MATERIAL AND EQUIPMENT STANDARD

FOR

MEDIUM VOLTAGE

AC SWITCHGEAR AND CONTROLGEAR

FOURTH EDITION

FEBRUARY 2021

FOREWORD

The Iranian Petroleum Standards (IPS) reflect the views of the Iranian Ministry of Petroleum and are intended for use in the oil and gas production facilities, oil refineries, chemical and petrochemical plants, gas handling and processing installations and other such facilities.

IPS is based on internationally acceptable standards and includes selections from the items stipulated in the referenced standards. They are also supplemented by additional requirements and/or modifications based on the experience acquired by the Iranian Petroleum Industry and the local market availability. The options which are not specified in the text of the standards are itemized in data sheet/s, so that, the user can select his appropriate preferences therein

The IPS standards are therefore expected to be sufficiently flexible so that the users can adapt these standards to their requirements. However, they may not cover every requirement of each project. For such cases, an addendum to IPS Standard shall be prepared by the user which elaborates the particular requirements of the user. This addendum together with the relevant IPS shall form the job specification for the specific project or work.

The IPS is reviewed and up-dated approximately every five years. Each standards are subject to amendment or withdrawal, if required, thus the latest edition of IPS shall be applicable

The users of IPS are therefore requested to send their views and comments, including any addendum prepared for particular cases to the following address. These comments and recommendations will be reviewed by the relevant technical committee and in case of approval will be incorporated in the next revision of the standard.

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GENERAL DEFINITIONS:

Throughout this Standard the following definitions shall apply.

COMPANY:

Refers to one of the related and/or affiliated companies of the Iranian Ministry of Petroleum such as National Iranian Oil Company, National Iranian Gas Company, National Petrochemical Company and National Iranian Oil Refinery And Distribution Company.

PURCHASER:

Means the “Company” where this standard is a part of direct purchaser order by the “Company”, and the “Contractor” where this Standard is a part of contract documents.

VENDOR AND SUPPLIER:

Refers to firm or person who will supply and/or fabricate the equipment or material.

CONTRACTOR:

Refers to the persons, firm or company whose tender has been accepted by the company.

EXECUTOR:

Executor is the party which carries out all or part of construction and/or commissioning for the project.

INSPECTOR:

The Inspector referred to in this Standard is a person/persons or a body appointed in writing by the company for the inspection of fabrication and installation work.

SHALL:

Is used where a provision is mandatory.

SHOULD:

Is used where a provision is advisory only.

WILL:

Is normally used in connection with the action by the “Company” rather than by a contractor, supplier or vendor.

MAY:

Is used where a provision is completely discretionary.

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APPENDICES:

1. SCOPE

1.1 This standard specification covers the minimum requirements for design, manufacture, test, inspection and quality control of medium voltage air insulated switchgear (AIS) and gas-insulated switchgear (GIS) and controlgear assemblies for alternating current of rated voltages above 1 kV and up to and including
52 kV for indoor installation and for service frequency of 50 Hz herein after referred to this specification as ”medium voltage switchgear” or “switchgear“.

For outdoor installation, requirement of related IEC standards shall be applied.

1.2 The switchgear will be installed in oil, gas and petrochemical industries under the environmental and service conditions specified herein.

1.3 The general requirements are given in this specification. The specific requirements of individual cases will be given in request for quotation and / or purchase order.

1.4 This standard specification will be supplemented by a single line diagram, data sheet and other attachments when necessary.

Note 1:

According to IEC 60050-601, high-voltage switchgear is the rated voltage above 1 000 V. However, medium voltage switchgear is commonly used for distribution systems with voltages above 1 kV and generally applied up to and including 52 kV.

Note 2:

The standard specification for switchgear IPS-M-EL-140(0) is withdrawn, and replaced by the following two standard specifications.

- IPS-M-EL-143 (1) “Low Voltage Switchgear and Controlgear”
- IPS-M-EL-144 (1) “Medium Voltage AC Switchgear and Controlgear”

Note 3:

This is a revised version of this standard, which is issued as revision (4)-2021. Revision (1)-2004, revision (2)-2013, revision (3)-2020 of the said standard specification are withdrawn.

2. REFERENCES

2.1 The medium voltage switchgear shall be designed, manufactured, inspected and tested in accordance with the applicable sections of the latest edition of the following International Electrotechnical Commission “IEC” standards. This standard specification is primarily based on IEC recommendations 62271.

IEC (INTERNATIONAL ELECTROTECHNICAL COMMISSION)

IEC 60038	“IEC Standard Voltages”
IEC 60044	“Instrument Transformers”
IEC 60051	“Direct acting Indicating Analogue Electrical Measuring Instruments and their Accessories”
IEC 60059	“IEC Standard Current Ratings”
IEC 60071-2:2018	“Insulation Co-ordination-Part 2: Application Guidelines”
IEC 60073	“Basic and Safety Principles for Man-Machine Interface, Marking and Identification-Coding Principles for Indicators and Actuators”
IEC 60079-1	“Explosive Atmospheres-Part 1: Equipment Protection by Flameproof Enclosure “d””

IEC 60079-10-1	"Explosive Atmospheres-Part 10-1: Classification of Areas-Explosive gas Atmospheres"
IEC 60282	"High Voltage Fuses"
IEC 60376	"Specification of Technical Grade Sulphur Hexafluoride (SF_6) and Complementary Gases to be Used in its Mixtures for Use in Electrical Equipment"
IEC 60445	"Basic and Safety Principles for Man-Machine Interface, Marking and Identification- Identification of Equipment Terminals, Conductor Terminations and Conductors"
IEC 60529	"Degrees of Protection Provided by Enclosures (IP code)"
IEC 60644	"Specification for High-Voltage Fuse-Links for Motor Circuit Applications"
IEC 60688	"Electrical Measuring Transducers for Converting AC. And DC. Electrical Quantities to Analogue or Digital Signals"
IEC 60947-5	"Low Voltage Switchgear and Controlgear- Control-Circuit Devices and Switching Elements"
IEC 60947-6	"Low Voltage Switchgear and Controlgear- Multiple Function Equipment"
IEC 60947-7	"Low Voltage Switchgear and Controlgear- Ancillary Equipment"
IEC 61850	"Communication Networks and Systems for Power Utility Automation"
IEC 61869	"Instrument Transformers"
IEC 62052-11	"Electricity Metering Equipment - General Requirements, Tests and Test Conditions- Part 11: Metering Equipment"
IEC 62262	"Degrees of Protection Provided by Enclosures for Electrical Equipment Against External Mechanical Impacts (IK Code)"
IEC 62271-1	"High Voltage Switchgear and Controlgear- Part 1: Common Specifications for Alternating Current Switchgear and Controlgear"
IEC 62271-100	"High Voltage Switchgear and Controlgear- Part 100: Alternating Current Circuit Breakers"
IEC 62271-102	"High Voltage Switchgear and Controlgear- Part 102: Alternating Current Disconnectors and Earthing Switches"
IEC 62271-103	"High Voltage Switchgear and Controlgear- Part 103: Switches for Rated Voltages above 1kV up to and Including 52kV"
IEC 62271-104	"High Voltage Switchgear and Controlgear- Part 104: Alternating Current Switches for Rated Voltages Higher than 52kV"
IEC 62271-105	"High Voltage Switchgear and Controlgear- Part 105: Alternating Current Switch-Fuse Combinations for Rated Voltages above 1kV up to and Including 52kV"
IEC 62271-106	"High Voltage Switchgear and Controlgear- Part 106: Alternating Current Contactors, Contactor-Based Controllers and Motor Starters"
IEC 62271-200	"High Voltage Switchgear and Controlgear- Part 200: AC Metal-Enclosed Switchgear and Controlgear for Rated Voltages above 1 kV and up to and including 52 kV"
IEC 62271-306	"High Voltage Switchgear and Controlgear- Part 306: Guide to IEC 62271-100, IEC 62271-1 and Other IEC Standards Related to Alternating Current Circuit-Breakers"

API (AMERICAN PETROLEUM INSTITUTE)

API RP505	"Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as class 1, zone 0, zone 1 and zone 2"

IEEE (The Institute of Electrical and Electronics Engineers)

C37.2 (IEEE C37.2)	"Electrical Power System Device Function Numbers, Acronyms, and Contact Designations"

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-E-EL-100	"Engineering Standard for Electrical System Design (Industrial and Non-Industrial)"
IPS-E-EL-110	"Engineering Standard for Hazardous Area"
IPS-M-EL-161	"Material and Equipment Standard for General Electrical Items"
IPS-M-EL-174	"Material and Equipment Standard for Battery and Battery Charger (DC Power Supply)"

2.2 Definitions of general terms conform to international electrotechnical vocabulary IEC 60050 (chapters 441 and 151).

2.3 Where standards other than IEC are specified (such as IEEE C37.2), it is understood that the equivalent IEC standard is acceptable.

2.4 Any deviation from this specification and the above mentioned references shall be clearly mentioned in the vendor's proposal.

