กรมพัฒนาพลังงานทดแทน
และอนุรักษ์พลังงาน
กระทรวงพลังงาน

โครงการไฟฟ้าพลังน้ำขนาดเล็กมากท้ายเขื่อนพลวง 1

PHLUANG 1 MINI HYDROPOWER PROJECT

จังหวัดจันทบุรี
CHANGWAT CHANTHABURI

เอกสารหมายเลข 2
VOLUME 2

ข้อกำหนดด้านเทคนิค (2/2)
TECHNICAL SPECIFICATIONS (2/2)

ส่วนที่ 2 : งานอุปกรณ์เครื่องจักรกล-ไฟฟ้า
(PART 2 : ELECTRO-MECHANICAL EQUIPMENT)

PHLUANG 1 MINI HYDROPOWER PROJECT HYDROPOWER PROJECT

CONTRACT C2

SUPPLY, DELIVERY, INSTALLATION AND COMMISSIONING OF ELECTRO-MECHANICAL EQUIPMENT

VOLUME 2: TECHNICAL SPECIFICATIONS

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SECTION 1 - GENERAL

S1.01 GENERAL

These specifications apply to all equipment, materials, devices and components, including pre-engineered or bought-out items, procedures, methods, techniques, and workmanship contained in the other Technical Specifications whether referred to specifically or not.

Where the other Technical Specifications conflict with these specifications, the former shall prevail.

All works shall be subject to a quality control program developed by the Contractor which shall be designed to prevent and readily detect and correct non-conformities in quality of the work. The Contractor shall make available to the DEDE's Engineer details of the quality control program at the Contractor's and sub-Contractors plants which are applicable to the work before manufacturing begins.

Material and equipment not covered by these Specifications shall be subject to acceptance by the DEDE Engineer.

S1.02 SERVICE CONDITIONS

All equipment shall be designed and manufactured for its particular location for continuous operation at the extremes of climate. Specifically, all equipment to be installed indoors shall be designed and manufactured for satisfactory continuous operation at an ambient temperature of 40°C and all equipment to be installed outside shall be designed and manufactured for satisfactory continuous operation at an ambient temperature of 45°C. Equipment supplied between ceilings and roofs shall be designed for satisfactory operation at an ambient temperature of 60°C.

S1.03 STANDARDS AND CODES

The supply must conform to the laws and regulations existing in the Kingdom of Thailand, in addition to the particular prescription given in the present Technical Specifications.

Except as provided in the specifications, all materials, equipment and fabrication and testing thereof shall conform to the latest applicable standards contained in the following list of internationally accepted standards.

AFBMA Anti-Friction Bearing Manufacturers Association
AGMA American Gear Manufacturers Association
AISI American Iron and Steel Institute
AMCA Air Moving and Conditioning Association
ASME American Society of Mechanical Engineers

ASTM	American Society for Testing and Materials
AWS	American Welding Society
CMAA	Crane Manufacturers Association of America
FM	Factory Mutual Engineering Corporation
IEC	International Electro Technical Commission
IEEE	Institute of Electrical and Electronics Engineers, Inc.
ICEA	Insulated Cable Engineers Association
ISO	International Organization for Standardization
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
SSPC	Steel Structures Painting Council
UL	Underwriters' Laboratories Inc.
USBR	United States Bureau of Reclamation
TIS	Thai Industrial Standard
EIT	Engineering Institute of Thailand
PEA	Provincial Electricity Authority of Thailand

References to standards or to materials and equipment of a particular manufacturer shall be regarded as followed by the words “or equivalent”. The Contractor shall submit to the DEDE’s Engineer, for approval, a comparison of applicable clauses of the proposed standard with the specified and relevant specifications of the materials and equipment in the English language. The Engineer's decision in the matter of equality will be final.

S1.04 UNITS OF MEASUREMENT

Units of measurement shall be in the international system of units (SI).

S1.05 CONTROL AND AUXILIARY POWER SUPPLIES

The following power supplies shall be provided in the powerhouse, switchyard, and control area. The equipment shall be suitable for operation on these supplies as applicable.

a)	DC control voltage	125 V (nominal) or suitable (for control and indication lamps) 108.5 V to 140 V (range)
b)	Lighting requirements	220 V, single-phase, 50 Hz ac supply (nominal)
c)	Power supply for motor	380 V, three-phase, 50 Hz ac

S1.06 MATERIALS

Materials for the equipment, which are not included in these specifications, shall be selected after thoroughly scrutinizing the properties thereof and shall be subject to approval by the DEDE's Engineer. The materials shall be of good quality and as usually used for equipment of the same kind.

Materials shall conform to the following requirements.

(a) Castings

The materials for each kind of casting shall be in accordance with the following.

- Iron castings ASTM A48, Class 30 or better
- Carbon steel castings ASTM A27, Grade 65-35 or better
- Stainless steel castings ASTM

The tests required for turbine runner castings shall be as follows.

Mass of Castings	**Number of Tension Tests**	**Number of Bend Tests**
Not over 9 t	Three-120 apart	2
Over 9 but not over 14 t	Three-120 apart	2
In excess of 14 t	Four - 90 apart	2

For castings of mass 250 kg or less, one tension and one bend test shall be required.

Bend tests shall be made on specimen 25mm by 15mm in cross-section with corner radii not exceeding 2 mm. They shall withstand being bent cold around a pin 25mm in diameter and through an angle of 90 without cracking on the outside of the bent portion.

The DEDE Engineer will inspect castings of all principal parts, including all parts subject to hydraulic pressure such as the runner and guide vanes, at the foundry. No steel casting shall be finally heat treated before inspection without the permission of the DEDE's Engineer. Castings will also be inspected after repairs, heat treatment and during machining. No major welding shall be carried out after the casting is finally heat-treated.

Repair welding on steel castings, other than repair welding of minor defects, shall be done by the metallic arc process followed by thermal stress relieving. Repair of 13-4 stainless steel castings shall be carried out with low carbon electrodes of the same chemical composition as the parent material. Minor repairs of hollows, shallower than 5mm, may be carried out with low carbon austenitic stainless-steel electrodes. Repair procedures must be submitted to the DEDE Engineer, and reviewed, before repairs are made. Repaired areas shall be re-inspected with MT or PT.

(i) Forgings l

Shaft forgings and all other forgings shall be in accordance with ASTM A668, Class D or better. Alloy forgings shall have physical properties at least equal to those required by ASTM A668 Class H.

All forgings shall be given such uniform heat treatments as are required to produce. Test coupons shall be provided in accordance with ASTM A370, unless otherwise specified.

(ii) Steel Plate for Pressure Vessel

Steel plate used for principal stress-carrying parts shall meet ASTM A516, unless otherwise specified.

All carbon steel plates for pressure-containing work shall be subject to Charpy V-notch, impact tests in accordance with ASTM A370. The test shall have a minimum impact strength of 20J for an average of 3 samples tested at 0°C, with no one sample having less than 13.6J impact strength.

(iii) Stainless Steel

Stainless steel, if not specifically specified, shall be in accordance with appropriate ASTM specification or better. The grade, specification number and chemical composition shall be submitted to the DEDE Engineer for approval.

(iv) Bronze and Brass Bushings

Bronze for guide vane bushings matched with stainless steel sleeves shall be in accordance with ASTM B 584, Alloy No.C93700, C86300, C90500 or approved equivalent. Rods shall be to ASTM B21, Alloy A, half-hard except for special applications (e.g., shear pins) which shall be to the Contractor's design. Bronze and brass for other purposes shall be submitted to the DEDE's Engineer for approval.

(v) Self-Lubricating Bearing

Self-lubricating bearings shall be of the type successfully used for respective applications intended, such as "Thordon", "Fiberglide" or accepted equivalent. Austenitic stainless-steel washers, pins or slide paths for operation in conjunction with self-lubricating bearings, unless otherwise specified, shall be included. Surface finish, hardness, tolerance of fit and other details of the mating surface shall be in accordance with best recommended practice of the bearing supplier.

(vi) Babbitt

Babbitt metal for bearings shall be in accordance with ASTM B23, Alloy No. 7.

(vii) Screws, Nuts, Springs, Pivots

The use of iron and steel shall be avoided in instruments and electrical relays wherever possible. Steel screws, when used, shall be zinc, cadmium or chromium plated, or when plating is not possible owing to tolerance limitations, shall be of stainless steel. The

threads of stainless-steel fastenings shall be coated with a suitable anti-galling compound at time of assembly.

All screws, bolts, studs, and nuts for the turbine parts shall be in accordance with ASTM A193.

S1.07 ALLOWABLE STRESS

Liberal factors of safety which make allowance for higher than anticipated loading shall be used throughout the design, particularly in the design of all parts subject to alternating or impact loading.

For the rotating parts of the turbine, generator and exciter, the maximum unit stress due to runaway speed conditions shall not exceed two thirds (2/3) of the minimum specified yield stress of the material, except as permitted below. Stresses shall be further reduced in accordance with good practice for parts subject to severe loading conditions and/or shall be further reduced on components where elastic stability governs and where combined stresses exist.

For operation at runaway speed with maximum head, the allowable stresses may be increased, but they shall not exceed two third of the minimum specified yield strength of the material.

For material subject to the specified water pressure, including surge, and for all other material subjected to specified operating conditions, including load rejection and load acceptance, the unit stress in the material shall not exceed the values in the following tabulation.

	Maximum Unit Stress	
Material	**In Tension (MPa)**	**In Compression (MPa)**
Cast iron	14	70
Cast steel	70	70
Plate steel	ASME Boiler and Pressure Vessel Code, Section VIII, pressure vessels, Division I, latest edition	

Non-specified material shall have a maximum stress of one quarter the minimum specified ultimate tensile strength as given for the appropriate material specification.

S1.08 GENERAL EQUIPMENT REQUIREMENTS

The equipment and all manufactured components thereof shall be new, durable to withstand long time use, and shall satisfy all requirements which a complete product should generally meet even if such are not expressly provided for in these specifications.

The runner, guide vanes and discharge ring shall be finished to a smooth surface and shall be free from hollows, depressions, projections, or other surface imperfections that may

cause local cavitation. The surface finish on these components shall not exceed the following maximum surface roughness in accordance with ANSI B46.1, "Surface Texture".

Surface	**μm**
Runner blades negative pressure side	1.6
Other parts	3.2
Runner except runner blade	3.2
Discharge ring	6.3
Guide vanes	12.5
Contact surfaces of adjacent guide vanes	1.6

All slings, beams, bracing, etc., necessary for handling, assembling, and placing of the equipment shall be supplied by the Contractor.

S1.09 ELECTRICAL EQUIPMENT

The Contractor shall supply all single line and three-line diagrams, block diagrams, logic diagrams, schematic control diagrams, cable and wiring diagrams, material take-off, equipment arrangement and detail drawings, and any other documents as deemed necessary to complete the works.

The Contractor shall supply all special test equipment and instruments required and supervise the testing of the equipment.

The equipment furnished shall be complete, including all safety devices and controls appropriate to the service intended and required for safe and reliable operation. Components and parts regularly replaced during scheduled maintenance periods shall be readily available in Thailand.

All joints of bus, male-female for plug-in and draw-out contact shall be silver-coated not less than 0.0127 mm. thickness.

(a) Motors

All motors shall be in accordance with ANSI/NEMA MG I, suitable for continuous operation and direct on-line starting.

All motors shall be totally enclosed, weatherproof, fan-cooled type suitable for operation in high ambient temperatures and high humidity conditions. Motors up to and including 250W shall be 220V, single-phase. All motors above 370W shall be 380V, three-phase. All motors shall be provided with local start–stop push–button switch. The starting current at full voltage shall not exceed six times full load current at normal starting torque.

All motors shall be capable of continuous operation at rated output, at any frequency between 47 Hz and 53 Hz at nominal voltage, and plus or minus 10% of nominal voltage at nominal frequency, without injurious overheating. The induction motors shall not be affected by a transient rise of 40% in frequency due to load rejection of the unit (s).

The motors and motor lead insulation shall have Class H for both stator and rotor, and a continuous rating at ambient temperature.

The motor terminal boxes shall be weather and vermin-proof and fixed to the motor frame. The terminal studs shall be sized for the current duty required and marked in accordance with NEMA ICS4 where applicable.

(b) Magnetic Contactors and Motor Starters

Magnetic motor starters shall have the following features and/or accessories:

- molded case circuit breaker disconnects with thermal time delay and instantaneous trips
- 380 to 220 V individual fused control transformer
- 220V ac operating coil
- motors rated under 10kW shall have thermal overload protection in each phase, temperature compensated with thermal elements and phase failure detection correctly related to motor nameplate, current and type of enclosure. Motors rated 10 kW and above shall have embedded thermistors for protection devices
- auxiliary contacts for the control of related auxiliary devices such as motor heating, indicating lights, interlocks, etc.

All starters and contactors shall comply with IEC Publication 60947-4-1 and shall be suitable for direct on-line starting of motors and continuous electrical duty capable of 30 operations per hour appropriate to the duty required with manual resetting and under voltage release features.

All motors shall be provided with quick-break molded case circuit breakers, as described in Section (d), with operating handle lockable in OFF position. They shall be rated to interrupt the full-load current of motor or other equipment in the circuit.

Contactors and motor starters of the electro-magnetic held type, shall comply with the following requirements:

- contactors shall close completely at any voltage where pick-up occurs with 70% voltage at the coil terminals
- the main contacts shall not chatter nor part when the stator current resulting from a stalled motor is being conducted.

(c) Relays and Devices

Relays shall comply with IEEE Std. C37.90 and shall be provided with non-flammable dust and moisture proof cases.

Relays shall be of the plug-in or withdrawable type and the plug-in connections shall be made and broken by pressure contacts.

Relay contacts shall be adequately rated for the service conditions. The coils shall be continuously rated and shall have a tropicalized finish and be air-sealed to prevent corrosion by hydrogen sulfide gas.

