

## SECTION – IV ERECTION, TESTING AND COMMISSIONING

### 4.1 MAIN POWER PLANT AND POWER HOUSE AUXILIARIES

The turbine, generators their auxiliaries and other common auxiliaries of the power house shall be erected at site after necessary overhauling, repairing and renovation works in most professional way and proper sequence in co-ordination with civil works. The main equipment to be erected are as follows:

Sl. No.	Item	Unit	Quantity
1.	Turbines & their auxiliaries	Set	4
2.	Generators & their auxiliaries including excitation AVR and terminal equipment	Set	4
3.	Main inlet valves and oil pressure units etc.	Set	4
4.	Governors, hydraulic & electronic cabinets complete	Set	4
5.	Control/Relay Panels / Distribution panels	Set	4
6.	Station auxiliaries		
7.	Transformers with panels etc.	Nos.	3
8.	33 kV switchyard equipment with bus bars etc. i/c switchyard structure	Lot	1
9.	Other remaining items		

#### 4.1.1 Test At Site

The contractor shall prepare and submit to the engineer for approval site testing manual not later than one month before commissioning is due to commence. The manual shall list in detail the tests to be performed during commissioning taking into consideration field tests to be performed for turbines, generators, transformer, breakers, control and protection equipment, switchyard equipment and auxiliary. The contractor shall provide all testing instruments and shall perform the tests set out in the manual in the presence of the engineer. The testing requirements are briefly described below.

##### Tests Prior to First Rotation

The contractor shall demonstrate to the engineer that the following items of equipment operate satisfactorily and where applicable are correctly adjusted or calibrated.

Tests shall include but not be limited to:

- a) Polarity testing, ratio testing and magnetizing curves of all current transformers
- b) Polarity testing, ratio and insulation testing of voltage transformers
- c) Initial charging, commissioning and testing of batteries.
- d) High voltage insulation testing of the following :
  - Cables
  - Transformers
  - Generators
  - Switchgear
- e) Full functional checking and setting up of the following
  - All ancillary AC apparatus
  - All ancillary DC apparatus –chargers/ distribution boards etc.
  - All alarms and trip
  - All electrical protection
  - All hydraulic systems
  - All cooling systems
  - Switchgear ( 415V and 33 kV)
  - All associated turbine and generator control protection and miscellaneous items

### **Initial Run, Test Runs and Test Service Period**

The procedure for initial run, and test runs including testing of speed and pressure transients on load acceptance and rejection shall be in accordance with IEC Publication 545 “Guide for Commissioning, Operation and Maintenance of Hydraulic Turbines” or relevant IS or standards of the country of origin.

### **Field Acceptance Test**

All field acceptance test as detailed for Turbine, Generator, Transformer, Breakers, Control and Protection Equipment, Switchyard Equipment and Auxiliary etc. shall be performed.

#### **4.1.2 Tests for turbine output**

The guaranteed range of outputs for each scheme shall be tested. The testing shall be in accordance with IEC Publication. No. 41 “International Code for the Field Acceptance Tests of Hydraulic Turbines” of relevant IS or standard of the country or origin.

The Contractor shall calibrate the pressure gauges with a mercury manometer prior to the testing.

The turbine output in each test will be determined by measuring the electrical output of each unit and subtracting generator losses calculated from the generator works test results.

When comparing the site test results with the Contractor's guaranteed performance, the error in the test results shall be assumed to be as allowed in IEC Publication No. 41 or relevant IS or standards of the country of origin.

#### **4.1.3 Generator Output and Temperature Rise**

The generator output in relation to guaranteed temperature rise shall be tested at site by performing a heat run in accordance with relevant IS. The resistance temperature detector installed in the generator stators shall be used to measure machine temperature.

#### **4.1.4 Generator Transformer Losses**

Test for determining transformer Losses guaranteed under penalty shall be performed.

#### **4.1.5 Tests on Completion and Handing Over**

The tests described in the foregoing subsection entitled "Field Testing" shall be the "Tests on Completion". The tests must be completed to the Engineer's satisfaction and the equipment retested where necessary before the taking over certificate will be issued

For successful completion of field tests of the mechanical equipment's, the calibration of various instruments shall be done by 'authorized agencies' only as approved by the owner.

A separate handing over certificate will be issued in respect of each set of generating equipment.

