.3.7.1 Plant & Equipment shall be suitable for operation in a pollution environment as defined in the following table

Insulation	IEC 60815 Pollution Class	IEC 60507 Salt Fog Withstand Test Specification[1] kg/m^3
Indoor	I	No test withstand required
Outdoor	III	80
Outdoor (special)	IV	>160
Outdoor Horizontal	III& IV	80

3.3.7.2 External insulation shall be in accordance with the relevant requirements and recommendations of IEC 60815.

3.3.7.3 For ceramic insulation, test conditions to prove this performance level shall be as defined in the tables in sections 3.3.7.1 and the following table of test voltage levels for pollution, salt fog and heavy wetting tests. Service experience offered in lieu of artificial pollution testing shall be identical to that detailed for composite insulation.

Rated Voltage of Insulation (kV)	420	245	123
Test Voltge (phase to earth) (kV)	242	142	71
Test Voltage (phase to phase)	420	245	123
Test Voltage for other Insulation (as per IEC 60060)	The maximum power frequency voltage to which the insulation may be stressed in service. For insulation enclosing a switchgear interrupting gap, or if insulation is specified for enclosures for isolating gaps, or for insulation connected in parallel with such an interrupting or isolating gap, this test voltage shall be the out-of-phase voltage.		

3.3.7.4 Insulation, including composite insulation, will comply with the requirements for minimum specific creepage as specified in IEC 60815.

3.3.7.5 Ceramic insulation for vertical application meeting the following criteria is deemed to meet the requirements of the tables in sections 3.3.7.1 and & 3.3.7.3 without further testing.

3.3.7.6 Phase-to-phase AIS solid external insulation is not acceptable.

3.3.7.7 The application of an anti-pollution palliative coating to the external surface of ceramic insulation in order to satisfy the requirements of this specification is not acceptable.

3.3.7.8 Products consisting of internally graded insulation contained within an external AIS insulating enclosure or weather-shield, such as bushings, instrument transformers or grading capacitors, shall be considered a single item for the purposes of pollution and heavy wetting tests where required.

3.3.7.9 Phase to earth insulation connected in parallel and having a shed-to-shed separation distance of less than 0.5 times the phase-to-earth clearance, shall be considered as a single item for the purposes of pollution and heavy wetting tests.

3.3.7.10 Horizontally oriented insulation and insulation intended for mounting > 15° from the vertical shall meet the pollution and heavy wetting requirements in its intended orientation.

3.3.7.11 The insulation shall be mounted at the orientation intended for service during pollution and heavy wetting tests.

3.3.7.12 Composite external insulation shall be supported by satisfactory evidence detailing the suitability of the insulation for the intended site.

4 Substations

4.1 Technical Requirements for Substations Connected to the Transmission System

4.1.1.1 This Section covers all types of substations with equipment installed for use on 110, 220 and 400 kV 50 Hz systems. Substations operating at other nominal system voltages are expected to comply with the general provisions of this document. It is applicable to both open-terminal air-insulated (AIS) and metal-enclosed gas-insulated (GIS) substation constructions and covers equipment operated at lower voltages on the same substation site. It is applicable to new construction and extensions to existing installations and all TSMO owned or operated plant and apparatus wholly within the substation and not covered more specifically by other technical requirements is within the scope of this document.

4.2 General Requirements

4.2.1 Designing For Safety

4.2.1.1 **TSMO** has declared its commitment to safety and therefore intends that its substations are as safe an environment as is reasonably practicable. This specification contains many detailed requirements intended to ensure safety however, due to the complex nature of substation design and construction, it is accepted that no single specification or suite of specifications can guarantee to address all potential dangers in the best manner. **TSMO** believes it essential that its suppliers join with **TSMO** in a collaborative manner to ensure a "best practice" approach to substation design safety at all times. In particular constructional issues such as tripping hazards, sharp edges, labelling and poor access which are difficult to specify effectively should be eliminated wherever possible in the design.

4.3 Legal Requirements

4.3.1.1 The manner in which plant and equipment is designed and installed as a system shall allow that system and its components to be operated and maintained in accordance with all relevant laws and regulations.

4.4 Environmental Impact

4.4.1.1 The siting and design of new substations shall take into account the best practice approach developed by the networks committee of eurelectric, in their report "Public Acceptance for new **transmission** overhead lines and substations" reference 2003-200-0005.

4.5 Design Life of Installations

4.5.1.1 The substation installation including busbars, connections, insulators, structures foundations and all other infrastructure shall be designed for a life of 40 years subject to periodic preventive maintenance being carried out in accordance with the instructions of manufacturers or suppliers.

4.6 Operational Access

4.6.1.1 Access, suitable for use by an unaccompanied person, shall be provided to the isolation facilities of each isolator and earthing switch including any locking device. The isolation facilities or locking devices shall be between 1 m and 1.8 m above ground or floor level or above a platform provided for access and shall be not further than 750 mm horizontally from the edge of a platform.

4.6.1.2 Access above ground level shall be from mobile or fixed platforms (although fixed platforms may be accessed by ladder). Where movement of equipment within the substation would be restricted by the presence of ladders it is acceptable that these are removable. Removable ladders and mobile platforms shall be easily handled and used on the finished substation surface by one person. Ladders and permanent platforms shall comply with relevant parts of ISO 14122 and their arrangement shall be approved by **TSMO**.

4.7 Maintenance Requirements

4.7.1.1 The substation layout and surfaces shall be adequate to allow the access and use of any powered access equipment, cranes or similar equipment which may be required for foreseeable maintenance activities Access suitable for gas handling equipment shall be provided to all equipment containing SF_6.

4.7.1.2 Roads shall be provided to access substation main buildings, relay rooms and heavy items of plant (e.g. transformers) and shall be to a standard consistent with that of the rest of the substation site. All other surfaces shall also be constructed to a standard consistent with the rest of the substation site.

4.8 Interlocking

4.8.1.1 Substations shall be provided with a full interlocking scheme as detailed in section 8.

4.9 Current Transformers

4.9.1.1 The accommodation of current transformers shall be as specified in section 5.26 The location of current transformers shall be as specified in section 5.27.

4.10 Switchgear Secondary Isolation

4.10.1.1 Isolation facilities shall be accessible from ground level or from fixed platforms and shall permit the application of isolation procedures.

4.11 Voltage Transformer Secondary Isolation

4.11.1.1 Voltage transformer secondary isolation links, or equivalent means of positive isolation, shall be provided in a separate isolation box mounted between 1 m and 1.8 m above substation floor or access platform level. The door of the isolation box shall be capable of being locked using a padlock with a hasp having a 5 mm diameter and 30 mm long.

4.12 Earthing

4.12.1.1 At every **connection point**, the **system user**'s earthing system shall be integrated with that of **TSMO**'s substation earthing system and shall, as a minimum, meet the same design and installation standards as **TSMO**'s earthing system.

4.13 Equipment Identification

4.13.1.1 Labels shall be provided to allow unambiguous identification of all plant and equipment and of associated operating facilities and points of isolation. The following are required:

- Each circuit-breaker, isolator and earthing switch mechanism box shall carry a label giving the operational reference of the device.

- Each pressure gauge or pressure readout device shall carry a label identifying the parameter it is monitoring.
- Each valve (including self-sealing gas filling valves) shall carry a label identifying its function.
- Each SF_6 filling valve shall be provided with a label identifying the mass of gas contained within the gas compartment to which it is fitted (at normal filling density). The volume of the compartment and normal filling density shall also be marked.
- Each control handle or switch for plant operation shall carry a label identifying its function.
- Each point of LV isolation associated with plant shall carry a label identifying its function.
- Each cabinet, cubicle or kiosk shall carry a label identifying all of the equipment contained within it.

4.13.1.2 Labels shall be sufficiently durable for the application and the environment in which they are to be used taking account of the expected operational lifetime of the equipment. They shall remain in place and legible for the design lifetime of the equipment.

4.13.1.3 The fixing of labels shall not compromise the degree of protection (IP rating) of the equipment.

4.13.1.4 All pipework shall be identified in accordance with BGV A 8.

4.14 Secondary Equipment

4.14.1.1 Electronic equipment shall be located in accommodation commensurate with its environmental performance, which is classified in section 3.3.4.1.

4.14.1.2 Light current accommodation shall meet the requirements of section 3.3.4.1, Class 3 under all ambient conditions.

4.14.1.3 Fixed heating shall be thermostatically controlled. Where no fixed heating is provided, provision shall be made for raising the air temperature in the vicinity of all equipment associated with any one circuit to 16C without causing condensation on the equipment.

4.14.1.4 All panels housing secondary equipment which are sited in equipment rooms or accommodation shared with equipment owned by other users shall be padlockable.

All panels housing metering equipment shall also be sealable in accordance with the requirements of the **metering code**.

4.15 Substation Auxiliary Cabling

4.15.1.1 All substation auxiliary cabling between substation buildings, relay rooms, common marshalling points and substation primary equipment shall, as far as reasonably practicable, be installed in buried cable ducts. Where cable trays (or similar) are used these shall not present a risk of injury and shall be suitably finished to prevent degradation due to environmental conditions. Auxiliary cables shall be installed such that they do not present a tripping hazard.

4.15.1.2 Substation auxiliary cabling shall be installed in such a way that hazards such as tripping and sharp edges (cable trays) are minimised. Cables between dispersed relay rooms or circuit marshalling points and local plant may be buried direct where armoured cables are used. In all other circumstances cable ducts may be used.

4.15.1.3 The location of all buried cables and ducts shall be clearly recorded on site.

4.15.1.4 All metallic cables shall be of low smoke, low fume, zero Halogen, armoured design.

4.15.1.5 Installation shall be in accordance with BS 7671:2001 (IEE Wiring Regulations sixteenth edition). Where cables are exposed to direct sunlight, suitable solar shields shall be provided

4.15.1.6 Substation auxiliary supplies shall be designed and installed in accordance with section 14.

4.16 Segregation of Equipment owned by TSMO and System Users

4.16.1.1 Protection relays and circuits associated with equipment owned by **system users** shall be accommodated in separate panels from those associated with equipment owned by **TSMO**. This requirement shall also apply to multicore cable terminations, marshalling facilities and jumper fields.

4.16.1.2 Where switchgear local controls are grouped on a bay control panel (or similar) then control of **TSMO** owned plant shall be segregated from that of **system user** owned plant. Separate individually lockable local/remote control selector switches shall be provided for **TSMO** and **system user** equipment such that staff with authority to operate only **system user** owned equipment are unable to access control of **TSMO** owned equipment.

4.16.1.3 Facilities provided for substation level control of **system users'** equipment shall have no facilities to operate **TSMO** owned equipment. Any electrical/mechanical supplies which are provided by **TSMO** to **system users'** equipment shall be equipped with segregated, clearly labelled isolation facilities. Auxiliary supply (48V dc, 110V dc and 400/220V ac) isolation facilities shall be located in the equipment local control cubicle (LCC) or, where installed in a common panel, shall be clearly segregated from isolation facilities for **TSMO** owned equipment. LCCs and common panels should be sited in areas to which access will be permitted to non-**TSMO** staff.

4.16.1.4 400V ac supplies to significant **system user** loads, such as transformer coolers, shall be supplied from separate circuits on the substation LVAC supplies board and provision shall be made for the installation of metering. Isolation facilities shall be provided at the load end of the circuit such that isolation at the LVAC board is not normally required during maintenance.

4.16.1.5 Common compressed air, hydraulic or other motive power systems supplying both **TSMO** and **system users'** equipment are unacceptable.

4.16.1.6 The ownership of equipment shall be clearly labelled particularly where **TSMO** and **system users'** equipment or isolation facilities are located in close proximity.

4.17 Lifting Equipment

4.17.1.1 Lifting beams or fixed overhead travelling cranes of adequate capacity shall be provided where their use is required to assist with maintenance, repair or dismantling of switchgear. Fixed cranes shall not be provided in outdoor substations or indoor AIS substations except where specifically required for maintenance or repair purposes. Provision shall be made to inspect beams or cranes where required by regulation or for insurance purposes and to fit lifting tackle.

4.18 Substation Facilities

4.18.1.1 As a minimum the following facilities shall be provided at all new 400 kV, 220 kV and **TSMO** owned 110kV substations.

- Adequate toilet and washing facilities for operation and maintenance staff taking into account the company's equal opportunities policies.
- Adequate lighting.
- Standby control rooms with provision to be equipped as a permit office and to be used for on-site drawing/record storage. At indoor GIS substations access to the control room shall not be through the switchgear hall and the room shall

prevent ingress of SF_6 decomposition products in the event of a switchgear fault.

- At sites where SF_6 gas-filled equipment is installed a standing area and suitable water and drainage connections for a mobile changing/shower facility. Where large volumes of SF_6 are installed e.g. GIS substations, a fixed installation is required.
- A small mess room with sink, worktop, electrical outlets and facilities for the supply of drinking quality water.
- An equipment store (including earthing equipment storage facilities) / small workshop.
- Vehicle parking.

4.19 Site Security

4.19.1.1 All equipment within the substation shall be installed further than 2 m from the security fence.

4.20 Fire Protection

4.20.1.1 **System users** must install fire protection on their bays to the same standard as that of the **TSMO** substation site.

4.21 Disturbance Recorder

4.21.1.1 A disturbance recorder as specified by **TSMO** shall be installed in each 400kV and 220kV substation.

4.22 General Requirements Applicable to AIS Substations

4.22.1 Electrical Clearances

4.22.1.1 The layout of AIS equipment shall ensure the integrity of the air space between live parts and other conductors (whether earthed or at different potential) for the rated voltage conditions for which the substation is designed. Where equipment configurations have not been dielectrically tested in accordance with IEC 60694 then minimum operational electrical clearances in accordance with the following table shall be applied.

Nominal System Voltage (kV RMS)	BIL/SIL (kV peak)	Phase to Earth Clearance (m)	Phase to Phase Clearance (m)
6.3	60	0.5	0.5
10	75	0.5	0.5
35	190	0.5	0.5
110	550	1.0	1.25
220	1050/900	1.7	2.0
400	1550/1425	2.8	3.6

The minimum clearance of 500mm is proposed to avoid problems of vermin and bird interference.

4.22.2 Safety Clearances/Distances

4.22.2.1 Safety to persons shall normally be achieved by the provision of adequate safety clearance to live parts taking into account the need for maintenance, vehicular and pedestrian access. Where adequate safety clearances to live parts cannot be maintained without limiting access, barriers or fences shall be provided.

4.22.2.2 The safety clearances to be maintained in AIS installations are listed in the following table:

Nominal System Voltage (kV RMS)	Safety Distance (m)	Vertical Design Safety Clearance (m)	Horizontal Design Safety Clearance (m)	Insulation Height (Pedestrian Access) (m)
6.3	0.8	3.2	2.3	2.4
10	0.8	3.2	2.3	2.4
35	0.8	3.2	2.3	2.4
110	1.3	3.7	2.8	2.4
220	2.0	4.4	3.5	2.4

400	3.1	5.5	4.6	2.4

In this table, the minimum clearances are quoted and an appropriate additional allowance should be made by the Supplier for constructional tolerances. The heading terms used mean:

Safety Distance: No part of the body or any object to should be able to infringe this distance to exposed conductors operated at high voltage.
Vertical Design Safety Clearance is the minimum clearance from a live conductor to a point to which pedestrian access is permitted. These figures are derived by adding the 'personal reach' (the vertical reach of a person with upstretched hand), which is taken to be 2.4 m, to the appropriate Safety Distance.
Horizontal Design Safety Clearance is the minimum distance between a live conductor and any point at the same height where a person may stand. These figures are derived by adding the horizontal reach of a person (taken to be 1.5m) to the appropriate safety clearance. Where possible, the vertical design clearance should be applied in all directions.
Insulation height is the minimum clearance from the lowest insulation part of a support insulator to a point where pedestrian access is permitted.

4.22.3 Clearances to Perimeter Fences

4.22.3.1 Exposed live conductors that cross perimeter fences shall, under worst-case conditions, be at a height no less than for 110kV line is 3m for 220 kV is 3.75 and for 400 kV is 5 m

4.22.3.2 Exposed live conductors that do not cross perimeter fences shall be a distance at least equal to the vertical design safety clearance as specified in section 4.22.2.2 (measured horizontally) from a substation compound perimeter fence.

4.22.4 Clearance to Roadways

4.22.4.1 The minimum vertical clearance from exposed live conductors to internal substation roadways or recognised maintenance access routes to which vehicular access is required shall be the greater of:

(i) Minimum height above ground of overhead lines as defined in the appropriate part of the table in section 17.5.1.1, or

(ii) Max vehicle height + 0.5m margin + Safety Distance

4.22.4.2 Where the latter criterion is used the maximum vehicle height used for the design shall be clearly marked at all vehicular access points.

4.22.4.3 The horizontal clearance from defined roadways to exposed live conductors shall be sufficient to ensure that:

(i) the safety distance is not infringed by any part of a vehicle, and

(ii) the horizontal design safety clearance in the table in section 4.22.2.2 is maintained from the driving and/or riding position of any vehicle taking account of cases where the driving and/or riding position falls outside (above) the envelope of the vehicle.

4.22.4.4 Lockable height barriers shall be provided at entrances to the substation and/or within the substation to restrict access for vehicles exceeding the maximum height for which unrestricted access is permitted.

4.22.5 Substation Profile

4.22.5.1 The height of the highest component of outdoor substations should be kept to a practical minimum to achieve a low substation profile.

4.22.5.2 On new sites the maximum height of equipment shall not exceed the values listed in the following table:

Nominal System Voltage (kV)	Maximum Equipment Height (m)
110	7.5
220	10
400	12.5

At existing sites the height of existing equipment shall not be exceeded.

4.22.6 Earthing Devices

4.22.6.1 Substations shall have sufficient earthing provision to enable the safe maintenance of any item of primary equipment including fixed earthing switches. In particular, it shall always be possible to apply an earth between the point of work and all potential fault infeeds.

4.22.6.2 As a minimum, earthing switches in accordance with Part 4, Section 10 shall be provided at circuit entries ('line' earth switches) and at one position on each section of busbar.

4.22.6.3 Line earth switches shall be power operated.

4.22.6.4 Further earthing provision may be by means of other types of interlocked earthing device which meet the specified rating.

4.22.7 Portable Earthing

4.22.7.1 Provision shall be made to employ portable earthing equipment designed for use with tubular conductors with diameters in the range 10-90 mm, 127 mm, 140 mm or 190/200 mm.

4.22.7.2 Where flexible conductors are used as substation conductors or where tube sizes are incompatible with the existing earthing equipment then earthing stubs shall be provided.

4.22.7.3 Points for attachment of the earth end of portable earthing leads shall be provided at each switchgear structure. Each portable earthing lead attachment point shall be connected to the substation earthing mat by a fully rated conductor system. Allowance shall be made for the attachment of sufficient leads at each attachment point to match the switchgear rating.