Timing delays shall adjust easily, and the relays shall hold that adjustment. The timing range of the relays shall overlap the expected setting plus or minus 50% unless the timing range is included with the specification. The setting adjustment shall be calibrated clearly.

Mechanical targets (operated at 125Vdc or suitable) shall be individually provided with any equipment that is annunciated as a group due to a faulty condition. In this manner the faulty equipment can be easily identified.

(d) Molded Case Circuit Breakers

All single-pole, two-pole and three-pole molded case circuit breakers shall have thermal time delay and instantaneous trips with ON-TRIP-OFF indicating operating mechanisms. Circuit breakers used in conjunction with motor starters or contactors shall have the operating mechanisms interlocked with the starter or contractor cover, so that the cover cannot be opened unless the circuit breaker is open. The circuit breakers shall be comply with the applicable sections of IEC Publication 60947-2. Circuit breakers shall be bolt-in type, interchangeable, temperature compensated, quick-make, quick-break type with symmetrical fault level interruption of 18kA for ac and 10kA for dc circuits, unless otherwise specified.

A group alarm contact shall annunciate an open breaker and each breaker shall have an individual light or mechanical indicator, which shall come on when the breaker is opened or tripped.

(e) Fuses

Fuse links and holders shall be dead front type. The rating of each fuse link shall be appropriate to the service conditions and shall provide discrimination with other fuse links or current protective devices connected in series.

(f) Pilot Devices

Pilot devices such as selector switches, push-button stations, thermostats, etc, shall be of the heavy duty, oil-tight type, housed in a dust-tight enclosure designed especially for the type of environment. Local stop buttons near the motors shall be lockable in pressed position for maintenance.

(g) Indicating Lights

All indicating lights shall be of incandescent type for long life and service under conditions of shock, vibration and rough handling unless otherwise specified.

(h) Instruments and Meters

All instruments and meters shall be heavy-duty industrial type, dust-proof and capable of withstanding severe shock or vibration. The instruments shall comply with ANSI C39.1.

All instruments flush mounted on the outside of enclosures shall be square case, have non-reflective glass and be provided with uniform high-grade narrow bezels.

The instruments shall be damped to ensure that the pointers come to rest rapidly after being deflected from their previous positions.

(i) Convenience Outlets

Convenience outlets in the control cabinets shall be rated for 15A, 250V double 3-pins plug pattern determined by Thailand local codes and regulations and as approved by the DEDE Engineer.

Where necessary, outlets shall be in weatherproof enclosures or suitably protected from weather.

(j) Light Switches

Light switches and door operated switches in the control cabinets shall be rated for 15A at 250V, suitable by Thailand local codes and regulations and as approved by the DEDE Engineer.

(k) Pressure, Level and Flow Switches

The sensing switches shall have weatherproof enclosures and shall be mounted for easy adjustment and for rigidly locking in position after being adjusted. They shall be of heavy-duty rating and shall have stainless steel rotating parts and permanently lubricated bearings.

(l) Equipment Enclosures

All outdoor electrical equipment enclosures shall meet the IEC Publication 60529 Index of Protection Rating IP55. All indoor electrical equipment enclosures shall meet the IEC Publication 60529 Index of Protection Rating IP44 for MV and IP33 for LV.

All hinged doors shall be equipped with semi-concealed hinges and handles with cylinder type locks. The locks on each set of doors shall be such that the key for operating one set of locks cannot operate any other set of door locks.

The cubicle required ventilation shall consist of ventilation vents or louvers with filter. The filter shall be of a type easily replaceable and readily available in Thailand. All ventilation opening shall be provided with corrosion-resistant screen to keep out rodents and insects, dust filter mean shall also be provided. Temperature rise in any electronic cubicle shall not more than 15˚C.

All medium voltage cubicles shall be furnished mimic bus with identification label showing main equipments inside the cubicle such as CT, PT, LA, SA, breaker, DS, grounding DS etc. status of the equipment indicating lamp shall also be provided.

Anti-condensation heaters shall be fitted in all enclosures or panels containing control or relay equipment, and in all enclosures and mechanism boxes located outdoors.

Panel lighting and a convenience outlet shall be fitted in all enclosures.\

(m) Equipment Wiring and Accessories

All internal equipment control wiring shall be 600 V, stranded annealed copper conductor 70ºC PVC insulation in accordance with IEC Standard or approved equal.

Minimum wire size shall be as follows:

Purpose	**Wire Size**
Instrumentation	1.0 mm^2
Control	1.5mm^2
Potential	4.0 mm^2
Current	6.0 mm^2
Power	Determined by rating of protection device, minimum wire size shall be 2.5 mm^2

Internal wiring of solid-state equipment may use solid conductors having a minimum size of 0.5 mm^2.

All current and potential circuits from protection relays and indicators, and trip circuits from protection relays to lockout relays shall be 7-strand copper conductor or 19-strand copper conductor, for connections with high flexibility requirements.

The following color identification shall be applied to the insulation of wires used for internal wiring of control cabinets, control boards, cubicles, control boxes and auxiliary equipment.

- Secondary circuit of potential transformer red
- Secondary circuit of current transformer black
- dc circuit blue
- ac circuit except power circuit yellow
- neutral white grey
- ground green

Wiring shall be neat and securely bundled, cleated, enclosed in ducts or conduits, or supported on trays and run in the most efficient manner from point to point. Wiring shall be kept bundled with of strips of plastic ribbon material at suitable intervals. Lacing of wire bundles will not be accepted. Wherever wiring is cleated to metalwork, it shall be insulated from the metal surface and shall be cleared by means of insulated straps in an approved manner. All wiring shall be left sufficiently long and neatly looped to allow a fresh termination to be made should the original termination break off. Where wiring crosses between a fixed panel and a hinged panel it shall be arranged so that flexing is reduced to a minimum and strain is not transmitted to any terminal.

The ends of each wire shall be provided with an approved type of crimped wire termination equal to the UTILUX super grip or A-MP pre-insulated type. The copper sleeve shall be insulation, applied with a ratchet type tool which leaves an identifying mark on the crimp thereby enabling post crimping checks on the tools used. The number of wires per terminal shall not exceed two.

(n) Terminal Blocks and Terminals

Terminal blocks for all external wiring shall be stud type and shall be suitable for ring tongue insulated pressure compression type connectors. Terminal blocks for current and voltage transformer circuits shall be stud type with a shorting bar provided for incoming CT secondary circuits. Terminal blocks for internal wiring shall be of the 600-V molded block type with an insulating barrier between terminals. Terminals of electrical devices shall comply with the following requirements.

Terminal material shall be copper, copper alloy, stainless steel or zinc plated and passivated steel. Terminals of devices shall be suitable ac test.

Terminal blocks shall be located in such a way that the incoming cables shall terminate neatly and conveniently. All numbered terminals on the schematic diagrams shall be brought out to the terminal block and labeled accordingly. All terminal blocks shall be anti-fungi protected.

(o) Electronic Equipment

All cabling to the electronic equipment shall terminate on U-links equipped with test sockets. Testing the input condition shall be permitted with the U-links in position.

Printed circuit cards shall be of quality fiberglass material. The cards shall be flow soldered and covered with protective enamel, adequate to protect the card from hydrogen sulfide gas encountered on site. Components and test points shall be clearly labeled. Type number, serial number and a reference to the relevant drawing number shall be clearly labeled on the PC card. Labeling shall be permanent and shall withstand cleaning with Freon or similar solvent.

Withdrawable cards, modules and cable plugs shall be keyed, coded or otherwise marked to ensure there is no possibility of incorrect replacement.

Contacts on both printed circuit cards and female sockets shall be gold plated.

The surface temperature of any component shall not exceed 70ºC at an ambient temperature of 40ºC. The equipment shall be designed to operate under the following service condition:

- temperature range 0ºC to 50ºC
- relative humidity 95% at 38ºC, non-condensing
- dust 10 mg/m³

All equipment shall withstand test voltages as follows:

- relays, switches, PT/CT circuits, I/O boards, dc & ac control and power circuits — 1500V ac for one (1) minute
- electronic equipment — 500V ac for one (1) minute

The equipment shall be protected for surges and shall include surge protection components, suppressors, noise filters, and electromagnetic shields. All input and output of the equipment, including the communication line, power supply unit, transducer, etc. Radio interference suppression shall be standard EN 55022 and EN 55014, interference immunity shall be to IEC 61000 Electromagnetic Compatibility, EN 60801 and VDE 0843.

(p) Conduits

The conduit shall be rigid galvanized steel conforming to IEC Publication 60423 except where flexible conduit is specified. The flexible conduit shall be galvanized steel and shall have an oil-resistant jacket and shall conform to the requirements of IEC Publication 60423.

Conduit fittings, covers and accessories shall be malleable iron and shall conform to the IEC Publication 60423. The minimum size conduit shall not be smaller than 3/4 in (20 mm) except when authorized by the DEDE's Engineer.

All conduit runs exposed to moisture or in areas where moisture may be prevalent, such as the turbine pit, sump, and valve pits, etc, shall be sealed against the ingress of moisture.

(q) Equipment Mounting and Supports

The support structures shall be fabricated from welded structural steel members. All structural steel, bolts, nuts, and washers shall be hot-dipped galvanized with a finish coat of zinc chromate.

(r) Equipment Grounding

All equipment enclosures containing control or power devices up to 240V shall have an external ground connector suitable for 35mm^2 stranded copper ground cable. Hinge door or swing panel shall also be grounded by flexible wiring.

All equipment enclosures containing multiple control units or power devices 400 V and above shall have an earth copper ground bus extending the width of the equipment. The current density of copper ground bus shall not exceed 200A/mm^2 under the specified earth fault conditions, however, its cross-section area shall not less than 50 mm^2 and according to EIT-Thailand Engineering Standard

(s) Lightning Protection System according to EIT-Thailand Engineering Standard

(t) The contractor shall design, supply, install, and test the fire detection and alarm system. All equipment must meet Thai Industrial Standards (TIS) or international standards. The contractor shall design and supply the main fire alarm control panel, fire detectors, fire alarm start button boxes, alarm bells, and other supporting equipment.

S1.10 PIPING

All piping larger than 65mm diameter shall be formed in the manufacturer's shop. A flange shall be fitted to one end of pipe in the manufacturer's shop, and another flange shall be fitted to the other end of pipe in the field connection. Flanges attached to pressure pipes shall be welded from both inside and outside.

Rim joint for the connection of copper tube (not more than 20 mm in diameter) shall be applied at the site.

Piping shall be sized for the maximum anticipated flow with velocities in the range of 1 to 3 m/s. Pipe longer than 10 m shall be not less than 25mm nominal size to ensure ruggedness or shall be adequately supported.

Line friction shall be calculated using conservative friction factors, equivalent to a Hazen-Williams coefficient of C=100 for steel pipe.

Due allowance shall be made for water hammer in accordance with AWWA C- 101.

S1.11 WELDING

Wherever welding is specified or permitted, the electric arc welding process, using coated welding rods, shall be used. All procedures except for pressure vessels shall be as established under the accepted welding rules of AWS.

All procedures for pressure vessels or pressure containing parts shall be to accepted welding rules of ASME Sections VIII and IX. All equipment and personnel shall be qualified in accordance with the AWS and ASME standards.

Fillet welds shall not be smaller than 6 mm; fillet welds larger than 8 mm shall be made with two or more passes.

Stainless type weld, used in the water passages for protection against pitting, shall be of chromium nickel steel. Type, chemical composition and ASTM class of welding rods used for this purpose shall meet with the approval of the DEDE's Engineer.

Welding electrodes shall be supplied by the Contractor and conform to the AWS Filler Metal Specification A5 or ASME Boiler and Pressure Vessel Code, Section II, Part C. Suitable meters shall be provided to show at all times, the welding current and arc voltage.

All welding and welding qualification procedures, including those for field welds, shall be subject to the approval of the DEDE's Engineer.

The Contractor shall furnish proof that welding operator and welders having the requisite qualifications are being employed. The Contractor shall furnish the necessary copies of all test reports, together with copies of the supplier's test reports on welding rod.

All unacceptable defects in welds shall be chipped out to sound metal. The areas shall be checked by magnetic particle testing (MT), dye penetrant (PT), radiography (RT) or ultrasonic (UT) by the Contractor as directed by the DEDE's Engineer, to ensure that the defect has been completely removed before repair welding.

Magnetic particle examination (MT) shall be performed in accordance with the ASME Code Section V, Article 7, and ASTM E709. Acceptance shall be in accordance with ASME Code, Section VIII, Appendix 6 and ASTM E125.

Dye penetrant examination (PT) shall be performed in accordance with ASME Code Section V, Article 6 and ASTM e165. Acceptance shall be in accordance with ASME Code, Section VIII, Appendix 8 and ASTM E433.

Radiographic examination (RT) on welds for pressure containing parts shall be performed in accordance with paragraph UW-51 of ASME Code, Section VIII, RT of welds on structural steel where required, including standard of acceptability, shall be performed in accordance with AWS D1.1, Structural Welding Code. RT examination and standards of acceptance of ferrous castings up to 50mm thick shall be in accordance with ASTM E446 for high-pressure castings, and for ferrous castings 50 to 115mm thick, ASTM E186.

Ultrasonic examination (UT) shall be performed in accordance with the ASTM Code, Section V, Article 5. Acceptance shall be in accordance with the ASTM Code, Section VIII, Appendix 12 and Section V, Article 5.

S1.12 NAMEPLATE AND MARKING

Nameplates, instruction plates, labels and tags, warning plate, warning signs, identification label and any marking whatsoever on the equipment and parts and accessories thereof shall be in English language, big enough for easy reading, except where otherwise indicated in the specifications.

Nameplates shall be made of stainless-steel plate, except nameplates attached to indoor control cabinets, control boards, cubicles and control boxes which may be made of engraved laminated acrylic resin, screw driven, and shall be in English language (white letters on black ground).

Phase and polarity identification means shall be furnished as follows.

