Annex VI: Battery & AC/ DC Boards

Contents

1 General requirements

Protection and control systems and telecommunication equipment in the substation shall be supplied from DC circuits.
AC power shall be provided for the auxiliary needs, as well as for monitoring, control or protection equipment not supporting DC power supply.

The AC/DC supply shall be monitored and a central alarm issued whenever the voltage exceeds the limits for reliable operation of the substation equipment.

AC power will be provided by two LV cables from the 0.480 kV buses of PS1 and PS2 respectively. The 480 V AC will be used to generate 110 V DC and lower AC power when needed, such as 1-phase 277 V AC or 208/120 V AC. Battery/charger and AC transformer equipment must be provided for these purposes.

Battery shall provide 110 V DC, 100 Ah output and shall guarantee 12 hours uninterruptable operation in case of lost mains power.

DC supply shall be used for protection, control and communication devices, for actuators driving circuit breakers and disconnect/earthing switches, as well as for emergency lighting and powering of the devices/equipment requested being operable during the AC power lost or black out.

AC distribution system shall be sized so that substation equipment, lighting, power sockets, air conditioning and water supply systems or any other systems serving the substation infrastructure shall be energized.

It should be noted that the battery parameters and AC/DVC power consumption purposes are described in general in order to allow the Bidder to present its technical and commercial proposals in a completed form.
However, the Bidder must clarify the exact size and quantity of the battery cells and AC/DC breakers during the project design phase and recalculate the total cost of the cable according to the unit prices presented by him in the proposal.

2 DC Systems

The DC distributions and the rectifiers shall be installed in metal-clad, partitioned cabinets with fixed equipment and a single busbar system, in the control building.

The necessary instruments and control switches shall be fitted on the front of the individual circuit breaker and equipment compartments. In the lower part of the switchgear cabinet the terminal strips and the attachment components for the cable end fittings shall be arranged.

Main power distribution should be performed via two lead acid for 110 V (via two Ni-Cd for 48 V) accumulators and two rectifiers.

The infeed switch shall be a manually operated circuit breaker, the outputs shall be equipped with load switches preceded by fused isolators. The busbar voltage shall be indicated by voltmeter.

The complete equipment, such as load switches, fuses, contactors, shunts and measuring instruments, are to be neatly arranged and fixed in the appropriate switch or instrument compartment. The cable connections from the rectifiers and batteries respectively shall be single-phase cables.

The complete installation shall be designed for continuous operation at 40°C ambient temperature.
The acidic (alkaline) battery shall be equipped with the necessary counter cells and/or regulator cells and chargers to enable it to cope with all operational shock loads within the given voltage tolerances.
Suitable heaters arranged in the switch cabinets must prevent any condensate formation.

The Contractor must ensure that after handing over, each switchgear installation still has a minimum of 5% fully equipped and 15% not equipped reserve capacity for the terminal strips of the switchgear.
The DC distributions shall fulfill the following requirements:

- busbar compartment with busbar protected against accidental contact
- infeed circuit breaker
- manual load switches preceded by isolators with fuses
- automatic MCB for output circuit preceded by main fuse
- contactors with fuses, bimetallic strips, control voltage MCB etc., for motor circuits
- in the partitioned cable connection compartment, the necessary contact-proof cable connection components and the plug-in connection combinations including the required attachment components for the cable end fittings

Colored mimic diagrams shall be provided on the front of the DC switchgear cabinets with the necessary position indicators, equipment symbols and signaling lamps. The mimic diagram should show at least the following:

- 480 V busbar with position indicator for the rectifier input circuit breakers
- rectifier and battery symbol with Y-connection
- DC infeed circuit breaker with position indicator and the necessary controls
- DC main distribution
- earth fault supervision

The switchgear cabinets shall be installed with rears nearest the wall. In front adequate space must remain to allow access by operating personnel.

The degree of protection of the switchgear must be at least IP 41.
An "emergency off" push button in the event of failure of the control voltage shall be foreseen.