4.22.7.4 For primary earthing **TSMO** require fully rated earthing capability to be applied in a single operation. Where portable earthing leads are used to achieve primary earthing, consideration should be given to safe application positions and compliance with good industry practice regarding manual handling.

4.23 General Requirements applicable to GIS Substations

4.23.1 Buildings

4.23.1.1 GIS installations comprising two or more circuit breakers shall be housed in a building. The building shall be of minimum life cycle cost construction consistent with environmental and planning requirements. Fixed cranes shall be provided in indoor GIS substations unless the supplier can demonstrate that they are not required for dismantling or removing any part of the substation for maintenance or repair purposes.

4.23.2 AIS Connections

4.23.2.1 AIS connections associated with GIS substations shall meet the requirements detailed in Section 4.21.

4.23.2.2 Line earth switches shall be of AIS design where reasonably practicable.

4.23.3 Portable Maintenance Earthing Devices (PMEDs)

4.23.3.1 Two three-phase sets of each type of PMED employed shall be supplied.

4.23.4 Gas service connections

4.23.4.1 A diagram of the gas system shall be displayed at the Local Control Cabinet or at any point where gas service connections are grouped together.

4.23.5 Pressure/Density Indication

4.23.5.1 All displays of pressure/density shall be readable from the substation floor level or from access walkways.

4.23.6 SF6 Gas Alarm Scheme

4.23.6.1 An audible alarm scheme to warn operators of a major loss of SF_6 gas shall be provided in indoor substations. This shall operate at the low pressure alarm setting of each gas zone.

4.23.6.2 Controls shall be provided at the substation control point to reset and isolate the audible alarm. Visual indications shall be provided in the switchhouse to show that the audible alarm is in service. Visual indications shall be provided outside the main entrances to the switchhouse to indicate that the alarm has operated.

4.23.6.3 SF_6 detection and alarms shall be installed in substations where a slow leak may foreseeably result build up of gas e.g. in basement areas.

4.23.7 Location of Light Current Equipment

4.23.7.1 Equipment panels may be located in the switchgear building either adjacent to the switchgear or in an annexe. Such equipment, together with its accommodation, shall meet the requirements of Class IP 54 of IEC 60529.

4.24 Performance Requirements for all Switchgear

4.24.1 Jointing of Current Carrying Conductors

4.24.1.1 Jointing of Current Carrying Conductors shall be undertaken as detailed in section 4.26

4.24.2 Primary Equipment

4.24.2.1 Calculations or tests shall be performed to demonstrate the mechanical capability of terminals for specified loading combinations of the conductor system in which the equipment is to be applied.

4.25 Routine Tests at Site

4.25.1 Current Carrying Conductors

4.25.1.1 Where joints between current carrying conductors are made on site then the joint electrical resistance shall be measured and recorded. The joints covered in this document are all large and their electrical resistance is low. Values can range from as little as 2 μΩ for large busbar connections to a few hundred microhms for small cable connections. As even poorly made joints are likely to have a relatively low resistance, it is important to be able to make accurate measurements of resistance to detect joints that are not satisfactory for service.

4.26 Conductor Jointing in Substations

4.26.1 Introduction to Conductor Jointing

4.26.1.1 Within a substation there are many electrical connections ranging from high current busbar and earthing joints down to small assemblies on electronic circuit boards. This section deals with connections required to carry either primary load current or fault current or both. The associated maximum permitted temperatures under these conditions are 90C and 405C (325C for aluminium). It does not cover equipment contacts, contactors, and sliding/moving contacts for which specific and detailed installation and maintenance instructions exist. The integrity of busbar and earthing connections is essential for the security and safety of the high voltage substation. They are heavily loaded and temperatures at the connection interface are high such that degradation of poorly made and maintained joints is likely.

4.26.1.2 Outdoor connections that operate under all weather conditions require protection to avoid corrosion induced long-term degradation. The aim of this part of the document is to provide guidance on good practice for conductor jointing in substations and it is Informative rather than Normative in nature. It aims to promote a good understanding of how to achieve high quality electrical connection and details typical problems encountered within the jointing process. Particular emphasis is placed on bolted joints for two reasons. Firstly, they can be less secure than joints which rely on fusion of materials e.g. welding and secondly, many bolted joints are disconnected for maintenance or to provide electrical isolation and thereby are at risk of being incorrectly remade.

4.26.2 Jointing Guidelines

4.26.2.1 There is a wide range of jointing methods available but, without exception, their effectiveness relies on trained people working to established procedures. Inadequately trained workers or a disregard of the precise instructions is liable to be unsafe and result in an inadequate connection. Where particular jointing instructions exist, they should be followed, since they will normally have been developed and tested by the manufacturer or supplier.

4.26.3 Preparation of Unplated/Untinned Surfaces of Bolted Joints

4.26.3.1 The removal of oxide films and contamination and the creation of the rough sharp peaks needed for good electrical contact shall be achieved by a combination of brushing using a steel brush and abrasion by using aluminium oxide cloth grade 80. Aluminium surfaces shall be subject to particularly diligent surface preparation.

4.26.3.2 To ensure consistent low resistance joints are achieved a suitable solvent shall be used to clean dirty or greasy surfaces, any burrs around bolt-holes or edges shall be removed, busbar or strip should be flat and any noticeable bowing or distortion should be removed, a fresh strip of aluminium oxide cloth shall be used to abrade the mating surfaces and each surface shall be coated with a thin layer of suitable grease for jointing. Bolted joints that are working in transformer oil should be coated with Petroleum Jelly as other greases may be chemically incompatible.

4.26.3.3 Since certain types of joint combinations can develop instability if operating at continuous high temperature, for these types of joint, a suitable transition interface such as the use of transition washers, shall be used, following the assembly instructions provided by the manufacturer or supplier.

4.26.4 Preparation of Tinned or Plated Surfaces of Bolted Joints

4.26.4.1 Where the surfaces of bolted joints have been tinned or plated, dirty or greasy surfaces shall be cleaned using a suitable solvent, any burrs around bolt-holes or edges shall be removed, busbar or strip shall be confirmed to be flat and any noticeable bowing or distortion shall be removed.

4.26.4.2 Except where nickel plating is used, plated surfaces shall not be prepared unless they appear badly tarnished when a nylon brush shall be used to remove tarnish without scratching the plating.

4.26.4.3 Nickel plated surfaces are likely to have a surface film which can inhibit good contact if the contact pressure is low and this surface should be lightly and carefully abraded with a fine oxide paper.

4.26.4.4 Each surface to be jointed shall be coated with a thin layer of a suitable grease for jointing. Bolted joints that are working in transformer oil should be coated with Petroleum Jelly as other greases may be chemically incompatible.

4.26.5 Assembly of Bolted Joints

4.26.5.1 After ensuring that nuts run freely on the bolts or studs, joints shall be assembled as soon as possible after the surfaces have been prepared to minimise oxide growth and contamination of the surfaces.

4.26.5.2 Before tightening, a check must be undertaken to ensure the correct sized washers have been placed under the bolt head and nut. Tightening shall be undertaken using a torque wrench set for the size and grade of bolt material.

4.26.5.3 If the electrical connections allow, the resistance of the joint shall be measured and checked against the resistance of the same length of un-jointed bar to ensure that the resistance of the joint is less than the resistance of the same length of un-jointed bar.

4.26.5.4 Outdoor joints shall be protected against corrosion by smearing a liberal amount of suitable grease around the joint edges of similar metal joints. If the metals are dissimilar e.g. aluminium bolted to copper, the whole area of overlap shall be protected with anticorrosion tape or a preinstalled heat shrink sleeve packed with a suitable grease. For complex shapes, mastic may be used. Copper to aluminium connections shall not be installed with the copper above the aluminium as copper salts can drain down and cause electrolytic action.

4.26.6 Service Performance of Bolted Joints

4.26.6.1 Bolted joints prepared and assembled in accordance with the above recommendations should give a long and trouble-free life making continuous monitoring unnecessary. However, joints which carry high continuous or cyclic currents or which experience mechanical disturbance, vibration or shock may be susceptible to some degradation and a consequent increase in electrical resistance. Overheating may result. Measurement of joint temperatures using an infrared camera or measurement of joint resistance can be used to ascertain the condition of current carrying joints. A joint resistance greater than the resistance of the same length of unjointed conductor is a cause for further investigation and, if possible, a comparison should be made with the resistance of similar joints and with commissioned resistance values.

4.26.7 Gas Shielded Electric Arc Welded Joints (MIG – TIG)

4.26.7.1 Welding of copper, aluminium and steel can produce efficient and compact joints and is useful for jointing tubular conductors and conductors of different cross-sections. Effective jointing relies on correct procedures being followed and appropriate training. Where this technique is employed, particular attention must be paid to the effective tenting of the work area to ensure a relatively draught free environment to prevent the gas shield being broken and the resultant risk of porous or oxidised welds. Measurement of the resistance of completed joints is unnecessary since the electrical contact area is relatively large but sample testing of completed joints should be undertaken in accordance with BS EN 1320:1997.

4.26.8 Fusion Electric Arc Welding, Gas Brazing and High Temperature Soldering

4.26.8.1 These techniques may be used to join copper, aluminium and certain other materials. Since during fillet or lap jointing of aluminium the fluoride flux used during the jointing process is liable to entrapment between contracting metal surfaces, this technique should be avoided. Similarly, electric arc fusion welding of copper should be avoided as porosity and brittle inter-metallic formations impair the mechanical properties of the joint.

4.26.8.2 Copper/aluminium jointing must be undertaken carefully with the provision of a 0.75-1mm layer of silver brazing alloy to the weld area of the copper as this is metallurgically compatible with both copper and aluminium. Jointing can then be performed by direct fusion welding using conventional aluminium-silicon filler metal.

4.26.8.3 Gas brazing may be used to joint copper to rebar steel or wrought iron. Joint preparation and cleanliness are essential to ensure that the molten filler metal flows over the complete joint area. However, because joint quality is not easy to determine since the electrical resistance will normally be very low a fracture test conducted with dynamic sensible strokes (3 off) applied from a hammer must be used to check that the joint is sound.

4.26.9 Explosive Jointing / Cold Pressure Welding

4.26.9.1 Because of difficulties achieving the required standard of consistency in the on site preparation of the surfaces to be jointed these methods of jointing are not acceptable.

4.26.10 Compression Jointing

4.26.10.1 This method may be used to join solid or circular conductors provided that:

- the dies, compression tools and the ferrules or lugs are from the same manufacturer,
- the conductors are cleaned in accordance with the instructions issued by the manufacturer of the compression fitting,
- the correct number and order of compression bites by the die are used,
- the correct pressure is applied to the die from the hand or hydraulic tool.

4.26.10.2 Where greasing of the conductor is specified in the manufacturer's instructions to enhance stability and inhibit corrosion, this must be undertaken since large compression joints used on down-droppers from an overhead line entry are particularly susceptible to inadequate greasing of the barrel allowing water to drain down into the joint and set up a corrosive cell.

5 Switchgear

5.1 General Technical Requirements

5.1.1.1 Switchgear shall have an anticipated asset life of not less than 40 years and shall comply with all mandatory requirements of IEC 60694. Records shall be kept of all time and duty based maintenance requirements and any refurbishment activity required to achieve the anticipated asset life.

5.1.1.2 Provision shall be made for condition monitoring, diagnostics and site testing. Where these facilities are integral to the switchgear they shall not reduce the integrity of the prime function of the switchgear or that of neighbouring switchgear.

5.1.2 Compressed Gas

5.1.2.1 If compressed gas is used for arc extinction or operation, then abnormal gas system condition lock-out devices shall be fitted and instruments and alarms shall be provided to ensure safe and reliable operation of all compressed gas systems.

5.1.2.2 Alarm facilities shall indicate falling gas density/pressure and operate at a higher level than the low gas density/pressure lockout devices. Remote indication or alarm of density/pressure recharging equipment failure, abnormal gas system conditions and low density/pressure lockout shall be available.

5.1.2.3 Provision shall be made for the connection of equipment for monitoring of the rate of change of gas density/pressure of insulation and interruption systems.

5.1.2.4 The function of the various components of the gas system shall be clearly identified at the switchgear. Different gases or different conditions of the same gas shall be identified by colour on pipework, vessels and diagrams. The colour shall conform to the standard colours for gases in BGV A 8 or BS 1710 . If it is necessary to use white pipework to reduce the effect of radiated heat then clear colour code marking will be applied at regular intervals to indicate the gas contained.

5.1.3 Operating Mechanisms and Enclosures

5.1.3.1 Local control and monitoring equipment shall be accommodated at the switchgear that it controls. Enclosures shall be clearly labelled to indicate the apparatus it contains and the switchgear controlled by that apparatus.

5.1.3.2 Local controls shall be located at ground level (if indoors, at the switchgear access level) and indication of the operational position of the switchgear being controlled shall be unambiguous and clearly visible from that level.

5.1.3.3 Switchgear with power operated mechanisms shall be provided with means of locally initiating closing and opening, and of selecting local/remote control. Three phase switching devices with separate phase mechanisms shall be locally controllable from a single point.

5.1.3.4 The maximum available number of auxiliary switches and the number normally pre-allocated for use within the switchgear itself shall be clearly stated.

5.1.3.5 Auxiliary switches shall be positively driven in both directions.

5.1.3.6 Where anti-condensation heaters are fitted in cubicles of switchgear, they shall be physically and electrically shrouded to protect operators from danger.

5.1.4 Outage Constraints

5.1.4.1 Switchgear design shall ensure that it is possible to safely perform foreseeable maintenance and testing activities including replacement of any enclosure and any necessary dismantling of equipment, circuit breaker timing, primary injection tests on CTs and the construction and testing of substation extensions with the minimum of circuit outages being required.

5.1.4.2 In any event, it shall be possible to perform the maintenance and testing activities specified in 5.1.4.1 without the need to work adjacent to a gas compartment partition that is under pressure on one side.

5.2 Technical Requirements for Gas Insulated Switchgear

5.2.1.1 All gas-insulated switchgear (GIS) shall comply with IEC 62271-203 and all pressurised gas-filled enclosures shall comply with EN 50052, EN 50064 EN 50068, and EN 50069 as appropriate. Cast resin partitions shall comply with standard EN 50089.

5.2.1.2 Fixed gas and hydraulic pipework shall be identified in accordance with BGV A 8 or BS1710.

5.2.1.3 Earthing switches of class E1 as defined in IEC 62271-102 shall be provided on the circuit side of each line isolator and at one position on each section of busbar. Earthing switches installed at positions where the only means of dissipating trapped charge is by closing the earthing switch shall be capable of remote operation.

5.2.1.4 Provision shall be made for fitting portable maintenance earthing devices (PMEDs) where these are required to permit maintenance/testing as follows:

- To allow an earthing switch that would normally be the point of earthing to be maintained.
- To earth cable terminations where disconnecting facilities are provided for cable testing.
- To provide an earth connection where a section of busbar is removed.
- To provide an earth connection visible from the point of work.

5.2.1.5 The positions on the GIS at which PMEDs may be fitted shall be clearly identified and switchgear design shall ensure that PMEDs that have been applied shall be clearly visible.

5.2.2 SF6 Gas Service Connections

5.2.2.1 The gas service connection for each gas compartment shall be readily accessible without the use of special access equipment.

5.2.2.2 A schematic diagram shall be provided showing the gas compartments within a bay and their relationship to the primary plant of that circuit or busbar section.

5.2.2.3 Filling points shall be fitted with self-sealing valves.

5.2.2.4 A lockable arrangement to prevent unauthorised operation of the gas service valves shall be provided at each filling point.

5.2.2.5 A permanently installed system for monitoring the gas pressure or density in each compartment shall be provided. This system shall provide a visual indication of the gas pressure or density in each gas compartment and be capable of detecting a gas loss equivalent to 0.5 % of the gas compartment volume per annum and initiating gas density alarms at user configurable trigger levels, locally and via the substation alarm scheme.

5.2.2.6 It shall be possible to replace a pressure or density sensor without taking the switchgear out of service and to temporarily block the density alarm signals from an individual gas compartment so that grouped alarms are not initiated.

5.2.2.7 Where 'low gas' alarms are grouped, then it shall be possible to identify the section of the substation that requires isolation from the system at the normal substation control point.

5.2.2.8 Where leakage of gas from a higher pressure gas compartment to an adjacent lower pressure gas compartment may result in operation of the pressure relief device of the lower pressure compartment, the lower pressure compartment shall be fitted with a high density alarm.

5.2.2.9 Provision for checking gas monitoring devices shall be achieved in such a way that operation of as much of the alarm circuit as is reasonably practicable be confirmed. Safe access for performing this check shall be provided.

5.2.2.10 Pressure relief devices shall be installed so as to eject debris away from normally accessible areas and they shall be set to minimise danger to personnel.

5.2.2.11 The position of each gas compartment partition shall be clearly identified by fixing clearly visible labels to the enclosure at each gas compartment partition showing the identifier of the gas compartments at each side of that partition.

5.2.2.12 It shall be possible to undertake primary injection tests on all current transformers without internal access to any gas compartment being required.

5.2.3 Partial Discharge Measurement

5.2.3.1 For GIS equipment for use at 220 kV and above, capacitive couplers for diagnostic monitoring of the GIS equipment and transient voltage measurements shall be provided in all phases at the following positions:

- The sealing ends of each cable connected circuit.
- The SF_6 side of each transformer bushing.
- Adjacent to the SF_6/air bushings of each circuit connected to AIS equipment.
- At intervals between these points such that all parts of the GIS shall be between two couplers and that the required sensitivity specified in Clause 5.2.2.5 shall be achieved.

5.2.3.2 To facilitate the use of couplers for in-service monitoring, coupler signal connections shall be cabled so as to be accessible from ground or, if indoors, at switchgear access level. Where located outdoors, test boxes conforming to IP65 of EN 60529 shall be provided.

5.2.3.3 Signal cables between the couplers and test boxes shall be double screened co-axial and signal cables and the connections shall be identified according to the associated coupler and phase. The signal propagation time of each cable shall also be marked. Signal connections shall be N series 50Ω sockets.

5.2.4 Performance Requirements

5.2.4.1 Voltage withstand between the point of isolation for cable testing and any parts of the switchgear that remain connected to the cable termination during the test, shall be:

Nominal Voltage	110kV	220kV	400kV
15 minute withstand test voltage to earth and, where appropriate, between phases in kV	335	465	780

5.2.4.2 GIS circuit breakers and disconnectors shall be able to withstand two fully asynchronous power frequency voltages applied to the opposite terminals of the same pole when in the OPEN position with each voltage equal to the rated phase to earth power frequency voltage when filled with the insulating gas at a pressure of 0 barg.

5.2.4.3 GIS equipment shall be able to withstand 1.5 times the rated phase to earth power frequency voltage between its conducting parts and earth and, where appropriate, between phases for a duration of 1 minute when filled with the insulating gas at a pressure of 0 barg.

