SESRIP P7 Lot A3 - Addendum to the Technical Specification

2.1.3.6 Breaker Switched Capacitor Banks

Automatically controlled Breaker Switched Capacitor Banks (reactive power compensation equipment) shall be installed at the substation as indicated in the Scope of Works. Capacitor banks and associated switchgear and control equipment shall be capable of switching on and off both automatically and manually to regulate voltage by injecting leading reactive power, and to control the power factor on the medium voltage (33 kV or 11 kV as may be applicable) busbar or windings of the power transformers to maintain it closer to 1 or a value set by the operator. It should also regulate the system voltage on the high voltage side of transformer automatically and manually. The total reactive power compensation requirement shall be distributed evenly among all power transformers as indicated in the Scope of Works. The capacitor bank reactive power compensation shall be switched in steps according to the step value specified in the Scope of Work at 33kV (or 11 kV), and the value specified in the Scope of Works is the MVA net value input to the system at the nominal voltage (33 kV or 11 kV).

Capacitor banks shall be three phase banks in double "Y" connection of two equally rated star connected modules with ungrounded neutrals, which is made up by connecting individual standard single phase capacitor units.

Studies, Calculations and Reports to be submitted before manufacturing

The Contractor has to carry out detailed study and submit a comprehensive report with preliminary design and calculations, justifying the values chosen for the design for approval by the Engineer. During the study voltage variation on the high voltage side and power factor variation and reactive power requirement on the medium voltage side shall be considered for appropriate period.

Influence created by the operation of Automatic Voltage Regulators (AVRs) of transformers shall be considered during the studies. Necessary coordination and modifications that need to be implement in both AVRs and Automatic Capacitor Controllers should be specified

In this study the contractor has to submit calculations justifying the MVAr rating selected for step sizes of capacitor banks to produce step size specified in the Scope of Works to the system at 33 V (or 11 kV). Proposed MVAr rating of capacitor step shall be common to both operating modes (voltage regulation and power factor control) with reactive power compensation. Further this study should also include harmonics, inrush and transient studies.

Safe capacitor switching sequence shall be proposed for both operating modes (voltage regulation and power factor control) with reactive power compensation. Necessary interlocks, which need be implemented in the bay controllers and protection IEDs shall

be submitted considering all possible operational scenarios such as automatic, manual and remote.

The Contractor also shall submit design proposal for the filter circuit according to the study and should submit how the capacitor system controls and monitors the harmonic overload of the equipment. Further, the Contractor shall prove that its design would prevent the equipment form additional resonances. Transformer impedance variation with tapping range and change of capacitance values due to aging of the capacitors during its lifetime shall be considered during the calculation of series and parallel resonance.

The Contractor also should prove that from its studies and calculations, all over voltage levels including rated voltage and insulation level selected for designing the capacitor bank are suitable for the installation.

Further this study should include calculations supported by the studies for selection of switchgear and justifying the switchgear ratings, proving that the switchgear selected is fully capable of handling all currents and surges that may occur under any switching operation of the capacitor bank The study report should also cover the effect of operation of the switchgear on the capacitors.

Shunt Capacitor Banks

This part of the Specification covers the design, manufacture, testing at the factory, delivery to site, erection, testing at site and commissioning of Medium Voltage (33 kV or 11 kV) shunt capacitor banks with associated switchgear and protection including all material and equipment required for a complete installation and for safe and reliable operation. This scope includes foundation, supporting structure and fencing as well as current limiting and discharging devices, voltage and current transformers and all electrical connections of these and to the substation earthing network. Also included are the power cables from the switchgear to the capacitor banks, control cables between the substation and the capacitor banks, and the protection relays. Any other equipment or devices necessary for safe and reliable operation shall be provided even if not specifically mentioned here.

The shunt capacitor banks will be used for reactive power correction. Both Capacitor banks and capacitor units shall be designed, tested and installed in accordance with IEC 60871 if not otherwise mentioned in this Specification.

The capacitor banks shall be suitable for outdoor installation under the environmental and service conditions as laid down in the respective Chapters of the Specifications, and the capacitors must be fully capable to operate and be switched under these conditions. Forced air cooling is not acceptable to reduce maintenance requirements.

Capacitor banks shall be three phase banks in Double-Y-connection of two equally rated star connected modules with isolated neutrals, which are made up by connecting individual standard single phase capacitor units.

Capacitor Units

Capacitor units may consist of one or several capacitor elements in the single container and insulated therefrom. Capacitor units shall be of the single phase type with both terminals being brought out through bushings.

The capacitor units shall have a dielectric formed of suitable material having well proven record and should meet the requirements of IEC 60871.

Capacitor impregnant should have a well proven record. Detailed characteristics of the impregnant must be furnished, and the impregnant shall not contain any PCB compound and be of low toxicity. The impregnant shall be a class 111 B (OSHA classification) combustible fluid and shall be easily disposable by burning without generating poisonous gases or shall be biodegradable.

Sufficiently high insulation level must be provided between capacitor element and the container.

Internal fuses shall be provided according to the IEC 60871 and for disconnection of any faulty capacitor element to prevent total failure of capacitor unit or bank. Any fuse operation shall not affect adjacent elements or fuses.

Each capacitor unit shall be equipped with an internal discharge device, which reduces the residual voltage from crest value of rated voltage U_n down to 50 Volts or less within 5 minutes after disconnection.

Unit Containers

Capacitor units shall have housing of stainless steel. These shall be given a suitable number of coats of weather proof paint for resistance to corrosive atmospheres. The outer paint shall be high gloss to reduce dust deposition. Both capacitor connections shall be brought out through bushings having minimum creepage distance of 25 mm/kV and terminals conforming to ISO standard (metric), with the container insulated. The container shall have stud for earthing.

Lifting eye shall be provided on each side of tank for easy installation of individual units.

The rupturing strength of the case when fitted with bushings, etc., and sealed as when in service for both steady pressures and shock pressures shall be tested at the manufacturer's works to demonstrate the ability of the case to withstand distortion due to internal pressure (e.g., pressure arising from dielectric, etc.).

Racks

Capacitor units are to be mounted on standard racks made of hot dip galvanised steel sections. These racks are also to be provided. The minimum substation clearances specified in section 1.3.2 of this Specification should be maintained. The mounting structures shall be suitable for bolting onto anchoring bolts of suitably designed foundations. Calculations on loading shall include an allowance for the weight of maintenance staff with tools (2 times 150 kg) and wind loads, etc. The safe removal and safe replacement of capacitor units shall not require the dismantling of any structural member or support, including insulators and main connections. Where necessary, approved means shall be provided on the capacitor equipment for the fixing and bonding of external connections to secure efficient earthing. Steel work and all items of the capacitor equipment shall have provision to temporarily earth the connections and apparatus during maintenance.

Power Losses

The loss of the capacitor banks shall not exceed 0.2 W/kvar,including the losses due to internal discharge resistors.

Capacitor Tolerances

Capacitor Tolerances shall be according to the IEC60871-1. Difference in capacitance between units or group of units when connected in series shall be selected to give minimum value to avoid over voltages caused by such differences.

Capacitance values shall be maintained equally for 3 phases to avoid unbalance.