#### **4.1.6 Commissioning**

The term "COMMISSIONING" shall mean the activities of functional testing of the complete system after erection, including tuning or adjusting the equipment for optimum performance meets the requirement of the specifications

### **4.2 SWITCHYARD EQUIPMENT**

#### **4.2.1 General**

- i. All electrical installation shall conform to the Indian Electricity Act, IE Rules and Regulations in force, in the State, as laid down Electrical Inspectorate.
- ii. All works under this contract including the installation of the equipments shall be got inspected and approved by the relevant authorities like Electrical Inspectorate etc.
- iii. The switchgear, current transformers, lightning arresters, power transformer, etc., shall be examined on receipt for damages. The contractor shall assemble, install and connect the equipment, wherever necessary, as per manufacturer's recommendations. The assembly of the unit including their operating mechanism, site adjustments shall also be carried out as per guiding instructions from the manufacturer. The equipment shall be placed and leveled

- carefully on their respective structures. All the preparatory works such as civil foundations, any concrete channels etc., shall be completed prior to this.
- iv. The operating mechanism and control circuit of the equipment shall be tested for proper opening, closing and position indication. The opening and closing tests shall be made from control points as in service operation.
  - v. Earthing of supporting structures and metal parts of operating mechanism, operating cabinets, operating handles at ground potential shall be ensured. Where moving parts are involved, flexible copper conductors shall be used.
  - vi. Before charging the equipment, contractor shall submit the completion report for each equipment indicating rectifications/modifications carried out during erection, site test certificates with observations if any. Contractor shall also indicate the correctness of operational and safety interlocks. Site test certificates shall also indicate the corresponding values obtained in the factory test.
  - vii. The conductor/jumpers shall be correctly and effectively connected to the terminals of equipment. The faces shall be cleaned with fine cloth and lightly coated with petroleum jelly before use. However, if contacts are silver plated, they shall not be cleaned with emery paper. The connection shall be flexible to withstand stresses during switching operation.
  - viii. The control cabling shall be effectively crimped to the cable lugs which shall be bolted tight after ensuring that the contact faces are clean. Small wiring that is necessary between units in accordance with the diagram of connection shall be made complete.
  - ix. The contractor shall be responsible for completion of the system necessary for successful operation as a whole and would provide any equipment which may be required but may not have been specifically mentioned in this specification.
  - x. The civil works required at switchyard for installation of various equipment/structure/cables etc is not covered in the scope of this tender.

#### **4.2.2 Scope**

It covers all the works related to Erection, Inspection, Testing & Commissioning etc. of all the equipments supplied / existing.

#### **4.2.3 Installation of Transformer**

- i. The transformers and their accessories and mountings like radiators, conservator, Silica-gel breathers, marshalling box, rollers etc shall be assembled at site after cleaning by the contractor in proper sequence as per manufacturer's drawings.
- ii. Contractor shall place the transformers on the channel at the location indicated in the layout drawing of outdoor yard. Suitable stoppers shall be provided both in front as well as rear of transformer to keep it stationary in its position. For the front wheels such stoppers shall be screwed on the channels.
- iii. BDV of the transformer oil shall be tested before energisation of power transformer. Drying out of transformer shall be carried out to get required dielectric strength as per relevant Indian Standards.
- iv. Oil shall be filled upto the mark shown.

- v. Wherever the power/control cables project above the ground, for termination to cable box/marshalling box, the same shall be run in GI pipes of suitable cross section upto the height of 2.0 m from ground and the same shall be supported properly and pipe ends shall be sealed with bitumen compound.
- vi. The contractor shall ensure the following checks on the Transformers:
  - a. Physically checking and inspecting, paying particular attention to the following components to ensure that the same are in sound conditions;
    - Tank sides or cooling tubes
    - Protruding fittings
    - Oil sight glass
    - Bushings
    - Tightness of Bolts
    - Oil leakage.
  - b. Transportation to erection site.
  - c. Proper erection on foundation/channels.
  - d. Assembly of transformer.
  - e. Checking of oil level filtration / drying of oil.
  - f. Alignment.
  - g. Anchoring and tack welding.
  - h. Mechanical Work.
  - i. Laying, meggaring, termination, dressing and clamping of cables.
  - j. Tagging and marking of cables.
  - k. Testing of cables.
  - l. Earthing of transformers, earthing strip, earth resistance to comply with IER (latest revision).
  - m. Testing of assembled plant.
  - n. Testing and calibration of meters, relays, CTs, PTs, etc.
  - o. Connection of busbars/cables to primary and secondary of transformers.
  - p. Series of tests on transformers as per engineer's instructions. IS 1886 and manufacturer's recommendations.