- Colored insulation cap for power, CT, PT cable and wirings
- Colored insulation of bus

For AC 3 phase

- Phase A Red
- Phase B Yellow
- Phase C Blue
- Neutral White Grey
- Ground Green
- Ground/Earth Green cap

For AC Single phase

- Line Black
- Neutral White Grey

For DC

- Positive White
- Negative Black

For Medium and High Voltage Equipment label

A Red background White letter
B Yellow background Black letter
C Blue background White letter

Size of letter shall not be smaller than 20 x 15 cm. (wide x high).

S1.13 PAINTING

All stainless steel, galvanized, bronze and aluminum surfaces, anchor bolt threads, machined, mating and close clearance surfaces shall be left unpainted and shall receive a corrosion-preventive temporary protective coating to provide protection during transportation to and storage at the Site.

Except miscellaneous metalwork specified, all surfaces which are embedded in concrete, surfaces, and edges to be field welded, and other surfaces for which painting is not specified in the final installed mode, shall be prepared to SSPC-SP1 and SP2 or 3.

Paints shall be applied only to surfaces, which are free of moisture as determined by sight and touch. The ambient temperature shall be at least 5˚C above the minimum temperature recommended by paint manufacturer for application on any coat.

Final thickness of protective coatings shall be checked by an approved film thickness gauge, supplied by the Contractor, calibrated on metal identical in composition, thickness, surface preparation and finish to that being painted. A sufficient number of measurements shall be made to establish the final thickness.

The color schedule, by Munsell color notation, for the equipment shall match the existing equipment, structures, vessels, etc.

The painting systems referred to in these specifications shall be as follows:

Paint System 1 - Surfaces in Contact with Water

(a) General

All surfaces shall be painted with an inorganic zinc primer and two coats of liquid epoxy. Final shop painting shall not be applied within 100mm of field welding. These areas will only receive one coat of inorganic zinc primer that can be removed prior to welding.

(b) Surface Preparation

Surfaces shall be blast-cleaned in accordance with SSPC-SP10.

(c) Paint Application

(i) Materials The painting system shall consist of one coat of inorganic zinc primer and two coats of a compatible liquid epoxy. All components shall be from the same manufacturer and the manufacturer's instructions shall be rigidly adhered to.

(ii) Film Thickness The dry film thickness of the primer shall be 80µm. The dry film thickness of each of the liquid epoxy coats shall be between 200µm and 260µm.

(iii) Acceptable System

An acceptable painting system supplied by the Jotun is outlined below:

- Primer Resist 78 inorganic zinc
- Intermediate Jotamastic 87 Aluminium
- Finish Jotamastic 87

(d) Final Dry Film Thickness

The final thickness of the three coats shall be between 480µm and 600µm. This shall be checked by a Type B film thickness gauge, supplied by the Contractor, calibrated on metal identical in composition, thickness and surface preparation and finish to that being painted.

Paint System 2 - Surfaces in Contact with Oil

(a) Surface Preparation

Surfaces shall be blast-cleaned in accordance with SSPC-SP10.

(b) Paint Application

The painting system shall consist of two coats of two-pack epoxy resin zinc phosphate with minimum dry thickness of 25µm per coat.

(c) Final Dry Film Thickness

A sufficient number of readings with a gauge supplied by the Contractor shall be taken to ensure a minimum film thickness of 50µm is attained.

Paint System 3 - Electrical Equipment, Cubicles, Panels and Boards

(a) Surface Preparation

Surfaces to be painted shall be blast-cleaned in accordance with SSPC-SP6.

(b) Paint Application

(i) Materials

The painting system shall consist of one coat of two-pack zinc rich epoxy primer and one coat of two-pack high gloss topcoat based on epoxy resin.

(ii) Film Thickness

The dry film thickness of the primer shall be 50µm. The dry film thickness of the finish shall be 50µm.

(c) Final Dry Film Thickness

A sufficient number of readings with a gauge supplied by the Contractor shall be taken to ensure that a minimum final film thickness of 100µm is attained.

Paint System 4 - Mechanical Equipment, Exposed Carbon Steel Piping

(a) Surface Preparation

Surface of pre-engineered, factory painted products such as pumps, motors and integral piping shall be degreased and cleaned in accordance with SSPC-SP1 and SSPC-SP2. Other surfaces to be painted shall be blast-cleaned in accordance with SSPC-SP10.

(b) Paint Application

(i) Materials

Manufacturer's standard paint finish for pre-engineered products such as pumps, motors and integral piping shall be over coated with one coat of compatible two-pack high solid, aliphatic polyurethane topcoat. For other surfaces the painting system shall consist of one coat of inorganic zinc primer, one coat of liquid epoxy and a finish coat of two-pack high solid, aliphatic polyurethane topcoat.

(ii) Film Thickness

The dry film thickness of the primer shall be 50µm. The dry film thickness of each of the liquid epoxy coats shall be between 200µm and 260µm. The dry film thickness of the finish shall be 80µm.

(iii) Acceptable System

Except: pumps, motors, and integral piping

An acceptable painting system supplied by the Jotun is outlined below:

- Primer — Resist 78 inorganic zinc
- Intermediate — Jotamastic 87 Aluminium
- Finish — Hardtop XP

(c) Final Dry Film Thickness

A sufficient number of readings with a gauge supplied by the Contractor shall be taken to ensure that a minimum film total thickness of 330µm is attained. Over coating shall also be sufficient to ensure complete hiding of underlying coating.

Paint System 5 - Civil - Miscellaneous Metalwork

(a) Surface Preparation

Surfaces to be painted shall be blast-cleaned as specified by the DEDE's Engineer.

(b) Paint Application

(i) Materials

The painting system shall consist of one coat of inorganic zinc primer, one coat of polyamide epoxy and a finish coat of acrylic asphaltic polyurethane. All

components shall be from the same manufacturer and the manufacturer's instructions shall be rigidly adhered to.

(ii) Film Thickness

The dry film thickness of the primer shall be 75µm. The dry film thickness of the intermediate shall be between 100µm and 150µm. The dry film thickness of the finish shall be between 40µm and 50µm.

(c) Final Dry Film Thickness

The final thickness of the three coats shall be between 215µm and 275µm.

S1.14 GALVANIZING

Where called for in the specifications, all materials and fittings shall be hot dip galvanized after fabrication in accordance with ASTM A123. The weight of zinc coating per square meter of actual metal surface shall not be less than 0.60 kg. All galvanized structural steel shall be chromate coated.

Galvanizing areas damaged during shipping and/or installation shall be repaired using galvanizing touch-up paint.

Galvanized material shall be subject to tests as outlined in ASTM A123.

S1.15 PACKING

All the Equipment shall be carefully packed. The same precautions and care shall be taken for equipment (including components) which cannot be packed or crated.

Machine finished surfaces of the equipment and the portions to be embedded in concrete shall be adequately protected by corrosion preventive means, as specified in S1.14.

S1.16 LUBRICANTS

The Contractor shall submit to the DEDE's Engineer for approval a list of proposed lubricants to be used on all the equipment specified in this Contract. All lubricating oils and greases not specified above shall be of a type generally available in Thailand.

Oil required for cleaning, flushing, and testing of turbine and generator guide bearings, governor equipment and piping after installation shall be supplied by the Contractor.

S1.17 INSPECTION AND TESTS - ELECTRICAL/MECHANICAL

(a) General

All materials and equipment shall be subject to tests and inspection while in process of, and upon completion of manufacture. For each piece of material, component, or equipment, the inspection and tests shall consist of:

- Tests and inspection required by the relevant standards
- Tests and inspection as specified herein.

The Contractor shall submit to the DEDE's Engineer certified copies of all test results. The results of each test shall be recorded in the form of test certificates or test reports.

The acceptance of factory inspection and tests shall not prejudice the right of the Engineer and DEDE to reject whole or part of the works if it does not comply with the Contract when erected on Site.

(b) Shop and Type Tests

All works shall be subject to type, sample, and routine tests at the manufacturer's factory in accordance with this specification.

If facilities are not available at the manufacturer's factory to execute the tests specified, the Contractor shall state, what alternative arrangements will be made.

The Contractor may offer type test results for identical equipment in lieu of the type tests specified, in which case the DEDE's Engineer may waive the specified type tests. If type test results for identical equipment are offered in lieu of the specified type tests, the Contractor shall also provide, to the DEDE's Engineer, evidence as to the similarity of the equipment tested and the Contract equipment.

(c) Field Tests

All tests to be executed at the Site will be performed by the Contractor under witness of DEDE and the Engineer.

The Contractor shall prepare and submit the detailed plan for each item of tests specified in the technical specifications.

The detailed plan shall consist of test procedures including test recording sheets, test summary sheet, required testing equipment and man-hours required for preparation and execution of the tests. The detail plan and test procedure shall be subject to the approval of the DEDE's Engineer.

The Contractor shall also prepare and submit the reports based on the test results. The Contractor, with advice from the DEDE's Engineer will be responsible for safety during the performance of all testing.

(i) Instruments, Equipment and Materials for Tests

The Contractor shall provide all instruments and equipment for all site tests.

(ii) Scope of Tests

The tests to be carried out and passed before taking over of the Works by DEDE shall be deemed to comprise two main stages of testing as follows:

- Preliminary tests which are tests performed prior to rotation of, energizing at normal voltage or admission of normal water or air pressure to the main or auxiliary services under test.
- Tests on Completion, which are tests to prove progressively the correct operation of complete auxiliary systems and of the main works.

(iii) Witness Acceptance Tests

The Contractor shall submit all test procedures for DEDE approval prior to test start.

(d) Mechanical and Electrical Requirements for Inspection and Testing

(i) Pressure Tests

The Contractor shall give adequate notice of any proposed pressure tests. Free access to the testing equipment shall be allowed to the DEDE's Engineer during the course of any test. The Contractor shall furnish the necessary copies of all pressure test reports on request.

All tanks, vessels and pressure containing components with maximum working pressure of 0.1MPa gauge pressure or greater shall be pressure tested in accordance with the ASME Boiler and Pressure Vessel Code Section VIII, Division I at a test pressure of 150% of the maximum working pressure. Pressure shall be maintained at test pressure for not less than 30minutes without additional pressurizing fluid being added.

(ii) Circuit Tests

All circuits shall be capable of being tested power frequency withstand for 1 min at the following voltages:

- 380V power circuits 2200V ac to ground
- V dc circuits 1500V ac to ground
- 220V ac and control circuits 1500V ac to ground

S1.18 CONSISTENCY OF SUPPLY

The Contractor shall ensure that all electrical and mechanical components and instrumentation such as, but not limited to motors, pumps, valves, relays, starters, indicating lights, meters, etc, are of a common manufacturer. This will ensure maximum interchangeability and minimize commissioning parts requirements.

SECTION 2 - TURBINE

S2.1 GENERAL

These specifications do not specify in complete details the various components of the turbine. This is left to the experience and practice of the Contractor who shall furnish turbine equipment, which shall meet in all respects the specified requirements in regard to performance, durability, and satisfactory operation. However, certain features, material and design requirements are specified.

The required performance and principal parts of the turbine are set forth in the following subsections, which outline the general features to be incorporated in the design. Any deviations from these specified requirements shall be approved by DEDE's Engineer.

S2.2 TYPE AND DESCRIPTION

The turbine shall be Cross Flow, horizontal shaft with single guide vane together with the turbine connecting to a synchronous generator with (or) without gearbox. The Contractor shall design turbine and generator speed to suit with the available design data stated in S2.3 of this section and also refer to the contract drawings.

All equipment such as turbine, draft tube, gear box, inlet valve, generator, hydraulic power unit and electrical control panels shall be installed inside the power box for which the power box shall be steel container type having enough dimensions and floor strength to install all equipment.

The power box floor shall be anchored on the concrete floor and the opening for the draft tube shall be prepared to suit with turbine discharge dimensions.

The layout arrangement of Turbine, Hill curve (or) turbine prototype Performance Curve indicating allowable operating Range, turbine prototype efficiency, needle valve opening, output and discharge against net head and the curves which are consistent with the guarantees relating to efficiency and output **shall be submitted together with the Bid. Failure to submit will reject of the Bid Proposal.**

S2.3 DESIGN DATA

The turbine shall be designed to operate in the ranges as specified below. The water level elevations and net heads on the turbine are as follows:

(a)	No. of unit	1	Unit
(b)	Rated Net Head	35	m
(c)	Rated Discharge	0.557	m^3/s
(d)	Turbine output	149	kW
(e)	Equipment Floor	+25.80	m MSL
(f)	Turbine center line level	+26.00	m MSL
(g)	Penstock center line level	+26.60	m MSL
(h)	Turbine rated speed	To be proposed by the Bidder	
(i)	Generator speed	To be proposed by the Bidder	

S2.4 OVERSPEED, RUNAWAY SPEED, CRITICAL SPEED AND MAXIMUM PRESSURE

The Contractor shall guarantee that the maximum overspeed and runaway speed of the turbine under any conditions shall not be greater than 1.2 to 1.8 times of the rated speed respectively. In all cases, the maximum hydraulic pressure in the penstock shall not be greater than 1.4 times of rated net head during normal stop or emergency stop condition.

The turbine shall be designed to have a wide margin of safety between critical speed and the rated speed, overspeed and the maximum runaway speed. The Contractor (by the turbine manufacturer) shall check the critical speed and torsion vibration characteristics of the combined rotating parts of the generating unit after determining the necessary data from the generator manufacturer excessive or unreasonable torsion vibration under any conditions shall be avoided. First Critical Speed shall be not less than 25% of maximum runaway speed without any vibration. **The Bidder shall submit the calculation rated speed to justify the regulation. <u>Failure to submit will reject the Bid Proposal.</u>**

S2.5 TURBINE OUTPUT AND EFFICIENCY

The Contractor shall be responsible for design, manufacture, install and test the turbine unit to suit with rated head and rated flow with (or) without gear box to couple with generator in capable to produce the generator output minimum 180 kVA output at 50 Hz as specified in Section 7 Generator specifications.

S2.5.1 TURBINE OUTPUT

The Contractor shall guarantee the rated output of each turbine under rated net head of 35.0 m and output shall be not less than 149 kW.