Standard Temperature Category

All capacitors shall be designed for standard temperature category of -5°C or higher in accordance with IEC 60871. Further the capacitors shall withstand dircct exposure to sun throughout the day.

Maximum Permissible Overloads

1 Capacitor units must be suitable for long duration operation under the maximum ambient temperature (Standard temperature category -5°C) at admissible voltage levels in service between terminals according to the IEC 60871-1 clause 19.1. Selection of admissible voltage level is the responsibility of the Contractor, who will to prove from its studies and calculations the levels selected is suitable for the installation.

2. Capacitor units must be suitable for continuous operation at an r.m.s. sine current up to 1.3 times the current which occurs at rated sinusoidal voltage and rated frequency excluding transients.

Name Plate

Following information shall be given on the name plate of each capacitor unit according to IEC 60871-1:

1. Manufacturer
2. Identification number and Manufacturing year.
3. Rated output in kvar for three phase units total output shall be given.
4. Rated voltage Un in kV
5. Rated frequency in Hz
6. Temperature category
7. Connection symbol
8. Insulation level in kV
9. Discharge device indicated by words and rated ohmic value
10. Indication for Internal fuse by wording
11. Chemical or trade name of impregnant.
12. Reference standard (IEC no) and year of issue.
13. Measured capacitance in absolute values.

Following information shall be given on the name plate of the completed capacitor bank:. according to IEC 60871-1

1. Manufacturer
2. Rated output in Mvar. Total output to be given.
3. Rated voltage Un in kV
4. Insulation level, both the rated power frequency short duration and peak value of the rated lighting impulse voltage in kV
5. Rated frequency in Hz
6. Connection symbol
7. Minimum time required between disconnection and reclosure of the bank.
8. Time to discharge to 75V.
9. Any special instruction for safety

Tests

Type tests:

Following type tests are required as per IEC 60871:

- Thermal stability test.
- Measurement of the tangent of the loss angle of the Capacitor at elevated temperature.
- AC voltage test between terminals and container, dry test.

- AC voltage test between terminals and container, wet test.
- Lightning Impulse voltage test between terminals and container for capacitors intended for exposed installation.
- Short circuit Discharge test.
- Test of an external fuse in combination with a capacitor.
- Ionisation test on internal fuses.

Test certificates are to be submitted for the approval of the Employer/Engineer. Should no satisfactory type test certificates can be submitted, then type tests shall be performed in the presence of the Employer/Engineer.

Routine tests on every capacitor bank:

Following routine tests must be carried out on every capacitor on completion in accordance with IEC 60871 and test certificates shall be submitted:

- Capacitance measurement.
- Measurement of the tangent of the loss angle of the Capacitor
- Voltage test between terminals.
- AC voltage test between terminals and container.
- Test of internal discharge devises.
- Sealing Test.
- Discharge test on internal fuses.

Factory acceptance tests:

Factory acceptance tests are to be performed on each completed capacitor in the presence of the Employer/Engineer unless these tests are waived by the Employer/Engineer. The factory acceptance tests shall be the same as those mentioned above under routine tests.

Insulation levels and Rated Voltage of a Capacitor.

The r.m.s. value of the alternating voltage for which the capacitor bank is rated, and such voltage of the capacitor unit shall be decided by the contractor considering the influence of the capacitor itself. The rated voltage shall be higher than the maximum system voltage indicated below. Design calculations shall be submitted to the engineer justifying the selection of said voltages before manufacturing. Increase in the voltage due to the connection of shunt capacitors and voltage increase due to light load conditions shall be considered for the design.

The insulation levels shall be in accordance to the IEC 60871 and shall be not less than the values listed below. Further correct insulation requirements and insulation paths shall be selected from table 7 of IEC 60871-1 justifying the reasons and suitability. Other factors such as altitude of the installation site shall also consider when selecting the insulation levels.

Highest system voltage (line to line) U_m	Power Frequency AC test voltage (r.m.s value)	Impulse Test crest value
36 kV r.m.s	70 kV	170 kV
12 kV r.m.s.	28 kV	75 kV

Surge Limiting Coils

Surge limiting coils shall be installed in each feeding phase of capacitor bank. The inductivity shall be designed such that surges harmful to any equipment or to the substation operation are avoided. The coils shall be air insulated with bird barriers and mounted rigidly on post insulators. The coils of the three phases may be mounted one above the other. The choice of inductivity shall be supported by a calculation to be submitted for approval.

Switchgear

Each capacitor bank assembly shall individually be switched through an individual isolator and circuit breaker [rated to the same rating or higher of the capacitor bank rated voltage]. Care should be taken to select switching devices which operate without causing excessive over voltage. However, if restrike cannot be prevented, it may be necessary to use capacitors having higher insulation level and higher rated voltage.

The Specification for medium voltage switchgear (refer to Chapter 2.3) shall apply, and additionally the Contractor must prove by calculations submitted for approval by the Employer/Engineer that the switchgear is fully capable of handling all currents and surges that may occur under any switching operation of the capacitor bank installation.

Protection

For protection of the capacitor banks and their feeders, refer to Chapter 5.17.

Automatic Capacitor Control

Automatic Capacitor Controllers shall continuously monitor followings.

1. The Voltage of High Voltage Side (220 kV or 132 kV) of the power transformers HV side or busbar

2. The power factor and reactive power flow at the Medium voltage (33 kV or 11 kV) windings of the power transformers or busbar.

3. Disconnector and Circuit Breaker positions of Transformers and busbar both High voltage and Medium Voltage (Transformer parallel group)

Automatic on and off commands shall be given by the controllers to the circuit breakers of the individual capacitor banks based on following control modes.

1. Voltage Regulation Mode - Considering the voltage of High Voltage side, required leading reactive power shall be injected to Medium Voltage side by means of turning on and off circuit breakers of the individual capacitor banks

2. Power Factor Control Mode – Considering the power factor and reactive power flow at the Medium voltage windings of the power transformers or busbar, required leading reactive power shall be injected to Medium Voltage side to maintain the power factor to set value by turning on and off circuit breakers of the individual capacitor banks. Set value of power factor shall be other than unity and it shall be set remotely (From SAS and SCADA)

3. Time of day Control Mode - Which allow the capacitor bank to switch based on time of day or week which shall be set remotely (From SAS and SCADA).

4. Manual Control Mode - During the manual circuit breaker operations of individual capacitor banks, all switching operations shall be executed through the Capacitor Controllers.

The regulation criteria will be decided at the time of detail engineering stage by the Employer/Engineer. However, care shall be taken that a suitable hysteresis between the on and off commands is maintained to avoid switching too frequently. To prevent unnecessary conditions occurring due to independent operation of Transformer Automatic Voltage Regulator (AVR) and Automatic Capacitor Controller, necessary coordination shall be implemented in AVRs and Automatic Capacitor Controllers.

The control shall include monitoring of the voltage to prevent excessive high voltages. The automatic regulation devices shall be incorporated in control cubicles located in the control room, together with manual/automatic selector switches, control switches for operation of the circuit breakers including position indication of isolators and circuit breakers, power factor meters, reactive power meters and alarm tableau. Suitable interlocking shall prevent any dangerous mal-operation.

