

13.2 ELECTRICAL PIEZOMETERS

13.2.1 General

The Contractor shall supply, install, test and survey:

- a. electrical piezometers at various locations as shown on the Drawings in the foundation of the embankment;
- b. electrical piezometers at the various locations in the impervious zone of the embankment;
- c. cabling up to terminal boxes in the gallery and the termination of such cabling.

13.2.2 Electrical Piezometers for Foundation

- a. Electrical piezometers for the foundation shall be of the model type BP-10KB manufactured by Kyowa Dengyo (Tokyo, Japan) or approved equivalent and shall conform to the following:

Capacity	: 10 kgf/cm ²
Rated Output (Output/Input)	: more than 1m V/V (or more than, 2000x10 ⁻⁶ strain)
Non-linearity	: 1% R.O
Recommended Excitation	: 2 to 10 V
Input and Output Resistance	: 350 ohm
Safe Temperature Range	: 0 to 80°C
Safe Overload Rating	: 150%

- b. The holes for the foundation type piezometer shall be 86 mm minimum diameter. Drilling shall be by rotary means using clear water. Use of artificial mud, mud emulsions or any other materials which might affect the permeability of the foundation around the piezometer tip will not be permitted. The holes shall be drilled at the locations and the elevations as shown on the Drawings or directed.
- c. The electrical piezometers shall be installed in the holes drilled in the foundation in accordance with the manufacturer's procedures and the details shown on the Drawings or directed.
- d. The electrical piezometers shall be embedded in sand at the bottom of the hole, sealed with bentonite and the hole then backfilled with grout.
- e. The electrical piezometers shall be connected by means of suitable cables to in the terminal boxes located in the internal gallery laid in trenches excavated and protected as specified in Sub-Clause 13.1.11.

13.2.3 Electrical Piezometers for Embankment

- a. Electrical piezometers for the embankments shall be of the model type BP-10KC manufactured by Kyowa Dengyo (Tokyo, Japan) or approved equivalent and shall conform to the following:

Capacity	: 10 kgf/cm ²
Rated Output (Output/Input)	: more than 1m V/V (or more than, 2,000x10 ⁻⁶ strain)

Non-linearity	: 1% R.O
Recommended Excitation Voltage	: 2 to 10 V
Input and Output Resistance	: 350 ohm
Safe Temperature Range	: 0 to 80°C
Safe Overload Rating	: 150%

- b. The electrical piezometers for the embankments shall be laid in protective surrounds in offset trenches excavated at right angles to the main trenches and to the same bottom elevation as the main trench.
- c. The Contractor shall install the piezometers type in a horizontal position in the offset trenches and shall install all connecting cabling in the main trenches. Detailed installation procedures shall be as directed in accordance with the detailed specification furnished by the manufacturer of the equipment and as approved.
- d. The electrical piezometers shall be connected by means of suitable cables to in the terminal boxes located in the internal gallery laid in trenches excavated and protected as specified in Sub-Clause 13.1.11.

13.2.4 Installation and Testing

- a. The Contractor shall install the cables and the electrical piezometers in the dam embankment and its foundations at the various levels required for each set of installations, in accordance with the approved procedures.
- b. The Contractor shall have available, at the time the surface of the earth fill of the dam embankment reaches a level at which the piezometers are to be connected to a terminal box, a suitable route for, and all labour materials and Equipment necessary for the satisfactory completion of all protective surrounds for instrument cables to the terminal boxes located in the internal Gallery as shown on the Drawings in accordance with Sub-Clause 13.1.11. Tubes and cables required to connect instruments at different levels in the dam embankment shall be raised as shown on the Drawings and in accordance with Sub-Clause 13.1.11.
- c. The Contractor shall not be cover any layer of cabling until approved by the Engineer. Backfill material and compaction shall be in accordance with Sub-Clause 13.1.11 and as shown on the Drawings or as directed. Puddling will not be permitted in trenches for piezometer apparatus.

13.2.5 Measurement

Measurement, for payment, for the supply, installation, testing and survey of electrical piezometers will be made of the number of instruments installed, in accordance with the Drawings or as directed by the Engineer.

13.2.6 Payment

Payment for the supply, installation, testing and survey of electrical piezometers will be made at the rate per installation tendered therefor in the Bill of Quantities (Item M.1.1 and M.1.1.2). These rates shall include the cost of supplying, installing, testing and surveying all instruments, cables, riser pipes, the cost of excavating trenches and constructing protective surrounds, drilling and backfilling drilled holes where applicable and the cost of terminating the cables at terminal boxes.

13.3 DEFORMATION MEASURING INSTRUMENTS

13.3.1 General

The Contractor shall supply, install, test and survey all the deformation measuring instruments comprising the following

a. Foundation Deformation Meter

The foundation deformation meter shall be installed in a borehole in the embankment foundation at the location and between elevations as shown on the Drawings or directed. The function of the foundation deformation meter is to measurement of change of elevation of the embankment foundation relative to the bottom of the borehole. The Contractor shall supply and furnish an electrical transducer for measuring the distance from the foundation surface to the end of the steel rod anchored at the bottom of the borehole. The transducer shall be connected by means of suitable cables to a terminal box located in the internal gallery along cable trays within the gallery.

b. Joint Meters

Electrical tri-axial joint meters shall be installed on the connection joints of the internal gallery at locations as shown on the Drawings or directed. The function of the joint meters shall be to measure relative displacement of adjacent blocks of the internal gallery. The joint meters shall be connected by means of suitable cables to a terminal box in the internal gallery.

c. Probe Extensometer

Probe extensometer with magnet/reed switch transducer shall be installed in the impervious zone at location and elevations as shown on Drawings or directed. The base of the probe extensometer pipe shall be anchored on the internal gallery concrete and shall consist of a column of telescoping lengths of rigid PVC pipes complete with horizontal crossarms with magnet rings at regular intervals as shown on the Drawings or approved equivalent. The installation will be carried out during construction of the embankment and shall be such as to allow the measurement of changes in the level of each crossarms by means of an inductance probe lowered down the column of pipes.

13.3.2 Instrument Specification

a. Foundation Deformation Meters

Foundation deformation meters shall be of the model type BJ-50DS manufactured by Kyowa Dengyo (Tokyo, Japan) or approved equivalent and shall conform to the following:

Rated output	= 1 mV/V (2,000 x 10 ⁻⁶ strain) or higher
Non Linearity	= ± 2% RO
Safe excitation voltage	= 10 V
Input and output resistance	= 350 ohm
Safe temperature range	= -20 to 70°C
Safe overload rating	= 110%

b. Electrical Tri-Axial Joint Meters

Electrical tri-axial joint meters shall be of the model type BJ-10AT manufactured by Kyowa Dengyo (Tokyo, Japan) or approved equivalent and shall conform to the following:

Rated output	= 1 mV/V ($2,000 \times 10^{-6}$ strain) or higher
Non Linearity	= $\pm 1.5\%$ RO
Safe excitation voltage	= 2 to 10 V
Input and output resistance	= 350 ohm (450 ohm output resistance at 0°C)
Safe temperature range	= -30 to 80°C
Safe overload rating	= 120%

c. Probe Extensometers

- (i) The column of the probe extensometer pipe shall consist of lengths of thick walled rigid PVC pipes manufactured to JIS K 6741 each 1.5 m long, with 0.5 m long overlapping joints between lengths and fitted with O-ring seals to exclude completely the entry of both soil and water. The inner tubes shall have a 77 mm internal diameter and 89 mm external diameter and shall be large enough to pass the inductance probe with a minimum annular clearance of 2.5 mm. The outer tubes shall have an internal diameter of 125 mm and external diameter of 140 mm and shall be designed to suit the O-ring seals. All tubing shall be capable of withstanding an internal pressure of not less than 2.5 kgf/cm² without showing any signs of rupture or leakage when this pressure is maintained for a period of 2 minutes. The base of the pipe shall be anchored on the internal gallery concrete as shown on the Drawings and the column shall terminate in a protective cover on the crest of the dam embankment.
- (ii) The crossarms shall be 1.6 m lengths of channel section with 300 mm x 400 mm steel settlement plates at each end and shall have a circular hole surrounded by a magnet ring in the centre of the base plate through which an inner length of tubing shall pass, but shall not be directly connected to it.