5.2.4.4 Enclosures shall be capable of withstanding an internal arc of rated short-time current such that no external effect other than operation of the pressure relief device on small gas compartments shall result for a duration not less than:

Nominal Voltage	110kV	220kV	400kV
Internal arc withstand time (mS)	200	160	140

5.2.4.5 Enclosures shall be capable of withstanding an internal arc of rated short-time current such that the resulting effect shall be limited to operation of the pressure relief device(s) or the appearance of a hole, provided there is no ejection of fragmented parts for a duration not less than:

Nominal Voltage	110kV	220kV	400kV
Internal arc withstand time (mS)	1200	500	300

5.2.4.6 Where GIS trunking falls within the line protection zone an internal fault would normally result in a trip and auto reclose operation. If these requirements cannot be met for the re-application of the fault, a mechanism for inhibiting the auto reclosing in the event of probable gas failure must be provided. On equipment having three phases in a common enclosure, allowance shall be made for the possibility of faults evolving to include two or more phases.

5.2.4.7 Partitions shall withstand the differential pressures to which they may be subjected during preventative or corrective maintenance. Where an adjacent gas compartment contains live high-voltage conductors, a reduction in its gas pressure during maintenance to limit the differential pressure across the gas compartment partition will not be acceptable.

5.2.5 Sulphur Hexafluoride Gas (SF_6)

5.2.5.1 New SF_6 gas shall conform to IEC 60376 and recycled SF_6 gas shall conform to IEC 60480.

5.2.5.2 At the time of commissioning of switchgear containing SF_6 gas, the gas shall have a moisture content of no greater than 25 mg/kg for indoor switchgear or 35 mg/kg for outdoor switchgear.

6 Circuit Breakers

6.1.1.1 **TSMO** specifies its requirements for circuit breakers primarily by reference to IEC 62271-100 and associated documents. This code defines the required enabling parameters and additional technical requirements for circuit breakers connected to **TSMO**'s System and rated at 123 kV (2kA and 2.5kA), 245kV (2.5kA) and 420 kV (2kA). This section of the code defines the performance requirements and testing for circuit breakers connected to **TSMO**'s system. It supports the more general conditions defined in the sections referring to switchgear.

6.2 General Requirements

6.2.1 General Requirements for Circuit breakers

6.2.1.1 All mandatory requirements of IEC 62271-100 and IEC 60694 shall be met for the specified rating.

6.2.1.2 The circuit breaker shall satisfactorily complete all initiated close and open operations.

6.2.1.3 In the event of a failure to latch in the closed position the circuit breaker shall open fully and shall be capable of performing all switching and fault interrupting duties during this opening operation.

6.2.1.4 In the event of opening immediately following a close operation and a continuous close signal being maintained there shall not be repeated attempts to close the circuit breaker.

6.2.1.5 All circuit breakers shall be fitted with a robust and reliable indicating drive system capable at all times of giving a clear and unambiguous representation of the position of the main contacts of the device. The indicating system shall be positively driven in both directions. **TSMO** accept the internationally agreed indication I/O in contrasting colours. Alternatively, indicators inscribed CLOSED in white letters on Signal Red (BS 381C Code 537) background and OPEN in white letters on Grass Green (BS 381C Code 218) background are acceptable.

6.2.1.6 The density of the arc extinguishing and insulating media shall be monitored and discrete low density alarm (or close lockout) and low density lockout levels shall be set. These lockouts shall ensure that operation is prevented if the density is outside its specified design criteria. Provision for local and remote indication of significant reduction in density of arc extinguishing and insulating media shall be provided. This indication shall be at a level in excess of the open (or general) lockout level however it is acceptable for this indication to coincide with a close lockout level. The monitoring system shall be such that any closing operations are only permitted if a subsequent opening operation remains possible. These requirements may be modified where a requirement for forced tripping is identified. Provision shall be made for low density, close lockout and open lockout levels, as appropriate, to be remotely alarmed. Provision shall be made for routine diagnostic monitoring, site testing and condition monitoring. The circuit breaker in its normal operational state (i.e. with all access doors etc closed) shall meet the pollution performance criteria associated with a degree of protection of IP54. All moving parts which are readily accessible during normal operation of the circuit breaker, including from the local operating position, shall have a degree of protection of at least IP2X such that they are adequately guarded to prevent injury. Where isolation facilities are provided between the main volume of any insulating or arc extinguishing media and the associated monitoring equipment this isolation shall fail to safety and it shall not be possible to put the circuit breaker into service with the monitoring isolated.

6.2.1.7 Operating tolerances, including those for simultaneity of poles, shall be as specified in IEC 62271-100 unless separately specified for special purpose applications such as capacitor bank switching, single phase auto-reclose or shunt reactor switching.

6.2.2 General Requirements for Mechanisms and Stored Energy Systems

6.2.2.1 Circuit breakers shall be arranged for three-pole operation by powered mechanism or mechanisms. The rated operating sequence in accordance with IEC 62271-100 shall be O – 0.3s - CO – 3 min - CO.

6.2.2.2 Provision shall be made for local and remote indication that the stored energy system has less than the specified minimum stored energy for a normal operating cycle, close-open (CO). The close lockout shall be initiated. This 'stored energy system incorrect' indication shall not be initiated due to normal operation of the circuit breaker.

6.2.2.3 Provision shall be made for local and remote indication that the stored energy system has less than the specified minimum stored energy for normal opening. The open lockout or, where required, a forced open operation, shall be initiated. This 'stored energy system incorrect' indication shall not be initiated due to normal operation of the circuit breaker.

6.2.2.4 Operating system lockouts shall be arranged such that if it is possible to close the circuit breaker normally then opening is not prevented as a result of the energy consumed during the preceding close operation.

6.2.2.5 In satisfying the above paragraph the maximum tolerance on setting of monitoring devices and an allowance for drift and short time adiabatic change together with either an ambient temperature change of up to 10C or the normal loss of stored energy during a two hour period, whichever has the greater effect, shall be taken into account. Where practical the close lockout setting shall be equal to or less than 85 per cent of the rated working pressure. Where a hydraulic system utilizes a compressed gas for energy storage, the precharge pressure of this gas related to the ambient temperature at the time of precharging shall be sufficient to prevent the initiation of a low gas alarm under normal operating conditions when the ambient temperature falls to the minimum specified in Section 3. Where such systems initiate lockouts following loss of the pre-charge they shall also initiate appropriate alarms indicating the conditions.

6.2.2.6 Changes in ambient temperature of 20C shall not initiate more than two operations of any self contained stored energy replenishment systems as numerous operations under such conditions may mask the presence of genuine energy loss. A replenishment system excessive running time alarm, or equivalent, shall be fitted.

6.2.2.7 The operating level of safety/relief valves fitted to replenishment systems shall be set with sufficient margin above the system replenishment cessation level to accommodate an ambient temperature rise of 10C

6.2.2.8 Facilities shall be provided to permit manual slow closing and slow opening of the interrupter assembly and its drive mechanism. These facilities shall enable the state (open or closed) of a circuit breaker to be changed following isolation from the high voltage system. These facilities must be capable of being secured such that they can only be used for maintenance purposes.

6.2.2.9 Means shall be provided to allow the stored energy system to be charged and discharged when the circuit breaker is either closed or open without causing operation of, or damage to, the circuit breaker. This requirement is waived for springs connected directly to moving contacts, such as opening springs. Loss of stored energy from the mechanism shall not cause the primary contacts to part.

6.2.2.10 Stored energy systems shall not be released due to vibration caused by normal operation or other normal service phenomena.

6.2.2.11 Mechanisms incorporating springs for energy storage shall be provided with an unambiguous indication of spring state (charged or discharged).

6.2.3 General Requirements for Control Schemes and Circuitry

6.2.3.1 If the opening circuit is initiated the closing circuit shall be rendered inoperative.

6.2.3.2 Operating mechanisms shall be provided with local, lockable initiation facilities for closing and opening and for selection of local/remote control. These facilities shall be in the immediate vicinity of the circuit breaker.

6.2.3.3 In the event of a failure to complete a closing operation involving poles having independent drive mechanisms provision shall be made for automatic opening of poles which have closed. Provision for a remote alarm indicating non-simultaneity of poles shall be provided. This requirement shall take account of any intentional non-simultaneity of poles.

6.2.3.4 Indications associated with the various monitoring requirements of this specification shall be provided adjacent to the circuit breaker. These devices shall be capable of being reset at this location. Provision shall be made for initiation of remote monitoring.

6.2.3.5 245 kV and 420 kV circuit breakers shall be provided with two opening releases per operating mechanism. The opening releases shall be arranged for supply from independent battery systems and shall have segregated circuits such that failure of one device in a circuit does not prevent opening of the circuit breaker. **System users** adopting an approach other than the use of independent battery systems must satisfy the requirements of Section 4 with regard to the safety and security of **TSMO**'s System at the point of direct connection.

6.2.3.6 If the dc power supply is removed from either opening circuit of a circuit breaker control scheme the closing circuit or mechanism shall be rendered inoperative.

6.2.3.7 Circuit-breaker opening coils and their associated opening circuits shall be provided with a continuous supervision scheme that is functional regardless of the circuit-breaker positional state (i.e.open or closed). This shall apply to both phase segregated and three phase operated circuit breakers. The system shall be self-monitoring and shall provide an alarm if the supervision system fails. The design of the supervision scheme shall be such that failure does not cause the circuit breaker to operate. As well as the circuit-breaker trip coils the system shall monitor all series connected links, auxiliary switches and other components between the protection trip initiation contacts and the trip coils. It shall be possible to remove a complete tripping circuit from service by use of suitable isolation facilities. Such isolation facilities shall be monitored by the trip circuit supervision scheme and be clearly and concisely labelled.

6.2.3.8 The alarm output of the supervision scheme shall not operate under normal circuit-breaker operation or transient conditions (to overcome this, a delayed alarm output is acceptable). The scheme shall not alarm for a persistent trip initiation signal with the circuit-breaker open.

6.2.3.9 For circuit breakers with independent pole operating mechanisms it is preferred that a single supervision circuit monitors the whole of each opening circuit or circuits where duplicated. The alarm output shall not operate due to normal circuit breaker operations. The system shall be self-monitoring and failure of a single component shall not cause the circuit breaker to operate. The system shall be supplied as part of the circuit breaker control equipment or be available as separate equipment for mounting on or in another control cubicle.

6.2.3.10 Isolation facilities shall be provided for circuit breaker opening coils. These shall be labelled appropriately. These facilities shall be such that the open circuit supervision system shall detect isolation of the opening coils. In addition, the isolation facilities shall be such that they can be secured against unauthorised reinstatement, preferably by a lock and removable key system.

6.2.3.11 Provision shall be made to select the forced opening of a closed circuit breaker in the event of the loss of stored energy to below the limiting conditions of the operating system. Site specific application of such provision shall negate the need of any device required to lock the mechanism closed under such loss of stored energy.

6.2.3.12 Electrical connectors used within the mechanism cabinet of a circuit breaker shall be suitable for the mechanical duty imposed upon them and their integrity shall not be compromised by operation of the mechanism.

6.2.4 Additional General Requirements for Special Purpose Circuit breakers for Capacitor Bank Switching

6.2.4.1 The control circuitry of all circuit breakers intended for capacitor bank switching shall be capable of the addition of an approved controlled closing facility to facilitate minimisation of closing transients when energising an earthed star connected capacitor bank.

6.2.4.2 110kV circuit breakers shall be mechanically suitable for controlled closing with an intentional 1/6th cycle (3.3 ms) delay between poles without compromising their basic performance.

6.2.5 Additional General Requirements for Special Purpose Circuit breakers for Shunt Reactor Switching

6.2.5.1 The control circuitry of all circuit breakers intended for shunt reactor switching shall be capable of the addition of an approved controlled opening facility to facilitate the minimisation of re-ignition transients. The circuit breaker shall be mechanically suitable for independent pole controlled opening without compromising its basic performance.

6.3 Performance Requirements

6.3.1.1 The Supplier shall state the density of the gaseous insulating medium at which the circuit breaker can withstand two fully asynchronous power frequency voltages applied to the opposite terminals of the same pole when in the OPEN position. Each voltage shall be equal to the rated phase to earth power frequency voltage.

6.3.1.2 The Supplier shall also state the density at which the gaseous insulation can withstand 1.5 times the rated phase to earth power frequency voltage between its terminals and earth.

6.3.1.3 Circuit breakers shall give a no-load sound pressure level of not greater than 90 dB (linear) measured at a distance of 25 metres from the centre line of the circuit breaker in the most disadvantageous direction.

6.3.1.4 When switching capacitive currents within declared rating the circuit breaker shall exhibit a very low probability of re-strike as defined by Class C2 of IEC 62271-100.

6.3.1.5 The short-circuit ratings specified apply to both three phase and single phase fault conditions including the relevant arc duration considerations.

6.3.1.6 The maximum short-circuit break time required to comply with Section 6.2 is 50 ms for 420 kV circuit breakers, 60 ms for 245 kV circuit breakers and 70 ms for 123 kV circuit breakers. This break time shall be determined as described in IEC 62271-100 with due regard to the rated voltage of the operating releases.

6.3.1.7 The Supplier shall declare the circuit breaker opening and closing times at the maximum, rated and minimum operating voltage of the opening and closing releases.

6.3.1.8 The maximum Make-Break time shall be 80 ms for 420 kV circuit breaker, 100 ms for 245 kV circuit breakers and 120 ms for 123 kV circuit breakers.

6.3.1.9 The Supplier shall declare the minimum Make-Break time at rated conditions and shall demonstrate the ability of the circuit breaker to perform all switching and fault interrupting duties under these conditions.

6.3.1.10 Operating tolerances, including those for simultaneity of poles, shall be as specified in IEC 62271-100 unless separately specified for special purpose applications such as capacitor bank switching, single phase auto-reclose or shunt reactor switching.

6.3.2 Performance Requirements for Special Purpose Circuit breakers for Capacitor Bank Switching

6.3.2.1 The circuit breaker shall be capable of at least 2000 service operations without maintenance and at least 10,000 mechanical operations prior to major maintenance activities.

6.3.2.2 The short-circuit current rating in accordance with the requirements of this specification shall be 63 kA at 420 kV, 40 kA at 245 kV and 40 kA at 123 kV.

6.3.2.3 The circuit breaker shall be capable of its rated capacitor bank switching duty when unaided by the addition of controlled switching facilities.

6.3.2.4 The circuit breaker shall be capable of operating satisfactorily under abnormal short-circuit conditions which may result from intentional non-simultaneity of the poles.

6.3.2.5 Circuit breakers with mechanically staggered poles shall close satisfactorily when subjected to fully asymmetric fault current in each phase sequentially at 3.3 ms intervals.

6.3.2.6 The controlled switching system shall be capable of controlling the closing operations of the circuit breaker such that the point of current initiation coincides with system voltage zero in each phase with a tolerance of +/-1 ms around the target voltage zero. Where this is not reliably achievable, and subject to **TSMO**'s approval, a wider tolerance of ± 2 ms may be deemed acceptable provided that exceeding the ± 1 ms requirement is a rare event and can be demonstrated to occur in less than 2% of cases.

7 Disconnectors and Earthing Switches

7.1.1.1 Disconnectors and earth switches shall comply with the requirements of IEC 62271-102, EN 60694 and associated documents.

7.1.1.2 Disconnectors rated at 420 kV and 245 kV shall be motor/power operated.

7.1.2 Rated Short-Time Withstand Current

7.1.2.1 If an earth switch is combined with an isolator as a single unit, the rated short-time withstand current of the earth switch shall be at least equal to that of the isolator.

7.1.3 Divided Frame Disconnectors and Earthing Switches

7.1.3.1 Divided frame disconnectors and earth switches shall be capable of operating to the limits of their rated contact zone as detailed in Tables 1 and 2 of IEC 62271-102.

7.1.4 Bus-transfer Duty

7.1.4.1 Disconnectors intended for bus-transfer or mesh-corner switching shall comply with the bus transfer requirements of IEC 62271-102 Annex B. Bus transfer switching contacts fitted to disconnectors which can be operated in service from a manual mechanism, shall be designed so that their operation is independent of the speed of operation of the main contacts. The design of the disconnector shall ensure that the operator is not endangered by arc debris during bus-transfer switching. Disconnectors intended for busbar transfer or mesh-corner switching shall be equipped with auxiliary switches for busbar protection CT secondary switching.

7.1.5 Rated Values of Mechanical Endurance for Disconnectors

7.1.5.1 Disconnectors shall be rated to Class M1 as specified in IEC 62271-102.

7.1.6 Rated Values of Electrical Endurance for Earth Switches

7.1.6.1 Air Insulated Earth Switches shall be rated to Class E0 as specified in IEC 62271-102.

7.2 General Requirements for Disconnectors and Earth Switches

7.2.1 Clearance Distances

7.2.1.1 Phase-to-phase and phase-to-earth clearance distances shall be as specified in Section 4.22.1 unless the disconnector or earth switch has been type tested in accordance with the relevant requirements of IEC 62271-102. This shall apply to all clearance distances when an isolator is in any position, including partially operated and for phase-to-phase clearance distance of earth switches in any position including partially operated.

7.2.2 Simultaneous Operation of Poles

7.2.2.1 The primary contacts of all poles shall operate (open or close) simultaneously, with a maximum spread of 0.5 seconds between first pole contact to open (or close) to the last pole contact to open (or close).

7.2.3 Flexibility of Design and Setting Adjustment Tolerances

7.2.3.1 All disconnectors and earth switches shall be designed and constructed with enough flexibility to cater for both coarse and fine adjustments associated with the dimensional tolerances required to achieve the correct settings under site conditions. The Supplier shall provide adequate instructions to ensure that the installer is aware of any restriction associated with such adjustment. These instructions shall be included in the product operating manual.

7.2.4 Position Indication

7.2.4.1 A clear unambiguous open/closed indication (O/I) label/indicator shall be fitted, identifying the position of the main contacts when the operator is operating the isolator or earth switch. This indication shall be visible following operation with the control cubicle secure. For remotely operated disconnectors and earth switches incomplete operation of the main contacts shall be remotely indicated by a position-indicating device. The position-indicating device shall be a part of the isolator or earth switch that enables a signal to be given, generally at a location remote from the isolator or earth switch. It shall indicate that the contacts of the main circuit are in the closed or open position and that the mechanical movement is complete. This indication shall be repeated at the local control point when primary contacts are not readily visible to a local operator. For GIS disconnectors and earthing switches, a reliable position indicating device (designed in accordance with IEC 62271-102, Annex A) may be provided as an alternative to the visible isolating distance or gap if easily accessible viewing windows are not provided.