If the measured output is below the corresponding guaranteed output value after the site completion test, the Contractor shall be bound to modify the turbine within a period of six (6) months in order to achieve the guaranteed output. If, after modifications have been carried out, the turbine still fails to achieve the guaranteed output, or if it is mutually agreed to waive the modifications or if the modifications are not possible, a sum equal to the stated in the Section 4-Special Conditions, Volume 1 of Contract shall be deducted from Contract Price.

S2.5.2 TURBINE EFFICIENCY

The efficiency of turbine under rated output and rated net head of 35 m. shall be proposed and guaranteed by the Contractor. The guaranteed turbine efficiency shall not be less than 78%.

S2.6 TURBINE INLET PIPE

The inlet pipe shall be made of cast or fabricated steel plates welded and shall be designed to minimize the losses due to flow transition from circumferential pipe to rectangular pipe. The inlet pipe shall also be designed to withstand a hydraulic pressure test equivalent to 150% of the maximum penstock pressure occurring under load rejection conditions. It fits between the round penstock and the rectangular inlet of the turbine casing. The pipe shall be complete set with gasket and connection material.

S2.7 TURBINE CASING

The casing shall be provided with turbine casing, corner casing and base plate frame. They shall be made of cast or fabricated steel plates welded and shall be designed to withstand a hydraulic pressure test equivalent to 150% of the maximum penstock pressure occurring under load rejection conditions. The turbine casing and corner casing shall be integrated and installed to the base plate frame by bolting. The corner casing shall be equipped with the suction valve.

The bearing housing shall be designed to prevent water leakage into bearings and contact of lubricants with working water.

S2.8 TURBINE RUNNER

The whole runner shall be fabricated construction of stainless steel, according to ASTM 743 Grade CA-6 NM with minimum of 13% chromium and 4% nickel or equivalent DIN standard. The proposed other material standards shall not be acceptable. The runner material shall be of the type which can be repaired by welding satisfactorily at site without the need for other than local heat treatment.

The runners shall be made up of special steel along with blade assembly placed on the shaft axially. The curved blades are welded to the shaft and produce only limited axial thrust. The hydraulic shape of the blades shall be designed to obtain the best possible results taking into consideration cavitation and efficiency. Both ends of the blades shall be fitted in runner discs and welded with intermediate discs of the runner following a specific procedure. Blades of wider runners shall be supported by multiple discs. Runner shall be carefully balanced before final installation of the turbine and shall be subject to crack detection control.

All runner welds shall be fully penetrated and furnace stress relieved. The surface of the runner in contact with water shall be ground to a smooth and even surface without any humps or hollows.

S2.9 GUIDE VANE AND REGULATING ARM

One guide vane shall be provided in turbine casing and guide vanes stem shall be cast or fabricated construction of stainless steel, according to ASTM 743 Grade CA-6 NM or equivalent DIN standards. The other material standards shall not be acceptable. The guide vane shall be uniform in shape and their cross-sections shall be such as to direct properly and accelerate gradually the water entering the runner smoothly with a minimum of friction and hydraulic disturbance.

The guide vane shall be designed and manufactured to get smooth profile with precise dimensions, and it shall be fitted inside the turbine casing to perform as the water flow adjusting device. The guide vane shall be fitted independently with regulating arm with counterweight to control the amount of water that is to be passed on the runner.

Guide vane shall be fixed in highly resistant slide bearings, which do not require any maintenance and also be able to close by gravity weight in the event of closing. The water flows over and under the inlet guide vane which directs flow to ensure that the water hits the runner at the correct angle to archive turbine maximum efficiency.

The water then flows over the upper runner blades, producing a torque on the runner, then through the center of the runner and back across the low runner blades producing more torque on the runner. The guide vanes are automatically controlled using regulating arms and servomotors.

Hydraulic Piston (or) Servomotor shall be designed and supplied having a sufficient capacity to operate opening and closing of guide vane under the rated operating head, so that the Contractor shall design the servomotor at suitable diameter and length to get the required oil quantity and pressure.

The servomotor cylinder shall be made of cast steel or welded steel plate. Welds shall be fully penetrated and stress relieved. The servomotor piston rod shall be provided with self-lubricated bushing.

S2.10 RUNNER SHAFT BEARING

The anti-friction spherical roller bearings shall be installed at both runner shaft ends. The bearings shall help in the reduction of frictional force and leakage occurring through the bearing. The bearings shall be long-lasting and require minimal maintenance and shall be able to continuous operating for not less than 100,000 hours. The manufacturer's bearing shall be well-known brand and available in Thailand market.

S2.11 DRAFT TUBE

The draft tube shall be made of welded plate steel and shall be adequately ribbed and stiffened to prevent distortion. It shall be completely assembled and match-marked in the shop with all ribs accurately fitted.

S2.12 SHOP ASSEMBLY AND TEST

All turbine components such as inlet pipe, casings, runner, guide vane, regulating arm, draft tube, etc. shall be assembled or sub-assembled at the Contractor's shop to prove the design, construction and machining for proper fits and clearances.

Controlling dimensions and small clearances of the assembly shall be measured and recorded on illustrated shop inspection forms, showing the design drawing dimensions and the actual measured dimensions as well as allowable tolerance. Copies of shop inspection forms in the English language shall be submitted to DEDE's Engineer for review prior to the first shop assembly inspection.

The witness acceptance tests for turbine and other related parts shall be witnessed by DEDE's Engineer. The Contractor shall perform witness acceptance test at manufacturer's factory and shall bear the cost for the acceptance test for at least five (5) DEDE's officers.

S2.13 FIELD TEST

The field tests after turbine installation shall be done to determine that the equipment meets these technical specifications and the "Guaranteed Informative Data" of the Contract.

Commissioning and acceptance tests shall include**.**

- Dry Test, Individual Tests for all equipment

- Wet Test, no load heat run bearing test, no load excite test, Dummy Load Test

During these tests, all turbine and generator, governor values shall be measured and recorded.

- Commissioning Heat Run Test with PEA grid
  After the unit stabilizes at speed-no-load, the unit shall be synchronized with PEA grid upon after the approval of PEA.

  The Unit shall be operated at rated speed with base load first for 5 hours and shall be increased at suitable increment of load.

  The increments shall be at 25%, 50%, 75% and at rated load.

  The values such as head, flow, temperature, pressure, current, voltage, frequency, power factors, shall be measured and submitted to DEDE after the test.

(a) Output Test

The turbine shall be subject to a full-scale output test to check that the guaranteed output is met.

The output test shall be carried out at rated net heads and rated discharge for which all parameter and measured values shall be as per the guaranteed informative data and technical specifications.

The net head shall be measured according to IEC Code Publication 62006 “Hydraulic Machines-Acceptance Tests of Small Hydroelectric Installations". The Contractor shall provide for the unit the pressure taps and the piping required as per IEC Code. The instrumentation for the test shall be provided by the Contractor but will remain his property.

The turbine power shall be determined from the power at generator control panel and from the measured generator efficiency.

The turbine shall also be tested to check the maximum continuous output at generator terminals.

(b) Load Rejection Test

Load rejection shall be carried out from 25%, 50%, 75% and 100% of the full load. The overspeed values and pressure rise in the penstock at each load rejection shall be measured and recorded to submit DEDE after the test performed.

(c) Performance Test

As a part of the tests on completion an index test for the turbine shall be performed. The tests will be made to confirm the run of the turbine efficiency curve.

DEDE’s Engineer and the Contractor shall cooperate to find a mutually satisfactory date for testing when sufficient water is available to demonstrate the efficiency and the output of the turbine.

The Contractor shall furnish to DEDE's Engineer two copies of the records and tabulated results of the index tests, certified by the testing Engineer. Such records shall include relative efficiency, hydraulic head, output, and speed for the turbine as determined by the tests.

The Contractor shall furnish all instruments, apparatus, and equipment necessary to make the above tests, which will remain his property, together with a trained and experienced test engineer.

The turbine capacity shall be determined from electrical measurements of generator output and generator losses, and the guaranteed efficiencies of the speed increaser (if applicable).

The power output of the generator shall be measured with the use of calibrated electrical test instruments. Unless otherwise mutually agreed upon by the Contractor and DEDE's Engineer, the tests shall be conducted in accordance with IEC Publication 62006 "Hydraulic Machines – Acceptance Tests of Small Hydroelectric Installations".

SECTION 3 - INLET VALVES

S3.1 TYPE AND CONSTRUCTION

(1) The turbine shall be provided with an inlet valve of the butterfly type designed for minimum head loss and disturbance and having the diameter which shall not be less than of the inlet pipe and penstock.

(2) The main elements of the valve shall be of cast, forged or fabricated steel and shall also be manufactured according to ASTM, ASME, BS, EN, AWWA and ISO Standards. If fabricated construction is used, all welds stressed directly or indirectly by pipeline pressure shall, to the maximum extent practicable, be full penetration butt or tee-butt welds. All wearing parts shall be renewable and all such parts in contact with water shall be of corrosion resistant material or sleeved with corrosion resistant material.

(3) The sealing shall be by metal to metal contact between the rotor seals and the body seats and shall not involve inflation or other similar forms of relative movement of elements in the seals or seats. If metal to metal contact between seal and seat is used the material shall be such that galling, or pick-up cannot occur on contact. To this end the hardness of any parts between which contact or sliding occur shall differ by at least 50 Brinell hardness.

(4) The trunnion and servomotor connecting rod bushes shall be of greaseless, self-lubricating type. Should weight closed valves be offered, provision shall be made to prevent dirt and foreign matter from entering the top of the servomotor.

(5) The seal leakage during both shop and site tests shall not leak under a head of 35m of water column.

(6) The seals, seats, trunnion bushes and trunnion glands shall be so arranged that they can be removed or installed without dismantling the valve bodies or removing the valve from the pipeline.

(7) The Contractor shall provide steel pedestals to support the valve and transmit all loads from the valve to the floor slab.

(8) The Contractor shall submit the layout dimensional arrangement of Inlet Valve and bypass valve together with dismantling pipes and drainpipe.

S3.2 OPERATION

(1) The valve shall be capable of opening by governor pressure oil system and closing against any flow up to and including that due to free discharge at the outlet of the valve with maximum water level in the upper reservoir.

(2) The valves shall be operated by oil pressure supplied by the governor pressure oil system. Operation in close direction shall be by counterweight.

(3) The hydraulic piston and its mounting, pressure piping and control valves shall be adequate for the pressure operated by pressure unit with the most adverse conditions of unbalanced closure against free discharge.

(4) A manually operated mechanical lock for securing the inlet valve rotor in the closed and open position shall be provided and shall be of adequate strength to resist the thrust of the servomotor in both the opening and closing directions. The locks shall embody provision for padlocking in the inserted and withdrawn positions.

(5) A system shall be provided for automatically checking, collecting, and returning oil to the governor oil sump tank any oil leakage of the servomotor.

(6) The initiation of opening of the inlet valve shall be interlocked with the establishment of a pressure in the nozzle substantially equal to pipeline pressure.

(7) The inlet valve opening and closing times shall be independently adjustable, but the adjustments shall be of a form that cannot be readily or inadvertently altered. In the interest of minimizing the times necessary to start up and to shut down in an emergency, the opening and closing times shall be the minimum consistent with safe operation.

S3.3 CONTROL AND INDICATION

(1) The control gear shall be such that the inlet valve may be opened and closed by local manual mechanical control and remote control as part of the starting and stopping sequence.

(2) Position indicators visible from the floor of the Machine Bay shall be provided for the bypass valve, inlet valve rotor and mechanical lock.

(3) The valve shall be equipped with proximity switches for opening and closing signals to send to Governor PLC as feedback signal for Turbine operation sequence.

S3.4 DISMANTLING JOINT AND SHORT PIPES

(1) A flanged stub pipe and a welded short pipe shall be provided to connect the inlet valve to the end point of the penstock. The short pipe shall be compatible for welding to the penstock and shall be designed in accordance with the minimum criteria used for penstock pipe. For maintenance of the inlet valve, the penstock shall be supplied with a blind flange with the separate bolts and nuts and the operation of the other unit can be done without any interruption during future maintenance.

(2) The short pipes shall supply with a suitable length as appropriate and shall incorporate connections for all equipment required to be connected to the penstock. The Contractor shall be responsible for trimming and fitting the short pipes with flange and also for the making of the welded joints between the pipeline and the short pipe.

(3) A flanged dismantling joint shall be provided between the turbine casing and inlet valve to adjust and to dismantle during maintenance. The dismantling joint shall be complete with nuts, bolts and jointing suitable for attaching to the turbine casing, the dismantling joint shall permit installation and removal of the inlet valve. The design shall be such that no forces are transmitted via the pipe to the turbine.

S3.5 PENSTOCK AND TURBINE DRAIN SYSTEMS

(1) A minimum 100 mm diameter manually operated valve with connecting pipes shall be provided with each turbine to drain water out from penstock upstream to the tail water. The connection to penstock tapping shall be located upstream of the inlet valve at the short pipe with flange.

(2) A minimum 75 mm diameter valve and pipes shall be provided to drain water from the turbine casing to the tailrace. The valve, piping and supports shall be suitable for operation under maximum unbalanced head and free discharge without any vibration.

(3) The Contractor shall submit the layout arrangement of turbine, reducer pipe, inlet valve, dismantling pipe and pipe arrangement shall be submitted.

S3.6 SHOP TEST

(1) Physical Inspection

Contractor shall perform the factory test for the valve under the witness of Client personals measuring the size and the dimensions indicated in the submitted shop drawings.

The inspection form and format shall be submitted for approval before the witness acceptance test.

(2) Assembly at the factory

The valve shall be preassembled at manufacturer's factory before witness acceptance test together with counterweight to perform operation test to record opening and closing time of the valve with counterweight assembly.

(3) Hydraulic Pressure Withstand Test

Hydraulic Pressure Withstand Test shall be performed for valve body with seals and seat assembly during witness acceptance test. Both sides shall be tested and record the values together during the witness acceptance test.