13.3.3 Installation

a. Foundation Deformation Meter

The foundation deformation meter shall be installed in accordance with the manufacturer's instructions, the Drawings and as directed.

b. Tri-Axial Joint Meter

Tri-axial joint meters shall be installed in accordance with the manufacturer's instructions, the Drawings and as directed.

c. Probe Extensometers

The probe extensometers installations shall be installed in impervious zone of the dam embankment in accordance with the Drawings and the approved procedures. The Contractor shall excavate trenches to the dimensions and procedures shown on the Drawings in the surface of the impervious Zone at every level required, and shall auger vertically below the floor of the trench to expose the protective cover on the top of the

preceding segment and carry out any hand trimming and hole clearing required. After installing the next segment and fitting the protective cover, the Contractor shall place and compact selected impervious zone material, in the hole and in the trench about and above the installation, using approved hand operated mechanical tampers. A minimum of 500 mm of compacted selected impervious zone material shall be placed above the protective cover in the trench before resuming normal placing and compaction. Crossarms shall be installed in every second trench at 5 m intervals above the foundation of the crossarms, in accordance with the approved procedures, and trenches and crossarms shall be orientated as shown on the Drawings. The selected impervious Zone material shall be in accordance with the requirements of Sub-Clause 13.1.11

13.3.4 Measuring Equipment

The inductance probe of the probe extensometer used for locating the crossarms with magnet rings installed in the dam embankment and for determining their levels shall be attached to but insulated from the measuring tape and their ends shall have suitable connections for attaching to a portable measuring unit at the top of the column which shall indicate the change in inductance as the probe passes through the hole in a crossarm. The measuring tape shall be wound on a suitable reel to facilitate the readings and the storage of the tape.

13.3.5 Measurement

Measurement, for payment, for supplying, installing, testing and surveying Foundation Deformation Meters, Electrical Tri-Axial Joint Meters and Probe Extensometers will be made of the number of instruments installed in accordance with the Drawings, the Specification, the manufacturer's recommendations or as directed by the Engineer.

13.3.6 Payment

- a. Payment for supplying, installing, testing and surveying Foundation Deformation Meter will be made at the rate per installation tendered therefor in the Bill of Quantities (Item M2). The rate shall include the cost of drilling and backfilling, installing the equipment in accordance with the manufacturer's instructions, supplying and terminating cabling at a terminal box.
- b. Payment for supplying, installing, testing Electrical Tri-Axial Joint Meter will be made at the rate per installation tendered therefor in the Bill of Quantities (Item M3). The rate shall include the cost of installing the equipment in accordance with the manufacturer's instructions, supplying and terminating cabling at a terminal box.
- c. Payment for supplying, installing, testing and surveying Probe Extensometers with Magnet/Reed Switch Transducer will be made at the rate per installation tendered therefor in the Bill of Quantities (Item M4). The rate shall include the cost of excavating and backfilling trenches, augering, if necessary, excavating and concreting the base of the column, placing and compacting selected impervious Zone material immediately adjacent to the installation, which shall include the PVC pipe, crossarms with magnet rings and supplying the inductance probe and all ancillary equipment including the read-out unit.

13.4 STRONG MOTION ACCELEROGRAPHS

13.4.1 General

The Contractor shall supply, install, test and survey strong motion accelerographs in the internal gallery and on the crest of the dam as shown on the Drawings or as directed by the Engineer.

13.4.2 Instruments Specification and Installation

- a. The strong motion accelerographs shall be of underground-type and surface-type corresponding to their installed locations and shall be to the approval of the Engineer.
- b. Each strong motion accelerographs shall be self-contained battery-powered and enclosed in a watertight case and shall have 3 accelerometers recording mutually perpendicular accelerations, 2 horizontal and 1 vertical, with at least 4 traces on film or magnetic tape, including a time reference trace in addition to the acceleration traces. Each accelerograph shall be activated within 0.1 second by a trigger which senses the initial ground motion and which by interconnection can trigger all other accelerographs in the dam. Each accelerograph shall continue to operate as long as the trigger detects the earthquake and for a minimum of 10 second afterwards. It shall be reactivated by subsequent shocks. The total recording time shall be not less than 10 minutes.
- c. The accelerographs shall also have the following characteristics:

Natural frequency	: 5 Hz
Range of frequency calibration	: 0.1 to 30 Hz
Sensitivity	: 10 mV/gal
Max. value of possible calibration	: 1000 gal.
- d. The accelerographs shall be mounted in a concrete pit on the crest of the dam and on a concrete plinth in the internal gallery, as shown on the Drawings and in accordance with the manufacturer's instructions.

13.4.3 Measurement

Measurement, for payment, of the supply, installation, testing and surveying of strong motion accelerographs will be made of the number of accelerographs installed in accordance with the Drawings or as directed by the Engineer.

13.4.4 Payment

Payment for the supply, installation, testing and surveying of strong motion accelerographs will be made at the rate per installation tendered in the Bill of Quantities (Item M.5). This rate shall include the cost of excavation, concrete pit, concrete plinth, the recorder, supply, installation, testing and any other necessary work connected therewith.

13.5 SURFACE MOVEMENT MARKERS

13.5.1 General

The Contractor shall supply, install and survey surface movement markers on the crest and on the upstream and downstream faces of the embankment, control stations and benchmarks as shown on the Drawings or as directed by the Engineer.

13.5.2 Materials and Installation

- a. Galvanised steel bar 25 mm in diameter with a cross cut into the upper end shall be furnished for all movement markers, bench marks and control stations as shown on the Drawings or directed. The survey pins shall be of shape and size as shown on the Drawings or directed.
- b. The Contractor shall carry out all work necessary for the installation of surface movement markers and crest movement markers and benchmarks within normal survey tolerance of the required position as shown on the Drawing and shall complete the installation as soon as practicable after placement of the rockfill in outer pervious and rip-rap zones in the locations at which surface movement markers are required.
- c. The Contractor shall construct the upstream and downstream surface movement markers at the locations and to the details shown on the Drawings.
- d. The Contractor shall construct the crest movement markers next to the crest roadway at the locations and to the details shown on the Drawings.
- e. The Contractor shall excavate and construct benchmarks and control stations at locations directed by the Engineer. Where practicable, and directed by the Engineer, bench marks and control stations shall be incorporated into permanent rigid structures on rock foundations.
- f. Concrete, reinforcement and construction shall be in accordance with Section 9 of the Specification.
- g. After construction of markers and concrete has gained sufficient strength, as approved by the Engineer, the Contractor shall backfill or place the outer pervious or rip-rap zone material taking due care not to damage the markers. Any damaged marker shall be repaired or replaced by and at the expense of the Contractor.
- h. After completion of work on the dam embankment, the positions and elevations of all surface markers shall be precisely surveyed and co-ordinates calculated to the nearest 5 mm and this data, including computation shall be reported to the Engineer in writing and shall be subject to the Engineer's approval. The surveys to establish elevations and co-ordinates shall be done using the permanent bench marks and control stations included in this clause whose elevations and elevations shall have been previously established using the construction survey control system and have had the Engineer's prior approval.

13.5.3 Measurement

Measurement, for payment, for movement markers of the various categories, bench marks and control stations will be made of the number of markers of each type installed in accordance with the requirements of the Specification.

13.5.4 Payment

Payment for supplying and installing movement markers in the upstream surface, downstream surface and crest of the embankment and in natural ground, benchmarks and control stations as directed will be made at the applicable rate per movement marker or benchmark or control station tendered therefor in the Bill of Quantities (Items M.6.1, M.6.2, M.6.3, M.6.4, M.6.5 and M.6.6). These rates shall include the cost of concrete, reinforcement, survey pins, excavation, backfilling, surveying and all other work required for the supply and installation and survey of the markers as described in this Clause.

13.6 STANDPIPE PIEZOMETERS

13.6.1 General

- a. The Contractor shall install Casagrande-type standpipe piezometers in the locations and to the depths shown on the Drawings or as directed by the Engineer.
- b. The Contractor shall submit full details of the Casagrande piezometer tip and reading device proposed to be used. The method of reading may be by sounding, pressure transducer, sonic or other and shall be subject to the approval of the Engineer.
- c. The piezometers to be furnished and installed shall include all tubing, cables, accessories and readout devices.
- d. In the event of a pneumatic type readout system being adopted the following specification shall apply.