7.2.5 Mechanical Key Interlocking

7.2.5.1 Where mechanical key interlocking is fitted to isolator and earth switch mechanisms the following requirements shall apply. Removal of a key shall, by means of an interference device, physically prevent operation of the mechanism. The interference device shall be so constructed that it will prevent operation when a normal operating force is applied by the recommended procedures, whether of power or manual means. On power operated mechanisms with facilities for in-service manual operation the interlocking shall be effective for both power and manual operations. Interlock keys shall be released when the mechanism is in either the fully open or fully closed position or both, as required by the interlocking scheme. The keys shall be trapped when the mechanism is in a partially operated position.

7.2.6 GIS Combined Disconnectors and Earthing Switches

7.2.6.1 Where an isolator and earthing switch is combined within a single unit, the diconnector shall be capable of being opened, immobilised and locked before the earthing switch is closed. It shall not be necessary to unlock the disconnector in order to close the earthing switch.

7.2.7 Drive System Mechanical Interference Device

7.2.7.1 Where no mechanical key interlocking is provided, the drive system shall have a mechanical interference device. This device shall be used to physically prevent operation of the mechanism when in the open or the closed position. The interference device shall be effective when any reasonable operating forces are applied by the recommended means, whether by power or manual operation. For operational and electrical safety reasons facilities shall be provided to lock the interference device in the operated position using a padlock with a 5 mm diameter and 30 mm long hasp. On power operated mechanisms, application of the interference device shall also prevent initiation of the power operation, unless it can be demonstrated no damage will occur as a consequence of the mechanism being stalled.

7.2.8 'Lockout' Interlock Keys

7.2.8.1 Lockout interlock keys shall be provided on all 420 kV, 245 kV and 123 kV disconnectors. These keys shall only be released when the isolator is open. Lockout interlock keys shall be provided on all 420 kV and 245 kV earth switches and shall only be released when the earth switch is closed. Lockout keys shall be distinctively labelled and shall be unique to other keys in use on the substation site. The key shall also be unique from the other keys associated with the mechanism.

7.2.9 Earthing Switch Magnetic Bolt Device

7.2.9.1 Earth switches provided with a manual push button to release an electrical magnetic bolt device within the mechanism shall employ a time delayed magnetic bolt release.

7.2.10 Operations Counter

7.2.10.1 An operations counter shall be fitted to isolator drive systems to record the total number of operating cycles (close-open) performed.

7.2.11 Construction Materials and Protective Coatings

7.2.11.1 The materials used in the construction of disconnectors and earth switches shall be demonstrated to be satisfactory for the environmental exposure detailed in the normal, special service and pollution conditions of section 3.

7.3 Operating Mechanisms, Ancillary Equipment and their Enclosures

7.3.1 'Sealing In' of Control Circuits

7.3.1.1 To ensure that, on reinstatement following failure of a motor operating supply when an open or close instruction has been initiated but not completed, disconnectors or earth switches do not unexpectedly operate without a check being undertaken on the interlock conditions then present, when an open or close operation is initiated, the mechanism control scheme shall be designed such that the open (or close) control circuit is not 'sealed in' to hold the supply voltage on to the drive motor for the duration of the disconnector or earth switch travel, if the motor supply voltage is not available to operate the disconnector or earth switch.

7.3.2 Drive Limit Switch

7.3.2.1 Power operated mechanisms shall be designed so that failures of the mechanism limit switches will not result in damage to the mechanism, drive linkages (with the exception of shear pins or mechanical protective devices) or the primary current path.

7.3.3 Control Switches

7.3.3.1 Local/Hand/Remote Close control switch shall be provided with a facility for locking in each position. The Open/Neutral/Close control switch shall be provided with a facility for locking in the Neutral position.

7.3.4 Auxiliary Switches

7.3.4.1 Auxiliary switches shall comply with IEC 62271-102. Auxiliary switches for disconnectors and earth switches are required to have a variety of different timings and senses with respect to the primary contacts. The number of each type will be specified on a site-specific basis.

8 Substation Interlocking Schemes

8.1 General Requirements

8.1.1.1 To ensure that operators do not compromise the integrity of the **Transmission** System by incorrect or inadvertent operation of equipment. substations shall be provided with a full interlocking scheme to ensure that all disconnectors, fixed earthing switches (or other interlocked earthing devices) and where required circuit-breakers, are operated in the correct sequence. In substations where **TSMO** is a joint occupier and/or has operational responsibility for switchgear then the interlocking shall also be designed with consideration for safety of personnel.

8.1.1.2 Interlocking schemes shall cover the following conditions:

- Interlocking between circuit breakers and disconnectors to ensure disconnectors do not make or break load currents.
- Interlocking between disconnectors and earthing switches to ensure that earthing switches cannot be closed on to a locally **energized** circuit and cannot be **energized**, when closed, by operation of disconnectors.
- Interlocking between disconnectors and adjacent earthing switches to permit operation of the disconnector when earthing switches are closed on both sides of the disconnector. Such interlocking is not required for equipment rated at 123 kV and below.
- To ensure correct sequence of on load busbar transfer switching operations at multiple busbar substations.

- To ensure that a bus-coupler or bus-section circuit breaker is only closed with its associated disconnectors both open or both closed.

- For equipment at **TSMO** operated sites, to restrict access to areas of the substation where safety clearances may be infringed unless appropriate safety measures, such as isolation and earthing, have been taken.

8.1.1.3 The interlocking of switching sequences involving only power operated switchgear shall be by electrical means. The correct interlocking status shall be confirmed automatically on initiation of an operation from any control position or from auto-switching or sequential isolation equipment.

8.1.1.4 The interlocking of switching sequences involving manually operated switchgear may be by electrical or mechanical means. The interlocking shall be designed such that the correct interlocking status must be confirmed immediately before an operation.

8.1.1.5 Interlocking systems shall, where reasonably practicable, be fail-safe. They shall not be defeated without the use of tools, clip leads etc or a purpose designed override facility.

8.1.1.6 Interlock override facilities shall be lockable with a unique lock or shall be lockable by means of a safety padlock.

8.1.1.7 Partial interlocking of earthing switches at circuit-entries to the substation is acceptable where it is not reasonably practicable to extend the interlocking to the remote end disconnectors. Any partially interlocked earthing switch shall be provided with a warning label stating 'WARNING, THIS EARTHING SWITCH IS NOT FULLY INTERLOCKED' in Albanian, English and Serbian.

8.1.1.8 Interlocking shall be effective for switching and operating sequences when they are being followed in either direction (for example; if an earthing switch must be closed before an access gate can be opened then the gate must be secured closed before the earthing switch can be opened).

8.1.1.9 Interlocking schemes shall, where reasonably practicable, provide the maximum operational flexibility and shall not unnecessarily impose fixed operating sequences.

8.1.1.10 Where an interlocking scheme is being supplied for an extension to an existing substation at the same operating voltage then, unless otherwise agreed by **TSMO**, the interlocking philosophy shall match that existing.

8.1.1.11 Interlocking for a substation extension shall be fully interfaced with the existing interlocking scheme to achieve the functional requirements specified in this document.

8.1.2 Mechanical Interlocking

8.1.2.1 Mechanical interlocking shall be by key operated systems.

8.1.2.2 Interlock keys shall be of a non-masterable design (ie no master key can be supplied or manufactured). Keys shall not be interchangeable with any other key on the same substation site.

8.1.2.3 Interlock keys shall be engraved with an identifying reference which shall be unique to that substation site. The identifier shall, where appropriate, include the system number of the switching device where the key is located during normal operation. Key locations shall be marked with the identifier of the required key.

8.1.2.4 Where key exchange boxes are provided they shall be located in convenient positions with regard to normal substation operating sequences.

8.1.2.5 Where mechanical key interlocking is fitted to disconnector and earthing switch mechanisms the requirements specified in sections 8.1.1.5 to 8.1.1.11shall apply.

8.2 Performance Requirements

8.2.1.1 Mechanical and hard-wired electrical interlocking schemes shall operate satisfactorily under the full range of environmental conditions specified for the associated primary equipment.

9 Solid Core Post Insulators for Substations

9.1.1.1 Post insulators shall satisfy the requirements in IEC 60273.

9.2 Type Tests

9.2.1.1 Type tests shall be as required IEC 60168. Where the purchaser is presented with test options within IEC 60168, the following apply:

- Dry Lightning-Impulse Withstand Voltage Test - either test method described in IEC 60168 is acceptable.

- Dry Or Wet Switching-Impulse Withstand Voltage Test - either test method described in IEC 60168 is acceptable.

- Mechanical Failing Load Tests - in addition to the bending test, the tensile and torsion tests shall be performed during type testing as described in IEC 60168.

- Test for Deflection Under Load - this test shall be performed during type tests to establish the top flange deflection obtained as a result of applying 70% of the specified mechanical failing load.

9.2.1.2 A radio interference test shall be performed as described in IEC 60168 and IEC 60437.

9.2.2 Routine Testing

9.2.2.1 Routine tests shall be as required in IEC 60168.

10 Bushings

10.1 General Requirements

10.1.1.1 Bushings shall comply with IEC 60137 and the requirements of this code.

10.1.1.2 Bushings with capacitance grading shall be provided with a test terminal (test tap) as defined in IEC 60137.

10.1.1.3 For bushings containing oil, an indicator to check the correct amount of oil is in the equipment should be provided (generally a sight glass). All oil-filled equipment shall be fitted with an oil sample valve, situated on the earth flange, suitable for taking oil samples for Dissolved Gas Analysis (DGA) in accordance with IEC 567. Valves where the oil is extracted by using a hypodermic needle are not acceptable.

10.1.1.4 For oil impregnated paper bushings, the bushing design shall have sufficient oil capacity to allow 1 litre of oil to be extracted over the lifetime of the bushing for dissolved gas analysis purposes. Alternatively the supplier shall provide instructions on how to replenish the bushing with oil.

10.2 Performance Requirements

10.2.1.1 Bushings shall comply with the performance requirements of IEC 60137 according to the relevant rating requirements detailed in this code and site specific specification.

10.3 Type Test Requirements

10.3.1.1 Bushings shall be type tested to IEC 60137.

10.3.1.2 During the Temperature Rise Test the thermal time constant shall be determined on raising and lowering the temperature.

10.3.1.3 An oil sample for DGA shall be taken from all oil filled bushings, before and after the dielectric type tests. There shall be no change in the dissolved gas levels before and after type tests.

10.3.1.4 Capacitively graded bushings for all switchgear applications shall have chopped impulse tests similar to those specified for transformer bushings in IEC 60137. The bushings shall be subjected to five impulses of negative polarity, chopping of the impulse being made by means of an air insulated gap. The peak voltage level shall be 100% of the rated BIL. The time to sparkover of the chopping gap shall be between 1 µs and 6 µs.

10.3.1.5 Capacitively graded bushings for gas insulated switchgear shall also be subjected to 30 impulses of both positive and negative polarities with a chopping gap immersed in SF6 and located adjacent to the SF6 end of the bushing. The peak voltage level shall be 60% of the rated BIL. The time to sparkover of the chopping gap shall be between 1 µs and 6 µs.

10.3.1.6 Routine tests shall be performed before and after all type tests.

10.4 Routine Test Requirements

10.4.1.1 All bushings shall be routine tested to IEC 60137.

10.4.1.2 An oil sample for DGA shall be taken not less than 24 hours after the final routine electrical testing has been performed. The results shall be included in the routine test report.

10.4.1.3 Routine test reports shall include details of all routine measurements made in accordance with this specification. For partial discharge (PD) tests, the values of measured PD at the specified partial discharge test voltage shall be recorded together with PD extinction voltages (as the voltage level at which measurable PD is extinguished upon decreasing test voltage). The background PD level at the time of the test should also be recorded in the report.

11 Surge Arresters

11.1 General requirements for all Surge Arresters

11.1.1.1 All surge arresters connected between phase and earth on the 400kV, 220kV and 110kV **transmission system** operated by KOSST shall comply with the requirements of IEC 60099-4 and this code.

11.1.1.2 Surge arresters shall be designed so that throughout its design life it will operate without failure, operation of the pressure relief device or change exceeding 5% to the protective levels declared by the manufacturer under short circuit conditions.

11.1.1.3 Unless otherwise specified surge arresters shall be suitable for upright or inverted mounting.

11.1.1.4 All surge arresters having a separated housing shall be provided with a pressure relief device to ensure that a surge arrester failure cannot rupture or cause explosive shattering of the housing when the power arc is established inside the housing for all conditions within the declared rating of the arrester.

11.1.1.5 A surge counter shall be supplied together with a permanent leakage current indicator or provision for external leakage current measurement that can be readable or accessible at ground level with the surge arrester in service. The surge counter shall be connected to the base of the surge arrester and the substation main earth system in such a manner that the total current through the surge arrester passes through the counter. The earth connection shall remain electrically continuous after being subject to the short circuit current and duration specified in section 3.2.

11.1.2 Air Insulated Surge Arresters

11.1.2.1 The surge arrester shall be designed to remain intact and serviceable after being subjected to the relevant short term current and duration specified in section 3.2.

11.1.2.2 The radio noise emitted by all connections shall not exceed the relevant values defined by IEC 60694.

11.1.2.3 The arrester manufacturer shall specify the high voltage connection from the busbar to the arrester. Suitable terminals and fittings shall be provided at the line side of the surge arrester.

11.1.3 Gas Insulated Surge Arresters

11.1.3.1 The suuplier will demonstrate to the satisfaction of **TSMO** that the metal enclosure will prevent leakage of SF6 to atmosphere over the lifetime of the unit. Where it is intended that the arrester should be mounted outdoors, this evidence must demonstrate that the enclosure seals will withstand the weathering effects of the environment described in section 3.3.3 during the lifetime of the arrester.

11.2 Functional and Performance Requirements

11.2.1.1 Surge arresters and their associated equipment shall comply with the general performance requirements in IEC 60099-4 and the following specific requirements:

	Specific Requirements at System Nominal Voltage			
Characteristics	**400 kV**	**220 kV**	**110 kV**	**10 kV**
Minimum surge arrester Maximum Operating Voltage	253 kV_{rms}	153 kV_{rms}	84 kV_{rms}	12 kV_{rms}
Minimum Surge Arrester Rated Voltage	312 kV_{rms}	192 kV_{rms}	102 kV_{rms}	15 kV_{rms}
Minimum Nominal Discharge Current	10 kA	10 kA	10 kA	10 kA
Minimum Line Discharge Class	3	3	3	
Minimum Lightning Impulse (10 kA_{peak}) Withstand Level	1200 kV_{peak}	745kV_{peak}	400 kV_{peak}	125 kV_{peak}
Maximum Lightning Impulse Residual Voltage	769 kV_{peak}	447 kV_{peak}	225 kV_{peak}	58 kV_{peak}
Minimum Switching Impulse Withstand Level	810 kV_{peak}	500 kV_{peak}	280 kV_{peak}	65 kV_{peak}
Maximum Switching Impulse Residual Voltage	650 kV_{peak}	402 kV_{peak}	216 kV_{peak}	42 kV_{peak}
Maximum Steep Current Impulse (10 kA_{peak}) Residual Voltage	860 kV_{peak}	508 kV_{peak}	286 kV_{peak}	65 kV_{peak}
Minimum Cantilever Strength	2 kN	2 kN	2 kN	2 kN

	Specific Requirements at System Nominal Voltage			
Characteristics	**400 kV**	**220 kV**	**110 kV**	**10 kV**
Maximum Radio Interference	250 µV	200 µV	125 µV	

11.3 Type Tests

11.3.1.1 All types of surge arrester shall be subject to type tests as specified in IEC 60099-4.

11.3.1.2 The supplier is required to demonstrate that:

- Satisfactory voltage grading is attained across all zinc oxide blocks.
- The thermal model of the arrester section used for the operating duty tests is representative of the most highly stressed parts of the arrester.
- All other tests including accelerated ageing tests are carried out with the blocks under physical conditions identical to those encountered in service.

11.3.1.3 The manufacturer shall supply details of the test method used for radio interference and partial discharge tests. Where they have not previously been performed, the details of the test method are to be declared prior to carrying out the type and routine test.

11.3.1.4 The supplier shall propose test methods, or submit evidence to demonstrate that the operation counter and associated monitoring equipment (eg current indicator) can withstand the relevant short time current and duration as specified in section 3.2.

11.4 Routine Tests

11.4.1.1 All types of surge arrester shall be subject to routine tests as specified in IEC 60099-4.

11.4.1.2 Test methods and descriptions of the routine tests showing the programme by which electrical and mechanical characteristics of the arrester, seal integrity, shock/vibration withstand etc, will be demonstrated following assembly, shall be declared by the manufacturer and agreed with **TSMO**.

11.4.1.3 Routine tests to demonstrate seal integrity and correct operation of the surge arrester operation counter/current indicator functions are required.

11.5 Commissioning Tests

11.5.1.1 In addition to the IEC 60099-4 specification, the supplier shall specify any commissioning tests that are recommended to ensure the satisfactory functioning of the equipment throughout the design life.

11.5.1.2 The supplier may witness these tests and will be required to confirm that equipment guarantees have not been invalidated.

11.6 Condition Monitoring and Maintenance

11.6.1.1 The supplier shall advise of any general maintenance procedures and monitoring techniques that should be applied during service throughout the design life of the surge arrester.

12 Measurement Transformers

12.1.1.1 All measurement transformers shall comply with the relevant sections of IEC 60044, IEC 60186, the requirements of this code and, where applicable, with the requirements of the **metering code**.

12.1.1.2 A single secondary terminal box shall be mounted on the measurement transformer to accommodate the necessary secondary terminal connections, alarm equipment, links and fuses or MCBs. Secondary terminals and connections shall be suitable for their required purpose regarding rating, reliability and the effects of environmental conditions and corrosion. Secondary terminal boxes shall comply with, as a minimum, the IP54 environment of IEC 60529.

12.1.1.3 Where measurement transformers are used for metering purposes, it must be possible to for the security requirements of the **metering code** to be met with respect to all terminals, links, fuses and MCBs and cabling that provide measurement quantities to metering equipment.

12.1.1.4 For all oil filled measurement transformers the supplier shall declare the type of insulating oil being used. For oil-filled equipment fitted with an external oil expansion system, means shall be provided to give a permanent visual indication of the volume of the oil. The status of the indicator should be visible from ground level.

12.1.1.5 For oil filled measurement transformers where the oil expansion system is wholly internal (gas cushion or flexible diaphragm), the transformer shall be fitted with a permanent internal pressure indicator. The status of the indicator shall be visible from ground level.

12.1.1.6 All oil filled equipment shall be fitted with an oil sample valve, situated at its base, suitable for taking oil samples for Dissolved Gas Analysis (DGA) in accordance with IEC 567. The sample valve shall be situated on the earthed base tank of the measurement transformer. Valves where the oil is extracted by using a hypodermic needle are not suitable.