3. SERVICE CONDITIONS

3.1 The switchgear specified herein shall be installed indoor in substation rooms, which will be ventilated and air conditioned.

3.2 As far as the area classification is concerned the substation rooms and other indoor locations where the switchgear will be installed are considered safe area. This standard specification specifies the equipment suitable for safe area indoor installation.

3.3 Unless otherwise stated in data sheet, the ambient air temperature for indoor equipment does not exceed 40 °C and its average value, measured over a period of 24 h does not exceed 35 °C. The ambient air temperature does not drop below –5 °C;

3.4 Ambient air temperature is that existing in the vicinity of the equipment if supplied without enclosure, or in the vicinity of the enclosure if supplied with an enclosure.

3.5 Unless otherwise indicated in data sheet, the altitude of the site of installation does not exceed 1000 meter.

For installations at an altitude higher than 1 000 m, the required insulation withstand level of external insulation at the service location shall be determined according to Clause 6 of IEC 60071-2:2018. The rated insulation level of the switchgear and controlgear should be equal to or higher than this value, reference is made to IEC TR 62271-306.

3.6 Unless otherwise indicated in data sheet,

the conditions of humidity are as follows:

– the average value of the relative humidity, measured over a period of 24 h, does not exceed 95 %;

– the average value of the water vapour pressure, over a period of 24 h, does not exceed 2,2 kPa;

– the average value of the relative humidity, over a period of one month, does not exceed 90 %;

– the average value of the water vapour pressure, over a period of one month, does not exceed 1,8 kPa.

Note 1: Condensation can be expected where sudden temperature changes occur in periods of high humidity.

Note 2: High humidity can also be due to ground level rainwater or for underground applications, from incoming cable raceways connected to switchgear.

In special service conditions, i.e. tropical indoor conditions, the average value of relative humidity measured during a period of 24 h can be up to 98 %.

Note 3: In certain regions with frequent occurrence of warm humid winds, sudden changes of temperature and/or atmospheric pressure can occur.

3.7 If special service conditions mentioned in data sheet, refer to IEC 62271-1.

3.8 The conditions during transport and storage will be a temperature range of -25ºC to 55ºC and relative humidity of up to 98%. The equipment subjected to these extreme conditions without being operated shall not be damaged and shall operate normally under the specified conditions.

3.9 Unless otherwise specified in the datasheet, the assembly and the components installed therein shall be suitable for use in medium site pollution severity class according to IEC 62271-1. However, the air will be laden with dust, salt and/or sulphur as encountered in the petroleum industries.The equipment subjected to these extreme conditions without being operated shall not be damaged and shall operate normally under the specified conditions.

3.10 The equipment shall be suitable for operation, without deleterious effect, with variations of voltage and frequency tolerances as follows:

- AC Voltage supply: ± 10%
- Frequency: ± 5%
- AC Auxiliary Voltage Supply: ±10%
- DC Auxiliary Voltage supply: +10 / -15%.

3.11 Impact strength shall be at minimum IK 08 as defined in the IEC 62262.

4. APPLICATION

4.1 The voltage levels adapted in the oil, gas and petrochemical industries of Iran are based on the IEC 60038.

4.2 The nominal and rated medium voltage and rated insulation levels are shown in Table 4-1.

Table 4-1: Rated insulation levels for rated voltages

System	3 Phase/3wire, 50Hz			
Nominal Voltage (kV)	6	11	20	33
Rated Voltage (kV)	7.2	12	24	36
Rated one minute power-frequency withstand voltage kV (r.m.s)	20	28	50	70
Rated lightning impulse withstand voltage kV (peak)	60	75	125	170

Note For special applications or existing facilities, other voltages such as 3.3kV, 6.6 kV,

and 10 kV may be specified.

4.4 Unless otherwise indicated in data sheet appendix A, the neutral point of medium voltage systems are earthed through current limiting resistors.

4.5 The incomer and bus tie shall be equipped with circuit breakers. Circuit breaker or fuse-contactor can be used for outgoing feeder and motor starter when appropriate, together with the required auxiliary components as specified in this specification and/or indicated in the single line diagram/s.

4.6 The incomer circuit breakers of the medium voltage switchgears, if more than one, shall be closed at normal operation. The tie breaker/s can be closed at normal operation, or can be open which shall close automatically when one of the incomer breakers opens. The mode of operation of the tie breaker/s will be decided by company representative and shall be indicated in the single line diagram/s and/or data sheet. The protection scheme and intertripping of incomers and tie breakers with upstream breakers shall be included accordingly. For more information refer to IPS-E-EL-100.

4.7 Single line diagram/s show/s only the major components of the switchgear. Control circuit schematic diagrams, wiring diagrams, schedule sheets, interconnection diagrams and data sheet/s will be attached when necessary.

5. GENERAL REQUIRMENTS

5.1 Enclosure

5.1.1 The enclosure for medium voltage switchgear assemblies shall be suitable for indoor installation.

5.1.2 AIS and controlgear shall be of the withdrawable type and GIS shall be of the non-withdrawable type both having either a single or double busbar system, and consist of a number of separate panels assembled into one or more sections.

5.1.3 The enclosure shall be metal enclosed, PM type partition class as defined in IEC 62271-200, self supporting, free standing, floor mounted and shall be constructed with steel structure/s of minimum thickness of 2 mm. Thickness of other parts of enclosure shall be in accordance with type test certificate.

5.1.4 All equipment shall be installed inside the enclosure, suitably subdivided into separate functional units or compartments. The internal partitions shall be metallic and shall be earthed.

5.1.5 Unless otherwise specified in data sheet, the enclosure shall provide a degree of protection of IP 41 according to IEC 60529 without using the floor of the switchroom as part of the enclosure. The partitions between functional units and shutters for the busbar side and cable side shall at least provide a degree of protection of IP 2X.

5.1.6 For GIS, cubicle minimum Ingress Protection for the gas filled compartments shall be IP 64.

5.1.7 The height and the depth of the enclosure shall be as per manufacturer standard and shall be indicated in data sheet. Switches, buttons and operating handles shall be installed at a height of not more than 180cm.

5.1.8 The enclosure together with busbars and wirings shall be extendable at both ends without the need to cut or drill any part of the enclosure.

5.1.9 Spare feeder units complete with all equipment and auxiliaries shall be included in the medium switchgears, as indicated in single line diagram or datasheet.

5.1.10 Medium voltage switchgears shall include at least 20% of outgoing feeders and in each situation not less than two spare feeders (one installed on each busbar) as spare units. The spare units shall be equipped with all necessary components. The exact number and type of spare units will be specified by company representative.

5.1.11 The switchgear enclosure shall be self (natural) ventilating. The design of the structures and

the placement of the components shall be such as to avoid heat build-up in the top of the cubicles.

5.1.12 The enclosure shall be equipped with anti-condensation heaters , according to clause 7.6 of this specification.

5.1.13 All structures, sheeting and other metal parts shall be adequately protected against corrosion. Frame and partitions may be of hot dipped galvanised (HDG) steel without further paint coating. Those parts/covers requiring painting shall be properly pre-treated (degreased, phosphatized, cleaned) before the final coat(s) of oil resistant finishing paint is applied. The doors and panel front side shall be painted. . The painting shall be done by means of electrostatic powder coating based on epoxy and polyester resins. The thickness of paint coating shall be 60 to 80 microns and shall be cured in accordance with powder manufacturer specification. The color of the enclosure will be decided by company representative. Manufacturer's standard painting system, if different from above shall be agreed by company representative.

5.1.14 All incoming and outgoing cables will enter the switchgear from trenches or floor cut-outs (openings). If busducts are specified for incomers, they enter the switchgear from above. In case incomers are specified to be via busducts, the switchgear supplier shall provide flanged entry to the switchgear with insulated copper bars extending to the flange point. The size of copper bars shall be agreed by company representative.

5.1.15 The incoming and outgoing power and control cables will be terminated in suitable cable glands (cable glands will be supplied by others). Undrilled gland plates shall be provided in the switchgear assembly for this purpose. Where single core cables are to be used the gland plate shall be non-magnetic.

5.1.16 The auxiliary wires shall be terminated in terminal blocks as specified in clause 5.3.

5.1.17 The switchgear assembly shall be complete with eyebolts/lifting eyes and or specific rollers kit, etc., to facilitate installation.

5.1.18 Foundation bolts and installation instructions shall be provided by the vendor.

5.1.19 Each GIS cubicle shall be divided in different gastight compartments (busbars, circuit breaker(s)) encapsulating all MV live parts.

5.1.20 The Loss of Service Continuity category (LSC) of AIS switchgear shall be LSC2B according to IEC 62271-200.

5.2 Busbars

5.2.1 Unless otherwise indicated in single line diagram/s the switchgear shall be equipped with a single busbar system. Busbars shall be manufactured from hard drawn, high conductivity copper.

5.2.2 Busbars shall be designed for the full rated current at the maximum ambient temperature specified without exceeding their temperature rise limits. Design of the busbars shall be such that future extension of the switchgear to either side will be possible.