Size	: 25.4 mm
Maximum pressure	: 280 m H ₂ O
Repeatability	: ± 0.035 m H ₂ O
Typical Diaphragm Displacement	: 0.01 ml
Filter	: Sintered Stainless Steel 50 micron pore size
Materials	: ABS and PVC plastic body, synthetic rubber diaphragm
Safe Overload Rating	: 120%

13.6.2 Installation

- a. Holes for casagrande piezometers shall be 100 mm diameter minimum drilled by rotary drilling using clean water.
- b. Casagrande piezometers shall be embedded in sand and sealed with bentonite at the bottoms of holes and the hole backfilled with grout.
- c. All work shall be in accordance with the approved working Drawings which shall incorporate the manufacturer's installation recommendations.
- d. The cap of the standpipe shall be finished in a manner appropriate to the type of read-out device to be used.

13.6.3 Payment

Payment for the supply, installation, testing and survey of standpipe piezometers will be made at the rate per installation tendered therefor in the Bill of Quantities (Item M.9). The rate shall include the cost of drilling and backfilling holes, supplying, installing, testing and surveying all instruments, tubes, cables, riser pipes and all ancillary measuring equipment and readout device.

13.7 TERMINAL BOXES

13.7.1 General

- a. The Contractor shall install terminal boxes of a design approved by the Engineer at the locations shown on the Drawings or as directed by the Engineer.
- b. The terminal boxes shall consist of steel cabinets complete with panels with capacity for 22 channels and suitable for reading by the portable digital readout unit.
- c. The output signal cables from the electrical piezometers, the foundation deformation meters and the electrical tri-axial meters shall be terminated at the panels in the terminal boxes.
- d. The Contractor shall complete each terminal box at least 21 days before the anticipated date of installation of instruments which will be connected directly to it.

13.7.2 Construction

Terminal boxes shall be surface mounted on the concrete walls of the internal gallery using approved masonry anchors.

13.7.3 Measurement

Measurement, for payment, for terminal boxes shall be made of the number of terminal boxes completed in accordance with the Drawings or directed by the Engineer.

13.7.4 Payment

- a. Payment for furnishing and installing terminal boxes will be made at the rate per terminal box tendered therefor in the Bill of Quantities (Item M.7). The rate shall include the cost of supply and installation of the terminal box complete with panel suitable for 22 channels.
- b. Payment for terminating instrument cables is not included in this item and shall be included in the rates for instruments for which the cables used.

13.8 SEEPAGE MEASURING FACILITIES

13.8.1 General

The Contractor shall construct two adjacent seepage measuring facilities in the internal gallery under the downstream toe of the semi-pervious zone at the locations shown on the Drawings or directed by the Engineer. Each facility to be provided shall include seepage drains of 300 mm diameter perforated reinforced concrete pipe, 200 mm diameter steel pipes leading

from the perforated seepage collector pipes to the seepage measuring pool, wave suppressing baffles, a vee-notch weir and staff gauge as shown on the Drawings, specified hereunder or directed by the Engineer.

Metalwork items supplied in accordance with this Clause shall comply with the requirements of Section 11 of the Specification.

13.8.2 Requirements

a. Pipes

Reinforced concrete pipes shall be precast and shall be constructed, handled and installed in accordance with the requirements of Section 9 of the Specification, the Drawings and the directions of the Engineer.

Steel pipes shall be galvanised 200 mm diameter schedule 40 steel pipe.

b. Seepage Measuring Equipment

Baffle plates shall consist of perforated stainless steel plate, 5 mm thick complete with stainless steel accessories and fastenings.

The vee-notch weir shall be made from 5 mm stainless steel plate cut to form a 90 degree vee-notch and shall include stainless steel accessories and fastenings. It shall be designed to permit easy removal of the weir plate.

As stainless steel staff gauge, graduated in mm shall be provided and mounted next to the weir to enable visual reading of the flow depth through the weir.

13.8.3 Payment

Payment for providing seepage measuring facilities as specified in this clause shall be made for each of the two facilities in place and approved by the Engineer at the rate per set tendered in the Bill of Quantities. (Item M.10) The rate shall include the cost of furnishing and installing reinforced concrete perforated pipes, furnishing and installing galvanised steel pipe (including bends, fittings and hangers), stainless steel baffle plates, vee-notch weir and measuring staff and all other works required to complete the works in accordance with this Clause.

13.9 DIGITAL READ-OUT UNIT

13.9.1 General

The Contractor shall provide a portable digital read-out unit for the purpose of reading outputs from the electrical piezometers, foundation deformation meters and electrical tri-axial joint meters from the terminal boxes in the internal gallery where output cables from those devices are terminated.

13.9.2 Requirements

The digital read out unit shall be a portable hand-held, battery operated, static strain indicator model SMD-20 manufactured by Kyowa Dengyo (Tokyo, Japan) or approved equivalent and shall conform to the following:

Sampling rate : 0.5 or 5 seconds, switchable

Peak Hold function accuracy : $\pm 0.3\%$ FS Response: DC to 100 Hz

Strain measuring	: 4-gauge method; 120,350 Ohm
Resistance measuring	: 0 to 19900 ohm
insulation measuring	: 1.0 to 500.0 MOhm

13.9.3 Payment

Payment for digital read-out units shall be made for the number of units provided and accepted by the Engineer at the rate per unit included in the Bill of Quantities (Item M.8). The rate shall include the cost of furnishing the digital read out unit, batteries, accessories testing and any other costs associated therewith.

13.10 THERMOMETERS

13.10.1 General

The Contractor shall supply, install and test nickel resistance thermometers in the diversion tunnel plug as shown on the Drawings or as directed by the Engineer. The Contractor shall also supply an approved portable reading device for monitoring the temperature.

13.10.2 Materials and Installation

- The thermometers and reading device shall be capable of measuring in the range 0°C to 70°C to an accuracy of plus or minus 0.3°C and shall have repeatability over a period of at least 5 years. The thermometers shall have a durability against a pressure of 2 kgf/cm².
- The nickel resistance thermometers shall be totally enclosed in copper sheaths and be attached to three-core industrial PVC or TRS flex which itself shall be totally enclosed in galvanised steel water pipe.
- Each thermometer shall be connected to its appropriate length of cable and shall be calibrated before being embedded in the concrete. A table and graph of the calibration data showing resistance against temperature of each thermometer shall be submitted to the Engineer.
- The Contractor shall embed thermometers in the fresh concrete during construction of the diversion tunnels plug, together with the necessary length of cable and galvanised steel pipe connecting to the downstream face.
- Where required, galvanised steel pipe suitable for electrical cables shall be furnished and installed in the concrete by the Contractor in to provide a conduit for the cables. The pipes shall be smooth on the inside surface.

13.10.3 Payment

Direct payment will not be made for supplying, installing and testing nickel resistance thermometers in the diversion tunnels plugs and all costs of the thermometers including the cost of supplying and installing cables, galvanised steel conduit and the reading device for monitoring the temperature at each instrument location shall be deemed to be included in the rate tendered in the Bill of Quantities for tunnel plug concrete.

**CONSTRUCTION OF THE JATIBARANG MULTIPURPOSE DAM
PACKAGE 1: JATIBARANG MULTIPURPOSE DAM INCLUDING
APPURTENANT STRUCTURES**

SPECIFICATION

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SECTION 14. GENERATING PLANT

14.1 GENERAL

14.1.1 Scope of Work

The work to be performed by the Contractor and covered by this Section 14 of the Specification includes the designing, manufacturing, supplying, testing, finishing, painting, packing for export, insuring, shipping, landing and delivering to the site, inland transportation, erection, site testing, placing in operation, commissioning and guarantee of the Plant as listed hereunder and more particularly described in the Drawings and in the relevant clauses of this section of the Specification.

- a. One horizontal shaft Francis type turbine 1630 kW
- b. One Horizontal shaft synchronous generator 2000 kVA
- c. One main transformer 2000 kVA.
- d. One station-service transformer 150 kVA.
- e. 3 Outdoor metal-enclosed cubicles for 20 kV equipment.
- f. 5 Indoor metal enclosed cubicles for station service equipment.
- g. Control and protection equipment.
- h. Station ancillary equipment.
- i. Cables and fittings.
- j. Grounding.
- k. Overhead travelling crane
- l. 20 kV transmission line

Established, reputable, Indonesian sub-contractors and Indonesian materials should be used to the maximum practicable extent provided that, in using them, the Works shall conform to the Contract requirements. A list of locally available materials is given in Clause 14.1.21.