12.1.1.7 On all post type measurement transformers an insulation test terminal (test tap) shall be provided for the purpose of performing capacitance and dielectric loss (tan δ) measurements of the primary insulation during routine maintenance. The test terminals shall be suitably identified.

12.2 Current Transformers

Secondary ratings and transformation ratios shall be selected from the following table and shall be specified in the invitation to tender document:

Rated Voltage and Current of Switchgear	CT Purpose	Turns Ratio	Rating and Class
420kV 2kA	Metering	1000/500/1	15 VA Class 0.2 FS 10
	Metering	1000/500/1	15 VA Class 0.2 FS 10
	Protection	1600/800/1	30 VA 5P20
	Protection	1600/800/1	10 VA 5P20
245kV 2.5kA	Metering	800/400/1	15 VA Class 0.2 FS 10
	Metering	800/400/1	15 VA Class 0.2 FS 10
	Protection	800/400/1	30 VA 5P20

Rated Voltage and Current of Switchgear	CT Purpose	Turns Ratio	Rating and Class
	Protection	800/400/1	30 VA 5P20
123kV 2.5kA Bus coupler circuits	Metering	800/400/1	15 VA Class 0.2 FS 10
	Metering	800/400/1	15 VA Class 0.2 FS 10
	Protection	800/400/1	30 VA 5P20
	Protection	800/400/1	30 VA 5P20
123kV 2.5kA Feeder circuits	Metering	600/300/1	15 VA Class 0.2 FS 10
	Metering	600/300/1	15 VA Class 0.2 FS 10
	Protection	600/300/1	30 VA 5P20
	Protection	600/300/1	30 VA 5P20
123kV 2.5kA Transformer circuits	Metering	400/200/1	15 VA Class 0.2 FS 10
	Metering	400/200/1	15 VA Class 0.2 FS 10
	Protection	400/200/1	30 VA 5P20
	Protection	400/200/1	30 VA 5P20
123kV 2kA Bus coupler circuits	Metering	800/400/1	15 VA Class 0.2 FS 10
	Metering	800/400/1	15 VA Class 0.2 FS 10
	Protection	800/400/1	30 VA 5P20
	Protection	800/400/1	30 VA 5P20
123kV 2kA feeder circuits – type 1	Metering	400/200/1	15 VA Class 0.2 FS 10
	Metering	400/200/1	15 VA Class 0.2 FS 10
	Protection	400/200/1	30 VA 5P20
	Protection	400/200/1	30 VA 5P20

Rated Voltage and Current of Switchgear	CT Purpose	Turns Ratio	Rating and Class
123kV 2.5kA feeder circuits – type 2	Metering	200/100/1	15 VA Class 0.2 FS 10
	Metering	200/100/1	15 VA Class 0.2 FS 10
	Protection	200/100/1	30 VA 5P20
	Protection	200/100/1	30 VA 5P20

12.2.1.1 Primary and secondary terminal markings, and rating plate markings shall be in accordance with IEC 60044-1 The rated continuous primary current of the current transformer shall be chosen to exceed the maximum continuous rating of the associated circuit and shall be selected from the standard values detailed in IEC 60044-1. A thermal short-time current rating (Ith) shall be assigned to all current transformers in accordance with IEC 60044-1. The value of Ith shall not be less than the corresponding value for the associated switchgear or transformer primary plant.

12.2.1.2 Current transformer secondary terminals should allow the application of shorting/earthing links or wiring for maintenance purposes. Separately, a terminal for earthing purposes shall be provided within the terminal box and shall be clearly marked.

12.2.1.3 Both ends of the CT secondary windings shall be earth free.

12.2.1.4 Current Transformers for GIS Application may be mounted internally or externally to the GIS enclosure. Adequate protection against adverse environmental conditions shall be provided for externally mounted CTs.

12.2.1.5 Ring-Type Current Transformers supplied as loose equipment for power transformer application shall be equipped with secondary terminals or shall be supplied with leads of suitable length for this application. Such leads shall be capable of withstanding a power frequency test voltage of 5 kV (peak).

12.2.1.6 Current transformers supplied with through-wall bushings can be mounted internally or externally to the bushing. Current transformers mounted internally shall be capable of operating within that environment. Current transformers mounted externally shall be suitably protected against the effects of adverse environmental conditions.

12.2.1.7 Current transformers supplied as loose equipment for other switchgear applications shall be capable of operating within that environment. Current transformers for other switchgear applications, mounted externally, shall be suitably protected against the effects of adverse environmental conditions.

12.2.2 Type Tests

12.2.2.1 All current transformers shall be type tested in accordance with IEC 60044-1 (type tests) and IEC 60044-1 (special tests).

12.2.2.2 Radio interference voltage tests to IEC 60694 are to be performed on open-terminal current transformers.

12.2.2.3 A multi chopped impulse test shall be performed on all oil filled current transformers rated 123 kV and above.

12.2.2.4 Temperature Rise - The thermal time constant of all equipment shall be determined on both rising and falling temperature.

12.2.2.5 For oil filled equipment oil samples for DGA shall be taken before and after the dielectric type tests and shall comply with 12.2.4.

12.2.2.6 Accuracy at Short-Term Continuous Current Levels - Current transformers which have a measurement specification shall have their errors determined at a current of 12000 A for 420 kV rating and 7500 A for 245 kV rating respectively. These currents shall be withstood for a period of 3 minutes.

12.2.2.7 Routine tests shall be performed before and after all type tests.

12.2.3 Routine Tests

12.2.3.1 All current transformers shall be routine tested in accordance with IEC 60044-1 (routine tests) and (special tests).

12.2.3.2 Additional Routine Tests shall be performed in a laboratory having traceability to National/International standards. The overall accuracy and uncertainty of the measurement shall be demonstrated prior to testing and shall be commensurate with the accuracy class of the transformer under test:

- Full accuracy routine tests to IEC 60044-1.
- Capacitance and dielectric loss angle (tan δ) measurements of the primary insulation over the voltage range 10 kV to rated voltage shall be performed.
- An oil sample for DGA shall be taken as described in 12.2.4 from all oil filled CTs. The sample shall be taken at least 24 hours after the final routine electrical testing has been performed. The results shall be included in the routine test report as detailed in section 12.2.4.

12.2.4 Routine Test Reports

12.2.4.1 Routine test reports shall include details of all routine measurements made in accordance with this specification. The information regarding the overall accuracy and uncertainty of the accuracy measurements shall also be recorded.

12.2.4.2 During the partial discharge (PD) test, the value of measured PD at the specified test voltage shall be recorded together with the value of the PD extinction voltage. Extinction voltage is defined as the voltage level at which measurable PD is completely extinguished upon decreasing test voltage. The background PD level at the time of the test should also be recorded in the report.

12.2.4.3 Where oil samples are taken for Dissolved Gas Analysis (DGA) the report shall contain the following information:

- Name and Address of the laboratory where the analysis was performed
- The Accuracy, Precision and Detection Limits for the individual gas measurement expressed in either parts per million (ppm) or percentage by volume.
- The Sampling Procedure (stating the Standard Method IEC 567 if applicable).
- The Gas Extraction Method used (stating the Standard Method IEC 567 if applicable).
- Calibration Procedure adopted by the laboratory, including details of the number of points used over the range and the gases used.
- Accreditation Status of the laboratory for the purposes of DGA testing.
- Date Sampled and Analysed.
- Report the following:

Measurement	Units	Number of Decimal Places
Oil Volume Tested	ml	0
Total Gas Content	%	2
Hydrogen	ppm	0

Measurement	Units	Number of Decimal Places
Methane	ppm	0
Ethane	ppm	0
Ethylene	ppm	0
Acetylene	ppm	0
Carbon Monoxide	ppm	0
Carbon Dioxide	ppm	0
Oxygen	ppm	0
Nitrogen	ppm	0
Moisture	mg/l	0

12.2.4.4 For DGA samples associated with Type Tests, the acetylene value shall be quoted to one decimal place

12.3 Voltage Transformers

12.3.1.1 Both ends of all secondary windings shall be brought out to the terminal box to permit connection to links, fuses or MCBs external to the transformer. Terminals that it is intended will be earthed will be provided with links in this terminal box for this purpose.

12.3.1.2 If required in the specification, Capacitor VTs to IEC 60186 and rated at 245kV or 420kV shall permit the use of power line carrier.

12.3.1.3 Resin Impregnated Post Type Voltage Transformers shall be provided with an effective and supervised means for protecting the primary winding. Where fuses are used, their condition shall be continuously monitored.

12.3.2 Performance Requirements of VTs

12.3.2.1 Voltage Transformers for protection and general use shall meet the following requirements:

Voltage Rating	Accuracy Class	Rated Burden (VA)	Rated Voltage Factor (pu)	Transformation Ratio
420	0.5/3P	50	1.5, 30 Secs	400kV/√ 3: 100V/√ 3
245	0.5/3P	50	1.5, 30 Secs	220kV/√ 3: 100V/√ 3
123	0.5/3P	50	1.5, 30 Secs	110kV/√ 3: 100V/√ 3
38	0.5/3P	50	1.9, 30 Secs	35kV/√ 3: 100V/√ 3
11	0.5/3P	50	1.9, 30 Secs	10kV/√ 3: 100/√ 3
7	0.5/3P	50	1.9, 30 Secs	6.3kV/√ 3: 100V/√ 3

12.3.2.2 Voltage Transformers for settlement metering purposes shall meet the following requirements:

Voltage Rating	Accuracy Class		Rated Burden (VA)	Rated Voltage Factor (pu)	Transformation Ratio
	Network inter-connections + generation ≥ 100MW	Generation < 100MW and Customers ≥ 10MW			
420	0.2	0.5	50	1.5, 30 Secs	400kV/√ 3: 100V/√ 3
245	0.2	0.5	50	1.5, 30 Secs	220kV/√ 3: 100V/√ 3
123	0.2	0.5	50	1.5, 30 Secs	110kV/√ 3: 100V/√ 3
38	0.2		50	1.9, 30 Secs	35kV/√ 3: 100V/√ 3
11	0.2		50	1.9, 30 Secs	10kV/√ 3: 100/√ 3
7	0.2		50	1.9, 30 Secs	6.3kV/√ 3: 100/√ 3

12.3.3 Type Tests

12.3.3.1 All oil filled voltage transformers shall be type tested in accordance with the appropriate sections of IEC 60044 - type tests and special tests.

12.3.3.2 All capacitive voltage transformers shall be tested in accordance with IEC 60186 and IEC 60358 as appropriate – type tests + special tests).

12.3.3.3 Radio interference voltage tests to IEC 60694 are to be performed on open-terminal voltage transformers.

12.3.3.4 All oil filled voltage transformers rated at 123 kV and above shall be subject to a 600 chopped negative polarity impulse test at 60% of the BIL for that equipment. The time to chop shall be between 2 and 5 µS. A full set of electrical tests shall be undertaken before and after this test. Oil samples shall be taken for dissolved gas analysis both before and three days after the test. This includes taking oil samples from capacitive voltage transformers.

12.3.3.5 For the transformer to pass this test, three criteria must all be met:

- The results of the electrical tests before and after the impulse test must be the same within the error specification of the test field.
- No degradation is found on dismantling the transformer after test
- Any increase in the dissolved gas analysis is within the following limits:

Dissolved Gas		**Allowable Increase after three days (ppm)**
Hydrogen	H_2	5
Methane	CH_4	3
Ethane	C_2H_6	3
Ethylene	C_2H_4	2
Acetylene	C_2H_2	Nil

12.3.3.6 For all oil filled voltage transformers (excluding capacitive units) dissolved gas analysis shall be undertaken before and after the specified dielectric type tests.

12.3.3.7 Routine tests shall be performed before and after all type tests.

12.3.4 Routine Tests

12.3.4.1 All voltage transformers shall be routine tested in accordance with IEC 60044 (routine tests) and (special tests).

12.3.4.2 Routine Accuracy Tests shall be performed in a laboratory having traceability to National/International standards. The overall accuracy and uncertainty of the measurement shall be demonstrated prior to testing and shall be commensurate with the accuracy class of the transformer under test.

- Full accuracy routine tests to IEC 60044-2.
- Capacitance and dielectric loss angle (tan δ) measurements of the primary insulation over the voltage range 10 kV to rated voltage shall be performed.
- In the case of inductive VTs, an oil sample for DGA shall be taken as described in 12.3.5 from all oil filled VTs. The sample shall be taken at least 24 hours after the final routine electrical testing has been performed. The results shall be included in the routine test report as detailed in section 12.3.5.

12.3.5 Routine Test Reports

12.3.5.1 Routine test reports shall include details of all routine measurements made in accordance with this specification. The information regarding the overall accuracy and uncertainty of the accuracy measurements shall also be recorded.

12.3.5.2 During the partial discharge (PD) test, the value of measured PD at the specified test voltage shall be recorded together with the value of the PD extinction voltage. Extinction voltage is defined as the voltage level at which measurable PD is completely extinguished upon decreasing test voltage. The background PD level at the time of the test should also be recorded in the report.

12.3.5.3 Where oil samples are taken for Dissolved Gas Analysis (DGA) the report shall contain the following information:

- Name and Address of the laboratory where the analysis was performed
- The Accuracy, Precision and Detection Limits for the individual gas measurement expressed in either parts per million (ppm) or percentage by volume.
- The Sampling Procedure (stating the Standard Method IEC 567 if applicable).
- The Gas Extraction Method used (stating the Standard Method IEC 567 if applicable).

- Calibration Procedure adopted by the laboratory, including details of the number of points used over the range and the gases used.
- Accreditation Status of the laboratory for the purposes of DGA testing.
- Date Sampled and Analysed.
- Report the following:

Measurement	Units	Number of Decimal Places
Oil Volume Tested	ml	0
Total Gas Content	%	2
Hydrogen	ppm	0
Methane	ppm	0
Ethane	ppm	0
Ethylene	ppm	0
Acetylene	ppm	0
Carbon Monoxide	ppm	0
Carbon Dioxide	ppm	0
Oxygen	ppm	0
Nitrogen	ppm	0
Moisture	mg/l	0

12.3.5.4 For DGA samples associated with Type Tests, the acetylene value shall be quoted to one decimal place.

13 Earthing

13.1.1.1 The requirements of this section shall apply to new substations, cable sealing end and tower constructions and where reasonably practicable to extensions or modifications of existing substations and cable sealing ends and tower refurbishment.

13.1.1.2 All earthing systems shall be designed and installed to comply with all relevant laws and regulations.

13.1.1.3 Where a substation, cable sealing end or tower is being extended or modified, **TSMO** will determine whether it is necessary to control the rise of earth potential in accordance with section 13.1.2. If not stated, this requirement need not be applied.

13.1.2 Rise of Earth Potential

13.1.2.1 The safety of all persons on, or in the vicinity of, high voltage sites, and persons who may contact any conducting services to, or passing through high voltage sites, is dependent on the design of the earthing system and its associated electrical isolation. The design of the earthing system at substations shall limit the step and touch potentials to safe levels given in the following table:

	Maximum Voltage for Touch	**Maximum Voltage for Step**
Chippings surface (150 mm)	1.4kV	4.6kV
Soil Surface	1.0kV	3.1kV

The limits in this table assume a 200 ms clearance time, a 1 m step distance and a footwear resistance of 2 kΩ per shoe. They are based on curve c1 of Figure 14 of IEC 479-1.

13.1.2.2 In the event that an insulating coating is required to be applied to the tower legs to manage the risks associated with touch potentials, then the coating specification shall comply with the following minimum requirements:

- Minimum Rated voltage withstand: 50kV
- Coverage: From ground level to 2.5m above ground level
- Minimum Service Life: 10 years
- The coating shall not serve to aid climbing of the tower
- The coating shall not prevent the fitting of step bolts
- The coating shall be resistant to minor impact damage
- The coating shall be dark or light grey and shall generally be unobtrusive

13.1.2.3 Cable sealing ends shall be treated as substations unless otherwise determined by **TSMO**.

13.1.2.4 Third **party** rise of earth potential impact voltage thresholds via proximity (conduction via the ground) effects are given in the following table:

Type of Third Party Property	Threshold Limit Voltage
Households and commercial property	1700V
Large hazardous process plants	650V
Railways and other traction systems	1150V

13.1.2.5 Where a **TSMO** substation provides a **connection** to a **system user**, the applicable threshold limit values via conduction (via metallic earth conductors) are given in the following table:

Type of Third Party Property	Threshold Limit Voltage
Households and commercial property	Not applicable
Large hazardous process plants	650V
Railways and other traction systems	430V

13.1.2.6 The design of the earth electrode system (whether this is as a result of adding to an existing system or the installation of new system), shall be optimised in so far as is reasonably practical to ensure third **party** impact threshold voltages are within the limits in the tables in sections 13.1.2.4 and 13.1.2.5. In particular, consideration shall be given to the arrangement of the electrode system and the use of all land within the substation boundary. It is only necessary to use land outside the substation boundary that is within **TSMO**'s ownership or control if stated by **TSMO**. The earth electrode depth and geometry shall be optimised to make use, as far as practicable, of lower resistivity ground strata.

13.1.2.7 Where reasonably practicable, the earthing system shall be designed using an earth return current which is 20% greater than that calculated, to allow for future increases in system fault current.

13.1.2.8 Communication cables connecting to all **TSMO** substations must be fitted with appropriate electrical isolation.

13.1.3 Earth Electrodes

13.1.3.1 Earth electrodes shall be designed to operate satisfactorily during faults, taking into account the area of the electrodes in contact with earth, the soil resistivity and earth electrode current magnitude and duration, in accordance with DIN 46011. The fault duration times to be used for rating the electrodes are 1 second for 220 kV and 400 kV and 3 seconds for all other nominal system voltages.

13.1.3.2 Buried bare copper horizontal earth electrodes shall be installed at around 500 mm depth. If the indigenous soil is hostile to copper (corrosive soils containing acids, nitrates, sulphides, sodium silicates, ammonium chlorides or sulphur dioxides that may have a significant effect on the earthing system over a design life of not less than 40 years), the electrode shall be surrounded by 150 mm of non-corrosive soil of fine texture, firmly rammed. Where there is a likelihood of soil migration and leaching, alternative materials may be used..

13.1.3.3 Conductors installed in ploughed farmland shall be buried at least 1 m deep, at all points, measured from undisturbed ground level. Where horizontal earthing conductors are exposed to indigenous soils that are hostile to copper, stranded copper conductors are not permitted within the earthing design.

13.1.3.4 Driven rod electrodes shall be used to exploit lower resistivity ground strata where present to reduce the site rise of earth potential in accordance with section 13.1.2. Where the ground is hard and rods cannot be driven, consideration shall be given to drilling holes to install the rods and back filling with a suitable low resistance fill material.

13.1.3.5 Buried conductors and electrodes shall be at least 3 m away from buried cables with uncovered metallic sheaths, unless the sheaths are used as part of the earthing system.