The automatic capacitor controllers need to be fully integrated into the Substation Automation System and Gateway through IEC 61850, so that it shall be possible to operate it om all the control modes remotely as well. It is necessary to submit IEC 61850 conformance certificate issued by an independent laboratory empowered by UCA

International Users Group tested according to the IEC 61850 for automatic capacitor controllers.

In the event of automatic capacitor controllers failure Bay Controller IEDs shall be programmed to switch capacitor banks in appropriate sequence only. Further it is necessary to integrate such sequence on the remote operation as well. (SAS and SCADA).

There shall be possibility of integrating additional capacitors banks which is equal existing number of Capacitor banks to Automatic Capacitor Controllers by CEB maintenance engineers. Therefore, necessary licenses, passwords and configuration software shall be handed over to CEB upon commissioning of capacitor banks by the Contractor. The configuration software shall be fully licensed software which can be used to undertake any of modification in the future by CEB. Further, hands-on training shall be provided on configuration, operation and maintenance of the Automatic Capacitor Controller and its software

Alarm Indication

One alarm indication tableau for each group of capacitor banks and all associated equipment shall be mounted on the control cubicles. Any protection action, supply voltage failure or MCB trip shall initiate an alarm tableau of the substation, along with initiation of the existing horn/buzzer.

Control Panels

The control panels shall be of self standing fully enclosed sheet metal type(please refer also to the specifications in other sections for similar panels.)

The front panels shall exhibit a single line diagram of the complete reactive power compensation installation with control and check back as described for control room panels.

Measuring instruments shall include:
Power factor meter for each busbar section
Voltmeter with selector switch for each busbar section
Ammeter with selector switch for each capacitor bank

Other controls shall include:
Local – remote switch
remote control through integration with SAS/SCADA
Automatic – manual switch
Alarm indication with multi- fascia annunciator panels
Lamp test pushbutton
The protection equipment shall be incorporated in the same cubicle. .

2.2.2. Metal Enclosed Capacitor Banks

2.2.1.1 General

Automatically controlled Breaker Switched Capacitor Banks (reactive power compensation equipment) shall be installed at the substation as indicated in the Scope of Works. Capacitor banks and associated switchgear and control equipment shall be capable of switching on and off both automatically and manually to regulate voltage by injecting leading reactive power, and to control the power factor on the medium voltage (33 kV or 11 kV as may be applicable) busbar or windings of the power transformers to maintain it closer to 1 or a value set by the operator. It should also regulate the system voltage on the high voltage side of transformer automatically and manually. The total reactive power compensation requirement shall be distributed evenly among all power transformers as indicated in the Scope of Works. The capacitor bank reactive power compensation shall be switched in steps according to the step value specified in the Scope of Work at 33kV (or 11 kV), and the value specified in the Scope of Works is the MVA net value input to the system at the nominal voltage (33 kV or 11 kV).

Capacitor banks shall be three phase banks in double "Y" connection of two equally rated star connected modules with ungrounded neutrals, which made up by connection of individual standard single phase capacitor units.

The general specifications of the installed medium voltage systems shall fulfil the following requirements:

1. Functionality
    a. Voltage Regulation
    b. capacitive reactive power compensation / harmonic suppression
    c. automatically switched steps for power factor control
2. Compensation System Design
    a. tuned capacitor banks with steps and tuning frequencies shall be supported by studies
3. Configuration
    a. Number of compensation systems and steps per system shall be according to the scope of works.
4. Data of compensation system
    a. each compensation system equipped with HV fuses and vacuum contactors
    b. iron core filter reactors
5. General system data
    a. installation place, indoor, IP 41

2.2.1.2 Studies, Calculations and Reports to be submitted

The Contractor has to carry out detailed study and submit a comprehensive report with preliminary design and calculations, justifying the values chosen for the design for approval by the Engineer. During the study voltage variation on the high voltage side and power factor variation and reactive power requirement on the medium voltage side shall be considered for appropriate period.

Influence created by the operation of Automatic Voltage Regulators (AVRs) of transformers shall be considered during the studies. Necessary coordination and modifications that need to be implement in both AVRs and Automatic Capacitor Controllers should be specified.

In this study the contractor has to submit calculations justifying the MVAr rating selected for step sizes of capacitor banks to produce step size specified in the Scope of Works to the system at 33 V (or 11 kV). Proposed MVAr rating of capacitor step shall be common to both operating modes (voltage regulation and power factor control) with reactive power compensation. Further this study should also include harmonics, inrush and transient studies.

Safe capacitor switching sequence shall be proposed for both operating modes (voltage regulation and power factor control) with reactive power compensation. Necessary interlocks, which need be implemented in the bay controllers and protection IEDs shall be submitted considering all possible operational scenarios such as automatic, manual and remote.

The Contractor also shall submit design proposal for the filter circuit according to the study and should submit how the capacitor system controls and monitors the harmonic overload of the equipment. Further, the Contractor shall prove that its design would prevent the equipment form additional resonances. Transformer impedance variation with tapping range and change of capacitance values due to aging of the capacitors during its lifetime shall be considered during the calculation of series and parallel resonance.

The Contractor also should prove that from its studies and calculations, all over voltage levels including rated voltage and insulation level selected for designing the capacitor bank are suitable for the installation.

Further this study should include calculations supported by the studies for selection of switchgear and justifying the switchgear ratings, proving that the switchgear selected is fully capable of handling all currents and surges that may occur under any switching operation of the capacitor bank The study report should also cover the effect of operation of the switchgear on the capacitors.

The targeted harmonic reduction shall be confirmed by real time monitoring for each operation case mention in the study report after the installation. Measurement shall be carried out as per the IEC 61000-4-30.

2.2.1.3 Shunt Capacitor Banks

This part of the Specification covers the design, manufacture, testing at the factory, delivery to site, erection, testing at site and commissioning of Medium Voltage (33 kV

or 11 kV) shunt capacitor banks with associated switchgear and protection including all material and equipment required for a complete installation and for safe and reliable operation. This scope includes foundation, supporting structure and fencing as well as current limiting and discharging devices, voltage and current transformers and all electrical connections of these and to the substation earthing network. Also included are the power cables from the switchgear to the capacitor banks, control cables between the substation and the capacitor banks, and the protection relays. Any other equipment or devices necessary for safe and reliable operation shall be provided even if not specifically mentioned here.
The shunt capacitor banks will be used for reactive power correction. Both Capacitor banks and capacitor units shall be designed, tested and installed in accordance with IEC 60871 if not otherwise mentioned in this Specification.

The capacitor banks shall be suitable for outdoor installation under the environmental and service conditions as laid down in the respective Chapters of the Specifications, and the capacitors must be fully capable to operate and be switched under these conditions. Forced air cooling is not acceptable to reduce maintenance requirements.

Capacitor banks shall be three phase banks in Double-Y-connection of two equally rated star connected modules with isolated neutrals, which are made up by connecting individual standard single phase capacitor units.

2.2.1.4 Capacitor Units

Capacitor units may consist of one or several capacitor elements in the single container and insulated there from. Capacitor units shall be of the single phase type with both terminals being brought out through bushings.

The capacitor units shall have a dielectric formed of suitable material having well proven record and should meet the requirements of IEC 60871.