In this section of the specification the term "equipment", shall include items to be included in the Permanent Works or are to be supplied by the Contractor and handed over to the Employer and shall have the same meaning as Plant as defined in the Condition of Contract unless specifically referring to Contractor's Equipment.

14.1.2 Embedded Components

The Contractor shall supply and install all necessary foundation bolts, nuts, embedded metalwork, piping, conduit and sleeves associated with and required for the Plant being provided and installed in accordance with the requirements of this Section 14, except as otherwise provided in the Specification.

The Contractor shall show the location and details of all components to be embedded on his drawings and shall be responsible for the completeness and accuracy of these drawings. The Contractor shall clearly indicate on his schedule of construction when embedded components are to be installed, and identify and indicate the date of delivery of all embedded components to be installed in primary concrete.

14.1.3 Tools and Appliances

The Contractor shall furnish one set of all special tools and appliances, including lifting gear, sufficient for the proper maintenance of all the Plant to be supplied and installed. These tools and appliances shall be included in the contract price for the generating plant.

Each tool and appliance is to be clearly marked with its size and/or purpose. The tools and appliances with the appropriate boxes or display boards shall be handed to the Engineer at the Employer's store in good condition prior to issue of the Taking Over Certificate for the associated item of Plant.

The Contractor shall also supply and install a work bench with vise, a drill press of 30 mm maximum capacity and a pedestal, 2-wheel grinder, voltmeter, ammeter, electrician tools and tool box.

14.1.4 Labels and Plates

All data, name plates and instruction plates on Plant and cubicles shall be in English.

14.1.5 Spare Parts

The rates and lump sum prices for generating plant shall be deemed to include provision of spare parts as specified in the relevant clauses of this Section 14 of the Specification. Any other spare parts recommended by the manufacturer shall be listed and quoted in the Tender, the Engineer may order all or any of the spare parts. Those ordered shall be delivered into the Employer's store prior to the date of issue of the Taking-Over Certificate. The delivery will not be deemed to be complete until the packages have been opened by the Contractor and contents checked by a representative of the Engineer and the articles re-protected and repacked by the Contractor to the satisfaction of the Engineer, or assembled into units at the Engineer's option.

The price of spare parts shall be subject to the same price conditions as associated Plant. The price of spare parts offered after the date of Taking Over Certificate shall be negotiated between the Engineer and the Contractor. All spare parts shall be interchangeable with the original parts. They shall be treated and packed for long term storage under the climate conditions of the Site.

Each spare shall be clearly and permanently labelled on the outside of its container with its description and purpose.

When several spares are packed in one case, a general description of the contents shall be given on the outside the case. Spare parts shall not be shipped in the same cases as component which are used for erection. The cases shall be clearly labelled to indicate that they contain spare parts.

All cases, containers, or other packages are liable to be opened for inspection and checking on the Site.

14.1.6 Contract Terminal Points

Construction of the 20 kV transmission line shall be carried out by the Contractor. A dead end pole for the transmission line, provided with arresters and fuse cut-out shall be supplied and installed under this Contract including all necessary connection work for the Plant and the grounding work. The connection termination to the 20 kV transmission line will be carried out by the Employer and all of the insulators for 20 kV line installed on the dead end pole shall be provided by the Contractor.

The Contractor shall supply a makeup piece which will connect the turbine butterfly valve to the penstock.

14.1.7 Instruction to Employer's Personnel

During the erection work at the Site, the Contractor shall instruct those personnel appointed by the Employer who will subsequently be responsible for the operation and maintenance of the Plant. The instruction shall be carried out to the satisfaction of the Engineer. The cost of such instruction shall be deemed to be included in the Contract price.

14.1.8 Drawings, Documents and Information to be Provided by The Contractor

- a. The Contractor shall prepare the documents specified in Section 1 of the Specification and shall comply with the procedures therein except as modified or further clarified as follows.
- b. The Contractor shall supply the following drawings, documents and information for the Engineer's approval within the following times.
 - (i) Within 60 Days of Commencement Date
Detailed schedule of manufacture, erection and commissioning.
 - (ii) Within 180 Days of Commencement Date
 - General arrangement drawings of turbine, generator, main transformer, switchgear equipment and their associated equipment.
 - Foundation drawings showing foundation details and forces. These drawings shall be sufficiently detailed to allow the final civil design of the powerhouse and switchyard to be completed. They shall show grouting allowances, block-outs for secondary concrete, positions for fixing bolts, trenches and openings for pipes and cables and all requirements for embedded items.
 - Drawings and instruction for installation of embedded items.
 - (iii) Within 300 Days of Commencement Date
Assembly drawings of the turbine, generator, transformer, showing sufficient detail to demonstrate compliance with the requirements of this Specification.

- (iv) Within 364 Days of Commencement Date
Schematic diagrams showing electrical details of all control devices, and all other devices together with supporting technical data.
- (v) Within 60 Days before Due Date of Delivery
Final copies of drawings required for erection.
- (vi) On Due Date of Delivery
Shop tests results.
- c. Site Modifications
Any modification made subsequent to delivery e.g. as a result of modifications made on the Site, shall be included on the Drawings
- d. Erection, Operating and Maintenance Instructions
Before the commencement of erection, the Contractor shall submit for approval fully detailed erection, operation and maintenance instruction manuals. The approved manuals and the as-built manuals shall also be submitted to the Employer and the Engineer in the same manner as the drawings.
 - (i) Erection Instruction Manuals
The erection instruction manual shall describe in detail the erection procedure and the use of all erection Plant and measurement devices. The procedure for assembling, adjusting, operating and dismantling of each component, system, and machine shall be described and illustrated with drawings and diagrams. The Contractor shall ensure that the erection supervisor has a copy in his office at the Site.
 - (ii) Operating and Maintenance Instruction Manuals
The operating and maintenance instruction manuals shall include a separate and complete section describing the normal and emergency operating procedures for the control of the generating and switching equipment, and shall include easily read diagrammatic drawings of the equipment to facilitate understanding the descriptive information.
The maintenance of each component shall be adequately described and illustrated including the recommended frequency of inspections and lubrication, material specifications, test results, and other pertinent information. The Contractor shall, in preparing the instruction manual, take into account the lack of experience and familiarity of the operating personnel with this type of Plant.
The manual shall include a complete list of all drawings prepared for this Contract, the spare parts list, and a parts list for each component of item of Plant. The parts list shall include manufacture's code and serial numbers and ordering instructions.
 - (iii) Test Procedure Instructions
The Contractor shall submit the test procedure to the Engineer for approval, during or immediately following the submission of drawings. The procedure shall define the sequence of the tests, the equipment preparation and operation procedures to be

followed shall contain performance guarantees, design values, technical particulars or any other standard data for testing which will be treated as criteria for the evaluation of each test. These instructions shall be submitted for approval and distributed in the same manner as the drawings.

14.1.9 Climatic Data

All materials and Plant shall be suitable for continuous operation in the region where climatic conditions are as shown in Sub-Clause 1.3.2 with a relative humidity of 70 to 100%.

14.1.10 Change of Material or Plant

The Contractor shall not make any changes to the Plant or to the materials to be incorporated from that specified or otherwise approved by the Engineer unless approval has been received from the Engineer.

14.1.11 Tropicalisation

Plant and materials and the finishes shall be selected by the contractor to be suitable for the humid tropical conditions (Relative Humidity 70-100%) which exist at the site. All enclosure for switchgear and control equipment shall be of dust-proof and vermin-proof, and where required weather-proof.

14.1.12 Grounding

The Contractor shall be responsible for the design and installation of the main grounding grid and grounding bus, for the connection of such with the various structures and penstock and for provision and connection of the lead wire connections from the grounding bus to all electrical plant.

Conductor size used for the main grounding network will be 60 square millimetre copper wire. The lead wire for main Plant such as generator, transformer and steel tower shall be 60 square millimetre copper wire. The lead wire for auxiliary Plant such as cubicles, panels, cable rack and conduit shall be 22 square millimetre copper wire.

The lead wire shall be connected to electric Plant and all ancillary equipment by the Contractor.

14.1.13 Working Stress and Design

The design, dimensions and materials of all parts shall be such that they will not cause damage or corrosion under the most adverse conditions and not result in deflections or vibrations which will adversely affect the operation of the Plant.