The test parameter shall be as follows:

- 1.5 times the rated design pressure for 10 minutes
- 1.5 times the rated pressure with additional pressure of 0.3 Mpa for 1 minut

SECTION 4- GEARBOX

S4.1 GENERAL

This section specifies the detailed requirements for the design, manufacture and testing of gearbox, with associated equipment, to be furnished in case of gearbox is used for increasing or reducing to match with the speed of the generator.

S4.2 TYPE AND DESCRIPTION

The gearbox shall be designed as speed increaser to increase the speed of turbine to match with generator speed. The type shall be **single stage helical gear** and selection shall be made and supply according to AFNOR or DIN or BS or ISO and able to support at least 2 times of the nominal torque and an instantaneous torque shall be at least 3 times the nominal torque.

The single stage gear drive is a parallel shaft arrangement enclosed in a rigid, heavy walled fabricated steel casing, employing gear wheels rotating on shafts supported by anti-friction bearings.

The low-speed shaft shall be made with a bore and is directly attached to the turbine shaft with a flange. The connection from the high-speed shaft to the generator shaft shall be done by means of and the flexible or mechanical coupling.

For case of maintenance, the gear drive shall be removable without disassembly of turbine and generator shafts.

The gearbox shall be equipped with temperature detector/ sensor which will send the temperature values to Governor PLC for protection function.

The guaranteed efficiency of speed increase shall not be less than **95.0%.**

S4.3 DESCRIPTION OF COMPONENTS

S4.3.1 Gear Accuracy

The pinion and helical gears shall be precision hobbing, carburizing and precision surface to DIN Quality level or other equal international standards.

S4.3.2 Housing

The gear housing shall be designed and constructed of modular cast iron or fabricated steel, suitably ribbed, and reinforced to withstand all normal loads imposed during operation and accurately machined to prove to ensure maximum strength and rigidity.

The housing shall have its strength concentrated at the point of attachment of the fixed member of the gear drive. The construction shall ensure that the torque reaction is directly transmitted to the foundation.

Opening hole shall be provided to permit internal gearbox inspection.

All housing sections shall be suitably stress relieved after welding, cleaned of mill scale and weld spatter, and sealed with an oil compatible sealer to prevent internal rusting

S4.3.3 Bearing

The bearings shall be heavy duty, anti-friction type and shall be the same grade with pressure oil lubricating system.

An integral thrust bearing arrangement shall be incorporated into the design in order to accept turbine thrust. The thrust bearing arrangement shall be double acting in order to accept thrust reversals.

The thrust bearing shall be capable of continuous operation under maximum load condition at any steady state speed up to steady state runaway speed and at the maximum transient over speed without limitation on the number of occurrences.

S.4.3.4 Servicing

The design shall allow for complete removal of the gearbox (as an assembly) from the turbine shaft and generator shaft connections. This entire assembly shall also be fitted with the power box dimension.

S.4.3.5 Lubrication System (if applicable)

The Contractor shall design and manufacture the lubrication system suitably sized to meet the requirements of the drive under all operating conditions.

This system shall be closed loop with its owned lubrication oil bath or opened loop design with the separate external lubrication unit with sump tank, oil pumps, heat exchanger, filters, check valves and flow switch, and temperature sensors.

In case of closed loop system is used, the Contractor shall provide instruments such as temperature and level monitoring sensors to send the signals to Governor PLC for protection. At least one sight glass shall be provided to monitor the oil level.

S4.3.6 Lube Oil Routing (if applicable)

In case of external lubrication used, all components except the oil cooler shall be mounted on gear housing (including oil sump). During operation, oil shall be supplied from the sump pump vertical check valves into the oil pump at low pressure. Upon exiting the pump, the higher-pressure oil is fed through oil filter and into the oil cooler.

Upon exiting the heat exchanger, the oil passed through a series of gauges and sensors after which it will be distributed to the key inlet points. Excess oil will be relieved back to the

sump along with oil whose is exhausted from areas of the drive system. The first oil filling shall be provided by the Contractor.

S4.4 SHOP TEST

The gearbox shall be given complete functional test at no load and other test according to the applicable standard with corresponding reports.

The efficiencies have to be proved with calculations according to the standards with the corresponding tolerances.

S4.5 FIELD TEST

Field test after installation shall be performed at site to determine whether the equipment meet these Technical Specifications of the Contract.

SECTION 5 - MECHANICAL AUXILIARY EQUIPMENT

S5.1 GENERAL

This section specifies the detailed requirements of the design of the systems listed below and of furnishing all plant, labor, equipment, material and supplies necessary for furnishing, installing, and testing the equipment, in accordance with the Technical Specification stated herein.

S5.2 WORK INCLUDED

The equipment covered under this section is for the following systems.

- Fire extinguisher equipment
- Ventilation and air conditioning equipment

S5.3 CODES AND STANDARDS

All materials, equipment design and methods of all works shall comply with the latest edition of applicable laws, codes and standards including, but not limited to, the following:

- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
- Factory Mutual Engineering Corporation (FM)
- National Fire Protection Association (NFPA)
- Underwriters' Laboratories Inc. (UL)

S5.4 FIRE EXTINGUISHER EQUIPMENT

S5.4.1 General

The Contractor shall provide one (1) rechargeable portable CO_2 extinguisher and one (1) rechargeable dry chemical extinguisher complete with wall mounting brackets and other accessories in power box. Their final mounting location shall be proposed to DEDE's Engineer during engineering period.

S5.4.2 Type and Construction

Dry chemical extinguishers shall be of a multi-purpose type suitable for Class A, B and C fires. While CO_2 extinguishers shall be of a multi-purpose type suitable for Class B and C fires. Each extinguisher shall be a minimum 6.8kgs (15lbs) capacity (weight of chemical) with UL approval.

Extinguishers shall be red with a glossy baked-enamel finish, chrome-plated trim, and safety pin. Each shall be completed with a wall-mounting clip.

S5.5 VENTILATION AND AIR CONDITIONING EQUIPMENT

S5.5.1 General

The ventilation and air conditioning equipment shall be furnished and installed in accordance with the drawings and specifications. Prior to execution of the work, the Contractor shall submit installation drawings that show all details to the DEDE's Engineer for approval.

S5.5.2 Ventilation Equipment

One (1) individual electrical ventilation fan shall be installed in the power box. The fan shall generate low noise and vibration in operation. The Contractor shall submit detailed calculations of air change (cfm) during engineering period.

S5.5.3 Air Conditioning Equipment

One (1) spilt type air conditioners shall be installed in the power box. The air conditioner capacity shall be at least 24,000 Btu/hr and shall consist of compressor, motor, fan, condenser, cooling coil, etc. It shall generate low noise and vibration during operation with energy saving level 5 regulation. Prior to execution of the work, the Contractor shall submit detailed calculations of heat load during engineering period.

The housing of indoor unit shall be made of galvanized steel sheet 1.0 mm thick or more reinforced sufficiently.

Outdoor unit shall consist of finned coil, fan, motor, and housing. The coil shall be copper pipe. The fin shall make of aluminum sheet treated by chromate method or coated with acrylic resin to prevent from corrosion. The fin shall be provided with protection not to be damaged.

The housing shall be made of galvanized steel sheet 1.0 mm thick or more coated with acrylic resin or melamine baked paint or epoxy resin, etc. as the rust resistance.

S5.6 ELECTRIC HOIST AND SUPPORT FRAME

(1) Type and Rating

(a) The Contractor shall provide an electrically driven hoist with movable steel support frame with wheels to lift turbine, generator, inlet valve and other equipment inside the power box during assembly and maintenance.
(b) The capacity of this hoist shall be determined by the Contractor during engineering stage and submit to DEDE for approval.
(c) The capacity of the hoist shall not be less than 1 ton and the heaviest weight of equipment installed inside the power box.
(d) The steel frame support shall be fabricated by using steel pipe having enough strength to resist the lifting weight of equipment so that the engineering design drawings for this support frame shall be submitted to DEDE for approval.
(e) The limits of lifting traverse and travel of the hoist and support frame shall be suit with the maximum possible height of power box.

S5.7 CONTROL AND AUXILIARY POWER SUPPLIES

All equipment supplied for the auxiliary mechanical systems shall be suitable for operation on the control and auxiliary power supplies specified in S1.05 Control and Auxiliary Power Supplies.

S5.8 ELECTRICAL EQUIPMENT

All electrical equipment associated with auxiliary mechanical systems and equipment herein specified shall meet the requirements in Section 1 of Electrical Equipment.

S5.9 PAINTING

All painted surfaces of new equipment supplied by the Contractor shall be, as far as is practical, shop painted in accordance with the specifications outlined in S1.13 Painting.

S5.10 INSPECTION AND TEST

S5.10.1 General

All auxiliary mechanical systems shall be subject to inspection and testing as specified in S1.17 Inspection and Tests-Electrical/Mechanical. All auxiliary mechanical systems shall be factory tested before shipment.

The Contractor shall furnish certified copies of all test results. The results of each test shall be recorded in the form of test certificates or reports.

S5.10.2 Type Test

Type tests may be offered by the Contractor as specified in S1.17 Inspection and Tests-Electrical/Mechanical, provided the Contractor gives evidence to DEDE's Engineer as to the similarity of the equipment tested and the equipment supplied.

S5.10.3 Shop Test

The equipment shall be subjected to shop tests in accordance with the latest issue of the applicable standards. In addition, the Contractor shall perform the following shop tests:

a) Material Test
b) Material tests shall be as specified in S1.17 Inspection and Tests-Electrical/Mechanical.
c) Shop tests as specified in S1.17 Inspection and Tests Electrical/Mechanical.

SECTION 6 - TESTS FOR MECHANICAL AUXILIARY EQUIPMENT

S6.1 TEST DURING MANUFACTURE

The mechanical auxiliary equipment shall be subject to the following tests at the Contractor's premises.

(1) Material Tests
Contractor shall test all equipment and components at the factory or supplier's factory during manufacturing, assembly including material test certificates of raw materials, internal tests, mill tests, etc.

Internal quality test program of supplier shall be performed, and the test reports shall be submitted to DEDE together with the equipment delivery.

(2) Hydrostatic Tests

Hydrostatic tests shall perform for inlet valve and pipes shall conform to the requirements stated herein.

(3) Performance Tests

For turbine performance, the Contract shall submit the similar
Operational tests, assembly check for all electric motors for hydraulic pressure unit under this specification shall be done simulating as the actual service for output, efficiency, power factor, temperature rise including functioning of equipment installed on the unit.

Hydraulic, pneumatic, and electric tests on all pumps, compressors, air-conditioning units, and fans under conditions simulating the actual service to demonstrate that the performance complies with the Contract and to establish complete operating characteristics. Particular attention shall be paid to limiting noise and vibration levels.

(4) Performance tests on the air-conditioning unit.

S6.2 TESTS AT SITE

(1) Preliminary Test

The preliminary tests for the mechanical auxiliary equipment shall include the followings:

- Hydrostatic pressure test.

(i) On all equipment subjected to water, oil, or air pressure during normal or abnormal working conditions, in accordance with the relevant American Standards, subject to the test pressure being not less than 1.5 times the maximum working pressure but the testing pressure shall not be less than the rated pressure occurred at penstock pipes during emergency trip.

(ii) Leakage and deflection tests on all equipment stressed by pipeline pressure.

(iii) Leakage tests with kerosene under gravity for all sump tanks.

Insulation and continuity tests on wiring including tests for correctness of connection.

Checking pipework for freedom from obstructions.

Checking for correct operation of each control, protection, and indication device.

Checking the operation of all pump and compressor assemblies for vibration, overheating, leakage from joints, seals, glands, etc.

(2) Tests on Completion

For the mechanical auxiliary equipment, the Tests on completion shall include the followings:

Tests of the correct functioning of automatic and manual control and protection equipment. These shall include a demonstration of correct repetition of twenty consecutive operating cycles.

Tests to verify that the operation and system performance of all pumps and compressors are in accordance with the Contract.

Tests to verify the performance of the ventilation and air-conditioning plant shall include:

- Continuous operation of all equipment to demonstrate that it will operate without overheating.
- The measurement of air quantities flowing in each ventilated fan or air-conditioned room.

- The measurement of temperatures and humidity in each air-conditioned room at regular intervals. These tests shall if practicable be carried out on days when outside air conditions are close to design extremes. The outside air conditioning shall be measured during the tests.
- The measurement of noise levels during the running of the plant at maximum load.
- Tests to verify that the operation and performance of other mechanical auxiliary equipment is in accordance with the Contract.

SECTION 7 - GENERATOR AND AUXILIARIES

S7.1 GENERATORS

(1) Scope of Work

The work to be done under this section consists of the design, manufacture, supply, delivery to site, installation, commissioning and guarantee of synchronous generator One (1) Complete Sets, unit capacity not less than 180kVA for 50 Hz operation, as specified herein.

The layout arrangement of Generator, The generator capability curve and efficiency curve which are consistent with the guarantees relating to efficiency and output **shall be submitted together with the Bid**. **Failure to submit will reject the Bid Proposal.**

(2) Purpose and Function

The generator supplied in this contract shall have a single driven shaft and have to connect with crossflow turbine runner. The unit shall generate 3-phase, 400V, 50Hz electric power at generator terminals.

(3) Responsibility of the Contractor

The Contractor shall guarantee and be responsible for the hydroelectric generator supplied under this project.

- The output and efficiency of the generator and temperature rises of the various parts as specified under this section.
- Generator bearing housings for both DE and NDE sides shall be fixed at the generator casing so that separate bearing housing design is not acceptable.
- The Contractor shall submit the equipment layout drawings of synchronous generator from the manufacturer as the preliminary design information to evaluate to be installed inside the power box

(4) Standards and Codes

The work covered by these Specifications shall be designed, manufactured, and tested generally in accordance with the following standards and codes or approved equivalent.