5.2.3 Power busbars shall be fully insulated with flame retardant non-hygroscopic insulation material and shall be color coded. Suitable insulation shall be provided for the bolted joints. The insulation of busbar joints and connections shall be removable for inspection purposes. Bus bar joints and connections shall be corrosion protected by silver-plating and secured to prevent loosening.

5.2.4 Unless otherwise indicated in data sheet the color or the color coding of the busbars insulation shall be red, yellow and blue for phase busbars, from top to bottom and from left to right when facing the front of the switchgear.

5.2.5 The main horizontal busbars shall be of the same cross sectional area throughout the length of the switchgear. The cross section and the continuous ampere rating of the main horizontal busbars shall be indicated in data sheet/s.

5.2.6 Vertical busbars, if any, shall be of the same cross sectional area throughout their length and their current rating shall be equal to the sum of the maximum full load ratings of the outgoing

functional units connected to that busbar.

5.2.7 The horizontal and vertical busbars shall be capable of withstanding, without damage, the magnetic forces and the thermal effects created by the maximum specified short circuit current for at least 1 second. The busbars short circuit withstand current shall be indicated in data sheet.

5.2.8 Main horizontal busbars shall be in separate compartment. The vertical busbars shall also be in separate compartment and can be installed behind functional units of each vertical section. The vertical busbars shall be arranged such that accidental contact with live parts shall be impossible when the breaker/s or starter modules are withdrawn.

5.2.9 Where bus section (tie) breaker/s are specified, they shall be so arranged that one complete section of busbars and associated connections can be made dead and safe to work on, while the adjoining section of busbars is still alive. Integral earthing arrangements for each section of busbars shall be provided, such that the isolated busbars could be earthed.

5.2.10 An earth busbar, rated for the maximum available earth fault current for 1 second, shall run the entire length of the switchgear. Adequate provisions shall be fitted to connect the cables screen and/or armor to the earth busbar. The type test of the earth busbar shall conform to IEC 62271-200.The earth busbar shall be equipped with suitable connectors or bolts to be connected to earth copper conductors at both ends. The size of earth copper conductors shall be considered accrding to IPS-E-EL-100.

5.2.11 For GIS, gas insulated busbar systems shall be located in fully separated SF6 filled compartments, with separated SF6 pressure monitoring gauge with clearly visible pointer and equipped with a low pressure alarm contact.

5.3 Wiring, Terminals and Markings

5.3.1 All internal wiring shall be continuous from terminal to terminal with no splicing.

5.3.2 Wiring shall be stranded copper conductor with flame retardant PVC insulation. Minimum conductor sizes shall be 2.5 mm^2 for protection (CT/PT) and bonding conductors, and 1.5 mm^2 for control and signal wiring.

5.3.3 Covers and/or doors with electrical apparatus attached to them shall be connected to the switchgear frame via bonding flexible copper braided conductors at least 6 mm^2.

5.3.4 Where wiring is run through a metal sheet or barrier, bushing or other mechanical protection shall be provided.

5.3.5 All internal power supply auxiliary cables and wires shall be suitable for the largest continuous current rating of the functional unit at maximum ambient temperature and the short circuit current as limited by fuses or circuit breakers.

5.3.6 Flexible wires shall be used for connection of door mounted equipment to the cubicle mounted equipment. Such wiring shall be wrapped with flexible PVC coil or installed in flexible conduit and shall be firmly clamped at both ends to prevent movement at terminations.

5.3.8 All wiring shall be numbered on each end with permanently embossed wire markers of the heat shrinkable type or slip-on ferrules. Wire numbers shall match the manufacturer's interconnection drawings.

5.3.9 All wires shall have cable lugs and shall be terminated in clamp type terminals such that direct contacts between screw, bolt or nut and cable lugs are avoided. For current transformers secondary wiring, ring type cable lugs shall be used.

5.3.10 The terminals shall be identified by suitable permanent numbers in accordance with the relevant wiring diagrams. Terminal marking shall comply with IEC 60445.

5.3.11 Not more than two wires shall be connected to any one terminal. Links shall be provided where more connections are required at one point.

5.3.12 Wiring in various circuit breakers, starter and feeder cubicles performing the same common function shall bear the same wire and terminal numbers.

5.3.13 The control terminal blocks shall include 20% spare terminals.

5.3.14 Nameplates shall comply with IEC 62271-200 and information on the nameplates shall be approved by company representative. Nameplates shall be made of durable, corrosion resistant material. The nameplates shall at least contain the following information: Manufacturer's name or trade mark, type designation, serial number, date of manufacturing, applicable rated values and number of relevant standard. Nameplates shall be riveted or screwed.

5.3.15 Labels on withdrawable units shall be duplicated on the withdrawable part and its relevant cubicles.

Cubicles, compartments, withdrawable starters, circuit breakers and components shall be identified by labels with circuit numbers. Cubicle label designations (at front and rear of panel) shall be in accordance with the switchgear assembly single line diagram and associated data sheets.

5.3.16 Both sides of cubicles (front and rear) shall have label of feeders name/tag. Front and rear labels of feeder name/tag shall be riveted or screwed.

5.3.17 when operation of certain items of the switchgear needs sequential actions such as the release of interlocking features, instruction plates shall be provided near the point of operation.

5.4 Safety Considerations and Interlocks

5.4.1 The medium voltage switchgear and controlgear shall offer a maximum degree of safety under all normal operating and fault conditions. It shall be impossible to unintentionally, without the use of tools, touch live parts of the switchgear or to perform operations that may lead to arcing faults.

5.4.2 Air Insulated Switchgear (AIS) shall be designed for continuous operation at full load for at least 7 years without maintenance that would require the busbar system to be de-energized. Gas Insulated Switchgear (GIS) shall be designed for continuous operation at full load for at least 10 years without maintenance, unless the total number of allowed switching operations is exceeded.

5.4.3 Circuit breakers, and contactor units shall be provided with required safety interlocks in accordance with the functions of such equipment in the overall electrical system and shall conform to the requirements of IEC 62271-100. Interlocks shall be mechanical in nature.

Requirements of design and considerations of Interlocks are stated in Appendix B (Normative).

5.4.4 In addition to mechanical interlocks, motor starters shall be equipped with electrical interlocks in the control circuitry, such that it will be impossible to withdraw the starter unit when the starter is in the ON position. A micro switch operated by the movement of the withdrawable unit shall trip the starter prior to withdrawing the starter unit.

5.4.5 The reversing and two speed motor starters shall be equipped with suitable mechanical interlocks, in addition to the electrical interlocks in the control circuitries.

5.4.6 All interlocks that prevent potentially dangerous maloperations shall be constructed such that they can not be easily defeated. If any mechanical interlock is capable of being defeated without the use of tools, provision shall be made for padlocking. The requirements for interlocks and/or padlocking shall be approved by company representative.

5.4.7 When a withdrawable unit has been removed from the switchgear assembly, the live parts inside the fixed compartments shall be protected against touch. Shutters shall be provided to cover the busbar side and cable side disconnected contacts automatically. The shutters shall be mechanically operated by the movement of the withdrawable units. The shutters for the busbar side shall be equipped with padlock facilities in their closed position. For some units as may be required such as incomers and bus tie units padlock facilities shall be provided for both busbar side shutters and cable side shutters. Shutters shall be metallic and suitably earthed. Shutters shall be suitably labeled for busbar and cable side. It shall also be colored red for busbar side and yellow for cable side. For incomers and bus sections, both shutters shall be colored red.

5.4.8 Each functional unit of the switchgear assembly and each section of the busbars shall have integral facilities for earthing. Earthing arrangement for each section of busbars can be provided in each incomer circuit breaker and/or at the bus tie circuit breaker. Earthing switch shall be provided

on the cable side of all functional units. The operation of the earthing switch shall be interlocked with the functional unit switching devices so that it can be manually closed only when the relative switching device is not in service position. For incomers, earth switch shall have adequate interlock with both upstream switchgear and local incomer PT secondary voltage and a signal from closed earth switch shall be also sent to close and trip circuit of upstream switchgear. Padlocking facilities for locking the earthing devices in closed position shall be provided. Earthing method of functional units and busbar sections shall be approved by company representative prior to manufacturing. The earth switch shall be directly connected to switchgear earth bus through earth conductor.

a. For Air Insulated Switchgear (AIS), an integrally mounted three phase earthing switch suitable for local manual operation shall be provided on the cable side of all HV switching devices.

Earthing facilities for the earthing of the busbar system of each section shall also be provided. This shall be arranged via the incoming HV switching devices or alternatively by a withdrawable earthing device capable of making and carrying the prospective short circuit current. The Manufacturer shall separately quote for one or more withdrawable earthing devices when applicable. Other type of busbar earthing facilities shall be subject to Principal's approval.

Circuit earthing devices shall be arranged for local manual operation only. Earthing devices for motor starters may be automatically or manually applied when the starter is withdrawn.