All parts which may have to be dismantled for the purpose of servicing or replacement shall be held in place with anti-corrosion type fasteners.

Wherever possible, all similar parts, including spare parts, shall be made interchangeable. Such parts shall be of the same materials and workmanship and shall be constructed to such tolerances as to enable substitution or replacement from spare parts to be easily and quickly.

Suitable structural steel bases or frames shall be provided where necessary to transmit to the concrete foundations all loads imposed by the various parts of the Plant, such bases or frames shall be supplied complete with suitable foundation bolts and shall be so proportioned that the bearing loads imposed on the concrete foundations will not exceed 50 kg per square centimetre.

All Plant shall be designed to minimise the risk of fire and consequential damage, to prevent ingress of vermin, dust and dirt, and accidental contact with electricity energised or moving parts. The Plant shall be capable of continuous operation with minimum attention and maintenance in the exceptionally severe conditions likely to be encountered in tropical climate.

Complete information regarding the design assumptions, loading and operating conditions, deflections and unit stress used in the design shall be provided by the Contractor.

The Contractor shall ensure that all items of Plant comply with the Contract and that they shall operate reliably, safely, free from undue stress with adequate drainage and other factors necessary for a satisfactory working plant.

14.1.14 Standards and Workmanship

All materials shall be new, of a first-class nature. All materials shall comply with the latest relevant authorised standards for Testing Materials unless otherwise specified or permitted by the Engineer.

All workmanship shall be of highest class throughout to ensure smooth and vibration free operation under all possible operating conditions, and the design, dimensions and materials of all parts shall be such that the stresses to which may be subjected shall not render them liable to distortion, undue wear, or damage under the most severe encountered in service.

All parts shall conform to the dimensions shown and shall be built in accordance with the approved drawings. All joints, datum surfaces, and mating components shall be machined and all castings shall be spot faced for nuts. All machined finished shall be shown on the approved drawings.

All screws, bolts, studs and nuts and threads for pipe shall conform to the latest standards of the International Organisation for the Standardisation covering these components and shall all conform to the standards for metric sizes. The Contractor shall use exclusively the standard and size system presented in his Tender and approved in the Letter of Acceptance.

a. Standard Specifications

The design, materials, manufacture, testing, inspection and performance shall, unless otherwise specified in the specific requirements detailed in this section 14, conform to international recognised standards. The standards to be used shall be those proposed in the Tender and approved in the Letter of Acceptance.

b. Shop Assembly

All items of Plant shall be assembled as far as possible in the shop prior to shipment and tests shall be performed by the Contractor as may be required to demonstrate to the satisfaction of the Engineer the adequacy

of the Plant and its component parts. All tests should simulated normal operating conditions as closely as possible, all dismantled parts shall be properly match marked and doweled to ensure correct assembly at the Site.

c. Castings

All castings shall be dense, sound and true to pattern, of workmanlike finish and of uniform quality and condition, free from blowholes, porosity, hard spots, shrinkage defects, cracks or other injurious defects, and shall be satisfactory cleaned for their intended purposes. All castings shall be checked for defects before final machining.

Castings shall not be repaired, plugged, or welded without permission of the Engineer. Such permission will be given only when the defects are shall and do not adversely affect the strength, use, or machineability of castings. Excessive segregation of impurities or alloys at critical points in a casting will be cause for its rejection. The largest fillets compatible with the design shall be incorporated where a change in section occurs.

Surfaces which do not undergo machining and are exposed in the firm installation shall be dressed to provide a satisfactory appearance so that they will not require surface smoothing at the Site prior to painting.

d. Forgings

The ingots from which the forgings are made shall be cast in metal moulds. The workmanship shall be first-class in every respect and the forgings shall be free from all defects affecting their strength and durability, including seams, pipe flaws, cracks, fins, porosity, hard spots, excessive non-metallic inclusions and segregations.

The largest fillets compatible with the design shall be incorporated wherever a change in a section occurs. All finished surfaces of forgings shall be smooth and free from tool marks.

The forgings shall be stamped with the heat number in such location as to be readily observed when the forging is assembled in a completed unit.

e. Finished Surface

Finished surfaces shall be indicated in the Contractor's drawing and shall be in accordance with International Industrial Standards for equivalent. Compliance with specified surface will be determined by visual inspection of the work compared to standard roughness specimens, in accordance with the provisions of the above stated standards.

f. Unfinished Surfaces

So far as is practicable, all work shall be arranged to obtain proper matching of adjoining unfinished surface. When there is a large discrepancy between adjoining unfinished surfaces, they shall be chipped and ground smooth, or machined, to secure proper alignment. Unfinished surfaces shall be true to the lines and dimensions shown on the drawings and shall be chipped or ground free of all projections and rough spots, Depressions or holes not affecting the strength or usefulness of the parts may be filled in and approved manner.

g. Keys and Keyways

Keys and keyways shall conform to the requirements of International Electrotechnical Commission (IEC) Standards or other approved equivalent standard, unless otherwise specified or required.

h. Balancing

All revolving parts shall be truly balanced both statically and dynamically so that when running at normal speeds and at any load up to the maximum, there shall be no vibration due to lack such balance and the Plant shall operate with the least possible amount of noise.

i. Handrails

Adequate safety handrails and guards shall be provided around the Plant, where necessary, to afford protection from all moving and electrical parts. Such items shall be designed to facilitate easy removal to permit free access to various parts of the Plant.

j. Welding

Wherever welding is specified or permitted, the approved welding process shall be used. All welders and welding operators shall be fully qualified in accordance with the requirement of the appropriate section of A.S.M.E boiler code section IX welding qualification or such other standards as may be approved. The Contractor may be required to submit evidence of the welder abilities. The Contractor shall develop a welding procedure for approval of the Engineer.

After the welding process has been approved, the Contractor shall record it on a special drawing which shall there upon become one of the Contract Drawings. Welding symbols shall shown on all Contractor's drawings where welding is required.

Radiographic inspection shall be carried out by the Contractor when required by the standards, these Specifications or the design criteria employed. All important welds which, on the induced on the adjacent plate, or which in the opinion of the Engineer, do not appear to conform to the welding standards shall be radiographed when required by the Engineer.

Unless otherwise specifically stated, welded parts requiring machine finish shall be completely welded before being finished. All welds shall be made continuous and watertight. The minimum throat dimensions of fillet welds shall be 4.5 millimetres.

k. Piping

Seamless steel pipe and/or copper tubing shall be used for all lines. Galvanised steel pipe shall be used for all air lines. Stainless steel pipe shall be used for water lines.

All necessary studs, bolts, screws, nuts, washers, gaskets, packing, supports, etc., required in connection with the field assembly of the piping systems shall be supplied by the Contractor. All gaskets and packing shall be of approved material and of a type that has proved satisfactory for the service to which they will be subjected.

Where pipe is embedded in concrete, it shall be carefully set to the required lines and grades and securely braced and held so that no

movement shall occur during concreting operations. Pipe supports to be embedded in concrete shall be made of material which will not deteriorate, weaken or cause damage to the pipe. The Contractor shall schedule and arrange his work of installing pipes and pipe supports in co-operation with Engineer.

l. Hangers and Supports

The Contractor shall supply and install all pipe hangers, brackets and supports required for the support of the piping, including the drilling and caulking for expansion anchor and any work incidental to the setting of such embedded anchors or inserts in concrete.

- m. Unless otherwise specified, pipe supports shall be spaced at 2-metre centres at maximum for steel and 1-metre centres for copper. Pipe hangers for copper tubing shall be copper-plated and of an approved type. Vertical runs shall be supported by means of pipe clamps or collars. Hangers and support shall be painted.**

n. Embedded Inserts for Supporting Pipes and electrical Conduits

The Contractor shall design and supply a support system and embedded inserts for pipes and electrical conduits and shall include the clamps to transfer loads from the items supported to the support system.

o. Installing and Workmanship for Piping System

All pipe lines shall be sloped to allow drainage to the low point. Where a branch cannot be drained through fixtures, a drain valve shall be provided in an accessible location.

All piping shall be fitted and assembled to introduce the minimal stress to the pipe and fittings, and the assembly shall conform to the best piping practice. All piping less than 75 mm diameter shall be supported at a minimum of 2 metre intervals. All piping shall be supported and installed to avoid configurations that will not drain completely.