Capacitor impregnant should have a well proven record. Detailed characteristics of the impregnant must be furnished, and the impregnant shall not contain any PCB compound and be of low toxicity. The impregnant shall be a class 111 B (OSHA classification) combustible fluid and shall be easily disposable by burning without generating poisonous gases or shall be biodegradable.

Sufficiently high insulation level must be provided between capacitor element and the container.
Internal fuses shall be provided according to the IEC 60871 and for disconnection of any faulty capacitor element to prevent total failure of capacitor unit or bank. Any fuse operation shall not affect adjacent elements or fuses.

Each capacitor unit shall be equipped with an internal discharge device, which reduces the residual voltage from crest value of rated voltage Un down to 75 Volts or less within 10 minutes after disconnection.

2.2.1.5 Unit Containers

Capacitor units shall have housing of stainless steel. These shall be given a suitable number of coats of weather proof paint for resistance to corrosive atmospheres. The outer paint shall be high gloss to reduce dust deposition. Both capacitor connections

shall be brought out through bushings having minimum creepage distance of 25 mm/kV and terminals conforming to ISO standard (metric), with the container insulated. The container shall have stud for earthing.

Lifting eye shall be provided on each side of tank for easy installation of individual units.

The rupturing strength of the case when fitted with bushings etc. and sealed as when in service for both steady pressures and shock pressures shall be tested at the manufacturers works to demonstrate the ability of the case to withstand distortion due to internal pressure (e.g. pressure arising from dielectric, etc.).

2.2.1.6 Power Losses

The loss of the capacitor banks shall not exceed 0.2 W/kvar, including the losses due to internal discharge resistors.

2.2.1.7 Capacitor Tolerances

Capacitor Tolerances shall be according to the IEC60871-1. Difference in capacitance between units or group of units when connected in series shall be selected to give minimum value to avoid over voltages caused by such differences.

Capacitance values shall be maintained equally for 3 phases to avoid unbalance.

2.2.1.8 Standard Temperature Category

All capacitors shall be designed for standard temperature category of -5°C or higher in accordance with IEC 60871. Further the capacitors shall withstand direct exposure to sun throughout the day.

2.2.1.9 Maximum Permissible Overloads

Capacitor units must be suitable for long duration operation under the maximum ambient temperature (Standard temperature category) at admissible voltage levels in service between terminals according to the IEC 60871-1 clause 19.1. If the capacitor influences the air temperature (i.e. indoor installations), the ventilation and/or choice of capacitor shall be such that the standard temperature category limits are maintained. The cooling air temperature in such an installation shall not exceed the temperature limits of temperature category by more than 5 °C. Selection of admissible voltage level is the responsibility of the contractor. Contractor has to prove from his studies and calculations the levels selected is suitable for the installation.

Capacitor units must be suitable for continuous operation at an r.m.s. sine current up to 1.3 times the current which occurs at rated sinusoidal voltage and rated frequency excluding transients.

2.2.1.10 Name Plate

Following information shall be given on the name plate of each capacitor unit according to IEC 60871-1:

6. Manufacturer
7. Identification number and Manufacturing year.
8. Rated output in kvar for three phase units total out put shall be given.
9. Rated voltage Un in kV
10. Rated frequency in Hz
11. Temperature category

12. Connection symbol

13. Insulation level in kV

14. Discharge device indicated by words and rated ohmic value

15. Indication for Internal fuse by wording

16. Chemical or trade name of impregnant.

17. Reference standard (IEC no) and year of issue.

18. Measured capacitance in absolute values.

Following information shall be given on the name plate of the completed capacitor bank: according to IEC 60871-1

1. Manufacturer

2. Rated output in MVAR. Total output to be given.

3. Rated voltage Un in kV

4. Insulation level, both the rated power frequency short duration and peak value of the rated lighting impulse voltage in kV

5. Rated frequency in Hz

6. Connection symbol

7. Minimum time required between disconnection and reclosure of the bank.

8. Time to discharge to 75V.

9. Any special instruction for safety

2.2.1.11 Tests

Type tests:

Following type tests are required as per IEC 60871:

- Thermal stability test.
- Measurement of the tangent of the loss angle of the Capacitor at elevated temperature.
- AC voltage test between terminals and container, dry test.
- Lightning Impulse voltage test between terminals and container for capacitors intended for exposed installation.
- Short circuit Discharge test.
- Test of an external fuse in combination with a capacitor.
- Ionisation test on internal fuses.

Test certificates are to be submitted for the approval of the Employer/Engineer. Should no satisfactory type test certificate be submitted, then type tests shall be performed in the presence of the Employer/Engineer.

Routine tests on every capacitor bank:

Following routine tests must be carried out on every capacitor on completion in accordance with IEC 60871 and test certificates to be submitted:

- Capacitance measurement.
- Measurement of the tangent of the loss angle of the Capacitor
- Voltage test between terminals.
- AC voltage test between terminals and container.
- Test of internal discharge devises.
- Sealing Test.
- Discharge test on internal fuses.

Factory acceptance tests:

Factory acceptance tests are to be performed on each completed capacitor in the presence of the Employer/Engineer unless he waives the test. The factory acceptance tests shall be the same as mentioned above as routine tests.

2.2.1.12 Insulation levels and Rated Voltage of a Capacitor.

The r.m.s. value of the alternating voltage for which the capacitor bank is rated, and such voltage of the capacitor unit shall be decided by the contractor considering the influence of the capacitor itself. The rated voltage shall be higher than the maximum system voltage indicated below. Design calculations shall be submitted to the engineer justifying the selection of said voltages before manufacturing. Increase in the voltage due to the connection of shunt capacitors and voltage increase due to light load conditions shall be considered for the design.

The insulation levels shall be in accordance to the IEC 60871 and shall be not less than the values specified in Chapter 1 Grid Specification. Further correct insulation requirements and insulation paths shall be selected from table 7 of IEC 60871-1 justifying the reasons and suitability. Other factors such as altitude of the installation site shall also consider when selecting the insulation levels.

Highest system voltage (line to line) U_m	Power Frequency AC test voltage (r.m.s value)	Impulse Test crest value
12 kV r.m.s.	28 kV	75 kV

2.2.1.13 Harmonic filter reactors

Three phase harmonic filter reactors are of iron core type with air gap. They are suitable for indoor use with an ambient temperature of 55°C. These reactors are resin-impregnated. The terminals are of flat copper bar type. The harmonic filter reactor is connected in series between the capacitor unit and the neutral point (insulated).

The following mentioned losses of the reactors have to be seen as valid with maximum harmonic current at continuous operation mode.

2.2.1.14 Switching

capacitor bank shall be switched only with capable circuit breaker or vacuum contactors, and have been tested for capacitive switching duty. Particularly if de-tuned or filter circuits have to be switched, the selection of the switching devices should be

done under consideration of the increased rated capacitor voltages. In order to guarantee re strike-free switching operation, it is recommend applying switching device with higher voltage ratings.

The specification for medium voltage switchgear (refer to Chapter 2.3) shall apply, and additionally the Contractor must prove by calculations submitted for approval by the Employer/Engineer that the switchgear is fully capable of handling all currents and surges that may occur under any switching operation of the capacitor bank installation.