13.1.3.6 Where beneficial, reinforcing steelwork incorporated within piling shall be utilised as an earth electrode. However, care must be taken to ensure that the current carrying capacity of the steelwork is not exceeded. Connections shall be made to each vertical steel bar within the pile cap. Connections brought out through the pile cap shall be provided with appropriate means to prevent moisture ingress into the cap.

13.1.3.7 Fortuitous connections must not be relied upon.

13.1.3.8 Where sheet steel piles of the interlocking kind are used as an earth electrode, connections shall be made to each pile.

13.1.3.9 Where there is more than one **TSMO** controlled substation on the same site a separate earth grid shall enclose each substation and these grids shall be connected together at the extremities by at least two fully rated conductors ideally taking secure separate physical routes. In order to facilitate testing of the interconnections, the conductors connecting the systems together shall each be made accessible at a designated point. At this point the conductors shall have dimensions which would fit inside a 25 mm diameter circular clamp meter jaws (min length of conductor 75 mm).

13.1.3.10 Where a **TSMO** substation is located on the same site as a **system user's** substation, the earthing systems shall be interconnected. Measures shall be taken to ensure that persons can not come into contact with hazardous transferred potentials between substations or directly connected customers, particularly where sites are separated. Where control of these potentials requires measures to be taken by a **system user** or other third **party**, **TSMO** shall be informed by the supplier at the time of production of the earthing design.

13.1.3.11 Disconnectable test links must not be fitted where HV earthing systems are connected together.

13.1.4 Earth Electrode Arrangement

13.1.4.1 Unless otherwise agreed, the earthing electrode arrangement shall be based on a peripheral buried main bare earthing conductor generally encompassing the plant items to be earthed, with buried spur connections, from the main conductor to the items of plant. The main earthing conductor shall be augmented with inter-connected buried bare crossconnections to form a grid. In addition, where beneficial, groups of earth rods distributed around the periphery shall be connected to this main earthing conductor.

13.1.4.2 For indoor substations the earthing grid shall be installed with spur connections to the steel reinforcing mat of the concrete floor, every 20 m. Additionally, a second peripheral main earthing conductor shall be buried at 1 m distance from the building, which shall be bonded to the first main conductor, and to the building if it is metalclad, both at 20 m intervals. Earth rod groups shall be connected to the second peripheral conductor as previously described.

13.1.5 Test Facilities

13.1.5.1 To allow testing of all earth electrode groups, a section of conductor connecting to each group shall be made accessible and shall have dimensions that would fit inside 25 mm diameter circular clamp meter jaws (min length 75 mm). This section of conductor shall be a part of a spur connection to the rod group so that all the test current flows into the rod group and is not diverted into the main earth system.

13.1.5.2 Disconnectable links must not be fitted in the connections from the main earth system to terminal towers or rod groups or in the connections between main earth systems, on sites where more than one main earth system exists.

13.1.6 Equipment Connected to the Main earth system

13.1.6.1 The following items of equipment shall be connected to the main earth system by a fully rated conductor:

- All points which may form the earth of a high voltage fault path.
- Transformer winding neutrals required for HV system earthing. Earthing connections for MV system may be via earthing resistors or other current limiting devices.
- In the case of a manually operated earthing or HV switch, a dedicated fully rated conductor shall be run from the handle or mechanism box to the main earth system as directly as possible and this conductor shall pass under the stance position of the person operating the switch. The conductor runs to any fault points associated with the switch shall, where practicable, be maintained separate from the handle or mechanism of the switch and connecting metalwork.

13.1.6.2 Where appropriate in the design of the substation, one point of a delta connected tertiary winding that is not providing load shall be connected to the main earth system by a fully rated conductor.

13.1.6.3 All metalwork e.g. panels, cubicles, kiosks etc, including the steelwork of buildings, shall be bonded to the main earth system by a conductor of no less than 70 mm^2 cross section. Strip conductor shall be no less than 3 mm thick.

13.1.6.4 Mechanical linkages, e.g. turnbuckles, shackles etc, which could form part of the earth connection shall be shunted across using fully rated flexible conductor to prevent damage by the passage of fault current.

13.1.6.5 Metallic trench covers shall be earthed to cater for the possibility of an earth fault on cabling in the trench and to cater for the possibility of induced or transferred potentials. To achieve this, metal trench covers may be laid on conducting support(s) that shall each be connected to the main earth system by a conductor as specified above.

13.1.7 Installation

13.1.7.1 Earth conductors in trenches containing power and/or multicore cables shall be fixed to the walls approximately 100 mm from the top to maintain separation from the cables.

13.1.7.2 Due regard shall be given to the possibility of mechanical damage to buried conductors and, where necessary, either marker tapes and/or mechanical protection shall be installed. A separation of at least 500 mm to civil works such as drainage pits, shall be maintained.

13.1.7.3 Conductor runs above ground shall be designed to minimise the possibility of mechanical damage.

13.1.7.4 When laying stranded conductors, care shall be taken to avoid distorting individual strands.

13.1.7.5 Conductors shall be fixed firmly and tidily to structures at a spacing of no more than 1 m. The fixings shall not allow galvanic corrosion to occur and shall not require the conductor to be drilled unless otherwise agreed.

13.1.7.6 Where earth conductors cross they shall be jointed (other than in the case of rod groups where these must be maintained separate to permit testing).

13.1.7.7 Where earth conductors connect to equipment the connections shall as far as practicable be made onto vertical surfaces only. Connections to the metal cladding of buildings shall be inside the building.

13.1.7.8 Aluminium conductor shall only be installed at least 250 mm above ground level. All conductor joints shall be in accordance with section 4.26.

13.1.7.9 Where specified, buried earth tape shall be protected from theft by measures such as concrete anchors or securing to driven earth rods.

13.1.7.10 Bolted joints are not acceptable below ground other than for earth rod screw couplings which shall be thoroughly greased. Connections to buried earth rods shall be welded in accordance with section 4.26.

13.1.8 Portable Earthing

13.1.8.1 Loops for portable earths shall be provided on the earthing conductor at each location where portable earths may be required to be applied. The loops shall be fully rated and suitable for **TSMO** standard portable earthing equipment, and shall be made of copper or aluminium. The loops shall be not less than 230 mm long and shall be 75 mm clear of the earthing conductor. Loops for portable earths shall be installed at a convenient height and shall be separately formed, ie not by bending the earthing conductor.

13.1.8.2 The rating of multiple portable earth leads shall be as listed in the following table:

Number of leads (150 mm^2 aluminium)	Rating
1	17.5kA
2	31.5kA
3	47.25kA
4	63kA

13.1.9 Steel Support Structures

13.1.9.1 Where the current carrying capacity of steel support structures is at least equal to the switchgear rating, it is preferred that the structure is utilised to form part of the connection to the main earthing system, in which case there is no need to fix an earth conductor along this section.

13.1.9.2 Where a steel structure is relied upon to provide an earth connection for supported equipment, current carrying joints within 2.4 m of ground level shall be in accordance with section 4.26. Above 2.4 m the normal structural joints are considered adequate for electrical integrity during fault conditions.

13.1.9.3 Steel structures shall not be relied upon to conduct high frequency currents or for earth connections to earth switches.

13.1.9.4 Where post insulators, other than those forming part of shunt connected equipment (eg CTs, VTs, surge arrestors) are supported by a steel structure the insulator base does not require a bridging connection to the structure.

13.1.10 Fences

13.1.10.1 Measures shall be taken to ensure that dangerous touch or transferred potentials cannot arise on substation fences. Perimeter fences may be independently earthed using 5 m long rod electrodes or may be connected to the main earth system.

13.1.10.2 Where a perimeter fence is independently earthed, 2m separation must be maintained between the fence and the main earth system and equipment connected to it.

13.1.10.3 Unless otherwise agreed, where a perimeter fence is connected to the main earth system an additional buried bare conductor shall be installed 1 m outside the fence buried at a depth of 0.5 m to control touch potentials. This conductor shall be connected to the main earth system and fence at 50 m min intervals.

13.1.10.4 Internal fences within the curtilage of the main earth system shall be connected to it at 50 m min intervals and at changes of direction and where power lines cross overhead. Unless otherwise agreed, internal fences not within the curtilage of the main earth system shall have an additional buried bare conductor installed 1 m on either side of the fence buried at a depth of 0.5 m connected to the fence at 50 m intervals to control touch potentials.

13.1.10.5 Where a fence, which is connected to the main earth system, abuts an independently earthed fence they shall be electrically separated using either a non-metallic fence panel or an insulating section having 5 cm (approx) creepage at each end of a 2 m section which is not connected electrically to either of the fences.

13.1.10.6 A cable having a metallic covering effectively in contact with the ground or a bare conductor which passes underneath an independently earthed fence shall be covered with insulation for a distance of 2 m on either side of the fence. For example this may be achieved by running the conductor in an alkethene pipe 2 m either side of the fence.

13.1.10.7 Where galvanised steel chain link internal fencing is used, a separate earth conductor shall be installed along the fence (min 70 mm^2) and shall be connected to each section of fence every 10 m or less and to the main earth system at 50 m intervals.

13.1.10.8 Where plastic coated steel chain link internal fencing is used, connection to the main earthing system shall be made at all fence guide wire anchor points (min 70 mm^2). Connections to the fence shall be via a conductor which shall be accessible and shall have dimensions which would fit inside 25 mm diameter circular clamp meter jaws. Where bolted joints are used to connect to the fence, these shall be protected with Denso Mastic and Tape or outdoor grade silicon sealer.

13.1.11 Access/Egress Gates

13.1.11.1 Access/egress gates are not required to be bonded to its supporting post. This should not be confused with the requirement to cross bond between gate supporting posts. This requirement should still be met.

13.1.12 Temporary Fences

13.1.12.1 Temporary metallic fences shall be installed with appropriate measures to limit touch or transferred potentials to safe levels.

13.1.12.2 An internal metallic fence within the curtilage of the main earth system shall be connected to the main earth system at 50 m intervals, at changes of direction and where power lines cross overhead.

13.1.12.3 Where a temporary metallic fence which is connected to the main earth system abuts an independently earthed fence they shall be electrically.

13.1.12.4 A fence outside the curtilage of the main earth system may present a greater hazard where it crosses the ground voltage profile. In this case, in order to limit the transferred potential, the fence shall either be non-metallic or shall have its sections electrically insulated from each other at intervals depending on the ground voltage profile at the site.

13.1.13 Terminal Towers

13.1.13.1 Where the earth wire of an incoming line terminates on a tower it shall be connected to the top of the tower. The tower shall be connected to the adjacent substations main earth system (not rod groups) at two separate points by two spur copper tape conductors following secure separate routes. The copper tape shall have a cross section no less than 50 mm x 6 mm. There shall be no disconnectable links in these connections. These conductors shall be connected to different legs of the tower and shall be adequately protected to prevent damage and deter theft. Where these conductors cross or come close to rod groups they shall be insulated to maintain an electrical separation between bare conductors of 2 m min.

13.1.13.2 Where a terminal tower leg is within 2 m of an independently earthed fence, the affected sections of fence shall be connected to the tower and insulated sections fitted either side of the affected sections.

13.1.14 Gas Insulated Substations

13.1.14.1 Gas insulated substations with single phase enclosures have specific earthing requirements to reduce circulating currents in supporting steelwork.

13.1.14.2 The main earth system shall be well integrated in the regions close to equipment with short spur connections taken to specific points. Connections to this system, together with direct connections between phases shall be made at all line, cable and transformer terminations, at busbar terminations and at approximately 20 m intervals in busbar runs. Inter-phase connections shall be rated to carry induced currents resulting from the flow of rated normal current in the primary conductors.

13.1.15 Anti-climbing Precautions Along the Tops of Walls

13.1.15.1 Where barbed wire or other metal anti-climbing devices are erected along the tops of brick walls etc these shall be connected to earth using the same procedure as with fencing.

13.1.16 Design Life of Installation

13.1.16.1 All parts of the earthing installation, both below and above ground, shall have a design life of 40 years taking into account the anticipated corrosion of the conductors resulting from site chemical pollution.

13.2 Test Requirements

13.2.1.1 Validation by electrical measurement of any design is required for all installed systems to confirm the satisfactory installation and design of the system. **TSMO** reserves the right to witness all tests.

13.2.1.2 The resistance to earth of all individual rods and rod groups shall be measured and recorded. Where the measured resistance of an individual rod is more than 50% higher than the average for the site the reason shall be investigated and the rod(s) re-installed if necessary.

13.2.1.3 The total substation earth electrode impedance shall be measured using the AC Fall of Potential Method and the result recorded. The measured result shall be compared with that predicted by calculation and any significant difference investigated.

13.2.1.4 Tests of all electrical joints shall be made in accordance with section 4.26.2.

14 Auxiliary Supplies

14.1.1.1 This section defines the technical requirements for the application of substation auxiliary equipment and describes the functional and performance requirements for both ac and dc auxiliary power supplies for equipment in substations. The operational security of substations and the availability of the high voltage plant and secondary equipment within the substation is dependent upon reliable and secure auxiliary supplies.

14.1.1.2 Manufacturing facilities for equipment forming part of an auxiliary supply installation shall be certified by a recognised accreditation organisation to ISO 9001.

Manufacturers shall preferably have in place or be working towards installation of management systems compatible with the environmental management system standard ISO 14001.

14.1.1.3 No-break supplies for protection, control, measurements, telecommunications and other electronic equipment shall normally be fed from 48 V (dc) and/or 110 V (dc) supplies. The preferred choice of supply for light current equipment is 110 V (dc).

14.1.1.4 Alternating current supplies may be used where a short duration supply interruption is tolerable (typically 0-2 mins arising from the time taken for a supply to change over or for diesel standby generation to run up to speed). Where a break is not acceptable and the equipment requires a no-break ac supply such as for a computer and monitor then it shall be fed from a dc supplied inverter or a stand-alone uninterruptible power supply (UPS).

14.1.1.5 For safety reasons, the use of 230 V (ac) supplies for control systems should be avoided where reasonably practicable. If ac supplies must be used for general control purposes, a suitable transformer providing 110 V with centre tapped earth is recommended to derive an acceptable control voltage.

14.1.1.6 The LVAC power supply shall be designed to provide a voltage maintained within the limits of 400/230 V + 10%, - 6% and 50 Hz ± 1%.

14.1.1.7 All components of the LVAC supply should be capable of operating correctly at the levels of harmonics specified in IEC 50160.

14.1.1.8 48 V and 110 V (dc) supply systems at 400 kV and 220 kV substations shall be provided by two independent dc supply systems.

14.1.1.9 Interconnection facilities between the independent dc supply systems for each voltage level shall be provided at each substation. Common mode faults shall be minimised wherever possible.

14.1.1.10 Cross connections of dc supply systems between adjacent dispersed relay rooms, where the relay rooms belong to primary 400/220 kV circuits carried on the same route, shall be arranged to avoid common mode faults.

14.1.1.11 Each independent system shall be designed for a six hour standby period with the maximum load of the associated distribution board.

14.2 Performance Requirements

14.2.1 Alternating Current Supplies

14.2.1.1 All equipment supplied shall be provided with the following degrees of protection against ingress of objects and moisture, as specified in IEC 60529.

14.2.1.2 In the case or outdoor equipment, the level of protection during normal operation shall be IP54. With access doors open, without the use of tools, the level of protection of live electrical conductors shall be IP20.

14.2.1.3 In the case of indoor equipment, the level of protection during normal operation shall be IP31. With access doors open, without the use of tools, for the level of protection of live electrical conductors shall be IP20.

14.2.2 Direct Current Supplies

14.2.2.1 Direct current systems shall provide no-break supplies at all times up to the end of the specified standby period.

14.2.2.2 The power supply systems and cabling shall be sized to ensure that the battery is capable of supplying the load requirements at the end of the 6 hour standby period. At the end of the 6-hour standby period the voltage measured at the distribution board , with an ambient temperature of 5ºC, shall not be less than 46 V in the case of 48 V nominal systems, 102 V in the case of centralised 110 V systems and 93 V for dispersed 110 V systems.

14.2.2.3 The 110 V battery shall be capable of supplying the maximum tripping load at the end of the 6 hour standby period. This is defined as the tripping of all the required plant associated with that battery for a primary busbar fault.

14.2.2.4 The battery/charger system shall at all times maintain the voltage at the distribution board(s) within the following levels (taking into account the permissible variance in alternating current supply voltage at the charger):

	Normal	**Maximum**	**Centralised Systems Minimum**	**Dispersed Systems Minimum**
Voltage Range for 110 V nominal systems	125	137.5	102	93

	Normal	Maximum	Centralised Systems Minimum	Dispersed Systems Minimum
Voltage Range for 48 V nominal systems	54	60	46	----

15 Protection and Protection Grading

15.1.1.1 This section defines protection grading arrangements at interfaces between **TSMO** and **system users** to ensure that adequate discrimination of protection is achieved and the arrangements that apply to shared protection equipment. It sets out the protection setting requirements that, when applied, will ensure compliance with the Grid Code with respect to protection discrimination. It also establishes principles applicable to protection in boundary substations to ensure the security of the **transmission system** is not jeopardised by non-clearance of faults on **system user's** networks.

15.1.1.2 Protection setting, and other information, that is to be used for the purpose of protection grading shall be exchanged between **TSMO** and the **system user** as required to ensure the secure and reliable operation of the combined networks. If the **system user** believes that the required grading stated in this section cannot be achieved **TSMO** must be consulted.

15.2 Protection Principles

15.2.1 Use of Differential Protection on Short Feeders

15.2.1.1 Distance protection will normally be installed on overhead circuits. Where circuits are mainly comprised of underground cable or where circuits are less than 5 km in length, a differential protection system shall be employed. Where two main protection schemes are employed, they shall be of different manufacture and, where possible, shall use different design components.

15.2.1.2 In the case of short circuits entirely comprised of overhead line then, where two main protection schemes are installed and subject to the agreement of **TSMO**, one main protection scheme shall be a differential scheme and the other shall be a distance protection scheme.

15.2.2 Supervision of Circuit Breaker Main Contacts and Trip Circuits

15.2.2.1 Equipment shall be provided on all three phase circuit breakers where the operating contacts of all phases are not mechanically interconnected to detect that the main contacts of all phases are in the same position (either all open or all closed). Where the contacts of all phases are not in the same position, and this situation continues for:

- longer than 2 seconds in the case of circuit breakers where single phase auto reclose is fitted, or
- longer than 500mS in all other cases,

then a trip signal shall be sent to all phases of the circuit breaker.

15.2.2.2 Two separate trip circuits, with separate trip coils, shall be provided on all circuit breakers connected to the **transmission** network. All trip circuits shall be fitted with trip circuit supervision facilities providing local and remote alarms. It shall be possible to isolate the remote alarm facility when circuit breakers are removed from service for maintenance purposes. The design of the isolation scheme should ensure that remote supervision is restored when the circuit breaker is returned to service.