All threads shall be accurately and clearly cut and all burrs shall be removed. The same standard of thread system shall be used throughout the power station. All piping to be embedded shall be tested and approved by the Engineer prior to be embedded. Sleeves or block-outs will be provided where a pipe passes through a wall, floor or beam; The space around the pipe will be filled except where pipe enters the turbine or generator. All surfaces of the pipe which come in contact with concrete shall be cleaned prior to placing the concrete in order to secure a satisfactory bond. Pipe unions shall be fitted where necessary to facilitate installation or maintenance of Plant. Junction of copper to ferrous pipes shall be made with bronze adapters.

p. Tests for Piping System

The Contractor shall test all pipe lines as directed by the Engineer and shall supply all his own employees, materials, pumps, plugs, gauges, etc., required to make the complete test. Lines shall be tested in convenient sections. In the case of failure due to faulty workmanship on the part to the Contractor, material failure or leaks, he shall repair all damage and leaks, replace the faulty material, and retest the piping at his own cost until the tested section is acceptable to the Engineer. All tests shall be carried out in the presence of the Engineer.

The Contractor shall provide all water and other equipment for testing of pipework.

Before testing, all supports, and hangers shall be in place. If piping is tested in sections, temporary end caps shall be fitted to the approval of the Engineer. Each section shall be slowly filled with the test medium, care being taken to expel all air from the piping if liquid is used.

For acceptance, the test pressure shall remain constant for the test period without pumping additional water into the section under test. If a drop in pressure occurs, leaks shall be repaired and the pipeline re-tested until acceptable.

q. Hydraulic Pressure Tests

All pressure vessels, cooling coils and piping shall be pressure tested, in the presence of the Engineer, and shall meet the following requirements:

- (i) Parts subject to penstock line water pressure:
23 kg/cm² for 10 minutes as the primary test.
- (ii) Parts subject to air and/oil pressure:
1.5 times the maximum design pressure for 10 minutes.
- (iii) All other parts:
Twice the maximum working pressure but not less than 5 kg/cm² for 10 minutes.

All pressures are gauge pressures. All leaks and evidence of excessive of permanent deflection shall be repaired to the satisfaction of the Engineer, and the test repeated until the test conditions are satisfied.

14.1.15 Protection, Cleaning and Painting

a. General

All parts which will ultimately be embedded in concrete shall be cleaned and protected by a cement wash or other approved method before forwarding from the manufacturer's shop. Before being installed, they shall be thoroughly descaled and cleaned of all rust and adherent matter. Such cleaning shall not affect the strength or final operation and function of the Plant.

All machined parts or bearing surface shall be cleaned and protected from corrosion by the application of and approved rust preventive lacquer, or a peelable plastic film before forwarding from the manufacturer's shop. Where the latter is impracticable, such parts shall be heavily covered with high melting point grease. After erection, such parts shall be cleaned with solvent and wiped or polished bright.

All parts other than machined parts, which will be exposed after erection, shall be thoroughly cleaned and given two coats of best quality approved primer and one coat of best quality approved finish paint before forwarding from the manufacturer's shop and further one coat of paint of and approved quality and colour after erection and touching up on the Site except such apparatus as panels and instruments which will be finish painted.

Primer shall be applied to surfaces prepared in accordance with the paint manufacturer's instructions. The surface shall be wiped clean immediately prior to applying. The primer and finish coats of paint shall be applied using the methods and painting equipment recommended by the manufacturer.

The internal surface of all pipelines shall be cleaned out by approved methods before installation and again prior to commissioning, to ensure freedom from dirt, rust, scale, welding slag, etc. All exposed pipes shall be colour-coded for identification after erection. The colour system of coding shall be approved by the Engineer.

The Contractor shall propose a colour scheme for all items of Plant and shall submit colour chips or paint sample for the Engineer's approval. A colour chip shall be included with the approved colour schedule, for each type of finish to be applied at the Site.

All Plant shall be painted as specified herein. The painting of Plant shall include the preparation of the metal surfaces, paint application, protection and drying of the paint coatings, as well as the supplying of all tools, labour and materials necessary for the entire painting work.

Sufficient paint shall be provided for field paint shall be the product of reputable manufacturers and its selection shall be approved by the Engineer.

All paint shall be the product of reputable manufacturers and its selection shall be approved by the Engineer.

b. Surface Preparation

All oil, paraffin, grease and dirt shall be removed from the surfaces to be painted using solvents. All weld materials, slag, burrs, loose rusted mill scale and other foreign substances shall be removed by shot or sandblasting to "white" metal. The interior surface of the steel pipe shall be mechanically cleaned or sandblasting to a commercial standard.

Special attention shall be given to cleaning of corners and converging angles. If rust forms or the surfaces become contaminated in the interval between cleaning and painting, re-cleaning to the same degree appropriate and adequate marking during the cleaning and painting of adjacent metalwork. Effective means shall be provided for removing all free oil and moisture from the air supply lines of blasting equipment. All surfaces preparation shall be subject to approval of the Engineer before any paint is applied.

c. Application Procedure

All paint, when applied, shall provide a satisfactory film and a smooth, even surface. Paint shall be thoroughly stirred, strained, and kept at a uniform consistency during application. Paint shall not be applied when the temperature of the metal or of the surrounding air is below 10°C.

Surface to be painted shall be coated by brushing or spraying. Each coat shall be allowed to dry or harden thoroughly before the succeeding coat is applied.

d. Surfaces Not to be Painted

Bronze, brass, surface of gear teeth, finished ferrous surfaces, surfaces in rolling or sliding contact after field assembly and wire ropes shall not be painted.

All corrosion resisting steel surfaces for bearings and machinery parts shall not be painted.

On completion of cleaning, such surfaces shall be coated with and adhesive plastic film to protect the surfaces from minor mechanical damage and corrosion during shipment and storage at the site. The film shall be stripped off immediately prior to field erection of the Plant.

e. Galvanising

Unless specifically mentioned to the contrary, iron and steel shall be effectively galvanised after all fabrication is completed.

The zinc coating shall be uniform, clean, smooth and as free from spangle as possible. Galvanising shall be applied by the hot dip process for all parts other than steel wires. All steel wires shall be galvanised by the manufacturer and approved before stranding.

The minimum quantities of zinc coating shall be 350 g/cm² for bolts and nuts and 550 g/m² for all other parts except steel wires. The uniformity of zinc coating, tested by dipping the sample into the solution of sulphate of copper, shall be such that no surface of iron or steel shall expose until four times of dipping for bolts and nuts and six times for all other parts.

The preparation for galvanising and the galvanising itself shall not distort or adversely affect the mechanical properties of the materials. After galvanising holes shall be free from modules of splatter.

Tenderer's attention shall given to that galvanised parts are subject to the formation of white rust during shipment or storage on the Site, and special treatment shall be made during galvanising process to prevent the formation of white rust, the detail of which shall be stated in the Tender.

f. Paint Schedule

The painting shall be performed as follows:

- (i) Tar-epoxy paint, total thickness of 0.45 - 0.60 millimetres, shall be applied to the following items:
 - Exposed surface of I guide frames
 - All gates leaves
 - Interior surface of steel conduits and valves
- (ii) Epoxy resin paint, total thickness of 0.15 - 0.25 millimetres shall be applied to the following items:
 - External surface of steel conduits and valves
- (iii) All unfinished surfaces of ferrous metal except those specified in the above shall given phthalic acid resin of alkyed resin enamel or other approved paints. Total thickness of these paints including primer coat shall be 0.12 - 0.15 millimetres. Commercial Plant

shall be painted in accordance with the manufacturer's standard practice.

All finished surfaces of ferrous metals including screw threads that will be exposed during transportation or while awaiting installation shall be cleaned and given a heavy uniform coating of gasoline soluble, rust preventive compound.

14.1.16 Packing

Each item shall be packed properly or protected for shipment from the place of manufacture to the Site.

Each crate or package shall contain a packing list in waterproof envelope and a copy in triplicate shall be forwarded to the Engineer prior to dispatch. All items of material shall be clearly marked for easy identification against the packing list.

All cases, packages, etc., shall be clearly marked on the outside to indicate the total weight, to show where the weight is bearing and the correct position of the slings and shall bear an identification mark relating them to the appropriate shipping documents. Cases which cannot be marked as above shall have metal tags with necessary marking on them. The metal tags shall be securely attached to the package with strong steel wire or equivalent.