When an earthing device has been fitted in a compartment, it shall not be possible to insert a withdrawable switching device into the service position of the compartment concerned.

b. For Gas Insulated Switchgear (GIS), an integrated three-position isolator, with busbar connected/isolated/earthed positions, shall be provided. A circuit or busbar earth shall only be applied via the HV switching device.

Unless otherwise specified in the requisition the busbar earthing system shall be integrated with the sectionaliser HV switching device.

c. Circuit and busbar earthing devices shall be normally arranged for local manual operation only. Suitable interlocks shall be fitted to prevent accidental earthing of a live busbar, refer to 5.11 of shell 33.67.51.31.

5.4.9 Temperature rise of current-carrying parts shall be limited to the values stipulated in IEC 62271-200 and derated in accordance with environmental conditions specified in data sheet.

5.4.10 The complete switchgear assembly shall be capable to withstand the thermal and dynamic stresses resulting from short circuit currents. The supplier shall state the short circuit withstand current of the assembly namely busbars, circuit breakers, starters etc. at quotation stage.

5.4.11 All the metallic non-current carrying parts of the switchgear including the main structure shall be bonded together and connected to the earth busbar. Doors shall be bonded to the main structure by means of flexible copper connections.

5.4.12 Metal-enclosed switchgear and controlgear shall be designed so that the following operations can be carried out safely:

– normal service, inspection and maintenance;
– determination of the energized or de-energized state of the main circuit including the checking of phase sequence;
– earthing of connected cables, locating of cable faults, voltage tests on connected cables or other apparatus and the elimination of dangerous electrostatic charges.

5.4.13 Each cubicle shall be equipped with voltage presence indicators (one per phase).

5.5 Internal Arc

5.5.1 The switchgear shall be qualified as classification IAC according to IEC 62271-200 with regard to its mechanical strength in the event of an internal arc. The test performance shall be in conformity with accessibility type AFLR.

5.5.2 The test shall be executed for all separate compartments within the functional unit containing HV equipment, i.e. busbar compartment, circuit breaker/contactor compartment and cable compartment.

5.5.3 Type test reports regarding internal arc withstand performance shall be available in the quotation stage.

5.5.4 All assemblies shall be type-tested against internal arc at their rated short circuit current, preferably with an arc withstand duration of 1s.

5.5.5 Where internal arc test withstand time is less than the short circuit withstand time of the busbars then manufacturer's proposal must clearly state that the protection responding to internal arcs must be arranged to operate before the tested internal arc withstand time is exceeded.

5.5.6 Manufacturer shall offer as an option, his proposals to meet this condition if the original enquiry does not incorporate protection capable of meeting this requirement without compromising discrimination with incoming or outgoing circuits.

5.5.7 Where the manufacturer's proposal includes detection of an arc and provision of a trip signal to the upstream or supplying circuit breaker then additional trip signal cable requirement shall be clearly stated in manufacturer's offer.

5.5.8 To provide enough space for arc extinguishing, there shall be at least 1600 mm clearance on top of arc relief flaps of MV cubicles (without any reservation for cable tray, HVAC duct, etc.).

Note: For arc resistance clearances, manufacturer recommendations shall be adhered to.

6. MAJOR COMPONENTS

6.1 Circuit Breakers

6.1.1 In the medium voltage switchgear, circuit breakers shall be used as incomer/s to the switchgear, bus coupler/s, feeders and when indicated in the single line diagram/s, as motor starters.

6.1.2 Circuit breakers shall be three pole withdrawable complete with vacuum interrupters and self aligning disconnecting devices.

6.1.3 The contacts of vacuum interrupters shall be made of proper material such as chrome-copper or equivalent in order to assure low chopping levels of current and produce no harmful overvoltages.

6.1.4 For special applications where vaccum technology does not fulfill the technical requirements (Such as switching of capacitor banks), SF6 circuit breakers could be proposed upon approval of company representative.

When sulfur hexafluoride (SF6) is used, technical grade shall comply with IEC 60376.

6.1.5 Circuit breakers shall conform to IEC 62271-100 in terms of rating, testing and performance and shall be suitable for uninterrupted duty.

Unless otherwise specified in the requisition, "Extended mechanical endurance" Circuit breakers class M2 shall be applied with "Extended electrical endurance" class E2.

6.1.6 Rated currents of circuit breakers shall be selected conforming with IEC 60059 recommendations taking into account possible deratings as per site condition specified in data sheet. Incomer circuit breakers shall be sized to feed all the loads indicated in the single line diagram including the spare units.

The making and the breaking capacities shall be as a minimum rated to the peak current values and the short time withstand current in compliance with IEC 62271-100.

However, when a switchgear assembly is close to a generator, it shall be capable of breaking a short circuit current with a higher percentage d.c. component than the value given in related figure

of IEC 62271-100.

In this case the percentage d.c. component shall be calculated and specified in the project particular specification.

6.1.7 The short circuit capacity of circuit-breakers shall be appropriate to the specified system short circuit and power factor, and shall not be less than 25kA symmetrical.

6.1.8 Circuit breakers shall be capable of interrupting the specified short circuit current without the aid of replaceable current limiters or fuses.

6.1.9 The operating mechanism of circuit breakers shall be stored energy spring operated type and shall conform to the recommendations of IEC 62271-100. The charging of the spring shall be by electric motor with provisions for manual charging by hand. The spring of the operating mechanism, when charged, shall be capable of performing three circuit breaker operations viz: open, close and open. Anti-pumping devices shall be included to prevent pumping actions of the mechanism.

6.1.10 Unless otherwise specified in the data-sheets, circuit-breaker rated operating sequence shall be O - t - CO - t' - CO with t = 0.3 sec and t' = 3 min as per IEC 62271-100, Clause 4.104.

6.1.11 Unless otherwise indicated in data sheet/s the voltage of the spring charging motor as well as the circuit breaker close and trip voltage shall be 110V DC. 110V DC will be supplied from the substations DC power supply system.

6.1.12 Tripping of circuit breakers shall be by means of manual mechanical tripping device and DC shunt trip coil. Electrical and manual closing release shall be provided.

6.1.13 The circuit breakers used as motor starters will be controlled from remote-local control stations. The other circuit breakers shall be controlled either locally from the switchgear panels or from a separate remote control panel which will be installed in the substation room. The purchaser shall indicate the choice of local or remote control of such circuit breakers in data sheet/s.

6.1.14 The local manual open facility of each circuit breaker for motor starters shall be fitted with a guard to preclude inadvertent operation.

6.1.15 Facilities shall be provided for testing the circuit breaker closing and tripping mechanisms and current protection functions when the breaker is in TEST position.

6.1.16 There shall be three distinct positions for circuit breakers. The draw out mechanism shall hold the breaker rigidly in the three positions of CONNECTED, TEST and DISCONNECTED. The breaker disconnect device shall be interlocked with the breaker trip-shaft to prevent withdrawal or insertion of the breaker from/into the cubicle with the breaker in the ON position.

6.1.17 If moving of the breaker from or into the operating position requires undue effort by the operator, mechanical aids such as handle shall be provided as indicated in article 7.7. The breaker shall be lockable in the TEST position.

6.1.18 Circuit breaker control connections (secondary disconnects) shall be via fixed, self-aligning disconnects, or via flexible cord type plug connection. Either system shall allow test-operation of the breaker in the TEST position.

6.1.19 In addition to auxiliary contacts required for breaker operation, 2 N.O. + 2 N.C. similar spare contacts shall be provided and wired to the terminal strip. Spare contacts for test and service positions shall be also provided and wired to the terminal strip. If additional auxiliary contacts are required, it will be indicated in data sheet.

6.1.20 All low-voltage wiring to and from the circuit breaker shall be terminated on an easily accessible terminal strip within the LV compartment with label numbering. Each terminal and each wire shall be clearly identified by the same symbols or numbers used in the circuit diagrams.

6.1.21 Circuit breakers of identical rating and control voltage shall be completely interchangeable. It shall not be possible to interchange breakers of different ratings.

6.1.22 Circuit breakers shall have mechanical indicators to show their contact positions and spring charging status. The cubicles shall also be equipped with red and green indicating lights as per IEC 60073 recommendations to show whether the breaker is in closed or open position. In addition, a yellow indicating light shall be provided to show trip on fault condition.

6.1.23 Each circuit breaker shall be provided with a trip circuit supervision (TCS) system complete with a white indicating lamp to indicate that the trip circuit and trip circuit supply are healthy. For microprocessor based relays, the TCS shall be implemented using two digital inputs.

6.1.24 All circuit breakers for each switchgear shall be supplied from a unique manufacturer.

6.1.25 Each circuit breaker shall be equipped with required indicating instruments and protective relays as specified in IPS-E-EL-100 and indicated on single line diagram/s. The relays function numbers are according to ANSI standard C37.2 (IEEE C37.2).

6.2 Motor Controllers

6.2.1 The medium voltage switchgear shall include withdrawable motor starters installed in individual compartments. The numbers and sizes of motor starters will be indicated in the single line diagram/s and/or data sheet.

