



Department of Alternative
Energy Development and Efficiency
MINISTRY OF ENERGY

KLONG LAM PLOK HYDROPOWER PROJECT

YAN TA KHAO DISTRICT TRANG PROVINCE

CONTRACT C2

ELECTRO-MECHANICAL EQUIPMENT

VOLUME 2

TECHNICAL SPECIFICATIONS



P AND C MANAGEMENT CO., LTD.

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KLONG LAM PLOK HYDROPOWER PROJECT

CONTRACT C2

**SUPPLY AND INSTALLATION OF
ELECTRO-MECHANICAL POWER PLANT EQUIPMENT**

VOLUME 2 : TECHNICAL SPECIFICATIONS

CONTENTS

	PAGE
SECTION 1 GENERAL	1-1
SECTION 2 TURBINES AND GOVERNORS	2-1
SECTION 3 INLET VALVES	3-1
SECTION 4 TESTS FOR TURBINE, GOVERNOR INLET VALVE AND AUXILIARIES, TURBINE MODEL TEST, TURBINE FIELD EFFICIENCY TEST	4-1
SECTION 5 MECHANICAL AUXILIARY EQUIPMENT	5-1
SECTION 6 TESTS FOR MECHANICAL AUXILIARY EQUIPMENT	6-1
SECTION 7 GENERATORS AND AUXILIARIES	7-1
SECTION 8 AC STATION SERVICE TRANSFORMER AND AC SWITCH BOARD	8-1
SECTION 9 TRANSFORMER TERMINAL CUBICLES, GENERATOR TERMINAL CUBICLES, BUS DUCTS AND NEUTRAL CUBICLES	9-1
SECTION 10 DC STATION SERVICES	10-1
SECTION 11 CONTROL, PROTECTION AND ALARM SYSTEM	11-1
SECTION 12 MAIN TRANSFORMER	12-1
SECTION 13 LINE PROTECTION EQUIPMENT AND SWITCHYARD	13-1
SECTION 14 COMMUNICATION SYSTEM	14-1
SECTION 15 GROUNDING SYSTEM	15-1
SECTION 16 ELECTRICAL AUXILIARY EQUIPMENT	16-1

Dr.

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VOLUME 2 : TECHNICAL SPECIFICATIONS

CONTENTS

	PAGE
SECTION 1 - GENERAL	
S1.01 GENERAL	1-1
S1.02 SERVICE CONDITIONS	1-1
S1.03 REGULATIONS AND STANDARDS	1-1
S1.04 UNITS OF MEASUREMENTS	1-3
S1.05 MAINTENANCE TOOLS AND INSTRUMENTS	1-4
S1.06 SPARE PARTS	1-5
S1.07 ERECTION, OPERATION AND MAINTENANCE INSTRUCTIONS	1-6
S1.08 DRAWING	1-12
S1.09 PACKING	1-13
S1.10 PHOTOGRAPHS	1-14
S1.11 LABELS	1-14
S1.12 PAINTING	1-15
S1.13 LOCKING FACILITIES	1-18
S1.14 TROPICALIZATION	1-19
S1.15 MISCELLANEOUS METALWORK	1-20
S1.16 EMBEDMENT, FOUNDATIONS AND PLINTHS	1-20
S1.17 POSITION OF INSTRUMENTS, CONTROLS AND HANDWHEELS	1-21
S1.18 FABRICATION AND WELDING	1-21
S1.19 PIPING, VALVES AND THREADED FASTENERS	1-24
S1.20 CASTING AND PATTERNS	1-28
S1.21 LUBRICATION	1-28
S1.22 SELF-LUBRICATING BUSHES	1-29
S1.23 TEST, GENERAL REQUIREMENTS	1-29
S1.24 ELECTRICAL EQUIPMENT	1-32
S1.25 OPERATOR TRAINING	1-38
SECTION 2 - TURBINES AND GOVERNORS	
S2.01 SCOPE OF WORK	2-1
S2.02 TURBINE	2-1
S2.03 GOVERNOR	2-6

PD

CONTENTS (Cont'd)