The Engineer shall reserve the right to inspect and approve the Plant and the packing before the items are dispatched. The contractor shall be entirely responsible for ensuring that the packing is suitable for transit and such inspection will not relieve the Contractor of responsibility for any loss of damage due to faulty packing.

The maximum weight and width of each packing of the cargo of any item of Plant shall be limited to 20 tons and 4 metres respectively for inland transportation.

All packing materials shall remain the property of the Contractor and shall be removed from the Site at the earliest opportunity and disposed of to the satisfaction of the Engineer.

14.1.17 Test Procedure Instructions

The Contractor shall submit to the Engineer for approval, at least two months before tests are to be performed an instructional testing procedure describing each test to be performed. The procedure shall define the sequence of the tests, the Plant preparation and operation procedure to be allowed and the detailed procedures for conducting the tests. These procedures shall be submitted for approval and distributed in the same manner as the Drawings as set out in Section 1 of the Specification.

14.1.18 Tests

During the construction and after the installation of each item of Plant, the Contractor shall perform the tests as described in the test procedure instructions to establish the accuracy of the assembly and to prove the adequacy of the materials and workmanship.

The tests and test results shall be approved by the Engineer. No part of the work shall be considered acceptable until it has successfully complied with these tests to the satisfaction of the Engineer.

Test records, data, calculation sheets and photographs, if any, shall be submitted to the Engineer in six copies within two weeks after the test had been conducted.

a. Tests at Manufacturer's Workshop

The tests to be carried out before shipment at the manufacturer's workshop are as stated in the relevant Clauses of this Section 14 of the Specification.

b. Preliminary Tests

During the construction and after the installation of each item of Plant, control device, piping system, etc., tests shall be performed, as specified herein, to establish the accuracy of the assembly and to prove the adequacy of the materials and the workmanship. All tests and tests procedures shall be subject to the Engineer's approval.

The Contractor shall perform the following tests, as applicable to ensure that the Plant has been correctly installed, all necessary adjustment and settling made and is in sound condition to run under load.

(i) Routine Checks during the Installation

- Centre, level and dimension check of foundation of the Plant, and the centring of the penstock, inlet valve, turbine and generator
- Centre, level and dimension check for temporary installation and fixing of draft tube before and after placing of concrete
- Check of foundation and installation of spiral case, and centring of it.
- Clearance check after installation of turbine parts and inlet valve
- Check of the installation position of all parts of inlet valve, spiral case and draft tube elbow after placing of concrete.
- Check and record of position and dimensions of runner, guide vane and turbine cover
- Check alignment check after and level check of the turbine and generator
- Assembly check of generator stator and rotor
- Shaft alignment check after coupling of turbine and generator shafts
- Measurement of clearance between stator and rotor
- Voltage check of generator rotor winding
- Pressure test of strainers and pipes

- Calibration of dial type thermometers
- Calibration of pressure gauges
- (ii) Governor
 - Check of control operation
 - Check of automatic start and stop device
 - Adjustment and setting of speed
 - Adjustment and setting of limits switches
 - Adjustment of servomotor closing and opening time
 - Adjustment and setting of servomotor stroke
 - Adjustable range of speed changer
 - Relation of guide vane opening and servomotor stroke
- (iii) Inlet Valve
 - Check of water leakage
 - Operation check
 - Adjustment and setting of operation time
- (iv) Cooling and Shaft Sealing Water Supply System
 - Operation check of strainers
 - Operation check and setting of flow relays
 - Water leakage check
 - Measurement of water discharge pressure
 - Measurement of insulation resistance of motors
- (v) Drainage Pumping System
 - Operation check and setting of flow relays
 - Water leakage check
 - Measurement of water discharge pressure
 - Measurement of insulation resistance of motors
- (vi) Compressed Air Supply System
 - Operation check and setting of pressure relays
 - Air leakage check
 - Measurement of insulation resistance of motors.

- (vii) **Generator**
 - Measurement of winding resistance
 - Measurement of insulation resistance
 - High voltage test of generator windings
 - Measurement of loss angle of generator stator
 - Operation check of protective relays and switches
 - Vibration check
 - Temperature rise
- (viii) **Excitation System**
 - Operation check of field circuit breaker
 - Characteristics of AVR
 - Operation check of protective relays
- (ix) **Transformers**
 - Measurement on all taps
 - Check of polarity and phase relationship
 - Measurement of winding resistance at each tap
 - Measurement of insulation resistance
 - Withstand voltage test of insulating oil
 - Calibration of dial thermometers
 - Operation check of protective relays and switches
- (x) **Circuit Breakers (20 kV and low voltage)**
 - Closing and opening operation test
 - Trip free operation test
 - Manual operation test
 - Remote operation test
 - Measurement of insulation resistance
 - Check of minimum coil operation voltage
 - Measurement of operating coil resistance
- (xi) **Current Transformers and Voltage Transformers**
 - Polarity check
 - Ratio check

(xii) Switchgear and Power Cables

- Measurement of insulation resistance
- High voltage test

(xiii) Control and Relay Board

- Sequential operation check
- Operation check and setting of protective relays
- Calibration of meters
- Measurement of insulation resistance

(xiv) Storage Batteries

- Measurement of voltage and specific gravity
- Capacity test

c. Tests on Completion

After the ancillary and control Plant have been installed, tested and approved and the generating units are fully installed, adjusted and successfully completed its mechanical run and the generator dry out, the Contractor shall carry out running tests in the presence of the Engineer to demonstrate that all guarantees and technical particulars as listed in the Tender have been met and that the entire work is properly installed, is free from objectionable leakage and is correctly adjusted to operate as specified. The tests shall be carried out in such manner and for duration as may be required by the Engineer to demonstrate that all requirements of the Contract have been met.

The Contractor shall make all final adjustments and setting to the control, detection and protective devices.

The Contractor shall be responsible for the operation of the unit during the tests. The Contractor shall not be required to operate the unit at runaway speed.

The tests on Completion shall include the following items, but shall not be limited to:

- (i) Bearing run operation test (trial running test)**
- (ii) Dry-out running operation test**
- (iii) Three-phase short circuit characteristics**
- (iv) No-load saturation characteristics**
- (v) Shaft voltage measurement**
- (vi) Residual voltage measurement at neutral point**
- (vii) Load rejection test**
- (viii) Sudden load increase test**
- (ix) Emergency stop test**

- (x) Overspeed test for checking overspeed relay
- (xi) Load test (temperature rise test)
- (xii) Automatic start and stop operation test
- (xiii) Vibration measurement and noise measurement
- (xiv) Relation between guide vane servomotor and generator output

The load test and load rejection test shall be performed using the commercial grid.

The output test shall be made at a net head as near as practicable to the design head. The turbine output shall be determined from electrical measurements of generator output and the shop test results of generator losses. The power output of the generator shall be measured by the use of properly calibrated electrical test instruments.

The Contractor shall carry out capacity, speed and pressure rise tests. The Contractor shall provide all supervision necessary to direct the tests and shall assume all responsibility for the Plant during testing.

During the tests on completion the Contractor shall also check that the auxiliary Plant has sufficient capacity and has characteristics to meet the requirements of the operating generating Plant and switchgear.

The final results of all tests including test run for period two weeks continuously by the Contractor using his own personnel shall be subject to acceptance by the Engineer and shall verify that the performance guarantees and technical particulars given the Form of Functional Guarantees and the Form of Technical Particulars have been fulfilled.

The Contractor shall be responsible for all routine maintenance, i.e. lubricating, inspection and adjusting of all Plant up to the date of the issuance of the Taking-Over Certificate.

Should the tests indicate that the performance of any item of Plant is below that guaranteed by the Contractor, the Contractor shall carry out at his own expense such measures as may be approved by the Engineer to rectify the deficiency. Notwithstanding this a reasonable adjustment of the Contract Price, in respect of any residual deficiency in performance at the time of acceptance of the unit, shall be made.

14.1.19 Electrical and Mechanical Design

a. Frequency

All Plant shall be designed for a frequency of 50 Hz.

b. Electrical Requirements

All switchgear Plant and fittings shall be electrically designed to avoid local corona formation and discharge likely to cause radio interference, and shall be designed to mechanically endure short-circuit current without thermal and mechanical failure for one (1) second.

c. Enclosures for Electrical and Control Plant

The enclosures for switchgear, control Plant, protective relays, turbine governor, AVR, D.C. panel, battery charger and storage batteries, etc., shall be totally enclosed, by sheet steel panels not less than 2 mm thick, with angle or channel edge bent, seam-welded at corners, and ground smooth. Panels shall be bolted at the bottom to suitable steel channels sills with necessary framing which will hold the structure rigidly together to form a self-supporting dead front type of structure. Outside panels shall not be drilled or welded for attaching wires, resistors, or instruments.