2.2.1.15 Protection

For protection of the capacitor banks and their feeders, refer to Chapter 5.

2.2.2.16 Automatic Capacitor Control

Automatic Capacitor Controllers shall continuously monitor followings.

1. The Voltage of High Voltage Side (220 kV or 132 kV) of the power transformers HV side or busbar

2. The power factor and reactive power flow at the Medium voltage (33 kV or 11 kV) windings of the power transformers or busbar.

3. Disconnector and Circuit Breaker positions of Transformers and busbar both High voltage and Medium Voltage (Transformer parallel group)

Automatic on and off commands shall be given by the controllers to the circuit breakers of the individual capacitor banks based on following control modes.

1. Voltage Regulation Mode - Considering the voltage of High Voltage side, required leading reactive power shall be injected to Medium Voltage side by means of turning on and off circuit breakers of the individual capacitor banks

2. Power Factor Control Mode – Considering the power factor and reactive power flow at the Medium voltage windings of the power transformers or busbar, required leading reactive power shall be injected to Medium Voltage side to maintain the power factor to set value by turning on and off circuit breakers of the individual capacitor banks. Set value of power factor shall be other than unity and it shall be set remotely (From SAS and SCADA)

3. Time of day Control Mode - Which allow the capacitor bank to switch based on time of day or week which shall be set remotely (From SAS and SCADA).

4. Manual Control Mode - During the manual circuit breaker operations of individual capacitor banks, all switching operations shall be executed through the Capacitor Controllers.

The regulation criteria will be decided at the time of detail engineering stage by the Employer/Engineer. However, care shall be taken that a suitable hysteresis between the on and off commands is maintained to avoid switching too frequently. To prevent unnecessary conditions occurring due to independent operation of Transformer Automatic Voltage Regulator (AVR) and Automatic Capacitor Controller, necessary coordination shall be implemented in AVRs and Automatic Capacitor Controllers.

The control shall include monitoring of the voltage to prevent excessive high voltages. The automatic regulation devices shall be incorporated in control cubicles located in the control room, together with manual/automatic selector switches, control switches for operation of the circuit breakers including position indication of isolators and circuit breakers, power factor meters, reactive power meters and alarm tableau. Suitable interlocking shall prevent any dangerous mal-operation.

The automatic capacitor controllers need to be fully integrated into the Substation Automation System and Gateway through IEC 61850, so that it shall be possible to operate it on all the control modes remotely as well. It is necessary to submit IEC 61850 conformance certificate issued by an independent laboratory empowered by UCA International Users Group tested according to the IEC 61850 for automatic capacitor controllers.

In the event of automatic capacitor controllers failure Bay Controller IEDs shall be programmed to switch capacitor banks in appropriate sequence only. Further it is necessary to integrate such sequence on the remote operation as well. (SAS and SCADA).

There shall be possibility of integrating additional capacitors banks which is equal existing number of Capacitor banks to Automatic Capacitor Controllers by CEB maintenance engineers. Therefore, necessary licenses, passwords and configuration software shall be handed over to CEB upon commissioning of capacitor banks by the Contractor. The configuration software shall be fully licensed software which can be used to undertake any of modification in the future by CEB. Further, hands-on training shall be provided on configuration, operation and maintenance of the Automatic Capacitor Controller and its software

2.2.1.16 Alarm Indication

One alarm indication tableau for each group of capacitor banks and all associated equipment shall be mounted in the control cubicles. Any protection action, supply voltage failure or MCB trip shall initiate an alarm tableau of the substation, along with initiation of the existing horn or buzzer.

2.2.1.17 Control Panels

The control panels shall be of the self standing fully enclosed sheet metal type, refer also to the specifications in other sections for similar panels.

The front panels shall exhibit a single line diagram of the complete reactive power compensation installation with control and check back as described for control room panels.

Measuring instruments shall include:

Power factor, active power, reactive power and THD meter for each busbar section
Voltmeter with selector for each busbar section

Ammeter with selector switch for each capacitor bank

Other controls shall include:

Local Remote Switch

Remote control through integration with SAS/SCADA

Automatic – manual switch

Alarm indication with multi-fascia annunciator panels

Lamp test pushbutton

The protection equipment shall be incorporated in the same cubicle. .

2.2.2.19 System and Human Safety

System and human safety requirements differ depending on where the system is set up. Reactive power compensation systems for indoor is designed with internal arc classification (IAC) as per IEC 62271-200: 2011

Compensation systems shall consist of IAC test as free-standing system with pressure relief valves or with arcing channel.

2.2.2.20 Medium Voltage Metal Enclosed System

2.2.2.20.1General

This part of the Specification covers the design, ratings, testing, shipping, installation and commissioning of factory assembled, type tested metal enclosed system.

The descriptions cover only those general aspects, which are considered minimum quality and performance requirements by the Engineer. Further detailed and specific

data are contained in the drawings, data sheets and other documents that form part of these Bidding Documents.

The panel shall be complete, ready for installation, with all components furnished unless specifically excluded herein and as may be listed in Scope of Works /Technical Particulars & Guarantees under Employer's Requirements.

Spare parts, if required by the Bidder for operation & maintenance, shall be quoted, separately as required by the Mandatory Spare Parts list.

The complete documentation, drawings, manuals, etc. shall be included in the Supply and will be subject to the approval of the Engineer according to the requirements of these Specifications.

Standard designs and models from the Bidder's manufacturing program are preferred, provided they meet the requirements of these Specifications, serve the intended purpose, and can be shown to have at least five years of successful service in the field.

If a substantial improvement of any or all of the specified requirements expressed or implied herein is available from the Bidder, and this improved design offers economical advantages to the Employer, this should be offered as an alternative, together with the basic proposal which shall conform to the requirements of these Specifications.

All the equipment described in these Specifications is intended for continuous duty at the specified ratings under the specified ambient conditions. Unless otherwise noted, the panels shall be for front access only during operation and maintenance.

Data and documentation submitted with the Bidding Proposal shall enable the Engineer to evaluate the quotation against the requirements of the Specifications. Full descriptive information and filled-in data sheets are required as a minimum.

2.2.2.20.2 Panel Particulars

The feeder bays or panels shall be delivered completely, including all necessary material for fixing them on suitable plinths or rails.

The equipment shall be dust-proof and vermin-proof and provision shall be made against condensation, particularly if the load is switched off.

The infeed transformer bay or panel shall be placed in such a way that the current stress of the busbars is minimized. In the case of the heavily loaded transformer feeders, requiring an ancillary bay or panel next to the transformer infeed, this may be provided to accommodate multiple cable sealing ends and auxiliary equipment. In this respect, the cable ducts for the cables running from the infeed transformers to the MV switchgear should be arranged to end exactly under the relevant transformer bay or panel.

Protection relays and their associated instrument transformers are part of Scope of Supply. The relays shall be installed in the low voltage compartments associated with each individual switchgear bay or panel and its circuit breaker. The functions of the protection relays are indicated in the typical single line diagrams in Drawings and their required performance shall be in accordance with Chapter 5 of Technical Specification– Grid Substation. If the Bidder is of the opinion that the indicated protection scheme is not optimal, he shall indicate this fact in his proposal along with suggested improvements.