	PAGE
 SECTION 3 - INLET VALVES	
S3.01 TYPE AND CONSTRUCTION	3-1
S3.02 OPERATION	3-1
S3.03 CONTROL AND INDICATION	3-2
S3.04 BY-PASS VALVE	3-2
S3.05 DISMANTLING JOINT AND CLOSING PIECE	3-3
S3.06 PRESSURE CONDUIT AND TURBINE DRAIN SYSTEMS	3-3
 SECTION 4 - TESTS FOR TURBINE, GOVERNOR INLET VALVE AND AUXILIARIES, TURBINE MODEL TEST, TURBINE FIELD EFFICIENCY TEST	
S4.01 TESTS FOR TURBINE, GOVERNOR, INLET VALVE AND AUXILIARIES	4-1
S4.02 TURBINE FIELD EFFICIENCY TEST	4-3
 SECTION 5 - MECHANICAL AUXILIARY EQUIPMENT	
S5.01 UNIT COOLING WATER SYSTEM	5-1
S5.02 COMPRESSED AIR SYSTEM	5-2
S5.03 VENTILATION AND AIR-CONDITIONING SYSTEMS (BY CIVIL CONTRACTOR)	5-4
S5.04 POWERHOUSE WATER DRAINAGE SYSTEM	5-4
S5.05 PORTABLE FIRE EXTINGUISHERS	5-5
S5.06 OVERHEAD TRAVELING CRANE	5-6
S5.07 DIESEL-DRIVEN STANDBY ELECTRIC POWER SYSTEM	5-9
 SECTION 6 - TESTS FOR MECHANICAL AUXILIARY EQUIPMENT	
S6.01 TESTS DURING MANUFACTURE	6-1
S6.02 TESTS AT SITE	6-1
S6.03 TESTS DURING MANUFACTURE FOR POWERHOUSE CRANE	6-3
S6.04 TESTS AT SITE FOR POWERHOUSE CRANE	6-3
 SECTION 7 - GENERATORS AND AUXILIARIES	
S7.01 GENERATORS	7-1
S7.02 SHAFT AND BEARINGS	7-7
S7.03 SIGNAL GENERATOR	7-10
S7.04 EXCITATION SYSTEM	7-10
S7.05 INSPECTION AND TESTS	7-12

Dr.

CONTENTS (Cont'd)

	PAGE
SECTION 8 - AC STATION SERVICE TRANSFORMER AND AC SWITCH BOARD	
S8.01 SCOPE OF WORK	8-1
S8.02 PURPOSE AND FUNCTION	8-1
S8.03 STATION SERVICE TRANSFORMER	8-1
S8.04 HIGH VOLTAGE LOAD INTERRUPTING SWITCH (Not applicable)	8-3
S8.05 AUTOMATIC TRANSFER	8-3
S8.06 NO-FUSE BREAKER	8-4
S8.07 SECONDARY WIRING AND TERMINALS	8-4
S8.08 CONTROL SWITCHES AND INDICATION	8-5
S8.09 INTERLOCKING	8-5
S8.10 CURRENT TRANSFORMERS	8-6
S8.11 VOLTAGE TRANSFORMERS (If require)	8-6
S8.12 INSTRUMENT SECTIONS	8-7
S8.13 GROUNDING	8-8
S8.14 NAMEPLATES	8-8
S8.15 CHANNEL BASES AND BOLTS	8-9
S8.16 TESTS	8-9
SECTION 9 - TRANSFORMER TERMINAL CUBICLES, GENERATOR TERMINAL CUBICLES, BUS DUCTS AND NEUTRAL CUBICLES	
S9.01 SCOPE OF WORK	9-1
S9.02 PURPOSE AND FUNCTION	9-1
S9.03 STANDARDS	9-1
S9.04 GENERATOR CIRCUIT BREAKER CUBICLES AND BUS DUCTS RATINGS	9-2
S9.05 EQUIPMENT DETAILS	9-2
S9.06 DESIGN AND CONSTRUCTION OF GENERATOR TERMINAL CUBICLES	9-5
S9.07 DESIGN AND CONSTRUCTION OF GENERATOR NEUTRAL CUBICLES	9-7
S9.08 WIRING AND WIRING TROUGHS	9-8
S9.09 TESTS	9-8
SECTION 10 - DC STATION SERVICE	
S10.01 SCOPE OF WORK	10-1
S10.02 PURPOSE AND FUNCTION	10-1
S10.03 BATTERY	10-1
S10.04 BATTERY RACKS	10-2
S10.05 INSTRUMENTS ON DC DISTRIBUTION BOARD	10-2
S10.06 BATTERY CHARGER	10-2
S10.07 DISTRIBUTION PANEL BOARD	10-4
S10.08 CABLE INTERCONNECTION	10-4
S10.09 TESTS	10-4

Dr.