6.2.2 Unless otherwise indicated in single line diagram/s the motor starters for single speed, two speed and reversing motors shall be direct-on-line.

6.2.3 Soft start and variable frequency drive may be used following the electrical system study and process requirement. Star-delta or auto transformer reduced voltage motor starting may also be employed, according to company representative approval. Such requirements will be shown on single line diagrams.

6.2.4 Motor starter installed in medium voltage switchgear are intended to control 3 phase up to 6kV electrical motors. Motors rated 150kW to 1000kW shall be controlled by contactor type motor starters, and circuit breaker may be used by approval of company representative, and motors rated above 1000kW shall be controlled by circuit breakers specified in clause 6.1.

6.2.5 Motor starters installed in medium voltage switchgear are intended to control 3 phase 11kV electrical motors. 11kV motors shall be controlled by circuit breakers specified in article 6.1.

6.2.6 Contactor type motor starters which are only employed in MV switchgear shall be in accordance with the requirements of IEC 62271 and shall consist of the following:

- HRC power fuses
- Electrically operated vacuum contactor
- Appropriate protective relays
- Other protection and/or control devices and indicating instruments shall be as specified in IPS-E-EL-100 and/or shown on the single line diagram/s
- Incorporation of mechanical latch type contactor will be decided by company representative.

6.2.7 Main power fuses shall be of the current limiting HRC type in accordance with IEC 60282-1. The selection of fuse rating shall be such as to carry the specified starting current and also the number of starts per hour of the motor for the specified run-up time in accordance with IEC 60644. The characteristics of the fuses shall be appropriate for motors.

6.2.8 The fuses shall incorporate striker pins which shall trip the contactor via an operating mechanism, in case of operation of any one fuse. The appropriate electrical type indicator shall be provided.

6.2.9 Contactors shall be three poles magnetically operated vacuum type rated for utilization category AC3. For motors in inching or reversing services contactors with utilization category AC4 shall be used according to IEC 62271-106.

6.2.10 The contacts of vacuum contactors shall be made of proper material such as chrome-copper or equivalent in order to assure low chopping levels of current and produce no harmful over-voltages.

6.2.11 All motor starters with vacuum interrupters either circuit breaker or contactor shall be

equipped with suitable surge protection devices.

6.2.12 The contactors shall be capable of interrupting motor locked rotor current. Furthermore the contactors shall be sized to withstand thermal and magnetic stresses resulting from all possible short circuit currents for the maximum clearing time of HRC fuses.

6.2.13 In addition to the auxiliary contacts required to operate the starter, two spares N.O. and two N.C. auxiliary contacts shall be provided for each contactor and shall be wired to the terminal block of the compartment. Spare contacts for test and service positions shall be also provided and wired to the terminal strip.

6.2.14 Control scheme of motor starters shall be as per the requirements, shown in control circuit schematic diagrams.

6.2.15 The control voltage of contactors shall be 110VDC supplied by substation battery charger.

6.2.16 The contactor type motor starters shall be provided with testing facilities to permit testing of the starter unit when racked in test position.

6.2.17 Unless otherwise stated in control philosophy, Motor starters shall be equipped with local control stations according to the requirements of clause 7.1 of this specification.

6.2.18 Stay-put type stop/reset push-button accessible from outside of the starter compartment shall be provided on the front of all motor starters. Unless otherwise indicated in single line diagram/s no start push button is required on the starter compartment, except for testing as per paragraph 6.2.16.

6.2.19 Each starter module shall be equipped with the following pilot lights installed on the door of the starter compartment.

As a minimum, the following color code shall be used:

• Status signal light:
- closed/Run: RED
- Open/Stop: GREEN
- Fault/Trip: YELLOW
- TCS (Only circuit breaker type): WHITE

• Non illuminated push button:
- Close/Run: GREEN
- Open/Stop: RED
- Emergency Stop: RED
- Lamp test: BLACK
- Reset: BLUE

6.2.20 Starter modules of identical rating and control scheme shall be fully interchangeable. Units which are mechanically identical but electrically different shall not be interchangeable e.g. it shall not be possible to install a motor starter unit into a space for a feeder unit of the same size.

6.2.21 Contactor type motor starters shall include overload relays supplied from appropriable current transformers, instantaneous earth fault relay supplied from a core balance current transformer, single phasing protection relay and under voltage time delay tripping relay as specified in paragraph 6.2.23. For selected motor starters indicated in single line diagram/s anti-restart protection relay shall also be included. For complete detail of protection refer to IPS-E-EL-100.

6.2.22 Circuit breaker type motor starters, used for starting motors above 1000kW shall be equipped with the protective relays specified in IPS-E-EL-100 with anti-restart protection relay to be included in all such starters. Motor starters above 1000kW shall additionally include motor differential protection relay. Six numbers of current transformers shall be used for differential protection. Three numbers of these current transformers for such relays which will be installed in the motor neutral terminal box shall be suitable for the area classification zone in which the motor will be installed. Other three numbers of current transformers shall be supplied by switchgear supplier in coordination with the relevant motor supplier.

6.2.23 An under voltage relay shall be provided in each section of the switchgear. The operation of the under voltage relay shall be instantaneous and the drop out voltage shall be adjustable between 50% to 85% of the system voltage. The pick up voltage shall be at least 85% of the system voltage. Under voltage relays shall reset automatically and shall be equipped with manual resettable operation indication. Under voltage relays shall energize time delay tripping relays adjustable between 0.2 to 5 second located in incomer circuit breaker/s and all motor starters. Motor starters with time delay tripping relay shall be equipped with restart relay when indicated in the single line diagram/s, otherwise space for future installation of restart relay shall be foreseen.

6.2.24 Motor starters shall also include other protective or control relays stipulated by the process requirement and indicated in the single line diagram/s.

6.2.25 Relays shall be according to article 7.3 of this specification. Microprocessor type (numerical) motor protection relays are preferred.

6.2.26 All motor starters shall be provided with one ammeter installed on the starter front panel. This ammeter shall be fed from a current transformer installed on the middle phase. Starters shall also be fitted with a 1 Ampere secondary current transformer for remote indication of motor current. The ammeter fed from this current transformer will be installed in the relevant local control station.

6.2.27 Each motor starter either circuit breaker or contactor type shall be equipped with a motor heater supply circuit such that the motor heater is automatically switched ON when the starter is in OFF position. This circuit shall consist of a single pole miniature circuit breaker wired through a normally closed auxiliary contact of the circuit breaker or contactor and terminated in a terminal block for the purchaser's connection. Means shall be provided to bypass this contact when the starter is withdrawn or removed. The voltage of the motor heaters will be 230V single phase, and will be supplied from the substation low voltage system. One common 230V supply will be provided for each busbar section. Power rating of the motor heaters will be shown on single line diagram/s.

6.2.28 Regarding to 110VDC control voltages the following points shall be considered:

a) All contactors coils shall be rated 110VDC.

b) The circuit breaker closing, tripping and charging motor voltage shall be 110VDC.

c) The 110VDC voltage shall be supplied from the substations DC power supply system (battery and battery charger according to IPS-M-EL-174 with suitably sized protective fuse/MCB in each motor starter unit.

d) It shall be possible to connect 110VDC to the starter unit in order to test the starter when isolated from the main circuit.

6.2.29 Spare motor starters shall be provided as specified in paragraph 5.1.10.

7. AUXILIARY COMPONENTS

7.1 Local Control Stations (LCS)

7.1.1 Local control stations will be located near the motors which they control. If local control stations are to be supplied together with the switchgear it shall be indicated in data sheet. The mentioned requirements shall be according to IPS-M-EL-161.

7.1.2 Unless otherwise stated in control philosophy, the local station shall at least include start-stop pushbuttons together with suitable ammeter. The ammeter can be located adjacent to or be incorporated in the associated control station. It shall be possible to lock the control station in stop position.

7.1.3 Separate current transformers shall be mounted in the motor starter compartments to be connected to ammeters at local control stations in accordance with the requirement of article 7.4.

7.1.4 Terminals shall be provided in the starter compartments to be connected to the ammeter and push buttons installed on the local control stations.

7.1.5 Unless otherwise stated in control philosephy, “Local-Off-remoteRemote” or “handManual-Off-autoAuto” tri-state selector switches shall be provided on the doors of the starterLocal Control Stations compartments, when indicated on the single line diagram/s. The “Off position” in tri-state selector switches may be defined as “no-state” and shall not cause to stop the motor.

7.2 Instruments

7.2.1 Indicating and measuring instruments shall be provided as shown on single line diagrams and/or data sheet.

7.2.2 All instruments shall be manufactured in accordance with the requirements of IEC 60051.

7.2.3 Where indicated in the single line diagram/s and/or data sheet, 4-20mA output transducer/s complying with IEC 60688 shall be provided for selected analogue signals to be transmitted to a remote supervisory system such as distributed control system (DCS).

7.2.4 Measuring instruments shall be flush mounting type and shall have an enclosure with at least a degree of protection of IP41 and IP55 for indoor and outdoor applications, repectively.