2.2.2.20.3 Performance, Standards and Codes

The panels shall operate satisfactorily within its rated values in the environment specified in Chapter 1 of this specification.

The panels are planned to be installed indoors in an air-conditioned room with a maximum service temperature of +30°C. However, service with rated data shall be guaranteed also in case the air-condition-system fails, or will not be installed. Therefore, the maximum ambient shade temperature at Site shall be the basic design data for the panels.

Routine maintenance to any of its external components, including the protective relays and instrument transformers, shall not be required in less than five year intervals; internal components shall be maintenance-free for at least ten years, including the refilling of SF6 gas (if any).

Performance, testing and rating shall conform to the latest edition of all relevant IEC Publications under the appropriate voltage category.

Bidder"s proposing other than the above standards must specifically indicate the standards to which his switchgear conforms, and indicate all deviations (if any) from the above codes that affect performance and rating.

Compliance of the panels manufacturer and the Contractor with the provisions of this Specification does not relieve the Contractor of the responsibility of furnishing panels and accessories of proper design, electrically and mechanically suited to meet the operating guarantees at the specified service conditions.

2.2.2.20.4 Design and Construction Electrical Data and General Requirements

a) Electrical key data as required by this Specification are stated in Scope of Works and in the enclosed single line diagram.

b) The switchboard, when installed and operating under the ambient conditions shall perform satisfactorily and safely under all normal and fault conditions. Even repeated operations under full rated fault conditions shall not lead to diminished performance or significantly shortened useful life of the panes. Arc faults caused by external reasons shall be positively confined to the originating compartment and shall not spread to other parts.

c) Temperature rise of current carrying parts shall be limited to the values stipulated in IEC 60694, i.e. +65°C for silver-plated contacts, +75°C for silver- plated connections, and +50°C for all other exposed parts, under rated current and the environmental conditions.

d) Lightning Impulse withstand capability and power frequency withstand capability for the entire switchboard shall be in accordance with IEC 60694, Table I and values required in schedules of technical particulars & gurantees.

e) Bracing of all mechanical components against the effects of short circuit current shall be a minimum of 2.5 times the rated symmetrical short circuit current.

f) Thermal rating for all current carrying parts shall be a minimum of one second for the rated symmetrical short circuit current. If the maximum short circuit time must be extended, the I^2 X t value shall remain constant.

g) The auxiliary voltages as per Chapter 1 are to be considered for the design, in particular for CB Motor control voltage, the Alarm voltage, the Close and trip voltage and the Space heater voltage.

h) The panels shall be of the free-standing, self-supporting, dead front design with all high voltage equipment installed inside metallic and earthed enclosures, suitably divided into individual compartments, at least for the

busbar system(s)

circuit breaker

cable connections

low voltage compartment

capacitors and reactors

i) Partitions between feeder bays or panels are required to avoid fault spreading from one feeder bay or panel to the other one and to the outside.

j) The row(s) of bays or panels shall be earthed through a suitable copper bar, which is to run along the full length of the switchgear, and to be connected to the station earthing, at least at two points.

k) The erection of the system shall not require any cutting, welding or drilling of material on site. Each line-up of switchgear shall be prepared for future extension on either end without any drilling, cutting or welding on the existing equipment.

l) The design shall provide for maximum levels of reliability, ease of operation and maintenance, and maximum flexibility. The possibility of field repairs and exchange of enclosure parts shall be taken into account. The panels shall be constructed identically to ensure that equivalent parts can be interchanged.

Design of the panels must allow for the removal of individual breaker bays, or parts thereof, without disturbing the remaining bays. It shall be possible to exchange an entire feeder, with or without its busbar section, without dismantling neighbouring bays.

m) Busbars and their enclosures shall take thermal expansion of the entire switchboard into account. Suitable mounting facilities, bellows and compensators shall be provided where necessary.

- **Safety Requirements**

a) The panel shall offer a maximum degree of safety for the operators and by-standers under all normal operating and fault conditions. In particular, it must be impossible to unwillingly, i.e. without the use of tools, touch live parts of the panels, or perform operations that lead to arcing faults.

For mechanical protection of the switchgear elements, panels with a minimum of Protection Class IP 41 is required, i.e. enclosed and inaccessible for granular foreign bodies during normal operation and protection against vertically falling water droplets.

All high voltage carrying parts shall be totally protected against contact with live parts.

b) Should internal arcing occur, the release of pressurised air or gas by suitable pressure relieve devices into the atmosphere must occur in such a way that personnel standing at the operating position of the switchgear will not be injured. Furthermore, no part of the enclosure or any loose parts may fly off in such an event, and no holes may burn through enclosures. All earthing connections must remain operational during and after an arc fault.

c) All interlocks which prevent potentially dangerous fail-operations must be constructed such, that they cannot be by-passed easily, i.e. the operator must use tools or force to bypass them.

d) Energy storing mechanism of breakers must be totally enclosed with the switchgear in the operating condition.

e) All low voltage terminals remaining "live" after the main feeder has been disconnected shall be wired to particularly marked terminal blocks and shall carry suitable warning tags.

f) The isolator/grounding selector switch and/or the line's side earthing switch must be able to be padlocked in the "ISOLATED" and the "OPEN" and the "GROUNDED" positions, respectively.

g) For each outgoing cable feeder an inductive or capacitive voltage detector with cable live indication shall be provided, indicating any reverse voltage, i.e. at least by means of voltage transformers plus lamps (including lamp test facilities).

2.2.2.20.5 Isolator and Earthing Switches

a) Means to safely isolate and ground any feeder in the switchgear shall be provided. Motor operated isolation/grounding switches suitably interlocked with the breaker shall be provided. In case of double busbar systems, the busbar selection isolators shall be provided with motor drive facilities, however, manual operation shall also be available for both single and double busbar system.

b) Isolation/grounding switches shall be designed to withstand the rated and fault current of the largest breaker interrupter element that can be fitted into the panels.

c) Designs where the actual grounding of the feeder is done via the circuit breaker,

i.e. where the isolator is used only to pre-select the grounding position are also accepted.

Such three-way switches must have definitive stops at their "ON", "ISOLATED" and "GROUNDED" positions, with no direct movement from the "ON" through the "ISOLATED" into the "GROUNDED" position.

d) View-ports or mechanical indicators connected directly and permanently to the operating shaft are required to positively display the actual switch position. Indirect position indicators are not acceptable.

e) With the selector switch of any feeder in the "GROUNDED" position, it must be possible to safely exchange the breaker element while the remaining switchgear is live.

2.2.2.20.6 Circuit Breakers

a) Vacuum circuit breakers or SF6 with totally enclosed and maintenance-free contact system are acceptable.

b) Circuit breakers shall conform to Publication IEC 62271-100 in terms of rating, testing and performance, but they may conform to the standards of the country of manufacture for construction requirements, provided these standards do not conflict with the corresponding IEC 62271-100 rules and are acceptable to the Engineer

c) Breaker operating mechanisms shall be of the electric DC motor operated, stored energy type, with provisions for manual operation in case of control power failure. All breakers must be electrically trip-free and have anti pumping circuits. After loss of control power, the springs of the operating mechanism shall be capable of performing a sequence of OFF-ON-OFF operations with rated data.

d) A manually operable local trip push-button (mechanically working onto the trip shaft) shall be available, and all breakers shall be suitable for remote control.