**Note:** All high voltage tests shall comply with IS 2071 Part I and II and all works in connection with the transformers shall comply with IS 1886 and IER (latest revision).

#### 4.2.4 Checking of Isolators

- i. The poles of the isolators shall be aligned accurately and levelled on the supporting structures. Sequence of installation of isolator parts shall be carried

- out as recommended by manufacturer.
- ii. Perfect operation of isolators, earthing switches shall be ensured after erection by normal operation. Working clearance between adjacent structures and switch blades in open position shall be checked.
- iii. The isolators shall be adjusted so as to permit operation with ease by one man.
- iv. Laying, termination of power and control cables, checking of internal wiring connections.
- v. The contractor shall also check for the key interlocking of the earthing switch with the main disconnect switch. Earthing between units, earthing terminals to structure, operating handle to structure and ground mat should be effective and neatly taken through structures and foundation. Ground mat shall be positioned right below the operating handle of the disconnect switch.

#### **4.2.5 Checking of Lightning Arresters**

The lead connecting lightning arrester with line should be direct without any splice or other joint and the connection should be effective to carry the lightning discharge currents. The lightning arrester shall be positioned in such a way that short and straight leads can be run from the earthing terminal of the arrester to the earth electrode specifically provided for this purpose. The arrester exhaust ports should be directed away from the equipment and other arrester.

#### **4.2.6 Interconnection of Equipments**

- i. The arrangement of connections shall be such that the connected apparatus are not subjected to any mechanical stress due to expansions, contractions etc., of the connections.

The connections shall ensure good electrical contact. The connector and joints shall be rigid to withstand all mechanical and electrical stresses. Suitable bi-metallic clamps shall be used for all the connections between the conductors of different materials.

All live parts shall have sufficient practical clearances from earthed parts and ground. The clearances of strung busbar shall be decided considering the effect of sag.

The contractor shall be responsible for supplying and installing the various conductors required for connection of the various equipment. The tenderers scope shall include all bolts, nuts and washers required for installation. All connections etc., shall be so made that stress between connecting terminals will be reduced to the minimum.

The physical layout of the system shall be such that the system extension or conversion can be carried out with minimum changes and easy methods. Further, it shall be ensured that all civil works for the foundations are completed by the agency before taking up erection of structure.

#### **4.2.7 Installation of Switchgear Panels**

- i. The base frame of all panels shall be welded to the structures or to the civil inserts provided on the floor. Fabrication of support/frames, wherever required, shall be done by the contractor.

- ii. The shipping section shall be placed in position before removing the protective covering to eliminate scratch/damage. The shipping section shall be moved by using rollers under the shipping skids wherever lifting cranes are not available. The contractor shall do the assembly at site as per the manufacturer's General Arrangement drawings and installation instructions. While assembling a complete board comprising several unit type cubicles, the board as a whole shall be aligned. The panels shall be properly leveled prior to grouting the holding down bolts or welding the panels to the inserts. All interconnection of the bus-bars and wiring between the panels shall be done as per manufacturer's instructions and drawings. Welding work on the panels shall only be carried out after consultation with the purchaser. Damage to the paint during welding shall be rectified by the contractor.
- ii. After mechanical installation of the board is completed, instruments shall be installed wherever required and wires shall be connected to the instruments. The wiring of intermediate terminal strips between two panels, wherever disconnected for transport, shall also be connected.