CONTENTS (Cont'd)

	PAGE
SECTION 11 - CONTROL, PROTECTION AND ALARM SYSTEM	
S11.01 GENERAL	11-1
S11.02 CONTROL SYSTEM REQUIREMENTS	11-10
S11.03 PROTECTION DESIGN REQUIREMENTS	11-12
S11.04 GROUP OPERATION INDICATOR	11-16
S11.05 FAULT INDICATOR AND AUDIBLE ALARM SYSTEM	11-16
S11.06 CONTROL AND PROTECTION CUBICLES	11-16
S11.07 TESTS	11-23
SECTION 12 – MAIN TRANSFORMER	
S12.01 SCOPE OF WORK	12-1
S12.02 PURPOSE AND FUNCTION	12-1
S12.03 STANDARDS	12-1
S12.04 TYPE OF TRANSFORMER	12-1
S12.05 MEGAVOLT AMPERE RATING	12-1
S12.06 VOLTAGE RATINGS, CONNECTIONS AND TAPS	12-1
S12.07 INSULATION LEVELS	12-2
S12.08 IMPEDANCE AND LOSSES	12-2
S12.09 SHORT CIRCUIT CAPABILITY	12-2
S12.10 SOUND LEVEL	12-2
S12.11 HIGH FREQUENCY INTERFERENCE	12-2
S12.12 BUSHINGS AND CONNECTORS	12-2
S12.13 OFF-LOAD TAP CHANGER	12-3
S12.14 CONSTRUCTION	12-3
S12.15 BASE	12-5
S12.16 TRANSFORMER TANK OR CORRUGATED TANK	12-5
S12.17 CONSERVATOR TANK (If applicable)	12-5
S12.18 RADIATORS OR CORRUGATED TANK	12-5
S12.19 CONTROL	12-6
S12.20 OIL	12-6
S12.21 ACCESSORIES	12-6
S12.22 TESTS	12-7
SECTION 13 – LINE PROTECTION EQUIPMENT AND SWITCHYARD	
S13.01 SCOPE OF WORK	13-1
S13.02 PURPOSE AND FUNCTION	13-1
S13.03 DESIGN RATINGS AND STANDARDS	13-1
S13.04 EQUIPMENTS	13-2
S13.05 DETAILED REQUIREMENTS	13-2
S13.06 DEDICATED PROTECTION	13-6
S13.07 LINE PROTECTION	13-6

CONTENTS (Cont'd)

	PAGE
SECTION 14 - COMMUNICATION SYSTEM	
S14.01 SCOPE OF WORK	14-1
S14.02 PURPOSE, TECHNICAL SPECIFICATIONS, AND PERFORMANCE DATA REQUIREMENTS	14-1
S14.03 SCADA SYSTEM	14-2
SECTION 15 - GROUNDING SYSTEM	
S15.01 SCOPE OF WORK	15-1
S15.02 GROUNDING WORKS	15-1
SECTION 16 - ELECTRICAL AUXILIARY EQUIPMENT	
S16.01 SCOPE OF WORK	16-1
S16.02 WORK INCLUDED	16-1
S16.03 CODES AND STANDARD	16-1
S16.04 CABLE TRAYS AND SUPPORTS	16-1
S16.05 CONDUIT, BOXES AND FITTINGS	16-2
S16.06 750 V WIRE AND CABLE	16-4
S16.07 CONTROL CABLES	16-4
S16.08 STATION CLOCKS	16-5
S16.09 MOTOR CONTROL CENTER	16-6
S16.10 FOREBAY WATER LEVEL TRANSMITTER	16-9
S16.11 TELEPHONE SYSTEM (Not Applicable)	16-9
S16.12 TESTS	16-10
S16.13 HV CABLE END TREATING MATERIAL	16-11

Pi

SECTION 1

GENERAL

SECTION 1 - GENERAL

S1.01 GENERAL

- (1) These General Specifications apply to all equipment, materials, devices & components, including pre-engineering or bought-out items, procedures, methods, techniques, and workmanship contained in the other Technical Specifications whether referred to specifically or not.
- (2) Where the other Technical Specifications conflict with these General Specifications, the Technical Specifications shall prevail.
- (3) 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 as specified in this section, or internationally recognized equivalent. The Contractor shall make available to the Engineer details of the quality control program at the Contractor, and Manufacturer's plants which are applicable to the Works before manufacturing begins
- (4) The Engineer will be the sole judge of material and workmanship, among all things, furnished and supplied by the Contractor. No patching, plugging, shimming or other such means to overcome defects, discrepancies or errors shall be employed without the written agreement of the Engineer. Failure to comply with this requirement shall constitute grounds for rejection of the item in question.
- (5) Material and equipment not covered by these Specifications shall be subject to acceptance by the Department.