- National Electrical Code	ANSI C2
- Rotating Electrical Machines	IEC 60034-1
- AC generators	ANSI C50.10, C50.12
- Standard Criteria and Definitions of Excitation Systems for Synchronous Machines	IEEE STD 421

- Shaft	ANSI B49.1
- Motors	MEMA MG 1
- Control Cubicles	MEMA SG 5
- Instrument Transformers	ANSI C57.13, NEMA EI 2
- Relays	ANSI C37.90
- Indicating instruments	ANSI C39.1
- Wire	Metric standard
- Screw threads	Metric standard
- Transformers	ANSI C57
- Definition of electrical items	ANSI C42
- Test Code for Synchronous Machines	IEEE No. 115
- Standard methods for determining losses and efficiency from tests	IEC 60034
- Electrical Insulation	IEC 60085, IEEE43

(5) Description

The units shall be of the horizontal-shaft, revolving field, synchronous brushless, two bearings type and shall conform to the latest standards of ANSI or IEC or EN or IEEE Standards unless otherwise specified herein.

(6) Capacity and Efficiency

The unit shall have a continuous rated output of not less than 180 kVA at 0.8 p.u. power factor. The maximum temperature rise of both stator and rotor windings at rated output and normal conditions shall be 80˚C based on ambient air temperature not exceeding 40˚C in accordance with ANSI or IEC standards.

The units shall be capable of operation over the following conditions: -

- Generator output up to rated kVA continuously at voltages 5 percent above or below voltage for a range of power factors from 100 percent to 80 percent (overexcited) at 50Hz system operation with a 40˚C ambient temperature.
- Guaranteed efficiency shall not be less than 93.0% at 0.8 P.F. running at rated output not less than 180 kVA.
- Short Circuit Ratio should be not less than 0.8.

(7) Speed, Direction of Rotation and Frequency

The Speed of unit shall be designed and selected based on turbine design for 50 Hz operation and shall be capable of operating continuously at a runaway speed to be determined by the turbine characteristics and **The Bidder shall be submitted together with the Bid. <u>Failure to submit will reject of the Bid Proposal.</u>**

The Contractor can also design the generator connected directly with the turbine without using a gearbox.

(8) Voltage and Phases

The unit shall be designed to deliver its rated capacity at a balanced 3-phase potential 400V between phases. The tests and guarantees shall be based on this voltage and 50 Hz operation. The unit shall operate successfully at rated capacity at 5 percent above or below rated voltage. **The Bidder shall be submitted together with the Bid. Failure to submit will reject of the Bid Proposal**

(9) Insulation

The generator stator windings and all connections, main and neutral leads, etc., shall be insulated in accordance with ANSI C50.10 and IEC 60085 and all windings shall be treated with VPI (Vacuum Pressure impregnation) and have Class B temperature rise and Class H insulation for both stator and rotor. **The Bidder shall be submitted generator stator windings together with the Bid. Failure to submit will reject of the Bid Proposal.**

(10) Harmonic Distortion, Wave Form and Telephone Interference Factor

The total harmonic distortion shall be not more than 5% according to IEEE standards or IEC 61000.

The telephone interference factor shall be within the limits specified in ANSI or IEC or EN standards.

(11) Flywheel Effect

The flywheel effect (WR^2) of the rotating parts of the combined turbine runner and generator shall be calculated as per the given information so that the Contractor shall submit flywheel dimensions and GD^2 value.

(12) Soleplates (Base Plate)

The Contractor shall provide a baseplate for mounting the generator and turbine on the common base plate complete with anchor bolts and soleplates with anchors for grouting as required. The Contractor shall be responsible for ensuring that the soleplates are placed at the correct position and approval by DEDE Engineer.

(13) Stator

The Stator winding shall be insulated with Class H insulation as defined in ANSI or IEC standards.

Stator Frame and Iron: The design of the stator frame, the soleplates, and the means of attachment of the soleplates to the frame shall be suitable to withstand all stresses to which they may be subjected in service as a result of all types of short circuits or faults.

Cast finger supports for the laminations will not be accepted.

To minimize the effects of end-iron heating during operation, adequate ventilation shall be provided, and nonmagnetic materials shall be employed where necessary.

The stator core assembly shall be constructed from low-loss cold-rolled silicon steel sheets. These shall be varnished to limit losses by Foucault current, cut into full sheets or sections, and stacked around a central mandrel. Radial ventilation ducts obtained by the welded air vents shall be provided to distribute air along the stator core.

(a) Stator Winding:

The stator winding shall be made of copper conductors and the conductor strands shall be transposed to minimize stray losses. Facilities shall be provided for terminating the cable on the unit housing. Final details of the main lead termination at the unit shall be subject to approval by the DEDE Engineer. All bolted main current-carrying terminals shall be silver or tin plated.

The stator winding shall be capable of successfully withstanding dielectric test in accordance with ANSI or IEC or EN standards.
Adequate means shall be taken in the design and assembly of the stator winding to ensure the followings:

- The stator coils shall be adequately supported and braced to prevent dropping in the slots and to withstand the full stresses developed due to electrical fault conditions. Adjacent coil ends shall be held apart by spacers and bound to each other. Cording used to hold coils in position shall not be continuous (i.e. each coil shall be tied separately). The support rings to which the coils are lashed and supported shall be made of nonmagnetic material.
- The stator coils, when installed, shall fit firmly in the slots. A coil rejected because of slot fit shall not be used unless rebuilt.

- The stator coils shall be tightly wedged in the slots with wedges that will not buckle or shrink.
- The wedge in each slot shall be prevented from dropping out should it become loose in service.
- The stator coils, including spares, shall be manufactured to fit the stator core and end deformation will be the minimum necessary during installation.
- The insulation of the stator coils shall be sufficiently durable that, should it be necessary at any time to remove the coils, their removal and replacement may be carried out without damage to the insulation of any of the other coils. The quality and life of the insulation shall be impaired in attaining the above requirements.
- The stator coil insulation, wedging, packing, bracing, and typing shall be such as to minimize the effect of thermal shock and of additional differential expansion which may occur as a result of the overload conditions.
- All possible measures shall be taken to maintain the tight fit of coils in the slots to prevent vibration, loose wedges, and consequent high intensity discharge in the slots.

(b) Resistance Temperature Detectors:

The resistance temperature detectors shall be embedded in a suitable location, one at each end of the stator core for temperature measurement for the detection of end-iron heating.

The exact location of the resistance temperature detectors in the stator winding and core shall be subject to the approval of the DEDE Engineer. All resistor temperature detectors in and around the generator shall be wired to a terminal box mounted on the outside of the generator air housing. This terminal box shall be separated from other terminal boxes.
All connections from the resistance temperature detectors to the terminal boards shall consist of twisted leads in shielded instrument cables.

The resistance temperature detectors shall have a resistance of 100Ohms at 0˚C over a temperature range of 0˚C to 120˚C.
All of the resistance temperature detectors shall be connected to AVR Module (or) the Unit PLC Control Panel for monitoring and protection of the Unit.

(14) Rotor

The rotor shall consist of shaft, polar wheel, fan, balancing disc, excitation armature and rotating bridge rectifiers.

The rotor winding shall be insulated with Class H insulation as defined in ANSI or IEC standards and shall be designed to withstand 10 times rated field voltage or standard voltage dielectric test to ground for 1 minute.

Each field coil shall be fabricated so that the space between adjacent turns is completely and solidly filled with insulating material to ensure uniform insulation thickness between conductors throughout the coil. Every effort shall be made to avoid excessive deformation or burring of the conductor during the forming of the coil.

The design of the rotor shall be such as to permit the easy removal and replacement of the field poles. If tapered keys are used to secure the field poles to the rotor rim, the drive key shall project above the rotor rim a sufficient distance to facilitate removal of this key by means of a key puller and to permit checking for tightness after overspeed tests have been performed.

The polar wheel, referred to as salient pole rotor, shall consist of a laminated assembly.

(15) Reactance

The reactance values shall be provided as manufacturer's preliminary design values such as the values for synchronous, transient, sub-transient and negative sequence reactance under unsaturated and saturated conditions with short circuit ratio values, armature time constants and armature resistance. The generator manufacturer's design curves such as Capability Curve, Short Circuit Curve, Efficiency Curve, and Transient Voltage Curve during load rejection, Stator Earth Fault Curve, shall also be submitted together with manufacturer's Drawings from factory having complete dimensions verifying such manufacturer is well proven and qualified manufacturer to produce the synchronous generator under European, American standards or equivalent.

(16) Generator Enclosure

The generator enclosure shall provide an open-circuit ventilation system. The enclosure shall be arranged to permit easy removal for the purpose of inspection and maintenance.

(17) Cooling System

The generator shall be self-ventilating with its own fan cooling action being utilized the force air through the windings, ducts, etc. Fan blades on the rotor shall be given special care in their design and in securing them to the rotor so that they will be held rigidly in position at any speed which the rotor may attain.

The generator shall be of an open-air cooled design. The generator cooling air, after passing over the field, stator iron and windings, shall be diverted through the generator housing.

The evidence of Main Dimensional Layout of synchronous generator from Manufacturer's factory shall be submitted together with specific speed, rotational direction, material descriptions, GD^2 values, anchor bolts, etc. shall be submitted to verify that the proposed manufacturer's design is complying with DEDE's specification and layout drawings.

S7.2 SHAFT AND BEARINGS

(1) General

(a) The arrangement of shaft and bearings shall be of the form specified as above in Clause S7.01 with heavy duty roller ball bearing type.

(b) Bearing housing shall be fixed at Generator housing and bearing operating life shall be properly designed to bear the weight of turbine runner and reliability of generating unit.

The Contractor shall attach the generator layout drawings showing the above requirements.

(c) The separate bearing housing from generator housing is not acceptable and it will be subject to the rejection.

(d) The Contractor shall carry out a detailed mathematical analysis of the rotating parts of the turbine generator and their support systems to ensure stability, considering amplitudes and frequencies of transient axial and lateral thrusts and tensional vibrations together with steady-state loads emanating from the turbine and generator. The calculations shall be submitted to the DEDE Engineer for approval.

(e) The Contractor shall be responsible for determining and applying the method of shaft and bearing alignment and for determining alignment tolerances.

(f) The Contractor shall provide a bending diagram for the turbine and generator shafts and the relevant information shall be incorporated in the Operation and Maintenance Instruction.

(g) The shafts, couplings and all rotating parts shall be designed to withstand any torque which the associated turbine can produce under any possible combinations of head, gate opening and speed.

(2) Shaft and Couplings

(a) The shaft shall be of forged steel machined all over. A secure means shall be provided to prevent water from entering into the shaft from the turbine end.

(b) Shaft couplings shall be made by flanges integral with the shafts. The couplings shall be provided with locating spigots and fitted bolts or shear bushes.

(c) The generator shaft and turbine couplings shall be coupled together and fully checked at the dimensions before delivery at the manufacturer's factory.

(3) Bearings

(a) The generator bearings shall be heavy duty roller ball bearing type for both DE and NDE suitable for all operating conditions for starting and stopping, normal and emergency stop operation at rated generator output, and operation at up to the maximum runaway speed.

(b) Provision shall be made to prevent the flow of electric currents through the bearings. The bearing insulation shall be arranged by the use of an insulation/ metal/ insulation sandwich or similar method, so as to permit the insulation to be tested without dismantling any part of the unit.

(c) The design of the bearings shall preferably be such that neither high pressure oil injection nor low pressure oil overflow during starting and stopping sequence is required.

(d) All generator bearings shall be provided with a resistance temperature detector specified and the value shall be sent to AVR or Governor PLC control system for protection and monitoring purposes. They shall be located at the parts most sensitive to the maximum temperature in the bearing housing.

S7.3 SIGNAL GENERATOR

(1) General

The Contractor shall provide all devices necessary for the PLC control system as specified in these Specifications and for the proper operation, maintenance, and commissioning of the units.

(2) Speed Detector

(a) The Contractor shall supply one speed detecting device for each generator which shall be sent speed analog signal directly to Governor PLC Controller as speed detector. The detector shall be the speed measuring (or) sensing equipment which shall be a part of the unit control and indication system as specified in this Specification.

(b) The output of the speed detector shall be wired to shrouded terminals in a junction box on the generator from which the Contractor shall connect instrument cables to the speed measuring equipment at Governor PLC Panel.

(c) Rotating Speed of generator and turbine shall be derived from the two (2) inductive (or) NAMUR type sensors located at Generator using tooth wheel and the speed signals from two sensors shall deliver to Speed Monitoring Relay to indicate and divert 4-20mA to Governor PLC for speed sensing function. The independent speed sensing method shall be provided and mounted on the generator shaft without passing any fuse.

S7.4 EXCITATION SYSTEM

(1) Type and Performance

(a) A complete brushless digital excitation system, including automatic voltage regulating components shall be supplied for generator.

(b) Auxiliary Winding at Generator shall be provided with complete wiring and components for this system to provide the continuous power supply to digital AVR in case of not using excitation transformer with excitation control panel.

(c) The excitation system shall comply with the following performance:

(i) The system shall maintain the generator voltage stable and equal to the value determined by the voltage setting device when the generator is operating connecting with the system (or) separated from the system.

(ii) The maximum variation in generator terminal voltage when the operating conditions change from no load to rated generator output shall not exceed 1 percent.

(iii) In the event of an increase in generator frequency up to that corresponding to the maximum rise resulting from the loss of the generator load, the excitation system shall remain stable, and it shall rapidly restore the voltage back to normal.

(iv) During transient disturbances such as load variation (or) short-circuits in the system, the excitation system shall be capable of functioning correctly and, in addition, providing increased excitation as required.

(v) Damping of oscillations between the generator and the power system shall be positive at all times and for all operating conditions within the capability of the generator.

(2) Exciter

(a) All equipment required for the excitation system offered shall be provided with ringless and brushless and PMI (permanent magnet insert type) and permanent magnets shall be mounted on the exciter armature poles to provide sufficient voltage. The voltage priming shall be performed in all circumstances, even after a long shut-down period.