#### **4.2.8 Installation of Grounding/Earthing**

- i. Entire system shall be earthed in accordance with the provisions of the relevant IEC recommendations/ IS code of practice IS 3043-1987 and Indian Electricity rules, so that the values of the step and touch potentials in case of faults are kept within safe permissible limits.
- ii. The principal requirements of the grounding are:
  - a. Low resistance and adequate current carrying capacity.
  - b. Uniform and near uniform ground potential on all structural metal work on all metal enclosures and/ or supports of equipment and apparatus.
- iii. The resistance of earthing network shall be less than 0.5 ohm for the network of outdoor yard under all conditions.
- iv. The contractor's scope of installation will also include all the civil works associated with complete earthing network.
- v. All earth connections shall ensure a permanent low resistance contact. Earth connections required to be removed for the purpose of testing of equipment/ earthing network shall have bolted connections and joints fastened. All earthing connections shall be visible for inspection.
- vi. All equipment located at switchyard, shall have 2 separate distinct earth connections. Switchyard fencing shall be earthed at every alternate section.
- vii. Lightning arrestors and transformer neutral shall be connected to two independent earth electrodes as per IS 3043.
- viii. Air termination rods of lightning protector systems shall be connected to earthing network as per IS 3043.
- ix. The grounding connection to the lightning arrestors, air termination points of lightning protection system shall be as short as possible. Sharp turns in these conductors shall be avoided.
- x. It has to be ensured that main earth bus in the installation as well as earth buses in individual sections/areas shall form complete ring and they shall be interconnected.
- xi. Duplicate earthing (two separate and distinct connections with earth) shall be employed for all equipments.
- xii. Wherever burying of earth conductors is specified, they shall be buried as per approved drawings.

- xiii. Wherever any earth conductor crosses the road, it shall be taken through GI pipes.
- xiv. At all the terminations of earth conductors on equipments, sufficient length shall be left for any movement of the equipment from its position for alignment purpose.
- xv. Wherever not detailed, the route of the conductor and location of the earth pit shall be arranged so as to avoid obstruction, crossing etc, according to convenience at site and shall be got approved by the owner's representative-in-charge of the works.

### **Installation Of Earth Pits**

- i. The arrangement of earth electrode/ pit shall be as shown in IS 3043. Termination arrangement of interconnecting earth strips is included in the scope of earth pit. Interconnecting earth flats shall be jointed by welding to the termination arrangement on the electrode. Electrode will be 50 mm dia GI pipe of 3 m length medium class, in a single piece.
- ii. The distance between two pits shall preferably be 4 to 6 meters.
- iii. All accessories required for the earth pits such as electrodes, charcoals, salt, clamps, clips, bolts/ nuts washer, GI pipes, funnel cast iron cover and also the masonry works of the pits including supply of necessary materials, bricks, cement and excavation of earth for providing earth pits shall be part of the scope.
- iv. The electrodes shall be well packed with earth, charcoal and salt mix up to the level of connections.

### **Joints/Terminations Of Earth Strips**

- i. All joints of bare galvanised earth strips shall be welded so as to form rigid earth ring. All such welded joints shall be given necessary coating of cold galvanised paint as per relevant standards and a coat of suitable bitumen compound to prevent corrosion.
- ii. In case the joints are made by using suitable connectors the entire joint shall be fully sealed by suitable compound so that no metallic part is exposed.
- iii. The contractor shall make his own arrangements for necessary crimping tools, soldering equipments drilling machines and other tools and tackles which are necessary for completing the installation.

### **4.2.9 Installation Of Cables**

#### **i) Scope**

The supply, laying, termination and commissioning of all control/protection cable is in the scope of the contractor. He shall also be responsible for providing, laying and commissioning LT cables for switchyard lighting at power station.

Cable schedules/termination drawings in respect of above cabling work shall be submitted to the bidder for his approval.

**ii) Mode of Cable Installation**

Straight through joints shall not be permitted in cables.

**iii) Trenches**

The maximum depth of all trenches shall normally be 1 .0 metre and the maximum soil cover above the protective slabs shall be 75 cms, unless otherwise agreed. The back filling of the excavation shall be carried out without disturbing the cover slabs or damaging the cables.

**iv) Cable Laying In Trenches**

- a) The cables shall be laid in trenches as steel radis duly clamped in proper and systematic manner.
- b) Unless agreed otherwise, all power cables shall be spaced at a distance of 15 cms horizontally.

**v) Markers**

- a) Approved cable markers of reinforced concrete shall be provided and fixed to mark each and every deviation of all cable routes. A marker shall also be placed every 50 metres along straight portions of each route.
- b) A concrete cable marker shall also be provided and fixed to mark the position of every joint, if any.

**vi) Supporting Steel Work For Outdoor Switchyard Equipment**

All supporting steel work shall be free from dirt, rust or scale and shall be galvanised.