S1.02 SERVICE CONDITIONS

All the equipment shall be designed and manufactured for its particular location for continuous operation at the extremes of climate as listed in Clause 7.02 of Volume 1. 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 ceiling and the roofs shall be designed for satisfactory operation at an ambient temperature of 60° C.

S1.03 REGULATIONS AND STANDARDS

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.



All materials and equipment to be incorporated in the Works and the fabrication of same except as otherwise provided shall conform to the latest edition of the Standards of the Engineering Societies given in the following list:

ANSI	American National Standards Institute
AGMA	American Gear Manufacturers Association
AISI	American Iron and Steel Institute
ASHRAE	American Society of Heating, Refrigeration and Air-Conditioning Engineers
IEEE	Institute of Electrical Electronic Engineers
ASME	American Society of Mechanical Engineer
ASTM	American Society for Testing and Materials
NEMA	National Electrical Manufacturers Association
ICEA	Insulated Cable Engineer's Association
AWS	American Welding Society
IEC	International Electrotechnical Commission
SSPC	Steel Structures Painting Council
NEC	National Electrical Code
AISC	American Institute of Steel Construction
NFPA	National Fire Protection Association
AWWA	American Water Works Association
ISA	Instrument Society of America
ISO	International Organization for Standardization
AFBMA	Anti-Friction Bearing Manufacturers Association
CMAA	Crane Manufacturer's Association of America
DEMA	Diesel Engine Manufacturers Association
TIS	Thai Industrial Standard

The latest edition of each standard shall mean the available edition at the date of signature of the Contract.

Other equivalent standards will be accepted provided that they are proposed with the Bid and accepted before the award of the Contract.

The Contractor shall submit two copies (one to the Department and to the Engineer) of the equivalent accepted standards in English or with English translation, showing the correspondence with the specified Standards.

If the Contractor, after the award of the Contract, proposes other equivalent Standards and Specifications and Standards of equivalent material, the Contractor shall state the exact nature of the change, and shall submit complete Standards and Specifications and information and data on the materials for the approval of the Engineer.

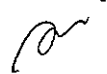
Such submittals shall be timely and failure to do so, or purchase of any proposed equivalent materials prior to the approval of the Engineer, will be at the Contractor's risk.



S1.04 UNITS OF MEASUREMENTS

Units of measurements shall be in the metric and Celsius systems, using the following abbreviations.

<u>Quantity</u>	<u>Unit</u>	<u>Symbol</u>	<u>Remarks</u>
Length	Metre	m	
Time	second	s	
	hour	h	
	day	d	
	minute	min	
Volume	litre	L	
Temperature	degree	°C	
	Celsius		
Force (weight)	Gram	g	
	kilogram	kg	
	tonne	t	kg x 10 ³
Pressure	kilogram per square centimeter	kg / cm ²	
Material Strength	Kilogram per square centimetre	f (y)	minimum yield point
		f (u)	minimum ultimate strength
Power	Watt	W	
Frequency	hertz.	Hz	
Electric potential	Volt	V	
Electric resistance	Ohm	Ω	
Electric Current	ampere	A	



The following is a list of prefixes used in conjunction with the basic units.

<u>Multiplying Factor</u>	<u>Prefix</u>	<u>Symbol</u>
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ

S1.05 MAINTENANCE TOOLS AND INSTRUMENTS

- (1) The Contractor shall supply all maintenance tools and instruments required or likely to be required for the proper maintenance of the Plant during its service life. The maintenance tools and instruments shall be sufficient to enable full dismantling and reassemble of the Plant, testing for wear or distortion of all wearing parts, diagnosing and locating faults in electronic equipment and replacement of all spare parts ordered.
- (2) The maintenance tools and instruments shall include but not be confined to:
 - (a) portable ladders and platforms to permit maintenance service;
 - (b) one (1) set of special tools and appliances to enable all maintenance tasks to be performed;
 - (c) one (1) grease gun (if grease lubrication is required) for each type of grease used in the plant with attachments to suit each size of grease nipple;
 - (d) one (1) complete set of hand tools and appliances sufficient for all maintenance tasks associated with the plant. The set shall include, but not be confined to:
 - (i) spanners to fit every size of nut and bolt used in the plant, screwdrivers, scrapers, files, hammers, pliers, wrenches, wiring tools, etc., as appropriate;
 - (ii) gauges, levels and other measuring instruments for checking clearances and dimensions;
 - (iii) insulation testers 500 V and 1,000 V 1 set (electronic type);
 - (iv) multi-meter, digital type 1 set
 - (v) clip-amp for AC current measurement 0-1000 A, 50 Hz digital type 1 set
 - (vi) Tachometer, digital type, 0-2,000 rpm, 1 set
 - (vii) Phase rotation tester, 1 set
 - (viii) Vibration measuring device (Digital type), 1 set
 - (ix) any tools necessary for changing lamps for instruments of control panels;