2.1 Main 110 V DC

The 110 V DC switchgear shall comply with IEC 61439. The switchgear shall be designed and manufactured as a type-test verified assembly.
The main DC switchgear assembly is to be metal-clad Form 4b type 4 and is to be termite and vermin proof (IP 54).
The main DC switchboard shall be a single busbar, 110 V DC board with two in-feeds.

The in-feeds from both 120 V DC rectifiers shall operate normally closed and shall automatically share the load. Loss of either in-feed due to a rectifier and battery failure will automatically open the circuit breaker for the affected in-feed, and the load shall be fully supported by the other infeed.

Restoration of voltage on the in-feed, within pre-set limits, shall initiate an automatic closing of the circuit breaker and rectifier load sharing when automatic mode of operation is selected.

The main 110 V DC switchgear shall be readily extensible. The Contractor must ensure that after handing over, each switchgear installation shall have a minimum of 5% fully equipped and 15% not equipped reserve capacity for the terminal strips of the switchgear.
The front panel of each compartment shall be provided with the following indicator lamps and controls:

- red indicator: circuit energized
- green indicator: circuit de-energized
- yellow indicator: circuit tripped
- handle for circuit energization/isolation.

The infeed compartments shall also be provided with:

- selector switch: manual/automatic
- red pushbutton: close circuit breaker
- green pushbutton: open circuit breaker.

Pushbutton controls shall be installed beneath protective covers to prevent inadvertent operation. The "Close circuit breaker" pushbutton shall only be operable when "Manual" operation is selected.
A 4-position selector switch shall be provided to control the in-feeds from the rectifiers: Charger 1 & 2 duty, Charger 1 duty & Charger 2 standby, Charger 2 duty & Charger 1 standby and OFF. Where a charger is selected as "Standby", the in-feed circuit breaker shall be automatically opened. The OFF position shall automatically open both in-feeds and shall be lockable.
The front panel of each in-feed compartment shall be provided with the following instruments:

- 48 x 48mm ammeter with a 3-position selector switch, +ive, -ive, OFF
- 48 x 48mm voltmeter with a 2-position selector switch, +ive to -ive, OFF.

Instrument dials shall be matt white with black print, glass shall be non-reflecting glass, instrument scales are to suit the Contractor's design.

The switchboards shall be built up of circuit-breaker units, isolators, contactors and miniature circuit-breakers. All units, when built up into a complete switchboard, shall be such that the completed switchboard is of free-standing flush fronted design having a neat and clean appearance and is readily extensible.

At the individual switch compartments all specified instruments, and necessary control and selector switches shall be fitted on the front of the panel.

All MCBs, MCCBs, and disconnectors contained within each compartment shall be provided with a minimum of two (2) spare NO & NC volt-free auxiliary contacts.

The main 110 V DC switchgear shall supply the distribution panels. The Contractor shall size the main 110 V DC switchgear to meet the requirements of the equipment to be provided under this project, including spare capacity as specified.

Fault detection on any outgoing unit shall alert the substation operator by a group alarm specific to the main 110 V DC switchgear.
All units are to be supplied with suitable locks and keys.

2.2 Distribution Panels

110 V DC Distribution panels shall be two wires fitted with double pole miniature circuit breakers. Type and manufacturer of equipment is to be approved by the Employer.

Panels are to be supplied with locks and keys.

Each voltage level of the switchyard is to have its own distribution panel(s) for 110 V DC supplies to switchyard equipment. Each item of switchyard equipment shall be supplied on its own circuit or circuits as necessary.

Contractor shall note the requirements of the protection and control system in regarding separate supply requirements for circuit breaker tripping coils, main and back up protection systems, etc.
Each distribution panel shall be provided with the instruments below.

2.3 Battery Charging Equipment

Each battery charger shall be suitable for the charging and floating of the battery and for supplying the DC consumers at the same time. The rectifiers shall be provided by the Contractor as thyristor-controlled devices with current voltage characteristic for standby parallel operation.

The following control and monitoring equipment shall be provided by the Contractor for the individual battery chargers:

- radio interference suppression of the battery chargers according to the appropriate IEC regulations
- monitoring the charging circuit for interruption
- voltage monitoring of the incoming three phase supply, with an overvoltage of + 15% and an undervoltage of - 15%, automatic disconnection of the battery charger shall occur. However, voltage surges shall not cause periodic interruption of chargers

With an undervoltage of - 15%, a fault alarm shall be given and indicated on the front door of the device. All cases of disconnection shall be indicated as a fault alarm in the front door of the unit.