**vii) Cable Supporting Structure**

- a) Cable supporting structures shall use angle of minimum size of 50 x 50 x 6 mm.
- b) The structure shall be painted.
- c) The cable supporting material shall be fixed to concrete and brick work by the use of anchor bolts. Fibre plugs shall not be used.

**viii) Cable in Pipe**

- a) Cable pipes shall be provided to protect the cables, where the cables rise through holes at ground level.
- b) Not more than one cable shall be drawn into one pipe unless agreed otherwise.
- c) After the cable has been drawn in, the pipe shall be sealed.

**ix) Cable Terminations**

- i. Cable shall be terminated in accordance with the relevant diagrams.  
The cable cores from the sealing box or gland, to the terminals of the apparatus shall be

neatly dressed & arranged, and shall be of sufficient length to prevent the development of tension or local pressure on the insulation. They shall be suitably supported wherever required.

**x) Identification & Marking**

- a) End of each core of every control cable shall be provided with tight ferrules of approved make and white non-flammable plastic insulation material, having the marking engraved in black to correspond with the relevant diagram. Where the ends of one conductor have different markings, each end shall also have white ferrules engraved in red with the remote marking.
- b) Distinguishing labels of non-corrodible material marked in accordance with the cable numbers of the cabling diagram shall be permanently attached to each end of every cable.
- c) The phase or polarity of each power cable core at the cable ends shall be identified as follows

AC System : Phase	-	Red, Yellow and Blue painted discs
Neutral	-	Black painted disc

**xi) Connection to Terminals**

- a) Power cable connections shall be made with cable lugs of approved type and materials, taking into account the bimetallic actions.
- b) All control circuit connections shall be made with the bare conductor with the use of washers crimped lugs etc.
- c) The ends of all stranded conductors shall be twisted tightly together.
- d) Solid or stranded conductors shall be connected to terminal studs by taking one complete turn around the stud between the flat washers.
- e) Connections to an easy wiring terminal shall be made with a straight end conductor.

**xii) Protection of Cables**

All cables shall be installed such that the risk of damage is minimised.

**xiii) Sealing**

The openings of cables passing from are basement to cable trench, basement to cable tunnel/spare ducts etc. to be sealed properly to prevent seepage of water.

**4.2.10 Guidelines For Clearances**

- i) Clearance from buildings/between equipments shall be decided as per the following guidelines:
  - s) All equipment/panels shall have minimum 1250 mm back clearance all around them (except when the panels are installed adjacent to each other).

- t) The front to front clearance of switchboards/panels shall be 2000 to 2500 mm as per drawing approved by the purchaser. Clearance between two panels installed in a row shall be minimum 1000 mm.
- u) Clearance between wall and end of the panels shall be minimum 1000 mm.

**ii) Cable Trenches**

- a) Cable trenches shall have removable covers for the full width.
- b) Minimum working passage of 500 mm shall be provided between cable racks or between cable rack and wall.
- c) Shall have suitable drainage facility to avoid accumulation of seepage water.

**iii) Safety Partitions and Entries**

All the cable openings on the equipment floor shall be sealed.

**4.2.11 Inspection And Testing**

- a) The procedure outlined in earlier shall be adhered to in regard to inspection and testing.

**b) Tests, Test Certificates And Documents**

For each of the items being manufactured following test certificates and Documents (as applicable for each of the equipment) in requisite copies shall be prepared and submitted to the purchaser for scrutiny & records.

Should the result of tests not come within the margin specified, the tests shall, if required, be repeated at contractor's cost without any liability to the Purchaser.

The site tests and acceptance tests to be performed by contractor are detailed below.

**c) Site Tests And Checks**

All the equipment shall be tested at site to know their condition and to prove suitability for required performance.

Following tests shall be conducted after installation. All tools, accessories and required instruments shall have to be arranged by the Tenderer.

Any other test which is considered necessary by the Purchaser of the equipment has to be conducted at site.

The tests to be carried out on all the equipment (whether existing or new) at pre-commissioning stage shall include but not limited to the following.

- **Vacuum Circuit Breaker**

- i. IR test on each pole by Meggar (Between phases and phase to ground) by 2.5 kV tester.
- ii. IR tests on control circuits.