- (e) One (1) set of AC-DC arc welder, 300A, AC 1Ø, 230 V, 50 Hz with power improvement capacitor and cable (50 m.), holder and earth clamp.
 - (f) One (1) of complete set Oxy-Acetylene Welder.
 - (g) One (1) set of disc grinder 100 mmØ, AC 1Ø, 230 V, 50 Hz.
 - (h) One (1) set of portable electric drill, Quick lock 20 mmØ, AC 1Ø, 230V, 50 Hz.
 - (i) One (1) set of electric hammer drill, Quick lock 19 mmØ, AC 1Ø, 230 V, 50 Hz.
 - (j) One (1) set of vacuum cleaner, Dust-liquid, industrial heavy duty type, AC 1Ø, 230 V, 50 Hz., 3.6 kW., 80 L, air flow 9,600 l/min
 - (k) One (1) set of air compressor, 7 kgf/cm², 200 liter/min, AC 1Ø, 230 V, 50 Hz. with wheels.
- (3) The individual tools and appliances shall be listed in price schedule. The prices of the tools and appliances shall be included in the Contract Price.
- (4) Any additional maintenance tools and appliances which are required for the proper maintenance of the Plant as defined in this Clause and which are not listed in Price Schedule, shall be included in the Contract Price.
- (5) The Contractor may use the mechanical handling equipment for initial erection of the Plant but shall make good any wear or damage before handing over.
- (6) (a) Maintenance equipment shall be suitably arranged in metal tool boxes of cabinets each fitted with a padlock and 2 keys. Each tool box or cabinet shall be clearly and permanently marked with the name of the plant to which the maintenance tools and instruments applies and with a list of the equipment it contains.
- (b) Large tools shall be mounted on a suitable shadow board arranged for wall mounting.

S1.06 SPARE PARTS

- (1) All spare parts recommended for the Plant by the Contractor shall be listed in Price Schedule with their individual prices. The spare parts offered shall include all parts subject to normal wear and tear and also such major sub-assemblies as may be subject to accidental damage.



- (2) The Department may order all or any of the spare parts at his discretion. The Contractor shall supply the specified and recommended spare parts at the individual prices stated in the price schedule provided that the selection is made by the Department.
- (3) All spare parts ordered shall be interchangeable and suitable for use in place of corresponding parts supplied with the Plant. They shall comply with the Contract and shall be clearly and permanently marked with their descriptions and identification members both on the parts and on the outside of the packages and prepared for permanent storage in an approved manner to prevent deterioration.
- (4) The Contractor shall provide a schedule of spare parts, which shall list for each spare part its identification number, description and quantity with a space for the Department to add his own identification number.

S1.07 ERECTION, OPERATION AND MAINTENANCE INSTRUCTIONS

(1) Scope

- (a) The Contractor shall provide erection, operation and maintenance instructions, the scope of which shall be suitable for fully informing the Department's staff on all aspects of the erection, operation and maintenance of the Plant.

The Contractor shall, in preparing the instruction, take into account the possible lack of experience and lack of familiarity of the operation and maintenance staff with the type of equipment supplied. He shall present the information as simply, clearly and precisely as possible.

The instructions shall be provided in draft and final forms. If the need to modify the final instructions arises, the Contractor shall provide the necessary modified content as soon as possible after the need for modification arises.

- (b) The content of the instructions shall be directly applicable to the plant. Typical instructions will not be accepted.
- (c) The Contractor shall require his site supervisor to comment from time to time on the draft instructions. He shall take account of these comments and comments by the Department and the Engineer when preparing the final instructions for approval.
- (d) All costs in connection with the provision of the instructions shall be deemed to be included in the Contract Price.