(b) Static electronic equipment shall be constructed, to the maximum possible degree, as plug-in withdrawable modules.

(c) The semi-conductor equipment shall contain a number of devices connected in parallel, so rated that continuous operation of the generator at rated load will be maintained despite failure of any one paralleled semi-conductor circuit.

(d) Protective devices shall be provided in the control and in the semi-conductor circuits to isolate a faulty device without interruption of the generator excitation. The Contractor shall provide details of the measures taken to ensure the reliability of the excitation equipment.

(d) The excitation equipment shall be protected from or shall otherwise withstand the maximum voltages and currents arising from short-circuits, out-of-synchronism operation of the generators, or failure of supply to the excitation system.

(3) Voltage Regulators

(a) A digital type of automatic voltage regulator (AVR) shall be provided for the generator excitation system. The excitation current capacity for the AVR shall

be limited for the safety of the device where the other parts of the exciter system design shall be able to work with this arrangement.

(b) A manual control facility shall also be provided for the generator excitation system. Facilities shall be provided at the excitation equipment, to enable changeover from AVR to manual control of the excitation level.

(c) Besides Manual Control, the AVR unit shall have Open Loop Control mode where there is no feedback loop on the Generator Voltage (Auto Mode) or Excitation Current (Manual Mode). Selector Switches shall be provided in front of cubicle.

(d) AVR control loop feedback algorithm shall be PID (Proportional, Integral and Differential) type only. Filter type algorithm, or any other algorithm besides the PID type is not acceptable.

(e) The AVR unit shall have build in soft start function under Auto Mode; where the Start Frequency (Hz), Start Level (% of Rated Voltage), and Ramp Time (Seconds), shall be provided under this function. External switches, Timer relay, separated PLC to achieve this function is not acceptable.

(f) Exciter Rotating Diode monitoring function shall be built into the AVR unit, where two dedicated switch outputs shall be provided in the event of Alarm and Trip, this is on top of the other AVR Alarm/ Trip outputs to main PLC.

(g) The AVR shall be supplied power from generator auxiliary winding source (or) excitation transformer from Excitation Transformer Panel.

(h) The AVR shall be responsive to the positive phase-sequence component of the generator voltage and shall be independent of frequency.

(i) The voltage setting device for the AVR shall be suitable for operation by hand at control cubicle and by remote control. The device shall provide a settable range of $\pm$10% (with adjustable) of nominal generator voltage.

(j) Communication ports shall be available at AVR module to configure without power supply such as Ethernet Modbus port, USB port, CAN BUS, etc.

The Contractor shall submit the manufacturer's catalogues for AVR, excitation transformer in the proposed excitation system with drawings and component list.

S7.5 INSPECTION AND TESTS

(1) Factory Test

Generators shall be tested at factory under witness of DEDE Engineers and the test program with procedures shall be submitted to DEDE for approval.

The Contractor shall perform the test for Generator, excitation system, at manufacturer's factory to verify that these are able used together without any trouble. Contractor shall bear all travelling expenses (air tickets, accommodation, meal, allowance, etc.) for five (5) DEDE's officers (as Witness) to attend the test at factory and sign for approval of test results before delivery to site. If there is any defect (or) rejection of manufactured equipment, the Contractor shall perform the same test at factory again after correction with his own cost.

(2) Individual Parts

All stator and rotor coils for the generator shall be tested in the factory for grounds and short circuit between turns. In testing the generator field coils for shorted turns, readings shall be taken of ac amperes, volts, and watts, preferably using the same value of current to test all coils. Certified test reports for generator current transformers, as specified elsewhere, shall be submitted to the DEDE for approval before Witness Test.

(3) Generator

Test for Generator Unit shall be done determine the performance to determine the guaranteed efficiency as per Contract. The tests shall be done at the manufacturer's factory together with the excitation system.

All tests shall be performed in accordance with IEEE Test Procedures for Synchronous Machines (or) IEC Test Procedures for Synchronous Machine so Contractor shall submit the test items, procedures to submit DEDE Engineer's Approval.

(4) Excitation System

Tests on the excitation system, including tests on the components shall be proposed by the Contractor, incorporating reputable international standards, for the approval of the DEDE Engineer.

(5) Performance of Tests after Installation

All tests made at the Site shall be performed by the Contractor. The Contractor shall submit to the DEDE Engineer for the method of performing tests. The Contractor shall ensure that all necessary precautions are taken to guard against accident or damage to persons or property in performing the tests and shall arrange for the supply and erection of all necessary barriers, guards, and danger signs for safety purpose.

The Contractor shall submit the Field Test and Dummy Load Test Procedures of Turbine and Generator Performance according to the applicable IEC Standards showing the diagrams, measuring methods with instruments and calculation criteria of efficiency.

Furthermore, for the completion of Testing and Commissioning, The Contractor shall perform the following tests for the generating units :

- Dummy Load Test
- Dummy Load Test Operation of complete excitation system including automatic voltage regulating equipment at various loads and including load acceptance and rejection test at 25, 50, 75, 100% of load.
- Continues Load Test for 48 hours

SECTION 8 - AC SWITCH BOARD

S8.1 SCOPE OF WORK

The work to be done under this clause consists of the design, manufacture, supply, delivery site, installation and guarantee of the following equipment: -

- One (1) set of 600Vac, AC Distribution Board, metal-enclosed, indoor type

S8.2 PURPOSE AND FUNCTION

Station service AC power shall be supplied from the existing transformer (200 -300kVA) 22kV/400Vac 3P 50Hz, used for gate building and the normal supply AC power shall be from a feeder from Flood Gate Building Control Panel and ACB Panel with safety interlock switch. The AC supply shall be used as AC service line.

The AC switchboard shall supply low voltage AC power inside the power box for lighting, receptacles, battery charger, air conditioner and other load.

S8.3 LOW VOLTAGE SWITCHBOARD

The low voltage AC station switchboard shall be completely factory assembled, metal enclosed, consisting of functionally compart-mentalized units for removable circuit breaker elements, cable termination, incoming and main buses, and appurtenances. The switchboard shall be designed and constructed in accordance with IEC (or) ANSI standards (or) approved equivalent, and as follows.

The switchboard structures shall be made of formed and smooth welded sheet steel enclosures at least 2 mm. thickness sheet steel covers to provide support and housing for the buses, cables, instrument transformers and appurtenances. The frame and tie members shall be assembled to form a rigid self-supporting dead-front type of structure. The assembly shall be completely adaptable so that additions and changes can be made in the field without cutting, welding, or drilling.

The ac low voltage station service switchboard shall be rated as follows:

Voltage	-	400/230V
Phase	-	3 Phase (4-wire) with grounded neutral
Frequency	-	50 Hz
Buses		
- main bus	-	300 A Continuous
- vertical buses	-	300 A Continuous
- momentary current	-	15,000 A rms asymmetrical
- circuit breaker	-	15,000 A rms asymmetrical
- control power	-	110 Vdc or suitable

S8.4 CIRCUIT BREAKER

Circuit breakers shall be molded case, manually operated, quick make, quick break with both thermal and magnetic trip elements on each pole. All breakers shall be rated for 600V and shall have an interrupting rating not less than 15,000Arms asymmetrical at 400Vac.

S8.5 SECONDARY WIRING AND TERMINALS

The switchboards shall be complete with all accessory secondary wiring. All wiring shall be switchboard type stranded copper conductors. Wire sizes shall not be less than standard for control, metering, annunciation, and potential circuits.

The test blocks of current transformers shall be provided with auxiliary contacts which automatically short circuit the current transformers when the cover or plug is removed. The test block contacts shall be rated 250V, 10A continuous.

All wiring shall be run in plastic wiring duct or shall be formed into compact flat groups suitably bound together and properly supported. The group shall be run straight, horizontally, or vertically, with short-radius right-angle bends. There shall be no splices in the wiring and all connections shall be made at 600V, 25A terminals. Suitable provision shall be made for training and supporting incoming cables from the point of entrance to the termination on the terminal blocks.

All wiring shall be identified at both ends with PVC cable markers which resist grease, oil, acids, and abrasion.

The arrangements and locations of all terminal blocks shall be subject to the approval of the Engineer. Circuit on the terminal blocks shall be marked with permanent marking fluid and shall be subject to the approval of the Engineer. A minimum of 20 percent spare terminal blocks shall be furnished.

S8.6 CONTROL SWITCHES AND INDICATION

The following control switches and indicating lights shall be provided.

- Breaker control switches for local control with spring return to center and pistol grip handle for the main circuit breaker (52SST)
- Breaker position indicating light assembles for the above item complete with
  - red caps - “breaker closed”
  - green caps - “breaker open”
- 1 selector switch for selecting automatic or manual control, 2 position with oval stay-put handle, escutcheon engraved “Selector” and positions engraved “Auto” and “Manual” with enough contacts to control circuits.

S8.7 CURRENT TRANSFORMERS

Current transformers shall be supplied in each of the transformer secondary breaker sections of the station service switchboard. The current transformers shall be of the 55˚C rise dry type, used for metering and protective relaying, and shall be supplied as follows in accordance with the latest edition of ANSI C57.13 for instrument transformers, or approved equivalents.

a) Purpose - metering
Ratio - 250/5A
Frequency - 50 Hz
Accuracy - 0.5

b) Purpose - protection
Ratio - 250/5A
Frequency - 50 Hz
Accuracy - 5P20 or better

S8.8 INSTRUMENT SECTIONS

The station service switchboard shall be provided with the protection relay and shall house current transformers, voltage transformers, protection relay and digital power meters.

Digital power meter shall have minimum accuracy class 0.5 comply with IEC standard. The meter shall be used for power monitoring and type of measurements are apparent and active energy power, active and reactive power.

Measurement voltage shall be from 50 to 480V AC, 50Hz between phases and 25 to 270V AC 50 Hz between phase and neutral. The rated current is 1 or 5A and frequency shall be 50Hz.

The display information shall be voltage, current, frequency, energy consumption, harmonic distortion, demand current past value, demand current present value, demand power past value, demand power present value, power factor, active power, apparent power, reactive power, unbalanced in %, harmonic amplitude. Display language shall be English.

Communication ports shall include Modbus RTU and RS 485 ports with real time clock function at minimum 64 sampling rate to connect with SCADA PLC. The mounting of meter shall be front panel mounted with minimum IP51 protection as per IEC standard

Protection relays shall be 27S, 3 phase voltage relay for use with automatic transfer scheme, semi flush mounting in draw out case and 50/51N, Overcurrent function.

S8.9 GROUNDING

A grounding copper bus bar not less than 5 mm by 50 mm shall be provided along the front and rear of the switchgear. The ground bus shall be solidly bolted to the steel framework so as to make good electrical contact. Provisions shall be made at both ends of the switchgear for connection of the ground bus to cables from the station ground mat. Two clamp type terminals suitable for 95-mm^2 stranded bare copper conductor shall be provided. All non-current carrying parts shall be connected to the ground bus.

S8.10 NAMEPLATES

Nameplates of black laminate with white lettering shall be provided for transformers, circuit function and switchgear identification.

S8.11 CHANNEL BASES AND BOLTS

The Contractor shall provide the foundation bolts and channels necessary for holding down of fixing the equipment to the concrete foundations. Where the design of the equipment requires special clamps to be used with the foundation bolts, these clamps shall be provided by the Contractor.

S8.12 TESTS

The assemblies and their individual components shall be factory and field tested by the Contractor in accordance with the test specifications outlined herein.

The tests shall be made according to the appropriate standards to ensure compliance with specifications.

Tests on instrument transformers shall be in accordance with ANSI C57.13 or approved equivalent. The following tests shall be made on each instrument transformer

- resistance measurements
- insulation
- ratio, phase angle and accuracy
- polarity

The Contractor shall perform the tests at factory for insulation and functional tests together with physical dimensional check as per the submitted drawings and specification requirements mentioned.

Field tests shall be carried out in the field, as they are necessary for the satisfactory start-up and operation of the apparatus. These will normally comprise

- control and secondary wiring check of complete installation
- dielectric tests on control and secondary wiring using 1,000 V megger
- functional tests of the breaker operation, metering, relaying and the automatic transfer scheme.

SECTION 9 – GENERATOR CONTROL CUBICLE

S9.1 SCOPE OF WORK

The work of be done under this section consists of the design, manufacture, testing, delivery to site, installation, placing in successful service, and guarantee of:

- One (1) set of Generator Control Cubicle with HMI touch screen at least 10”
- One (1) set of Protection Relay
- One (1) set of Annunciator Window and indicating lamps
- Other necessary equipment must be provided

S9.2 PURPOSE AND FUNCTION

The generator control cubicle shall contain generator circuit breakers, surge arresters, dry type single phase current and voltage transformers for digital metering, protection, and synchronization.

S9.3 STANDARDS

The equipment and accessories shall be designed, manufactured, and tested where applicable, in accordance with the IEC (or) EN (or) ANSI standards.

S9.4 GENERATOR CIRCUIT BREAKER CUBICLES AND BUS DUCTS RATINGS

The generator circuit breaker cubicles shall be of metal-enclosed construction in accordance with the requirements of IEC (or) ANSI standards unless otherwise stated herein.

S9.5 EQUIPMENT DETAILS

The Contractor shall supply one (1) generator control cubicle, and each cubicle shall consist of the following.

A metal-clad compartment design (Circuit breaker compartment, busbar compartment, cable compartment and control compartment) shall be supplied to house the generator circuit breaker, current transformer, and voltage transformer.