7.2.5 Measuring instruments shall be operative by the passage of fault currents in the primary of current transformers or voltage variations on the system within the specified system characteristics.

7.2.6 Analog ammeters, voltmeters and watt-hour meters shall be of the accuracy class 1.5 or better. The accuracy class of the above digital devices shall be class 1.0 or better.

7.2.7 Ammeters for motor duty shall be analog-type and suitable to withstand the motor starting currents and shall have a compressed overload scale of at least 6 times the full load motor current. Scales for such ammeters shall be selected at least 120% of nominal load current appears in meter. Full load motor current shall be indicated by a red line on the ammeter scale.

7.2.8 Analog ammeter and voltmeter shall be considered for all incoming feeders.

7.2.9 All analog meters installed on the switchgear shall be of the square pattern type 72×72 mm. 96×96 mm meters are acceptable, but 72×72 mm is preferred. Scales shall be in actual values .

7.2.10 The accuracy class of digital instruments (such as ammeter/voltmeter) shall be compatible with relative class of instrument transformers.

7.3 Protective Relays

7.3.1 The protection function codes shown on single line diagram/s will be according to the latest edition of ANSI standard C37.2 (IEEE C37.2) and IPS-E-EL-100.

7.3.2 All protective relays with the same function shall be similar type and interchangeable. Prefferably the relays to be such that, the removal of each relay automatically short circuits the relevant current transformer.

7.3.3 All protective relays shall have provision for testing and microprocessor type relays shall be configurable. Each protection function shall be activated individually. Activating and de-activating each protective function does not disturb other function operation in any way.

7.3.4 All feedres shall be equipped with microprocessor type protection relays. Protection scheme shall be based on failsafe scheme and watchdog (self-monitoring) contacts must be provided in these relays to indicate the health of the device. This device shall have hardwired contacts for sending alarm signals..

7.3.5 Relays shall be equipped with clear trip indication, visible to the operator.

7.3.6 Relays shall be manually resettable. Undervoltage and under frequency relays shall be self resetting with indications of operation which shall be hand reset.

7.3.7 An individual external electromechanical lockout relay (86) shall be installed on all feeders to prohibit automatic restart after a failure. It shall be reset manually.

7.3.8 In all feeders, the secondary terminals of each current and voltage transformers shall be connected to accessible test block.

7.3.9 If programmable digital protective relays are employed, the relevant software together with instruction manuals and troubleshooting guidelines shall be included.

7.3.10 Unless otherwise stated in datasheet, all digital protective relays shall support the protocols stated in IEC 61850.

7.4 Current Transformers

7.4.1 Current transformers shall be in accordance with IEC 61869-2.

7.4.2 The rated secondary current shall be 1 or 5 Ampere for protective relays and 5 Ampere for measuring devices mounted in switchgears. For remote mounted instruments, rated secondary current shall be 1 Ampere, either directly or via intermediate current transformers.

The secondary leads of current transformers for remote mounted instruments shall be short circuited by a removable link at the switchgear factory.

7.4.3 The switchgear manufacturer shall be responsible for assessing and selecting the output rating of the current transformers. If there is any discrepancy from single line diagram of company representative, the manufacturer shall present sizing calculations of the output rating of the current transformers for confirmation of client.

Note: For classes 0,1 – 0,2 – 0,5 and 1, the ratio error and phase displacement at rated frequency shall not exceed the values given in IEC 61869-2, where the burden can assume any value from 25% to 100% of the rated output.

7.4.4 Current transformers for measuring purposes shall be of the accuracy class 1 or better. Current transformers for remote ammeters shall be of the accuracy class 3 or better.

7.4.5 Current transformers for protection purposes shall be of the accuracy class 5P. The accuracy class of current transformers used for motor protection relays shall be as specified by the relay manufacturer. In such case class 10P will be acceptable. The accuracy class of differential protection (ANSI code 87) current transformers shall be class X as defined in IEC61869-2.

7.4.6 The secondary of the current transformers shall be earthed on one side. Where current transformers are connected in Wye, the Wye point shall be earthed. The wiring of the secondary circuits shall be at least cross section of 2.5 mm^2. Separate earth wire shall be used for measuring and protection current transformers.

7.4.7 Secondary terminals of current transformers shall be wired up to terminal block with short-circuiting link, located at an accessible place.

7.4.8 Current transformers for circuit breakers and contactors shall be installed in the stationary part of the relevant cubicle.

7.4.9 Current transformers shall be capable of carrying, the specified fault current of the switchgear, without injurious heating or mechanical damage.

7.4.10 Current transformers shall have appropriate VA rating and security factor. The security factor shall not be less than 5.

7.4.11 The markings on the current transformers shall be in accordance with the requirements of IEC 61869-2.

7.4.12 Current transformers shall be encapsulated and dry type as per IEC 61869-1

7.5 Voltage Transformers

7.5.1 Voltage transformers shall be in accordance with IEC 61869-3, with secondary voltage 110V unless otherwise specified in data sheet.

7.5.2 Voltage transformers shall be withdrawable unless otherwise specified in data sheet and shall be protected by disconnect type current limiting fuses on primary side and fuses or miniature circuit breakers (MCB) on secondary side. Protective fuses for voltage transformers used with generator AVR/s may be eliminated if they are installed within the protection zone of the generator differential protection.

7.5.3 One side of the secondary winding of single phase voltage transformers and the star point of three phase voltage transformers shall be earthed through a removable link.

7.5.4 The voltage transformers for measuring purposes shall be of accuracy class 1 and for protection purposes shall be class 3P. Voltage transformers for use with generator AVR/s shall be of accuracy class 0.5.

7.5.5 Voltage transformers shall be encapsulated and dry type as per IEC 61869-1.

7.5.6 The switchgear manufacturer shall be responsible for assessing and selecting the output rating of the voltage transformers. If there is any discrepancy from single line diagram of company representative, the manufacturer shall present sizing calculations of the output rating of the voltage transformers for confirmation of client.

Note: For classes 0,1 – 0,2 – 0,5 and 1, the ratio error and phase displacement at rated frequency shall not exceed the values given in IEC 61869-3, where the burden can assume any value from 25 % to 100 % of the rated output.

7.5.7 For Gas Insulated Switchgear (GIS):
- Voltage transformers shall be connected via an isolator device or shall be mounted such that they can be relatively easily removed without depressurizing any gas filled chambers.
- Where isolator devices are fitted it shall be possible to isolate the voltage transformer without de-pressuring any gas filled compartment.
- Busbar voltage transformers shall be directly connected to the gas-insulated busbar systems without any HV cable connections.
- Any normally live connection on the primary side of a voltage transformer that is not within a gas filled compartment shall be fully insulated to withstand at least the line voltage of the system.

7.6 Anti-condensation Heaters

7.6.1 Anti-condensation heaters shall be installed at the bottom of each vertical section and shall be individually protected by miniature circuit breakers. It shall be rated for continuous service and shall operate on single phase voltage of 230Volt, 50Hz.

7.6.2 The numbers and sizes of the heaters, if not shown on drawings, shall be selected by the switchgear supplier.

7.6.3 The heaters shall be fed from dedicated power supply. This power supply system may be energized from a dedicated heater panel, independent lighting panel, or electrical distribution panel. The panels feeding the heaters in one section of the switchgear shall be fed from the opposite section of the bus bar.

7.6.4 Heater/s in each cubicle shall be protected by a miniature circuit breaker and an earth leakage protection device or residual circuit breaker of 30mA sensitivity.

7.6.5 In each cubicle a thermostat/hygrostat shall be provided for the operation of heater/s. An indicating light (preferably blue) shall be provided on the switchgear enclosure to indicate that the relevant space heater/s is in operation.

7.6.6 Heater/s terminals shall have safety cover.

7.7 Accessories

7.7.1 Accessories required for proper and safe operation of the switchgear shall be supplied. At

least the following accessories shall be furnished for each assembly or group of assemblies in the same switch room.

a) Device for manually charging the stored energy operating mechanism of circuit breakers.

b) Handle for moving circuit breakers and earth switch into positions.

c) Fuse pulling device.

d) Lifting trolley to remove circuit breakers or starter modules and PTs from the cubicles.

f) Test plugs and adaptor cables for protection relays and meter testing.

g) Test cabinet for testing circuit breakers, if required (optional).

h) Special tools for erection and maintenance if applicable.

8. TESTS AND INSPECTION

8.1 Fully type tests and routine tests shall be carried out on the switchgear according to the requirements of IEC 62271-200, IEC 62271-1, and the relevant IEC publications referred to therein. Type test certificates shall be provided. Type tests shall be performed on the unique type with same design.

8.2 Components installed within the assembly shall be type and routine tested in accordance with the applicable IEC standards. Certificates obtained from the component manufacturers shall be made available at the request of principal.

8.3 Purchaser will require the presence of his nominated representative to witness the tests based on IEC requirements as per agreed Quality Control Plan (QCP) and Inspection Test Plan (ITP). The supplier shall inform the date of such tests at least four weeks in advance.