The enclosures shall be provided with access doors to facilitate inspections of the Plant. The doors shall be provided with suitable handles with locks.

All enclosures shall be of dust-proof and vermin proof, and where required, weatherproof.

Interior illumination lamps for enclosures shall be provided for each panel operated by door switches.

Space heaters for 220-volt AC shall be provided inside the cubicles to prevent moisture condensation. A manual switch to control the heaters shall be provided in the cubicle.

d. Painting for Enclosure

All outside panel surfaces shall be primed, filled where necessary, and given not less than two coats of synthetic undercoat. The finishing coat for the outdoor installations shall be a gloss paint and for the indoor installation shall be a semi-gloss paint.

The inside surface of the enclosures shall have two prime coats and one finishing coat of light cream colour.

The colour scheme for the finishing coats of all Plant, frames for meters and relays, and switch handle shall be proposed by the Contractor with presentation of colour sample or colour chips and shall be subject of the Engineer's approval.

The humid and tropical conditions shall be taken in account on selection of the paints and painting procedure.

e. Meters and Instruments

Unless otherwise specified in the Specification, each indicating instrument shall be flush-mounted back-connected, dust-proof and heavy duty switchboard type. Each indicating meter and instrument shall have a removable cover, either transparent or with a transparent window. Each meter and instrument shall be suitable for operation with the instrument transformers shown on the drawings under both normal and short-circuit conditions.

Scale plates shall be of a permanent white circular or rectangular finish with black pointer and markings. The scale range shall be determined from the current transformer and voltage transformers ratios.

All indicating instruments shall be approximately 110 mm square enclosures and shall be provided with clearly readable long scale, approximately 240 degrees. The maximum error shall be not more than one and a half (1.5) percent of full scale range.

f. Indicating Lamp Assemblies

Indicating lamps assemblies for the enclosures shall be of the switchboard type, insulated for 240-volt D.C. service, with approximately coloured lamp covers and integrally mounted resistors. The lamp covers shall be made of a material which will not be softened by the heat from the lamps.

Indicating lamp assemblies for the outdoor switchgear shall be of outdoor type, designed for operation on 100-volt D.C.

Red indicating lamps shall be used for "ON" position and green lamps for "OFF" position.

g. Nameplates, Escutcheon Plates and Rating Plates

Each cubicle, panel, meter, relay, switch and device shall be provided with a nameplate or escutcheon plate for identification. Each turbine, generator, transformer and switchgear Plant shall be provided with a rating plate containing the necessary information specified in the relevant IEC standards.

The plates shall be made of weather-proof and corrosion-proof material and shall not be deformed under the service conditions at the Site.

The entries on the plates shall be indelibly marked by engraving to black letter on a white background.

The language of all plates shall be English and Indonesian unless otherwise instructed by the Engineer.

h. Porcelain Insulators and Fittings

All porcelain insulators of outdoor switchgear Plant shall be brown glazed. The porcelain insulators to be mounted inside the enclosure shall be white. The resin insulators for indoor Plant may be of the inherent colour of the resin. All fittings shall be malleable iron hot-dipped galvanised alloys.

i. Terminal Blocks

Terminal blocks for control wiring shall be rated not less than 600-volt with cover and be of the moulded type with barriers.

White or other light-coloured marking strips, fastened by screws to the moulded sections at each block, shall be provided for circuit designation.

Each connected terminal of each block shall have the circuit designation placed on the marking strip with permanent marking fluid. The terminal arrangement, including the terminal blocks for current transformer and voltage transformer connections, shall be subject to Engineers approval. Space marking strips shall be furnished with each block.

j. Wiring

(i) General

All wiring shall be done with PVC insulated wire of adequate size and rating. A suitable wiring duct system shall be installed for all inter-panel and front-to-rear panel wiring which will provide easy access for inspection and replacement. As far as possible all wiring shall be installed in wiring ducts.

All wiring from hinged door panels to the fixed panels shall be done with flexible conductor of equivalent size.

Wiring between terminals of the various devices shall be point to point. Splices or tee connection will not be acceptable. Wire runs shall be neatly trunked or clamped.

Exposed wiring shall be kept to a minimum, but where used shall be formed into compact groups suitably bound together and properly supported.

Instrument transformer secondary circuits shall be grounded only at the first panel entered, and not be grounded at any point on the outside of the enclosures.

Cable supports and clamp type terminating lugs shall be provided for all incoming power wiring terminating at each cubicle. All wire shall be marked near each terminal end with circuit or wire designation. These markers shall be of an approved type and permanently attached to the conductor insulation.

(ii) **Phase Arrangement**

The standard phase arrangement when facing the front of the panel shall be R-S-T-N and R-N-S from left to right, from top to bottom, and front to back for AC three-phase and single-phase circuits and N-P from left to right, P-N from top to bottom and front to back for D-C polarity. All relays, instruments, other device buses and Plant involving three-phase circuit shall be arranged and connected in accordance with the standard phase arrangement where possible.

(iii) **Wiring colour code**

Standard electrical wiring colour codes shall be used and a suitable legend will be provided by the Contractor.

14.1.20 Attendance of Employers Personnel at Shop Tests

The Contractor shall arrange for two (2) persons of the Employer's or Engineer's staff to witness tests of major Plant at the manufacturer's workshop.

The Contractor shall submit to the Engineer all shop test schedules of major Plant including the test items, the date on and place at which the tests are carried out. Thereafter the witness test items will be informed by the Engineer.

Necessary expenses for the Employer's personnel including a round-trip economy air fare between Indonesia and the manufacturer's country, costs of foods, lodging and inland transport, etc. for stay in the manufacturer's country for ten days shall be borne by the Contractor.

14.1.21 List of Materials Available in Indonesia

The following materials are readily available in Indonesia.

- Frequency
- Fuel oil settling tanks
- Fuel oil storage tanks

- Fuel oil leak tanks
- Lube oil storage tanks
- Lube oil circulation tanks
- Lube oil leak tanks
- Nozzle cooling oil tanks
- Cooling water compensation tanks
- Complete piping inside and outside
- Steel plates for tanks etc.
- Manufacturing of all 20 kV high voltage switchgear panels, assembling, installation wiring and testing
- All types of PVC insulated LV power cables inside and outside of the Powerhouse
- All types of PVC insulated control cables
- All types of cables and wires for installation of lighting and small power outlets.
- Station transformer of all stations and step up transformer
- Manufacturing of ventilation system for engine hall and switchgear annex
- Air conditioning Plant for the control office
- Plant for building installation (lighting fixtures, switched, outlets, boxes, etc)
- Miscellaneous materials and consumables for installation and erection of electrical Plant
- Complete office equipment and furniture
- Supply of all standard furniture
- Overhead crane including basic electrical Plant and steel structure
- Fuel oil storage tanks including accessories
- Hydrants for fire fighting
- All portable fire extinguishers
- Incinerator for burning of waste sludge
- Workshop equipment of tool machinery, tools and other equipment
- All kinds of insurances for Plant and personnel
- Shipping of Plant from abroad to Indonesia

- Project head office, site management and supervision of erection (foreign currency portion)
- Local transportation, on loading, off loading, customs clearance
- Erection and installation of all mechanical and electrical Plant
- Testing and training, assistance to supervisors and commissioning engineers
- Complete steel structure for power station building
- Complete civil works for power station
- Concrete poles
- Gates
- Penstock
- Trash rack
- Metal Surge tank
- Draft Tube
- Staircase
- Cabling
- Cabinet cubicle
- Vacuum type circuit breaker
- Spiral casing
- Pit liner
- Stay Ring
- Pier nose
- Suction con

14.2 HYDRAULIC TURBINE AND ANCILLARIES

14.2.1 Scope of Work

This clause 14.2 covers the design, manufacture, tests before shipment, transport to the Site, erection and tests at the Site of the following Plant:

- a. Horizontal shaft Francis turbine rated at 1630 kW at 64.30 m design head.
- b. Governor, complete with controls
- c. Butterfly type or Biplane type inlet valve with controls