The fault alarm and disconnection shall be combined as a collective alarm - "rectifier fault" - and wired up as potential free contact to the terminal strip for remote alarm (if applicable).

The battery chargers shall be equipped by the Contractor with automatic boost charge stages which shall be adjustable between 1 to 8 hours after input failure.
The chargers shall be equipped with filter units having a ripple content of less than 2 percent.

A warning lamp "boost charge" shall be installed and wired up outside the battery room (if applicable).
On the front of the rectifier cubicles, the Contractor shall provide all the necessary monitoring equipment, measuring instruments, other devices, switches, indicator lamps and corresponding fixings for the cables.
Rectifiers shall -as a minimum- be monitored for the following fault conditions:

- input voltage failure
- rectifier fault
- rectifier high temperature
- output voltage high
- output voltage low
- high DC ripple
- battery circuit failure/battery voltage low
- ground fault alarm.

All alarm conditions shall be indicated on the front panel of the rectifier by LEDs and shall be repeated as a group alarm per rectifier at the substation control room.

The 110 V DC outputs shall supply a common 110 V DC busbar and automatically load share.
Failure of a 110 V DC rectifier and battery output shall automatically trip the relevant circuit breaker in the main 110 V DC switchgear.

2.4 Batteries

For the 110 V DC system, a battery of the lead-acid type shall be provided. Batteries must comply with international standards.

The battery shall be mounted on insulated wooden or metal frames with consoles, and all interconnections and fixing material as necessary. The capacity of the battery shall be matched to the requirements of the station. The battery capacity must meet the requirements (2x100%).

The capacity of the battery shall be justified by the Contractor, considering a discharge time as specified in the data sheets. The discharge capacity of the battery must be sufficient to provide the load during the discharge time given in the tables of these specifications.

A complete set of test and maintenance accessories suitably boxed shall be provided for each battery. A syringe hydrometer and a durable instruction card shall be included in each set.
Battery cases shall be of high impact polystyrene translucent plastic.

Cells shall be numbered consecutively and terminal cells marked to indicate polarity.

The 110 V DC system shall meet the power requirements of the connected equipment at each site with 100% spare capacity.

2.5 Inspection and testing of DC installation

All tests on material and equipment shall be made in accordance with the following IEC Standards (latest editions):
The lists of tests do not restrict the Employer's right to call for further tests if these are considered necessary.
High temperature operation tests shall be performed at the maximum ambient temperature of 50 °C.

2.5.1 Type tests

Must be type testing equipment. Contractor shall supply a copy of type test report of respective material, issued by an independent, lawful, internationally recognized laboratory, with all type test results as stipulated in the relevant IEC standards.

2.5.2 Routine tests

Routine tests shall be performed on each piece of equipment to be supplied for the purpose of revealing faults in material or construction. They shall not impair the properties and reliability of any part being tested or reduce its lifetime.
The following routine tests shall be performed:

- visual checking of all the equipment to verify conformity with the specifications
- power frequency withstand voltage test for all LV AC equipment with 2500 V, 1 min. and for all DC equipment with 1500 V, 1 min
- electrical test of charging rectifier to check the automatic current limitation, trickle and boost charging, ripple and manual control
- operational test.

2.5.3 Site tests

On arrival at the site, during and after completion of erection, all items of equipment shall be inspected and tested in order to check quality, correct operation and correct installation of the equipment.
The following tests shall be performed:

2.5.4 Batteries

- verification of proper and complete erection of the batteries
- checking of intercell connections
- first filling with electrolyte and initial charging
- checking of electrolyte level and density
- checking of voltage of each cell after the charging
- measuring of the insulation resistance to earth
- charge and discharge tests.