8.4 Factory Acceptance Test (FAT) shall be carried out in presence of client/purchaser representative(s). The tests shall be carried out either on 100% of the plans or on sample panels selected by inspectors on random basis. FAT procedure and plan shall be decided upon and finalized by purchaser and manufacturer prior to tests.

FAT does not relief the manufacturer from its quality and contractual obligations. Manufacturer is obliged to conduct all routine tests according to relevant IEC standards on 100% of the panels. Routine test reports shall be presented to inspector during FAT as reference.

8.5 The purchaser's inspectors shall be granted the right for inspection at any stage of manufacture and testing.

8.6 Certificates shall be available at the quotation stage. Certificates issued/supported by independent testing laboratories are preferred

8.7 Routine Tests

Routine Tests are listed in Appendix C (informative).

8.7.1 Design and visual checks

Switchgear shall be visually inspected for conformity with the latest issue of the approved drawings, the requisition and the order. The following shall be verified:

Visual check (aspect, painting, finish, welding, sheet metal, lifting ring, assembly bolt torque, busbar bolt torque, conformity of torque values for main connections, lining up of measuring apparatus, handling devices, remote control and signaling, labels)

- The effectiveness and reliability of operating mechanisms, padlocks and interlock systems
- The internal wiring and cabling system
- The correct wiring of main and auxiliary circuits
- The suitability of clamping, earthing and terminating arrangements

- The insulation of the busbar system
- The availability of the earthing system throughout the switchgear
- Switchgear and main equipments current rating and short circuit interrupting capacity

- Dimension check (terminals, the inlet and terminal parts of cable shall have enough space for leading in and connecting the specified cables, busbar and wires, leakage path and insulation distance, fixation axis, overall dimensions)
- Check for conformity and existence of name plates, marking labels, notice boards for danger, marking of miscellaneous switchgear, wire marking, terminal marking, earth marking, phase marking with colors and all extra markings depending on specification requirements
- Check for interchangeability of equipment
- Check for the non-interchangeability of mechanically identical but electrically different withdrawable units
- Quality and quantity check for wearable parts and spare parts according to the specification concerned
- The following items shall be visual checked for CTs and PTs:
  - Check phasing and polarity
  - Check ratios and burdens
  - Check fuses of links for PTs
  - Check short circuit capacity for CTs

The type test certificates and routine test reports for above items shall also be submitted to company by vendor.

- Switchgear electrical operation test
- Check for validation of the interface link with the Electrical Control System (if applicable). The tests will be carried out in accordance with the tools and support (meeting, procedure and documentation) proposed by the Electrical Control System manufacturer.

Participation in the Factory Acceptance Tests of the Electrical Control System in order to test all the protection and Measurement Management Units (MMU), and the specific functions (restarting, automatic transfer, load-shedding, etc.), if applicable.

A test report shall be made of the routine tests.

9. SPARE PARTS

9.1 Together with the supply of all equipment under this specification, a complete set of spare parts for commissioning shall be supplied for each switchgear. The supplied spare parts shall comply with the same specifications as the original parts and shall be fully interchangeable with the original parts without any modification.

9.2 The vendor shall also supply a list of recommended spare parts for two years of operation.

10. DOCUMENTATION

10.1 The vendor shall supply the necessary information with the quotation to enable evaluation of the submitted proposal. General documents/drawings are not acceptable unless they are revised to show the equipment proposed.

The documents to be supplied with the quotation shall at least include the following:

a) Completed enquiry data sheet/s.

b) Summary of exceptions/deviations to this standard specification.

c) Brochures and catalogues containing description of typical switchgear and technical data on major and auxiliary components such as circuit breakers, contactors, relays, meters etc.

d) Type test certificates of the pertinent switchgear

e) List of accessories included in the bid.

f) Preliminary dimensional drawings.

g) Approximate shipping weights and sizes.

10.2 The documents which shall be supplied together with the equipment shall at least include the following:

a) Generated drawings and schematics shall be delivered in native type and hardcopy.

b) Updated and completed enquiry data sheet/s.

c) Final single line diagram/s.

d) Schematic control circuit diagrams of each kind of circuit breaker and starter module.

e) General arrangement drawings showing main dimensions, panels' layout, floor panel and shipping sections.

f) Drawing/s showing the location of field wiring terminal strips and power cable connections.

g) Information concerning interlock sequences and all logic diagrams if applicable.

h) List of major and auxiliary components, showing complete reordering information for all replaceable parts.

i) Recommended spare parts list for two years of operation.

j) Test reports and performance curves of the final routine tests.

k) Painting specification and test result/s.

l) Applicable test certificates.

m) Installation, operation and maintenance instruction/s.

n) Fault finding and troubleshooting manual/s.

o) Protective relay/s manuals, curves and setting ranges.

p) Cut-off current characteristics of fuses.

q) Total weight of the assembly and weight of the individual shipping sections.

r) List of accessories and/or any special tools required for erection, operation and maintenance.

11. SHIPMENT

11.1 The supplier of the equipment under this specification is the sole responsible for packaging and preparation for shipment.

11.2 The packaging and preparation for shipment shall be adequate to avoid mechanical damage during transport and handling.

11.3 Each shipping section shall be provided with permanently attached identification tag containing necessary information together with the switchgear identification number indicated in data sheet Appendix A.

11.4 Shipping documents with exact description of equipment for custom release shall be supplied, with the equipment.

11.5 Special precautions may be essential for the protection of insulation during transport, storage and installation, and prior to energizing, to prevent moisture absorption due, for instance, to rain, snow or condensation. Vibrations during transport should be considered. Appropriate instructions should be given by the manufacturer.
Special packaging should be proposed by the manufacturer for long term storage of parts for maintenance needs according to customer specifications.

12. GUARANTEE

12.1 The supplier of the equipment under this specification shall guarantee the equipment and shall replace any damaged equipment/parts resulting from poor workmanship and / or faulty design.

12.2 The supplier shall replace any equipment failed under the following condition:

- Failure under startup and commissioning tests performed according to IEC recommendations.
- Failure under normal usage for a period of 12 months, not exceeding 18 months from the delivery date to company.

APPENDICES

APPENDIX A

MEDIUM VOLTAGE SWITCHGEAR AND CONTROLGEAR TYPICAL DATA SHEET

The vendor shall complete and submit data sheet with his proposal.

Items marked with asterisk will be specified by purchaser.

1.	Name of project or plant	*
2.	Switchgear identification No	*
3.	Single line diagram number	*
4.	Site elevation above sea level (m)	*
5.	Maximum ambient air temperature, indoor	*
6.	Minimum ambient air temperature, indoor	*
7.	Maximum ambient air temperature, outdoor	*
8.	Minimum ambient air temperature, outdoor	*
9.	Average value of relative humidity (over a period of 24h)	*
10.	Average value of water pressure (over a period of 24h)	*****
11.	Average value of relative humidity (over a period of one month)	*****
12.	Average value of water vapor pressure (over a period of one month)	*****
13.	Average value of relative humidity for tropical indoor conditions (over a period of 24h), if applicable	*****
14.	Site pollution severity class	*
15.	Installation (indoor/ outdoor)	*
16.	Installation type (Concreted floor, False floor, Base frame, Concrete trench)	*
17.	Nominal system voltage, 3phase	*
18.	System voltage variation	*
19.	Nominal frequency and frequency variation	*
20.	AC auxiliary voltage supply	*
21.	DC auxiliary voltage supply	*
22.	Impact strength (IK)	*****
23.	Partition class	*****

24.	Switchgear short circuit withstand current rms symmetrical (KA)	*
25.	Switchgear short circuit withstand time	*
26.	Neutral earthing system (current limiting resistor)	*
27.	Incomers to the switchgear by duct or cable	*Attached Documents
28.	Enclosure degree of protection (IP code) for AIS	*
29.	Enclosure degree of protection (IP code) for GIS	*
30.	Plate thickness of the enclosure	
31.	Color of the enclosure	*
32.	Power busbars cross section	
33.	Busbars rated current	
34.	Busbars short circuit withstand current rms symmetrical (KA)	
35.	Busbars short circuit withstand time	
36.	Busbars joints (silver plated)	
37.	Busbars insulation	*
38.	Busbars colors	
39.	Loss of service continuity category (for AIS)	
40.	Internal arc classification	
41.	Circuit breaker extended mechanical endurance class	
42.	Circuit breaker extended mechanical electrical class	
43.	Circuit breaker operating sequence	
44.	Total length of the switchgear	
45.	Height of the switchgear	
46.	Depth of the switchgear	
47.	Shipping weight of the switchgear/individual shipping sections	
48.	Numbers of incomer circuit breaker/s	*
49.	Numbers of bus tie circuit breaker/s	*
50.	Tie breaker/s mode of operation OPEN/CLOSE	*
51.	Numbers of poles and current rating of incomer and tie breakers	*