- iii. Functional check of breaker operation on minimum and maximum specified control voltages.
- ii. Checking of interlocks with Isolators & Earthing switches.
- iii. Measurement of contact resistance.
- iv. Checking of operation and tripping of protection release.
- v. Checking tightness of termination connectors and earthing connections.
- vi. Checking of insulators for cracks etc.
- vii. Check for closing and opening time and simultaneous closing of all poles through oscillograph.
- viii. Tripping of circuit breaker at reduced or over voltage of 60% & 110%

- **Isolator/Disconnecting Switches**

- i. IR test by HV Meggar on main poles.
- ii. IR test on control circuits.
- iii. Measurement of Contact resistance for all three phases.
- iv. Functional checking for manual operation.
- v. Checking of interlocking with earth switch
- vi. Checking of earth switch operation .
- vii. Checking tightness of earthing connections.
- viii. Checking of insulators for cracks.

- **Lightning Arrestors**

- i. Continuity Check (for metal oxide type only)
- ii. Check for connection to ground.
- iii. Check insulators for cracks.
- iv. HT and IR test of each element.
- v. Check reading of leakage current

- **Current Transformers**

- i. IR test on each winding, winding to earth and between windings.
- ii. Checking of winding ratios by primary injection test set.
- iii. Polarity check on each winding.
- iv. Continuity check for all windings.
- v. Check for connections to correct taps.
- vi. Checking of oil level (if applicable).
- vii. Checking of continuity and IR values for cables form CT to Marshalling Box.
- viii. Checking tightness of earthing connections.
- ix. Checking of insulator for cracks.
- x. Check output after loading of the main circuit

- **Potential Transformer**

- i. IR test on each winding, winding to earth and between winding.
- ii. Polarity check on each winding.
- iii. Continuity check for all windings.
- iv. Turns ratio test
- v. Check for connections to correct taps.
- vi. Checking of oil level

- vii. Checking tightness of earthing connections.
- viii. Checking of insulator for cracks

- **Power Transformer**

- i. IR test on each winding to ground and between windings.
- ii. Turns ratio test on each tap.
- iii. Polarity and vector group test
- iv. Measurement of winding group test.
- v. IR test of wiring and operational tests on all control devices in control cabinet, oil level indicator, winding and oil temp. indicators etc.
- vi. Checking of earthing w.r.t transformer tank (flexible from top cover in tank) other parts, neutrals.
- vii. Testing of Buchhloz relay for alarm and trip conditions.
- viii. Setting of oil/winding temperature indicators, level gauge and checking of alarm/ trip circuits.
- ix. Check insulators for cracks.
- x. Checking for oil leakage and arresting of leakages (if observed).
- ix. Checking for open position of all the valves (except drain and filter valves).
- x. Filtrations of oil by using fine filter vacuum pump and heater set.
- xi. BDV test on oil samples from top and bottom.
- xii. Measurement of magnetizing current and no load loss.
- xiii. Measurement of PI Value.
- xiv. Checking of silica gel breather.
- xv. Checking of other points given in manufacture's commissioning manual.

- **Insulators**

- i. Check for minor damage/cracks after cleaning.
- ii. Verification of number of disks as per drawings.
- iii. Check heating at termination point during shut down.

- **ACSR Conductor**

- i. Check for continuity.
- ii. Check for tightness of connections for all the termination points.
- iii. Check for phase sequence marking and for their correctness.
- v. Physical verification.

- **Cables**

- i. Checking of continuity/phasing and IR values for all the cables
- ii. HV test and measurement of leakage current after termination of cable kits (for H T cables).
- iii. Checking of continuity for Armour and fourth core (if applicable).

- **Earthing**

- i. Check tightness of each connection
- ii. Check earthing of all metallic equipment, busbar supporting structures, yard fencing, steel structures of yard, rails, gates, building column (if steel) etc.
- iii. Measurement of earth resistance for each electrode.
- iv. Measurement of total earth resistance.

- **Lightning Protection**

- i. Check continuity of all the earth strips/shield wire.
- ii. Check tightness of all connection.
- iii. Measure earth resistance of each electrode and combined system.

- **Miscellaneous**

- i. Checking of continuity of the system.
- ii. Checking of phase sequence from overhead line to consumer end.
- iii. Checking safe accessibility of all operating points.
- iv. Check availability of control/aux supply.