15.2.3 Fault location facilities on long overhead line circuits

15.2.3.1 In the case of all overhead lines over 30km, fault locators shall be installed.

15.2.4 Power System Instability and Under Frequency

15.2.4.1 To guard against power system oscillations causing instability in the regional power system, protection systems shall be installed on all 400kV circuits to detect power swings and to trip the circuit breaker where power flow oscillations continue for a period of 3 S.

15.2.4.2 All **system users** whose networks may supply a net demand of more than 20 MW shall install under-frequency protection to trip the incoming circuit breakers in the event that system frequency falls.

15.2.4.3 The setting of all under frequency relays shall be under the control of **TSMO** and it shall be possible for **TSMO** to apply security seals to ensure that settings are not altered without the direct involvement of **TSMO**.

15.2.4.4 Where the network of a **system user** supports a key public service, then the **system user** may also provide under-frequency protection on all circuits from the same incoming switchboard and seek that higher settings are applied to this protection than are applied to the incoming circuits.

15.2.5 400kV Network

15.2.5.1 At all points of the 400kV network, two totally separate main protection schemes shall be installed, operating separate trip coils on the appropriate circuit breakers. On overhead circuits greater than 5 km in length, these two protection schemes shall both be distance protection systems but of different manufacture and, where possible, use different design components.

15.2.5.2 Distance protection shall be set such that zone 1 shall be 80% of the line length and shall initiate a trip signal within 40mS; zone 2 shall extend to 50% of the shortest subsequent circuit and shall initiate a trip signal after a fault duration of 250mS; zone 3 shall extend to 120% of the longest subsequent circuit and shall initiate a trip signal after a fault duration of 500mS and zone 4 shall be a reverse direction zone initiating a trip signal after a fault duration of 750 mS.

15.2.5.3 To ensure high resistance earth faults at the remote end of a circuit are cleared, distance protection schemes shall incorporate directional earth fault protection connected in the CT residual circuit. This shall be set such that a trip signal is immediately initiated if an earth fault current of 50% of the normal line current is detected.

15.2.5.4 In compliance with the requirements of the Grid Code, a two stage overcurrent (as thermal overload) protection will be installed on all circuits and single phase high speed auto-reclose facilities shall be provided on all overhead line circuits.

15.2.6 220 kV Network

15.2.6.1 At all points of the 220kV network, two totally separate main protection schemes shall be installed, operating separate trip coils on the appropriate circuit breakers. On overhead circuits greater than 5 km in length, these two protection schemes shall both be distance protection systems but of different manufacture and, where possible, use different design components.

15.2.6.2 Distance protection shall be set such that zone 1 shall be 80% of the line length and shall initiate a trip signal within 50mS; zone 2 shall extend to 50% of the shortest subsequent circuit and shall initiate a trip signal after a fault duration of 400mS; zone 3 shall extend to 120% of the longest subsequent circuit and shall initiate a trip signal after a fault duration of 800mS and zone 4 shall be a reverse direction zone initiating a trip signal after a fault duration of 1200 mS.

15.2.6.3 In compliance with the requirements of the Grid Code, a two stage overcurrent (as thermal overload) protection will be installed on all circuits and auto-reclose facilities shall be provided on all overhead line circuits. The auto-reclose equipment may permit either single phase or three phase reclosure depending on the fault tripping arrangements.

15.2.6.4 Three phase auto-reclose equipment shall permit reclosure onto an overhead line that has tripped on transient fault either where the circuit has been confirmed to be de-energised or where the voltages on both sides of the circuit breaker have been proved to be in synchronism within established limits.

15.2.7 110kV Network

15.2.7.1 On 110kV circuits, one main protection system plus a two stage overcurrent (as thermal overload) protection scheme shall be installed and shall operate separate circuit breaker trip coils. Where the main protection continues to detect the passage of fault current and this is confirmed by the detection circuits of the two stage overcurrent protection, a trip signal shall be sent without delay to the trip coils operated be the overcurrent protection.

15.2.8 Breaker Fail Protection

15.2.8.1 Where a fault continues for 150mS after a trip signal has been initiated, breaker fail protection shall operate so that the circuit breakers on all infeeds to the affected busbar zone trip. The continuing fault condition shall be proved by more than one protection system. In the case of 220kV and 110kV circuits where only 1 main protection scheme is fitted, this may be a combination of main and back-up protection where the time setting of the back-up overcurrent protection is set to zero on operation of the main protection.

15.3 Use of shared Current Transformers

15.3.1.1 Current transformers as described in section 12.2 shall be installed at the network boundaries. One of the two protection cores may be used by the **system user** for their main protection and the other core will be used by **TSMO** for busbar protection purposes. With the consent of **TSMO** to the burden to be applied, the **system user** may connect overcurrent protection on the busbar protection CT.

15.3.1.2 Before any tests that involve primary injection of shared current transformers are carried out by the **system user**, the approval of **TSMO** to the proposed test schedule shall be obtained.

15.4 Transformer Protection

15.4.1.1 Transformers connected to the network of the TSMO shall have the following protection:

- Overall Differential Protection
- Restricted Earth Fault Protection
- Buchholtz Protection – Alarm and Trip
- Winding Temperature – Alarm and Trip
- Overcurrent Protection on HV and LV sides
- Earth Fault Protection on LV side
- Earth Fault Protection on Transformer Neutral Connections
- Tank Earth Protection

15.4.1.2 In the case of transformers having tertiary windings, overcurrent and earth fault protection shall also be applied to the tertiary winding.

15.5 Overcurrent Protection on Networks of System Users

15.5.1.1 Overcurrent protection shall be set to provide both current and time grading with two stage overcurrent protection installed on the **TSMO** network . The settings applied to overcurrent protection on the TSMO network shall be:

Conductor	**Winter**		**Summer**	
	Stage 1	**Stage 2**	**Stage 1**	**Stage 2**
Al/Fe 150/25 mm^2	620 A	740 A	350 A	510 A
Al/Fe 240/40 mm^2	840 A	1010 A	480 A	710 A
Al/Fe 360/57 mm^2	1080 A	1310 A	610 A	910 A
Al/Fe 490/65 mm^2	1290 A	1570 A	710 A	1090 A
Al/Fe 490/65 mm^2 * 2	2580 A	3140 A	1420 A	2180 A
Cu 150 mm^2	700 A	850 A	280 A	550 A

Conductor	Winter		Summer	
	Stage 1	Stage 2	Stage 1	Stage 2
Cu 95 mm^2	510 A	640 A	220 A	420 A

The time settings that are applied shall be:

	Alarm	Trip
Stage 1	20 Seconds	20 Minutes
Stage 2 – Overhead Lines		20 Seconds
Stage 2 – Underground Cable		3 Seconds

15.5.1.2 Current grading shall be achieved to ensure that the current setting deployed on the **system user's** plant (e.g. outgoing feeder, transformer, reactor) protection is smaller than the setting used on **TSMO**'s overcurrent protection. In cases where overcurrent protection is installed on both sides of a **TSMO** owned transformer, the **system user's** current setting shall be smaller than the lower of the HV and LV transformer overcurrent protection setting applied by **TSMO**. The **system user's** current setting shall take into account relay and CT errors.

15.5.1.3 Where the **system user** applies different settings during summer and winter seasons, the **system user** shall implement a system that ensures the protection settings are changed on the date advised by **TSMO** to ensure that the required current grading is maintained. Where the **system user** applies one setting throughout the year, that setting must ensure that the required current grading is maintained at all times.

15.5.1.4 Time grading shall be achieved by using an adequate minimum grading margin that should be calculated taking into account the following factors:

- The fault current interrupting time of the circuit breaker.
- Relay timing errors – as a shift from the ideal characteristic as defined in IEC 60255 – both (upstream and downstream) protection errors are included.
- The overshoot time of the relay.

- CT errors (on both protections), and
- an appropriate safety margin - typically 0.1 s for electromechanical and 0.05 s for static and numeric relays. In setting the safety margin, it is noted that relay timing errors and the overshoot time of the relay depend on the relay technology used - an electro-mechanical relay will have a larger overshoot time than a numeric relay.

16 Power Transformers

16.1.1.1 This section establishes particular requirements for power transformers used by **TSMO** and, where appropriate, requirements for power transformers used by **system users** where they are connected at the same voltage level as the connection to the **TSMO** network. These are additional requirements to those contained in sections 3, 4, 10 and 15 of this code. Earthing of transformer neutrals shall be undertaken as established in section 13.

16.2 Transformer Construction

16.2.1.1 Except where five limb cores are required for transport reasons or to control zero phase sequence currents, three limb transformers will be used as standard on the network of the **TSMO**. In general, the maximum height of transformers that may be transported by road in Kosovo is 6m. The cross section of the core and limb height shall be chosen to ensure that the natural frequencies of the core do not coincide with the frequencies of the magnetic field.

16.2.1.2 Transformers shall be outdoor type bushing transformers capable of connection to air insulated busbars at all voltage levels. Primary and secondary winding bushings will be installed on the longitudinal axis opposite one another. Tertiary winding bushings will be fitted on the transversal axis.

16.2.1.3 The cooling liquid shall be mineral oil or other agreed cooling liquid to IEC 60296 with a fire point ≤ 300^{o}C. The cooling liquid of all transformers must be PCB free.

16.2.1.4 Transformers shall be fitted with a conservator oil tank on the transversal axis opposite the tertiary winding bushings. The conservator tank will be fitted with an oil level indicator that can be read from ground level. An appropriate diaphragm shall be inserted in the conservator tank to separate oil from air and a dehydrating breather shall be fitted to dry air entering the tank. Where this breather uses silica gel as the dehydration agent it shall be impregnated by an appropriate indicator clearly demonstrating the level of saturation of the silica gel. Cobalt chloride shall not be used as an indicator. To allow changing of the breather for reactivation of the silica gel, the breather shall be attached to a threaded [xxx] (external) diameter pipe.

** KOSTT will later insert details of standard pipe work connections. **

16.3 Transformer Ratings and Connections

16.3.1.1 Transformers operating at new substation sites on the network of the **TSMO** shall be ONAN/OFAF autotransformers fitted with stabilising tertiary windings capable of providing substation auxiliary supplies complying with the requirements of IEC 60076 as detailed in the following table:

Nominal Transformation Ratio	Standard Transformer Ratings		Transformer Connections
	ONAN	OFAF	
400/231/10.5 kV	200/200/50MVA	400/400/100MVA	YNa0d5
400/115/10.5 kV	150/150/25MVA	300/300/50MVA	YNa0d5
220/115/10.5 kV	75/75/75 MVA	150/150/150MVA	YNa0d5

16.3.1.2 Tertiary windings shall be connected in closed delta with three connections brought out.

16.3.1.3 Where new transformers are required to operate in parallel with existing transformers on the network of the **TSMO**, the specification may be varied from that in sections 16.3.1.1 and 16.3.1.2 to the extent required for successful parallel operation. This approach will only be taken where appropriate system spares are available that will allow the declared system security level to be maintained.

16.3.1.4 **System users** shall establish the ratings of their own transformers having due regard to the technical requirements of their own plant and the conditions established in the connection agreement for the site.

16.4 Pumps and Fans

16.4.1.1 It must be possible for pumps and fans to be exchanged without taking the transformer out of service. All cooling circuits shall be provided with the necessary valves for shutting off each oil circuit separately. The maximum total operating load of pumps and fans to achieve the declared OFAF rating of the transformer shall be 18.5 kW.

16.5 Noise

16.5.1.1 When determined as established by IEC 60076-10 the total sound pressure caused by all transformers that it is planned shall be installed at the site under all normal operating conditions shall at all times be less than:

Type of location	Sound Pressure in dB
Residential Area	45
Commercial Environment/Agricultural Area	60
Industrial Environment	75

16.5.1.2 To achieve these limits, it shall be permissible to use pads of suitable damping material between the active part of the transformer and the tank bottom and between the transformer or any part of the cooling system and their mountings.

16.6 Guaranteed Transformer Losses

16.6.1.1 The Guaranteed transformer losses for transformers in the TSMO operated network shall be as detailed in the following table:

Transformation Ratio	Guaranteed No Load Losses	Guaranteed On Load Losses
400/231kV	133kW	586kW
400/115kV	140 kW	620 kW
220/115kV	100.5KW	375kW

Note: Guaranteed No Load Losses shall be the maximum no load loss at rated voltage and frequency and rated tap position. Guaranteed On Load Losses shall be the on load losses at 75^{o}C, rated voltage and frequency, rated voltage tap position and OFAF power rating.

16.7 Loss Capitalisation

16.7.1.1 The loss capitalisation figures to be applied to transformer design are:

No Load Losses	3500 €/kW
On Load Losses	1500 €/kW

16.8 Tapchangers

16.8.1.1 Tapping windings and on load tapchangers shall be fitted as detailed in the following table:

Transformation Ratio	Tapping Winding Location	Number of Taps	Tapping Range	Tapchanger
400/231 kV	HV terminals	3	420/400/380 kV	No Load tapchenger
400/115 kV	Transformer Neutral	17	± 10% in 1.25% steps	On Load tapchenger
220/115 kV	Transformer Neutral	±12	220±12x1.25/115	On Load tapchenger

16.8.1.2 The full power rating of the transformer shall be available at all tap positions.

16.8.1.3 Tap selector connection switches and tapchanger diverter switches shall be enclosed in separate tanks that are not connected to the main transformer tank. These tanks shall not be pressurised, shall have oil level indicators that are clearly readable from ground level and be fitted with a pressure release system to avoid distortion in the event of internal fault. The pressure release mechanism shall be fitted with auxiliary contacts to provide a trip signal when operated.

16.8.2 Tapchanger Control

16.8.2.1 On load tapchangers fitted to 400/220kV, 400/115kV and 220/115kV transformers shall be capable of manual control locally and remotely at the transformer control panel. Facilities shall also be provided to allow operation of the tap change control using the SCADA system.

16.8.2.2 On load transformers fitted to 400/115kV and 220/115kV transformers shall be also be capable of automatic voltage regulation using [xxxxx] transformer controller. Transformers operating in parallel shall be capable of being controlled using [xxxxx] tapchange control schemes.

16.8.3 System Users' Equipment

16.8.3.1 **System users** should provide appropriate tapchangers and tapchanger control schemes to ensure that their operations are unaffected by variation in voltage at the point of connection falling within the tolerance bands stated in the **electrical standards code**.

16.9 Surface Treatment of Transformer Tank and Accessories

16.9.1.1 All contaminants and sharp edges shall be removed prior to surface treatment and all surfaces cleaned to SA 2½ as specified in ISO 8501 -1. Where practicable this will be achieved by blast cleaning of all surfaces.

16.9.2 Transformer Tank

16.9.2.1 Unless otherwise agreed by **TSMO**, external surfaces of the transformer shall be coated with epoxy based primer and final coat with a minimum total thickness of 100 µm. The final coat colour shall be grey.

16.9.2.2 Unless otherwise agreed by **TSMO**, internal surfaces shall be coated with epoxy based paint inert to transformer oil. A minimum of one primer and one final coat shall be applied. The final colour shall be white.

16.9.3 Radiators

16.9.3.1 Radiators shall be hot dip galvanised to ISO 1461:1999

16.10 Protection against Catastrophic Failure

16.10.1 Fire Protection

16.10.1.1 The layout of outdoor substations shall be such that fire in a transformer containing a liquid volume exceeding 1000 litres of cooling liquid will not cause a fire hazard to other equipment or buildings. Where the clearance between any part of the transformer and other equipment is less than the distance in the following table, fire resistant separating walls shall be provided.

IEC 61100 cooling fluid class	Liquid Volume (litres)	Clearance to other transformers or non-combustible building surface (metres)	Clearance to combustible building surface (metres)
Class O (mineral oil or other cooling liquid with a fire point ≤ 300°C)	1 000 – 2 000	3	7,6
	2 000 – 20 000	5	10
	20 000 – 45 000	10	20
	≥ 45 000	15,2	30,5

16.10.1.2 Where separating walls are provided between transformers, they shall have a fire resistance of at least 60 minutes. The minimum height of the wall shall be that of the top of the expansion chamber or, if none is fitted, the top of the transformer tank. The minimum length shall be the length or width of the sump adjacent to the other transformer as appropriate.

16.10.1.3 Where separating walls are provided between transformers and buildings, they shall have a fire resistance of at least 60 minutes. As an alternative, the fire resistance of the material of the building may be increased to 90 minutes full integrity. The minimum height of the wall shall be that of the top of the expansion chamber or, if none is fitted, the top of the transformer tank unless the building is higher when the minimum height of the separating wall or upgraded fire resistance shall be that required until the distance from any point on the transformer to any point on the building with normal fire resistance is the clearance distance specified in the table in section 16.10.1.1. The minimum length shall be the length or width of the sump adjacent to the other transformer as appropriate unless the building extends beyond that point when the minimum length of the separating wall or upgraded fire resistance shall be that required until the distance from any point on the transformer to any point on the building with normal fire resistance is the clearance distance specified in the table in section 16.10.1.1.

16.10.2 Environmental Protection

16.10.2.1 To protect the environment from the effects of loss of cooling fluid resulting from catastrophic failure of transformers, a secure means of containing the fluid shall be provided. The capacity of the catchment system shall be no less than the total capacity of the transformer and cooling system including tapchanger compartments plus any fire extinguishing material plus 3 days winter average rainfall less an allowance for 24 hours evaporation.

16.10.2.2 It shall be permissible to install a catchment system which is common between some or all of the transformers on site. The capacity of the system shall be no less than the total capacity of the largest transformer and cooling system including tapchanger compartments plus any fire extinguishing material plus 3 days winter average rainfall less an allowance for 24 hours evaporation. Where a common catchment system is provided, it shall be so arranged that a fire in one transformer cannot spread to another.

16.11 System Users' Transformers – Special Requirements

16.11.1.1 Where the operating conditions of **system users** systems is significantly different from balanced three phase condition, then they must provide special transformers that ensure that the conditions applied at the **connection point** with the TSMO network is as close to balanced three phase condition as is reasonably practicable.

17 Overhead Lines

17.1.1.1 This section specifies the construction of all overhead lines (at nominal voltages of 400kV, 220kV and 110kV) that form part of the network operated by **TSMO** or form part of the networks operated by **system users** at the same voltage level as the point of connection to the network of the **TSMO**.

17.1.1.2 The minimum safety factor applicable for all tower types, conductor sizes, insulator systems and fittings shall be 1.5.