52.	Circuit breakers interrupting medium (vacuum/SF6)	*
53.	Circuit breakers closing mechanism (direct manual/motor driven)	*
54.	Circuit breakers maximum interrupting capacity rms symmetrical	
55.	Short time current rating of circuit breakers at 1 sec. and 3 sec.	
56.	Circuit breakers breaking capacity (kA) rms asymmetrical	
57.	Circuit breakers making capacity (kA) asymmetrical	
58.	Rated interrupting time of circuit breaker	
59.	Closing time of circuit breaker	
60.	The voltage of the spring charging motor of circuit breakers	*
61.	Circuit breakers closing and tripping voltage	*
62.	Control of circuit breakers (local/remote)	*
63.	Circuit breakers protective relays	Attach list or diagram/s
64.	Circuit breakers indicating instruments	Attach list or diagram/s
65.	Contactor breaking capacity (kA) rms asymmetrical	
66.	Contactor making capacity (kA) asymmetrical	
67.	Watt-hour meter for incomers (supplied or not)	
68.	Additional auxiliary contacts for circuit breakers (paragraph 6.1.18)	*
69.	Numbers and sizes of outgoing feeder breakers	Attach list or diagram/s
70.	Numbers and sizes of motor starters, circuit breaker type	Attach list or diagram/s
71.	Numbers and sizes of motor starters, contactor type	Attach list or diagram/s
72.	Contactor type motor starters control voltage	*
73.	Motor starters protection relays	Attach list or diagram/s
74.	Communication protocol of digital relays	
75.	Motor starters indicating instruments	Attach list or diagram/s
76.	Local control stations (included or not)	*
77.	CT type and ratio for protection and indication	
78.	CT type and ratio for remote ammeter (on control station)	
79.	Minimum conductor size for protection wiring (CT, PT)	

80.	Minimum conductor size for control & signal wiring (CT, PT)	
81.	Numbers and wattage of anti-condensation heaters (if any)	
82.	4-20 mA output transducers	
83.	Manufacturer of MV circuit breakers	
84.	Manufacturers of MV contactors	
85.	Manufacturer of protective relays	
86.	Manufacturer of indicating instruments	
87.	Type test certificates for complete switchgear and components.	To be attached
88.	Accessories	Attach list
89.	Deviation from this specification if any	Attach list

APPENDIX B

ADDITIONAL REQUIREMENTS

FOR

INTERLOCKS AND EARTH SWITCHES

B.1 All normal operation of switching device including followings shall be behind closed doors:

- Rack-in / Rack-out Operation
- Manual Tripping of the circuit breaker
- Manual Closing of the circuit breaker (For firefighting feeders)
- Manual VCB spring charging (only in TEST position)
- Visualization of VCB Open/Close Status (Inspection window)
- Opening / Closing the feeder earth switch.

B.2 Required inherent (Design based) interlocks for CB withdrawable mechanism/CB/Feeder E/S:

When	And	Interlock to be satisfied
CB Truck/Cassette in service position	—	1 - CB Compartment door cannot be opened. 2 - E/S cannot be closed. 3 - VCB LV Control plug cannot be removed.
	CB is closed	CB Truck/Cassette cannot be racked out
CB Truck/Cassette in intermediate position (Neither in test nor in service position)	—	1 - CB Compartment door cannot be opened. 2 - E/S cannot be operated. 3 - CB cannot be closed. 4 - CB spring cannot be manually / automatically charged.
CB Truck/Cassette in test position	E/S is closed	1 - CB Truck/Cassette cannot be racked in.
	CB is closed	1 - CB Truck/Cassette cannot be racked in.
CB Compartment door is open	—	1- CB Truck/Cassette cannot be racked in
Feeder Earth Switch is closed	—	1 - CB Truck/Cassette can not be racked in. 2 - Rear cable compartment door can not be opened.

B.3 Required interlocks / Procedures for busbar earth switch (BES):

Suitable electrical or mechanical interlocks (Trapped keys) shall be utilized in order to ensure:

B.3.1 Busbar earth switch cannot be closed unless all feeders including bus couplers on same bus section are in racked-out (test) position.

B.3.2 Feeders on the earthed bus section cannot be racked-in unless the BES is open.

Table B.1- Other Requirements of Interlocks

Action	Required interlock
Closing feeder earth switch	**Electrical interlock using solenoid:** - External permissions if any (Dry contact) - Cable should be dead (using the contact from CVD (capacitive voltage display) or voltage relay where applicable), measures to be taken to defeat this interlock in case of auxiliary voltage failure. OR **Mechanical interlock using trapped key (where applicable):** - Upstream / Downstream CB is open.
Closing the CB in service position:	**Electrical interlock on closing coil:** - E/S is Open - No fault (According to the logic) - Permission from Up/Down stream feeder or logic. OR **Mechanical interlock using trapped key (where applicable):** **Upstream / Downstream Earth Switch is open.**

B.4 Circuit (Feeder/Line) Earthing

B.4.1 Provision for earthing each Feeder/Line shall be made by using individual spring assisted manual independent switch located within each fixed portion as an integral part of each switchgear panel. The switch shall be spring-assisted such that the closing action is not dependent upon the speed or continuity of movement of the operating handle. Switching portion of this Earthing switch shall be located in Cable compartment .

B.4.2 Each Feeder Earth-Switch is a three pole, linked (ganged) earthing switch device shall be full fault rated and its 'peak withstand current' (making capacity) and 'short-time withstand current' ratings shall be equal to that of main Circuit-Breaker .

B.4.3 The Earth switch shall be interlocked mechanically to prevent its closing operation unless the circuit breaker is fully withdrawn from the unit and secured into the isolated/TEST position. It shall not be possible to move the circuit breaker into the service position with the earth switch closed position .

B.4.4 Operation of the switch shall be by means of a separate operating handle, which shall be inserted into the front of the switchgear through a fully interlocked and padlockable access orifice. It shall not be possible to operate the switch by means of any device other than the operating handle. Positively driven mechanical indicators shall be provided to distinctly show the Earth-Switch OPEN and CLOSE positions.

B.4.5 An arc proof inspection window shall be provided at the rear of the panel through which the position of the earthing blades can be visually inspected.

B.5 Bus-bar Earthing

B.5.1 By using a separate and integral, 3-pole, linked (ganged), fully rated, spring assisted manual independent Earth-switch located within fixed portion of switchgear panel with different and individual access and location (i.e feeder earth switch and bus-bar earthing switch shall not be in same compartment), having clear and permanent identification labels to differentiate from Feeder E/S. Its 'peak with stand current' (making capacity) and 'short-time withstand current' ratings shall be equal to that of main Circuit-Breaker. Operation of the switch shall be by means

of a separate operating handle, which shall be inserted into the front of the switchgear through a fully inter-locked and lockable access orifice. It shall not be possible to operate the switch by means of any device other than the operating handle. As a minimum, this device shall be fitted to all individual busbars .

B.5.2 Inter Panels interlocking: An Electrical inter-locking system, between 'bus-bar earthing panel (s)' and the remaining switchgear panels in same section of the substation, need to be provided. The Wiring in the inter-locking system shall be such that closing of 'bus-bar earthing switches' is possible only when the CB trucks, in other panels of same section , are placed only in 'TEST' position. Further, it shall be possible to make bus-bar earthing of each section of sub-station individually or simultaneously .

Alternatively, a mechanical inter-locking system, by castle key method, between 'bus-bar earthing panel (s)' and the remaining switchgear panels in same section of the sub-station, need to be provided. The inter-locking system shall be such that, closing of 'bus-bar earthing switches' shall be possible only when the CB trucks, in other panels of same section, are placed in 'TEST' position only. Further, it shall be possible to make busbar earthing of each section of sub-station individually or simultaneously. However, a separate wall mounted metallic key-box shall be provided for each sub-station to place these keys. Each parking slot for the castle keys shall be clearly identified with the corresponding panel of the switch-board.

APPENDIX C

(INFORMATIVE)

TYPE AND ROUTINE TESTS

Type Test	Routine Test
Dielectric Tests	Dielectric Test on the Main Circuit
Resistance Measurement	Tests on Auxiliary and Control Circuits
Continuous Current Tests (Temperature-Rise Tests)	Measurement of The Resistance of The Main Circuit
Short-Time Withstand Current And Peak Withstand Current Tests	Tightness Test
Verification Of The Protection	Design and Visual Checks
Tightness Tests	Partial Discharge Measurement (Optional)
Electromagnetic Compatibility Tests (EMC)	Mechanical Operation Tests
Additional Tests on Auxiliary and Control Circuits	Pressure Tests of Gas-Filled Compartments
X-Radiation Test for Vacuum Interrupters	Tests of Auxiliary Electrical, Pneumatic and Hydraulic Devices
Verification of Making and Breaking Capacities	Tests after Erection on Site
Mechanical Operation Tests	Measurement of Fluid Condition after Filling on Site
Pressure Withstand Test for Gas-Filled Compartments	
Tests to Verify the Protection of Persons Against Dangerous Electrical Effects	
Internal Arc Test	