Manual, mechanical ON-switching shall be prevented if interlocking condition exists. Mechanical indicators shall be provided to shown the ON/OFF position of the breaker contacts. Operation counters shall be provided.

e) Maintenance intervals of circuit breakers shall not be less than 25 full rated short circuit interruptions, 10,000 rated current interruptions, or 10 years, whichever comes first.

Replacement of the breaker interrupter must be possible (at gas-insulated switchgear, the remaining part of the switchgear may be kept "live" and must not involve the use of special tools or delicate alignments).

f) Spare auxiliary contacts, 2 N/O, 2 N/C, 1 Impulse, rated at least as specified in schedule of technical particulars & gurantees shall be provided in addition to those required for breaker operation.

These contacts shall be wired to the terminal blocks for use at the LDC terminal cubicles. Additional contacts as required, e.g. for interlocking, shall be provided and incorporated in the control system.

g) Rated nominal current of circuit breakers shall be selected to the rated values listed in Scope of Works & Technical Particulars & Guarantees in order to reach the required rating, once the breaker is installed inside its enclosure. The feeder nameplate shall indicate the actual site rating of the feeder at maximum ambient temperature in addition to the nominal rating of the breaker.

2.2.2.20.7 Interlocking System

Electrical and mechanical interlocking, which shall at least fulfil the conditions as listed below, shall be provided. The final interlocking scheme shall be proposed by the Contractor and shall be subject to the approval of the Engineer.

a) The interlock system must positively prevent an operator from reaching or creating unintentionally a dangerous or potentially dangerous condition. Systems that can be by-passed without the use of tools and/or force are not acceptable.

b) All necessary electrical interlocks shall be provided as specified, particularly for the incoming feeders and the bus-tie breaker. Reference is made to the related sections of the High-Voltage switchgear of this Specification.

c) When the manual emergency crank for the breaker is in use, it shall be impossible to control the breaker electrically (provision of limit-switch or de- clutching of the crank).

d) All breakers for remote control shall have a key-operated switch, allowing the selection of LOCAL - REMOTE operation modes as detailed below.

e) The interlocking of the circuit breakers of the SF6 gas insulated switchgear type shall prevent the following in addition:

- operating the breaker with the isolator/grounding switch not fully engaged in any of its three stops
- closing or opening of the isolator/grounding switch whilst the breaker is closed.

2.2.2.20.8 Enclosures and Busbars

a) Metal enclosures shall be made from steel or aluminium, offering mechanical and thermal properties suitable for this application. Enclosures shall withstand the full rated fault current during arcing faults without puncturing for at least 1 second or means have to be provided to trip any such fault current prior to puncturing (e.g. busbar protection).

In no case shall arcing cause holes in the outer freely accessible sides of the enclosed feeder compartment. Gases and vapours escaping under pressure shall be deflected by front and side covers in a direction such as to minimize the danger to an operator performing his normal operation duty.

b) Assembled enclosures must withstand at least twice their rated internal operating pressure. This fact must be proven on each individual section of the switchgear.

c) Design of the switchgear must allow for the removal of individual breaker bays, or parts thereof, without disturbing the remaining bays.

d) All operating elements and indicators of the switchgear must be located on, or be visible from the front side of the equipment.

e) The fully enclosed busbars shall be made from electrolytic drawn copper. They shall be rated for the continuous current of the switchgear under the site conditions and shall be braced for the maximum peak short circuit current or the minimum of 2.5 times the rated symmetrical short circuit current whichever is higher.

Rounded edges shall be used to reduce the number of potential arc root points, and to retain the ability of the switchgear to carry the rated operating voltage in case of a total insulating gas loss in a compartment.

2.2.2.20.9 Instrument Transformers and Protective Relays

a) All instrument transformers must be suitable for continuous operation for 20 % overload when installed in the switchgear under the ambient site conditions and for service under all rated and fault conditions.

b) Accuracy classes and burdens shall be in accordance with IEC 61869 and scope of works of the Bidding document for current- and voltage-transformers.

c) Cores for measuring instruments shall have accuracy classes of not less than

0.2 % and saturation factors below 5, cores for relaying shall have accuracies better than 5 % and saturation factors of more than 10.

d) Current transformer ratios (secondary side) shall be as indicated in the scope of works of the Bidding document

e) Current transformers must have shorting type secondary terminals. The current transformer-rating plate and the terminals must be accessible after power cables have been installed. Current transformers of the epoxy type, mounted inside the high voltage enclosure on ground potential are preferred; other designs require the approval of Engineer.

f) Potential transformers must be able to withstand the full rated power frequency withstand and lightning impulse capability.

g) Potential transformers for busbar metering shall be of the inductive type, mounted in a separate compartment of the bus coupler/sectionalizer switchgear bay panel or at the end of the busbars.

The ratio shall be as per single line diagram, the rated burden suitable for the measuring and metering equipment connected, however, with a minimum of 100 VA.

h) The potential transformer shall be of the metal-enclosed, gas-insulated type or approved equal.

i) Potential transformers on the line side of incoming feeders or the load side of outgoing feeders shall be of the inductive type, suitable for the measuring and metering equipment connected to it. They may be mounted at or within the cable connection compartment.

2.2.2.20.10 Low Voltage Equipment and Control Circuits

a) The feeder bay or panels LV compartment shall be completely enclosed by steel sheets of 2 mm minimum thickness and shall be separated from the other sections. It shall provide a protection degree IP 54, to accommodate protection relays and auxiliary devices. It shall have a separate access door with key-locks provided.

b) In each LV compartment a main terminal board shall be provided to which all incoming auxiliary cables are connected.

c) Mimic diagram, all instruments, operating elements and indicators of the switchgear, DC trip circuit test facilities, push buttons and lamps shall be mounted on the front of this compartment.

d) Indicating instruments shall be included for the functions as specified in the Chapter 3.

e) All control circuits shall be according to the specified standards and designed for the application as required and shall be subjected to the approval of the Engineer.

f) All necessary auxiliary contacts shall be provided to enable remote control, remote alarm, and indication of the position/state of any circuit breaker, isolator and earthing device.

In addition, two potential-free NO and NC contacts shall be provided for the above purposes each and the contacts shall be connected to the terminal board and to the control room where specified.

g) Completely separated and isolated circuits shall be used for switchgear control, tripping, alarms, and auxiliary devices.

These circuits shall have separate control power buses and feeders, suitably protected, for each power bus section with outgoing feeders, and for each pair of incoming power feeders and the associated bus-tie breaker in secondary selective systems.

h) Each control circuit shall be protected by a two-pole miniature circuit breaker with auxiliary NC contact. The auxiliary contacts of all MCB's of the same circuit type, e.g. breaker motor control, alarm, space heater, trip, etc. shall be wired in series to suitable group alarm terminals.

i) Control wiring shall be executed with finely stranded copper wires of at least 2.5mm2 cross-section, insulated with flame-retardant PVC or TEFLON.