17.2 Tower Construction

17.2.1 Tower Format

17.2.1.1 Overhead line towers utilised on the network of **TSMO** shall be as detailed in the following table:

Nominal Voltage Level	Double Circuit Tower Types	Single Circuit Tower Types
400kV	Special PI	Y or PI
220kV	Pine	Y, PI or Pine
110kV	Pine	Y, PI or Pine

17.2.1.2 The applicable standards for towers used on the network operated by **TSMO** are:

- Overhead Line Support Loadings – VDE 0210/12.85
- Design and structural calculations – VDE 0210/12.85
- Steel tower members - DIN 17100
- Steel bolts, nuts and washers – ASTM A325 or A394 DIN 267
- Galvanising – VDE 0210, BS 729 or IEC 1461:1999

17.2.2 Tower Extensions

17.2.2.1 The standard tower extensions that are employed by **TSMO** to allow adequate clearances to be maintained in all conditions are -6, -3, +3, +6 and +9m. Tower locations will be modified if necessary to accommodate standard extensions.

17.2.2.2 Extension of the tower legs shall not be permitted.

17.2.3 Anti-climbing Devices

17.2.3.1 Towers shall be fitted with anticlimbing devices on all sides between 3m and 5m above ground level. The devices shall be provided with collapsible gates each step-bolt leg to allow access by authorised personnel for maintenance purposes. The gates shall be locked in anti-climbing position by a brass lock of cylinder type with metal dust-proof covers to key holes. The locks on the access gates on all towers for one circuit shall be identical and shall differ from those employed for all other nearby circuits operated by **TSMO**.

17.2.4 Step Bolts

17.2.4.1 To provide access for erection and maintenance personnel, step bolts shall be fixed on one leg of a single circuit line and on two diagonally opposite tower legs of a double circuit line. Step bolts shall be applied on the same legs throughout the complete line. Fixing shall start just above the anticlimbing device and continue to the tower top.

17.2.4.2 Step bolts shall be fitted on each face of the angle plate from which the tower leg is formed and positioned so that personnel can climb with one foot on each side of the angle. The distance between the bolts on each face shall be 600 mm and shall be positioned so that each climbing step shall be 300 mm. The free side of the bolt shall be the head and the end of the bolt fixed to the tower shall be equipped with one nut on each side of the main tower leg. The distance from the outside of the nut on the outer face of the tower and the inside of the head of the step bolt shall be 100 mm.

17.2.4.3 Below the anticlimbing device, 3 keyways shall be provided, spaced at the same distance as the step bolts, for locating circuit specific removable steps. The format of the keyway and the keyed step shall be the same for all towers on a circuit and shall differ from those employed for all other nearby circuits operated by **TSMO**. For the remainder of the tower leg below the anticlimbing device holes will be provided, the same diameter as are drilled for the fitting of step bolts so that removable step bolts may be fitted to allow access for maintenance works.

17.2.5 Identification Plates and Signs

17.2.5.1 Provision shall be made for the fixing of the following identification plates and signs on towers:

- Safety Sign;
- Circuit Identifier;
- Tower Number;
- Phase Identifier;
- Tower Top Identification Plate for use in aerial patrols;

The plates shall be of nonferrous material with vitreous enamel finish or anodised aluminium.

17.2.6 Safety Sign

17.2.6.1 A safety sign as shown below shall be fitted to each tower just above the anticlimbing device adjacent to each access gate facing the route of the conductors. Where the tower is within 100 m of a railway line or roadway to which the public have access, an additional sign will be fitted facing that roadway or railway line, with further additional signs being fitted where the tower is in proximity to more than one roadway or railway line. The colours used shall be signal black (DIN 5381 RAL 9004) and signal yellow (DIN 5381 RAL 1003). Where specified, the safety sign shall include additional text the letters of which shall be shown in signal yellow and shall have the same proportions as the letters shown in the diagram. The minimum size of the sign shall be 250mm across and 200mm high.

17.2.7 Circuit and Tower Number Identifier

17.2.7.1 Circuit and tower number identifier plates shall be installed in the centre of one side of each tower in line with the overhead conductors and shall be fixed just below the anticlimbing device on a properly designed support. On double circuit lines two circuit identifier plates shall be fitted side by side with the identifier applicable to each circuit closer to the appropriate conductors. The plate shall be a minimum of 250mm across and 200mm high and shall be of the form below:

The colours used shall be signal black (DIN 5381 RAL 9004) and signal yellow (DIN 5381 RAL 1003). Where specified, the safety sign shall include additional text the letters of which shall be shown in signal yellow and shall have the same proportions as the letters shown in the diagram.

17.2.8 Combined Safety Sign and Circuit and Tower Number Identifier Plate

17.2.8.1 The safety sign may be combined with the circuit and tower number identifier plate into a sign with minimum dimensions of 250mm across by 400mm high as shown below:

17.2.9 Phase Identifier

17.2.9.1 On single circuit lines, phase identifier plates shall be fixed adjacent to each phase conductor crossarm on the main body of each terminal tower, towers on each side of roadways to which the public have access and a tower every 10 km of circuit length. At transposition and tee-off points, phase identifier plates shall be fitted on the transposition or tee-off tower and on the towers on each side of it.

17.2.9.2 On double circuit lines, phase identifier plates shall be fixed adjacent to each phase conductor crossarm on the main body of every tower.

17.2.9.3 The phase identifier plate shall show the number 8, 0 or 4 as appropriate in black lettering on a white background as shown below and shall be of minimum size 150mm across be 200mm high:

17.2.10 Tower Top Identifier

17.2.10.1 A tower top identifier plate, as shown, for use in undertaking aerial patrols shall be installed on each terminal tower, transposition tower, towers on each side of surfaced roadways and a tower every 10 km of circuit length. At tee-off points, tower

top identifier plates shall be fitted on the tee-off tower and on the towers on each side of it. The tower top identifier plate shall identify the circuit and tower number and be fixed on the tower top in such manner that it can be seen from a helicopter.

17.2.11 Finish of Tower Steelwork

17.2.11.1 All individual steelwork sections and bolts and nuts used for tower assembly shall be hot dip galvanised after all preparation works (including drilling of fixing holes and tapping) have been carried out. The minimum coating weight on steel sections less than 5mm thick shall be $0.61kg/m^2$. The minimum coating weight on steel sections 5mm thick or over shall be $0.915kg/m^2$. Appropriate allowance shall be made in all fabrication processes (including the drilling of fixing holes and tapping) to ensure that it is possible to assemble all components without damaging the galvanised finish.

17.2.12 Tower Earthing

17.2.12.1 Terminal Towers in substations shall be earthed in accordance with the provisions of section 13.1.13.

17.2.12.2 At all other towers an endless loop of 10mm galvanised steel cable shall be installed in such a way as to surround the complete tower foundation. The depth of burial will be such that normal land use shall not result in its disturbance. This cable shall be clamped to two diagonally opposing tower legs at least 50cm above the foundation surface using bronze clamps and 12 mm diameter galvanised steel bolts. Where the earth resistance of such an arrangement is not lower than 5 ohms in the case of the three towers closest to the terminal substations or 10 ohms in all other cases, sufficient steel cored earthing rods 1.5m long and 20mm in diameter shall be installed and connected to the earthing system as is required to meet the maximum tower earth resistance.

17.2.12.3 All circuits shall be earthed circuits using earth conductor specified in section 17.4.2 clamped to each tower top.

17.3 Insulators and Fittings

17.3.1.1 Suspension, pilot and tension insulator sets shall be polymeric or toughened glass cap and pin type to the following standards:

- Insulator units IEC 60120, IEC 60305, IEC 60433, IEC 60372, IEC 60575, IEC 60797, IEC 61466, VDE 0111, VDE 0210, ANSI-C 29, Part 1 and 2
- Pins IEC 60120, IEC 60372-1, DIN 17200
- Caps IEC 60120, IEC 60672, DIN 1692
- Cement ASTMC 151

- Testing IEC 60383, IEC 60437, IEC 60507, ASTM A153, ANSI-C 29, Parts 1 and 2

17.3.1.2 Retaining pins or locking devices for cap and pin insulator units shall be "W" type, security clip and shall comply with IEC 60372-1. The design shall be such as to allow easy removal of insulator units or fittings without the need to remove the insulator set from the crossarms. Retaining pins or locking devices shall be not be capable of rotation when in position. All ball and socket joints shall be slightly coated with appropriate grade of grease prior to insulator set assembly.

17.3.1.3 Where Portland cement is used precaution shall be taken to guard against cement growth failure. In particular the presence of excessive gypsum shall be avoided. Autoclave expansion limit to Portland cement when tested in accordance with ASTM C151 shall not exceed 0.13%. The recess of the cement/cap boundary of the insulators shall be filled with a suitable compound to prevent accumulation of dirt.

17.3.1.4 For all types of insulator operating as suspension or pilot sets, insulator set creepage distance shall be calculated based on 20 mm/kV and the peak phase to phase voltage specified in the **electrical standards code**. Tension units shall be equipped with one additional unit in the case of cap and pin insulators or one additional length in the case of polymeric insulators.

17.3.1.5 All terminal or angle towers shall be fitted with double tension insulator sets where the cross sectional area of the conductor is 240/40 mm^2 or greater. In other locations where the use of higher strength tension or suspension insulator sets is required to meet the loading requirements, a double (tension or suspension) set shall be used. In other locations a single suspension set will be installed.

17.3.1.6 On all angle towers with a line deviation exceeding 30°, jumpers on the circuit which is on the outer angle of the tower shall be supported by pilot suspension sets. Where necessary, two or more sets per crossarm shall be fitted.

17.3.1.7 All fittings shall comply with the following standards:

- Materials IEC 60120, VDE 0210, DIN 48215, BS 3288
- Testing IEC 60383

17.3.1.8 All fittings shall be supplied with bolts, nuts, washers, cotter pins, etc. to facilitate assembly and erection. All fittings made of ferrous metals shall be galvanized. The design of all adjacent metal parts shall be such as to prevent corrosion or excessive wear of the contact surfaces, or any electrolytic action between dissimilar metals. All aluminium parts fitted to aluminium conductors shall be of at least 99,5% purity.

17.3.1.9 All bolts and nuts shall be locked by means of locknuts or other approved means and all bolt threads shall be greased before erection. With the exception of turnbuckles in down leads, line conductor and earth conductor fittings shall not employ screw threads in tension.

17.3.1.10 Split pins for securing assemblies shall be of stainless steel and shall be backed by washers of an appropriate size and gauge.

17.3.1.11 All clamps shall be such that deformation and/or separation of stranded conductors or earthwires is prevented. Suspension clamps should permit the conductor to slip before failure of the conductor occurs. Tension clamp and joints shall not permit slipping of the conductors, cause damage to them or result in their failure.

17.3.1.12 All live fittings shall be designed so that there are no sharp corners and projections that might cause high electrical stress under the full range of operating conditions specified in the **electrical standards code**. All surfaces, including those of bolts and nuts shall be round or spherically shaped.

17.3.1.13 The temperature rise on any fittings carrying current shall not be greater than that of the associated conductor. The electrical conductivity and current carrying capacity of each joint and tension clamp shall not be less than those of an equal length of an unjointed conductor.

17.3.1.14 The yoke for double insulator sets shall have the facility to attach a pull lift or other hoisting device. This facility shall be so designed that when pulling the conductor for maintenance purpose, the yoke shall be symmetrically pulled without overstressing any part of the insulator sets.

17.3.1.15 All tension and suspension insulator sets, shall be fitted with arcing devices. The design of these devices shall be such to ensure no damage to the clamps and conductors occurs and to prevent cascading over the insulator units when flashover takes place.

17.3.1.16 When midspan joints are used particular care shall be taken to ensure the correct centering of the sleeves. Cutting of layers of conductor shall be carried out with tools designed to prevent damage to underlying strands. An approved oxide inhibiting compound shall be used for all compression joints and tension clamps. It should be applied in such a manner as to exclude air or moisture. No joint will be permitted within 20 m of a suspension clamp and not more than one joint will be permitted in any one span.

17.3.1.17 Jumper terminals shall be attached to compression clamps by high tensile steel bolts and nuts.

17.3.1.18 All phase conductors and earthwires shall be fitted with stockbridge dampers. A minimum of one vibration damper at each end of every span is required. Fitting dampers to the conductors must not cause and damage to them. Clamping bolts shall be provided with domed self-locking nuts designed to prevent corrosion to the threads.

17.3.1.19 Armour rods shall be used around the conductor and earthwire at the point of suspension clamp clipping. The rods shall be of aluminium alloy and suitable for the specified conductor or earthwire. The direction of the armour rods lay shall be the same as the direction of the last wire lay of the conductor. The suspension clamp must have a groove big enough to carry the conductor with the armour rod..

17.4 Conductors

17.4.1.1 Conductors used for all new works on the network of the **TSMO** shall be aluminium alloy conductor with steel reinforcing (ACSR) to IEC 61089 and the sizes used in any works shall be selected from the following table:

Voltage Level	Standard Conductor Sizes
400kV	2*490/65 mm^2
220kV	490/65 mm^2 360/57mm^2
110kV	240/40mm^2 150/25mm^2

17.4.1.2 The particular size to be installed on each circuit will be chosen to suit overall network development requirements rather than any specific connection request.

17.4.1.3 Where modifications are required which extend existing circuits, it may be necessary for these extensions to be undertaken using other conductor sizes which match those used in construction of the existing circuit. This will be considered an abnormal situation and will be undertaken at the sole discretion of the **TSMO**.

17.4.2 Earthing Conductors

17.4.2.1 Earthing conductors shall be ACSR 150/25 mm^2 to IEC 61089.

17.4.2.2 Optical fibre ground wire (OPGW) shall be installed on all extensions or upgrading to the network of the **TSMO** where the circuits being extended or upgraded already have OPGW installed; where the circuits being extended or upgraded are identified on the plan approved by the ERO as circuits that will form part of the **TSMO**'s proposed fibre optic telecommunications network; or where the extension being undertaken requires the provision of telecommunications circuits (for example to facilitate the installation of protection systems requiring the provision of secure end to end telecommunications circuits). The number of fibres shall be no less than 48 with an operational wavelength of 1300nm and **transmission** speed of 565Mb/s. Where OPGW is used, the metallic component shall be equivalent to 126.1 mm^2 ACSR earthwire.

17.4.2.3 Where OPGW is used, splicing boxes shall be fitted as required by the drum length and at each location that it is intended to drop off telecommunications circuits. The minimum splice capacity shall be 48 single mode fibres from metal free optical cable with loose tube construction. The maximum optical attenuation shall be 0,1 dB per splice. The housing of the closure shall be galvanized sheet steel or stainless steel construction to Class IP 65 of IEC 60529. The joint cabinet shall be mounted 1.5 m above the anti-climbing device.

17.5 Line Clearances

17.5.1.1 The minimum height above ground level (or any other place where a person may stand, including a ladder or scaffolding placed against any building or other structure) of any conductor forming part of an overhead line shall, at the maximum likely temperature of the conductor, be as established in the following table:

Nominal Voltage of Line	***Minimum Clearance***
110 kV	6.7 metres
220 kV	7.75 metres
400 kV	9.3 metres

17.6 Line Crossings

17.6.1.1 Where any overhead line crosses under a line of a higher nominal voltage, the towers on both sides of the crossing point shall be section towers.

17.6.1.2 The minimum vertical clearance between **transmission** lines and the conductors of overhead lines operating at lower voltages shall be as detailed in the following table:

Nominal Voltage of Line	***Minimum Clearance***
110 kV	2.8 metres
220 kV	3.5 metres
400 kV	4.6 metres

17.6.1.3 The vertical distance between the conductors of **transmission** lines and the supports of overhead lines operating at lower voltages shall be as detailed in section 17.5.1.1.

17.7 Air Navigation

17.7.1.1 Where required by air navigation authorities, aircraft warning spheres shall be fitted to the earthwires of **transmission** lines. The warning spheres shall be 600 mm diameter, made of anodised aluminium coloured International Orange so that they will not fade when subjected to the direct rays of the sun. They shall be manufactured in two halves with appropriate provision for drainage and designed to allow easy assembly and attachment to the conductor. Clamping devices shall not damage the conductor but will prevent the sphere from twisting or slipping on the conductor. All metal parts used for holding the spheres in position shall be of mild steel and galvanized.

17.8 Rights of Way and Tree Clearance

17.8.1.1 Overhead lines will be constructed over routes for which rights of way shall be obtained as established by articles 26 – 31 of the **law on energy**. In accessing property not in the ownership of the **TSMO**, representatives of the **TSMO** and any contractors operating on behalf of the **TSMO** shall do so in accordance with the requirements of the **code of practice for access to land and/or property**.

18 Disputes Procedure

18.1.1.1 Disputes arising from the operation of this **electrical equipment code** shall be dealt with in accordance with the **rule on dispute settlement procedures** approved by the **regulator** as a means for resolving disputes arising between parties in the power market.

19 Management of the Electrical Equipment Code

19.1.1.1 This **electrical equipment code** is prepared by the **TSMO** in accordance with its obligations under article 38.7 of the **law on electricity** and approved by the **regulator.** It lays down the conditions that have to be met by all **parties** in the circumstances covered by this code.

19.1.1.2 Revisions to this **electrical equipment code** will be undertaken by the **operational codes governance committee** established in accordance with the **rule on governance procedures** for technical/operational codes approved by the **regulator**. The **TSMO** shall take responsibility for incorporating any amendments that are agreed by the **OCGC** and approved by the **regulator** and will issue amended versions of the code as required.

19.2 Unforeseen Circumstances

19.2.1 In this Electrical Equipment Code

19.2.1.1 If circumstances arise that the provisions of this **electrical equipment code** could not reasonably have foreseen, the **TSMO** shall, to the extent reasonably practicable in the circumstances, consult promptly with all affected **parties** and the **operational codes governance committee** (**OCGC**) in an effort to reach agreement as to what actions, if any, should be taken. If agreement between the **TSMO** and those parties cannot be reached in the time available, the **TSMO** acting as a **reasonable and prudent operator** shall determine what actions, if any, should be taken. The **TSMO** shall notify the **parties** and the **regulator** of its decision and the reasons for it as soon as practicable.

19.2.1.2 Whenever the **TSMO** makes a decision, it shall do so having regard, wherever possible, to the views expressed by the other parties and, in any event, to what is reasonable in all the circumstances.

19.2.1.3 After the event the **TSMO** shall promptly refer all such unforeseen circumstances and any such decisions to the **operational codes governance committee** for consideration in accordance with section 19.1.1.2

19.2.2 Affecting the ability of Parties to Comply with this Code

19.2.2.1 Where a **party** is unable to comply with its obligations under this code for a **force majeure** event, it may send a notice to all affected **parties** and to the **regulator** detailing the reasons for it being unable to meet its obligations, why it believes these reasons are a **force majeure** event and the time during which the **force majeure** event will last.

19.2.2.2 During the period of **force majeure**, the **party**'s obligations shall be suspended to the minimum extent required by the **force majeure** event.

19.2.2.3 If any **party** believes that the declaration of **force majeure** is unreasonable, he may refer the matter to the **regulator** for review and the decision of the **regulator** shall be final. In the event that the **regulator** determines that the reasons for non compliance were not a **force majeure** event, then the obligations of the **party** claiming **force majeure** will not be considered to have been suspended.

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