2.5.5 Chargers

- verification of proper and complete erection of chargers
- verification of proper AC supply voltage, all connections
- measuring of insulation resistance to earth
- checking of operation of chargers in each mode
- checking of control, signalling and tripping circuits
- load voltage - characteristics
- LV AC and DC switchgears
- verification of proper and complete erection
- checking of all connections
- checking of labelling of the cubicles, fuses, circuit breakers, etc.
- measuring of insulation resistance
- operation checking of different elements such as contactors, relays, circuit breakers, signalling devices, etc.

Commissioning tests shall be done according to a program agreed with the Employer.

2.6 Compliance with Technical Specifications

As proof of compliance of the equipment, relevant to AC/DC installations, the following shall be submitted:

- filled in technical data sheets
- brochures/Catalogues of the equipment proposed
- reference lists.

Instrument dials shall be matt white with black print, glass shall be non-reflecting glass, instrument scales are to suit the Contractor's design.
The incoming circuit breaker at each distribution panel shall be non-automatic manually operated.
Contractor shall size the panels and define the number required to meet the substations' requirements as detailed in these specifications.

3 AC/DC Boards

3.1 AC Distribution

The function of the AC Station Supply System is to feed the auxiliary equipment as well as the lighting, small power and other services via the relevant AC boards.
The LV AC system shall provide the following voltages:

- 480 V, 60 Hz, 3-phase, for power supply to auxiliaries
- 277 V, 60 Hz, single phase, for lighting, outlets, etc.

In the normal operation conditions the AC power is normally supplied from the main source i.e. from the station service transformers, whereas in case the main supply is out of service, the emergency standby Diesel generator (automatic switching on) shall supply the entire load.

The AC system shall consist of a star connected, solidly grounded four-wire system as well as a star-connected system for lighting, AC sockets and other essential AC loads.

The station AC distribution boards shall be equipped with all equipment for the future final stage of the concerned station, and shall be supplied complete with all boards, instruments, meters, indicators, control switches/circuit breakers, pushbuttons, annunciators, indicating lamps, terminal blocks, wiring and miscellaneous devices, etc.

3.2 AC Low-Voltage Equipment

The following basic technical values must be supported according to the following table:

Rated system voltage:	*277/480V*
Max. voltage change:	*+ 15% - 20%*
System configuration:	*3-phase line (4-wire), solidly earthed*
Test voltage (min) for new plants:	*2.5 kV (1 min)*
Minimum resistance of the insulation material for new plants: • phase-to-phase: • Phase - to - earth	*500 kΩ* *500 kΩ*

3.3 DC Low-Voltage Equipment

The DC low voltage installation shall feed the control and protection circuits as well as the telecommunication equipment.

The function of the 110V DC systems is to provide the DC supply for all auxiliary and substation DC dependant equipment, through the DC distribution boards. This equipment comprises the protection relays, the control system, the communication systems and the emergency lighting.

The 110 V DC battery charger and battery systems shall be designed in a redundant manner for 2 x 100%. The protection, control and lighting systems (in emergency cases only) are fed by the 110V DC through the 110V DC distribution board.

The input to the 110V distribution boards is obtained from the battery/charger systems respectively.

The batteries and rectifiers are sized to supply the required DC loads taking into considerations the present and future services at the substation final stage and shall have a spare capacity of 30%, if not specified otherwise.

Therefore, the station DC distribution boards shall also be equipped with all hardware/equipment to cater for the present and future services.

The DC distribution boards shall be provided with all hardware required for reliable operation and safe isolation as well as with the protection against short circuit incidents.

The DC distribution boards shall be supplied complete with all boards, instruments, meters, indicators, control switches/circuit breakers, pushbuttons, annunciators, indicating lamps, terminal blocks, wiring and miscellaneous devices, etc.

The DC distribution boards, shall be of metal-enclosed, indoor floor-mounted, free-standing type

The basic technical design features are as follows (if not otherwise mentioned in the technical requirements):

General:

Rated system voltage:	*110V DC*
Test voltage (1 min) for a new installation:	*2 kV (1 min)*
Minimum resistance of the insulation material for a new installation:	*220 kΩ*

For Protection and Control system:

Trip voltage:	*110V DC*
Rated secondary voltage:	*100/ √3, 100V*
Rated secondary current	*1 A or 5 A*