The rating of the generator circuit breaker cubicles shall be as follows:

- Voltage	400 V
- Frequency	50 Hz
- Phases	3
- System	3-wire delta

- Continuous current (minimum) 630 A (minimum)
- Short-time (3 seconds) current 50 kA
- Momentary (1 second) current 50 kA
- Temperature rise (above 40˚C outside of the enclosure) 70˚C indoor

Generator Circuit Breaker

Indoor, fixed type, three (3) pole, air insulated circuit breaker with auxiliary contacts for receiving and tripping command from protection and control system and shall have the following ratings:

Type	Indoor, fixed
Rated Operating Voltage	400V
Rated Insulation Voltage	0.69 kV (or) higher
Frequency	50 Hz
Continuous current	630 A (minimum)
Short Circuit Breaking capacity	25 kA (minimum)
Short time withstand (3s)	25 kA (minimum)
Control Supply Voltage	125V DC or suitable

Current transformer single phase, ring type for relaying, dry type:

- Ratio 400/5A or suitable
- Accuracy 5P20 for protection and 0.5 for metering

Voltage transformers, single-phase, dry type, indoor

- Ratio 400/110V or suitable
- Capacity 10VA or suitable
- Accuracy 0.5 for metering and 3P for protection

Lightning arrester, gapless type

S9.6 DESIGN AND CONSTRUCTION OF GENERATOR CONTROL CUBICLE

The Generator control cubicle shall be indoor, air-insulated, metal-enclosed, switchboards and it shall be complete, ready for installation at site, with all components furnished unless specifically excluded herein.

The cubicle shall be designed and tested as per the latest updated IEC standards. The housing, partitions, etc., shall be fabricated from sheet steel panels having a minimum thickness of 2mm, structural shapes and nonmagnetic materials where required, in such a manner that the complete structure shall be rigid, self-supporting, and free from magnetic vibration, twist and weave.

The switchboard shall have the compartments that are busbar compartments, circuit breaker compartment, and low voltage compartments. Each cubicle shall be provided with a steel channel base frame with provision for bolting it to the concrete floor and placed inside the power box.

The openings shall be provided in the bottom of each panel housing to permit the entrance of instrument transformers, power cables and control cables which will be terminated in the auxiliary compartment. An electric heater 230Vac to prevent condensation shall be provided for each panel.

The Contractor shall be responsible for the coordination, proper physical fit, and other interfacing functions, including the location and phasing of bus terminations.

The surge protectors, voltage transformers, buses and bus connections in each cubicle shall be installed in cable compartment of the same panel and the auxiliary compartment shall be provided containing the voltage test devices, voltage transformer secondary fuses, current test link blocks and termination boards.

A hinged door shall be provided on the front of the auxiliary compartment. All hinged doors shall be equipped with semi-concealed highs and suitable locks. Similar locks shall also be provided on the voltage transformer drawers.

Ventilating louvers shall be provided in the hinged doors, and in other locations where required, to prevent undue temperature rise. The ventilating louvers in the hinged doors and in other locations of the housing shall have openings small enough to prevent the entrance of rodents and insects.

Entrance bushings shall be used for insulating and supporting the buses and bus connections that pass from 1 compartment into another. Where the use of bushings is not practical due to space limitations, panels of approved insulating materials may be used instead for this purpose. The arrangement chosen shall ensure a reasonably tight seal between compartments.

All materials used in the cubicles, such as bus insulation, bus supports, etc., shall independently support combustion.

Equipment and connections within each compartment shall have their mounting bolts arranged so that it will be possible to replace them without removing from service equipment in adjacent compartments.

The voltage transformers shall be single-phase, and each voltage transformer circuit shall be furnished with the current-limiting fuse.

The voltage transformers and fuses shall be completely disconnected and visibly grounded when in position to permit inspection or to permit access for removal or replacement of fuses.

The voltage transformer core shall not saturate at voltages lower than 110 percent of system voltage. The voltage transformer assembly shall have provision for padlocking in the disconnected position, and it shall be possible to close the outer door with the voltage transformers left in the disconnected position.

The buses and bus connections shall be of copper bar and supported on suitable insulators and properly braced to withstand the short-circuit forces. The bus bars shall be fully insulated throughout and also at tap-off points using flame-retardant, track-resistant, non-hygroscopic materials.

Joints between bus sections, etc. shall have their contact surfaces, and shall be fastened with stainless steel bolts, nuts and locking devices.

Bus bar supports between panels shall be tightly sealed between compartments. means of linear expansion shall be provided.

Means shall be provided for permanent grounding of all exposed non-current-carrying metal parts of the generator terminal cubicle and secondary neutrals of the instrument transformers as required by the specified standards. All parts of the framework shall be in good electrical connection with one another for grounding purposes.

A continuous ground bus, extending the full length of each cubicle, shall be provided. A non-solder lug, suitable for connection of the stranded copper conductor, shall be provided at each end of the ground bus.

S9.7 WIRING AND WIRING TROUGHS

Care shall be exercised in routing and clamping the switchboard wiring to prevent damage to the cotton-braid covering and thermoplastic insulation.

Circuits of different voltages shall not be run in the same wiring trough. Separable wiring troughs or ones with barriers shall be used for this purpose.

Connections for termination boards shall be readily removable for test purposes.

Secondary devices shall be adequately protected from possible faults on the power circuits.

S9.8 TESTS

Complete tests shall be made at the factory by the Contractor on the various components of the equipment, in accordance with the IEC (or) EN (or) ANSI standards, to determine the performance and operating characteristics, and to determine whether or not the guarantees have been met. The following tests shall be included for each of the components as outlined below.

Qualification and factory tests on voltage transformers shall be in accordance with IEC Standards.

The factory tests shall be made on each instrument transformers including type test and routine test reports shall be submitted to DEDE for approval before delivery.

SECTION 10 - DC STATION SERVICES

S10.1 SCOPE OF WORK

The work to be done under this section consists of the design, manufacture, testing, delivery to site, installation placing in successful service and guarantee of: -

- 1 (one) battery charger with dc distribution circuit breakers
- 1 (one) set of battery cells with rack

S10.2 PURPOSE AND FUNCTION

The DC station service system, comprising of battery, battery charger dc distribution circuit breakers shall be used for instruments and component power supply for Generator Control Panel and ELC controller, protection system, metering and alarm annunciator system, emergency lighting and other essential dc loads for power box and the generating unit.

S10.3 BATTERY

The batteries shall be Maintenance-Free Sealed Lead Acid Battery, Gel type tubular indoor type in shock-absorbing complete with intercell connectors and standard accessories.

- Battery Type : Maintenance-Free Sealed Lead Acid Battery.
- Self Discharge : Shelf Life Up to 2 Years at 20 °C without Recharge Due to the Very Low Self Discharge Rate.
- Container Material : Polypropylene (PP)
- Plate : Grid Plate Construction Consisting of Lead Calcium Alloy, Optimized for High Corrosion Resistance.
- Separator : Microporous and Robust for Electrical Separation of The Positive and Negative Plate and Optimized for Low Internal Resistance.
- Pole: Stuck or Screw Connection for Easy and Safe Assembly And Maintenance - Free Connection With Excellent Conductivity.
- Electrolyte : Gel Type
- Relief Valve : Release Gas in Case of Excess Pressure and Protects The Cell against Atmosphere
- Design life : Not Less Than 12 Years at 20 °C
- Mounting : Vertical Installation
- Standard : IEC, JIS, DIN

Battery shall be designed and supply battery cells with enough capacity to perform the sequence of operation for start and shutdown of the generating unit as minimum: -

- To operate inlet valve opening
- To operate hydraulic pressure unit to open guide vane
- Closing breaker and tripping functions
- Emergency lamp for 5 hours
- Indicating lamps, annunciation at control panels
- Continuous dc supply for ELC board or PLC, protection relays, meters, etc.

The battery shall be supplied complete with covered copper intercell, and connector ratings shall suit the maximum discharge current of the battery.

The Contractor shall submit the type and capacity of battery for approval.

S10.4 BATTERY CHARGER

The battery charger shall be fully automatic, rectifier-controlled design for automatic float and boost charging of batteries, to be enclosed inside a metal cabinet suitable for floor mounting. The charger is to supply DC at constant voltage for the average dc powerhouse load and for maintaining the battery output voltage, connected in parallel with the loads required, in a fully charged floating state. The ac supply source will be single-phase, 230V nominal rating, 50 Hz.

Voltage regulation shall be ±5 percent, with ac supply voltage variation of 10 percent and frequency variation of 5 percent from 0 to full load of the charger.

The nominal output of the charger shall be depending on the dc voltage required by control system and the instruments used.

The charger panel shall be of the static type, with no moving parts. It should be equipped with an automatic float-equalizer, timer and with protection against sudden line voltage variations. Protection shall also be provided against damage due to overload.

The charger shall be connected with PLC Controller by using ethernet (or) RS485 cable to send the real time status of information about the battery, charger, and load information.

The charger shall have manual switching to the high-rate charge mode. Switching from high rate to float charge mode shall be automatic.

Each of the annunciator circuits shall be wired to terminal blocks for connection to a remotely located annunciator. Alarms at the charger are according to manufacturer standards.

The charger shall automatically return to service on restoration of ac supply after an interruption. Indicating lamps equipment status indications shall be provided.

The battery charger and auxiliary equipment shall be contained in a single, general purpose, ventilated enclosure, suitable for floor mounting indoors. The enclosure shall be fabricated from sheet steel panels. It shall be rigid, self-supporting, and free from magnetic vibration, twist, and weave. All panels used in the construction of the enclosure, including partitions and doors, shall be adequately supported, and stiffened where necessary to prevent flexing.

Components shall be arranged within the enclosure, with access via a hinged front door, for convenient inspection and maintenance and for making external connections.

Meters, indicating lamps and other externally accessible devices shall be located for convenient viewing or operation.

A copper clamp type connector having a conductor range of 25 mm^2 shall be bolted to the enclosure for connection to the station ground system.

The enclosure shall have a nameplate giving charger input and output ratings and other pertinent information.

Identification tapes, Dymo embossing type, 13 mm wide or equivalent, shall be used for identifying fuses.

S10.5 DISTRIBUTION PANEL BOARD

The distribution panel board shall be suitable for floor mounting and shall have sufficient capacity for containing a main circuit breaker and branch circuit breakers. The panel board shall have a voltage rating of 250V dc and a short circuit capacity of 10,000ADC. Its current-carrying capacity shall be sized for the maximum discharge capacity of the battery selected. The main breaker shall be a molded case type, 2-pole having voltage rating of 250V dc and an interrupting capacity of 10,000A DC. This breaker shall have a thermal magnetic trip unit.

The panel board shall have minimum 6 branch circuit breakers, molded case type, 2-pole, each with a thermal magnetic trip unit. Each breaker shall have a voltage rating of 250V DC, an interrupting capacity of 10,000A DC and a frame size of 100A DC.

The breaker trip ratings are provisional. The Contractor shall determine final ratings according to design requirements.

The main and branch breaker auxiliary switches shall be wired to separate terminal blocks. The normally closed auxiliary contacts of the branch breakers shall be connected in parallel and wired to 1 pair of terminal blocks. The contacts of each spare breaker shall be wired to 1 set of terminals.

S10.6 CABLE INTERCONNECTION

The Contractor shall supply properly sized cables between the battery, the instrument panel, and the battery charger. The Contractor shall also supply and coordinate cable size between the battery circuit breaker and the distribution panel.

S10.7 TESTS

Complete tests on the equipment shall be done at the factory by the Contractor to determine the performance and operating characteristics and to confirm that the equipment functions properly. Details of the tests to be performed on the various components of the equipment shall be submitted, and the following tests shall be done as follows: -

Battery Charger

- Mechanical operation of the components to ensure that all parts operate properly.
- Standard insulation withstands tests on all circuit breakers, relays, switches, and other devices and on all wiring at 1,500V to ground, 50Hz for 1 minute.
- Continuity and polarity test on all circuits.
- Functional and operational checks of all equipment and all control, metering, and protection circuits.
- Load simulation under various input voltages.

Distribution Panel board

- Mechanical operation of all circuit breakers to ensure that they operate properly.
- Standard insulation withstands tests on all circuit breakers and on all wiring at 1,500V to ground, 50Hz for 1 minute.

SECTION 11 - CONTROL, PROTECTION AND ALARM SYSTEM

S11.1 GENERAL

(1) Responsibilities

a) The Contractor shall design, supply, procure, delivery to site, installation, testing and commissioning the control, protection and alarm system for the turbine, generator, governor, AC switchboards, and DC service including all interfaces and associated equipment.

b) For Protection, Metering, and Alarm System, the Contractor shall provide overall electrical single line diagram complete with ANSI protection relay numbers, ratings of all transformers, digital meters, excitation system, AC/DC Station Service System, standby diesel generator according to ANSI, IEC and IEEE standard codes and the description details.

c) Equipment and Components, which are to be used in Automation Control System, shall be submitted with the manufacturer's product catalog such as ELC modules with protection functions, and meters.

d) The system must be according to PEA's regulation and standard

(2) Requirements for Systems

a) Each system shall be designed to have high reliability and availability and however it shall be simple to operate and monitor by DEDE operator. The failure of any equipment or the loss of power supply to equipment shall not jeopardize the plant and shall initiate an alarm at annunciator Windows.

b) The control system shall comprise the Electronic Load Controller (ELC) (or) Programmable logic controller (PLC) to work with digital automatic voltage regulator (AVR), having the protective functions and synchronizing system.

c) The operation for Generating Sets shall be by both automatic and manual mode for load control, power factor control and frequency control mode. It can be selectable front panel. In the automatic mode, the Unit shall operate until the rated speed and excite automatically at the rated generator voltage. The demand and extra loads shall be adjustable together with ballast load air heater continuously.

d) The contractor shall be provided disconnecting switch 400V, 300 A , 25 kA (min.) and interlock transfer switch 400 V, 600 A, 25 kA (min.)

The Contractor shall submit ELC or PLC manufacturer's catalog complying with the Specifications specified under this section.

e) The scope of supply for the control system of this generating unit shall include

- Generator Control Panel (1 set) 3P, 400Vac, 50Hz with generator protection relay, circuit breakers, contactors, indicating lamps, annunciators unit, emergency push button switches, current and voltage transformer, lightning arresters, surge protection fuses, digital power multimeter (accuracy 0.5) including ELC control board inside the panel.
- Ballard Load Heater 3P, 400V, 50Hz (tubular air heater, industrial standard) with support frame and anchor to install inside power box nearby generator control panel.