Wherever terminals are not marked permanently and conspicuously, each end of each control wire shall be permanently marked with plastic ferrules (closed ring type) and terminated with crimp-type pin or plug terminators.

Identification of control wires and terminals must conform to the symbols used in the circuit diagrams. All control wiring shall be installed such that the likelihood of damage during normal operation, maintenance and fault conditions is minimized.

j) Terminal strips of the line-up type are preferred for all control wiring requiring external connections. Terminals must be corrosion-proof, and use indirect pressure, captive screw type mechanisms. Internal wiring terminations of the push-on type, e.g. AMP plugs, are acceptable, and wire-wrap connections are preferred for matrix-connections on electronic sub-assemblies.

Additionally, at least a 16 core pilot cable, allocated to each outgoing cable feeder, shall be considered. A terminal strip and separated routing channel for the pilot cable is to be provided.

k) Terminal strips for different voltage levels must be physically separated from each other and suitably identified. Terminals carrying dangerous voltages even when the main breakers are off, must be marked with a particular colour and carry suitable warning labels.

Further terminals shall be provided for the current transformers, which shall permit instruments to be connected without interrupting the secondary current transformer circuits.

l) Voltages for control, trip and alarm shall be monitored by built-in normally energized auxiliary relays, separate for each bus or feeder section. These relays shall be time delayed on drop-off and their contacts shall be wired to group alarm terminals.

m) Remotely controlled breakers shall have key-operated selector switches installed in their low voltage compartment with the following functions. The key shall be removable in a "remote" position only.

The switch shall have these positions/functions:

LOCAL : The breaker can only be operated locally by its push-buttons or mechanically.

OFF : The breaker cannot be operated electrically.

REMOTE : The breaker can only be operated from the remote control room location.

n) Space heaters shall be installed in each low voltage cabinet to prevent condensation. Each heater element shall have an integral thermostat for control. Each switchgear section shall have a common space heater feeder, fed from a separate power source, and protected by a two-pole MCB with auxiliary NC contact wired to a group alarm terminal.

2.2.2.20.11 Cable Terminations

a) All high voltage cables will be connected from below through cut-outs in the floor. To maintain the totally insulated design concept of the switchgear, only fully insulated terminations shall be used. The cut-out in the floor shall be filled out with fire proof material after the cable termination work.

b) A cable termination with direct solid dielectric-to-gas insulation transition shall be used.

Suitable plug type connection facilities shall be provided; the actual cable terminators shall be supplied fitting to the cables for the outgoing feeders.

c) Sufficient space must be provided in the switchgear to terminate and connect up to three XLPE or cables per phase. Suitable cable support and grounding facilities must be provided in this area.

d) Low voltage control and signal cables are fed into the switchgear from above or below. Exposed runs of control cable through the switchgear structure shall be protected by suitable covers.

e) Bidder"s documentation shall clearly show all termination facilities and their dimensions.

2.2.2.20.12 Nameplates

Each breaker bay shall be identified with its feeder designation engraved on laminated plastic tags of at least 40 x 100mm size.

Tag information will be supplied by the Engineer at site. If a second language will be required, a second tag of identical size shall be mounted adjacent to, or underneath the first one, but left blank for customer inscriptions.

The tags must be bolted or riveted onto a non-removable part of the cubicle. Stick-on or glued labels are not acceptable for this purpose.

Each cubicle shall have a rating plate with the information required by IEC 60298, i.e. at least the following:

- manufacturer's name
- type number
- serial number
- rated voltage

- rated frequency
- rated current
- rated interrupt power
- actual rating at site conditions.

Each device installed in the breaker bay, each terminal strip, and each indicating and operating element shall be identified with permanently attached plastic tags or labels of approved design. Inscriptions on these tags must coincide with those used on the drawings.

Each circuit breaker must have its own rating plate with information according to IEC 62271-100, i.e. at least the following:

- manufacturer's name
- type and serial number
- rated voltage
- rated insulation level
- rated frequency
- rated normal current
- rated short circuit breaking current
- weight
- rated duration of short circuit, if different from 1second
- rated supply voltage of closing and opening devices
- rated supply voltage and frequency of auxiliary circuits
- actual rating at site conditions.

2.2.2.20.13 Corrosion Protection

The enclosure shall be treated and protected to withstand at least fifteen years of operation after final taking over, under the site conditions without sustaining significant corrosion or attacks from fungus or rodents, provided the surfaces remain mechanically undamaged.

Reference is made to Technical Specification – Grid Substation Protective Treatment for structural steel works of this Specifications and requirements specified there shall be fulfilled provided they are not contradictory to those below.

As a minimum painting standard for all steel surfaces, the following is applicable:

- cleaning to the bare metal by mechanical and/or chemical means
- phosphatizing, or priming with at least one coat of zinc or lead-based primer
- finish painting shall preferably consist of electro-statically applied and oven-dried epoxy-powder to a thickness of at least 80 microns. Alternatively, at least two coats of epoxy-based compound lacquer may be spray-applied.

If approved by the Engineer, manufacturers standard paint colour may be used, but a light grey finish with high scratch resistance is preferred.

All hardware used in the assembly of the switchgear must be either of corrosion proof material, or be hot dip galvanized.

2.2.2.21 Inspection and Testing

The switchgear is subject to inspection during manufacture. Routine testing of each switchgear bay shall be performed according to IEC 60694. The Contractor shall submit proposals for special tests, subject to the approval of the Engineer.

The accepted limits of test results for each test shall be provided in advance to perform the test.

Tests shall be performed generally at independent institutes, at the Contractor's premises if approved by the Engineer, and at site (if applicable) in the presence of the Engineer and further in strict accordance with:

- IEC 60298 for all the switchgear and control gear

(Note: For internal arc tests to be regarded as type test, performance shall be according to the IEC 60298 Appendix AA)

- IEC 62271-100, IEC 62271-101 and IEC 60694 for the circuit breakers
- IEC 60265 for MV switches
- IEC 61869 for current and voltage transformers
- IEC 60060, and others, as applicable.

Hereby, all test results and calculations evidencing the ratings under site conditions have to be submitted for approval to the satisfaction of the Engineer.

2.2.2.22 Routine Tests (Minimum requirements):

Tests shall be performed as per the relevant IEC including following tests.

- power frequency voltage dry test on each shipping assembly
- rated voltage test on all auxiliary circuits
- insulation test with 2 kV on all auxiliary circuits
- complete mechanical operation test
- function tests of all auxiliary devices, including all protective relays, alarm and trip circuits
- verification of wiring against drawings and specifications
- leakage test for insulating gas.

These tests shall be witnessed by the Engineer according to Chapter 11 of this Specification.

2.2.2.23 Type tests

Type tests shall be performed on switchgear bays and circuit breakers of each different type if type test certificates are not made available with the Bidding Proposal.

Type tests may be waived if satisfactory type test certificates are submitted with the Bid.

All defects detected as a result of testing shall be repaired by the manufacturer at his own expense and shall be documented and corrected prior to shipment. If, in the

opinion of the Engineer, re-testing is required after such repairs, this shall also be at the expense of the Contractor.

Acceptance by the Engineer of any equipment shall not relieve the manufacturer and the Contractor from any of his performance guarantees, or from any of his other obligations resulting from this contract.