(2) Format and compilation - Content of Final Instructions

- (a) The instructions shall be reproduced in ink by letterpress or offset printing or in carbon by electrostatic printing. Reproductions obtained by using dyes, chemicals or photo-sensitive or heat-sensitive materials are not acceptable.
- (b) All text shall be on size A4 paper.
- (c) Diagrams and drawings provided as part of the instructions shall be size A3 wherever the original is size A3 or larger and size A4 for all others. Insertion of loose drawings into cover pockets is not acceptable
- (d) Text, drawings, diagrams and illustrations included in the instructions shall be easily readable by a person having normal eyesight.
- (e) Each copy of the final instructions shall be bound into loose-leaf volumes in strong, durable, washable, vinyl plastic covers inscribed with bold letters upon the front and spine. A sample of the proposed inscribed covers and binding shall be submitted to the Engineer with the draft instructions for approval.

(3) Program for Delivery of Instructions

- (a) The Contractor shall deliver the complete draft and the complete final instructions within the periods nominated in Clause 6.06 of Volume 1.
- (b) Failure to deliver the required number of copies of approved final instructions shall be sufficient reason for the Engineer to withhold the issuing of a Provisional Acceptance Certificate in accordance with the Conditions of Contract.

(4) Detailed Instruction Content

(a) General

- (i) Each volume shall have a table of contents for the volume and a list of the other volumes at the front.
- (ii) The instructions content for each plant feature, as defined in sub-clause (1) of this Clause and Table S1.06, shall include, but not necessarily be limited to, all the material required by this sub-clause.

(b) Section 1 - Contents Section

The feature name and list of sections as in sub-clause (1) (d) of this Clause.



(c) Section 2 - Introduction

(i) Subsection 2.1 - History

Brief description of the basic purpose of the plant feature. Also a brief definition of type of plant with main performance characteristics such as rating, head, speed, voltage.

(ii) Subsection 2.2 - Purpose and Nature

Brief statement of the organizations involved in the design, manufacture and erection of the Plant, and date when Plant entered commercial service.

(d) Section 3 - Description

A comprehensive description defining the generic type of plant and component, method of construction, materials of main components, design features, control and protection functions. relationship with other plant and including the description of auxiliaries specific to the plant feature.

(e) Section 4 - Operation

(i) Subsection 4.1 - Operating Sequences

Brief description of the operational functions of which the plant feature is capable and a reference to the instructions volumes covering operation in detail.

(ii) Subsection 4.2 - Operating Limits

Tabulated data on limits for all operating parameters and reason for limit.

(iii) Subsection 4.3 - Pre-start check List

Comprehensive tabulated list or sequence diagram of all conditions which must be checked before the Plant may be started after being out of service for overhaul or any reason. (This is not intended to cover checks required before each routine start up, i.e., when the plant has been stopped and is nominally ready to re-start on demand).

(iv) Subsection 4.4 - In-service Check List

Comprehensive tabulated list of all observations to be made during periodic inspections and tests, defining the location, range of acceptable values and action to be taken if incorrect values are found.

(f) Section 5 - Maintenance

(i) Periodic service and maintenance procedures including maintenance schedules defining:

- component and condition to be checked
- required frequency of checking
- equipment and stock required



- required plant condition for service or maintenance including instructions for isolating the whole or any section of the plant so that maintenance or repairs can be done in complete safety
 - dismantling sequence and methods
 - inspection of components, detailed checks for condition and criteria for acceptance, rejection or reconditioning
 - reconditioning, replacement and adjustment procedures
 - re - assembly sequence and methods.
- (ii) Fault diagnosis based on symptoms of malfunctions and wear.
- (iii) Recommissioning procedures after major overhaul.
- (iv) Lubrication requirements incorporating lubricants recommended in Clause S1.21 including a comprehensive lubrication chart, instructions on filter maintenance, and instructions on testing and maintenance of lubricating oil.
- (v) Testing and maintenance requirements for electrical insulating oils.
- (vi) Ordering data shall be provided in sufficient detail to allow any part of sub-assembly to be re-ordered and/or a satisfactory substitute to be made on site. Nameplate information including model and serial number is required for each item of equipment supplied.

(g) Section 6 - Drawings

- (i) Index of drawings contained in Section 6 of the Instructions.
- (ii) One copy of drawing referred to in the text or necessary for clear understanding and use of the text, including all assembly, layout and arrangement drawings.

(h) Section 7 - Brochure for Proprietary Equipment

Manufacturer's brochures, instruction pamphlets and the like, containing the operation and maintenance information as specified in paragraphs (e) and (f) of this sub-clause in respect of proprietary equipment.



TABLE S1.07

VOL NO. & TITLE	PLANT FEATURE REF. NO.	PLANT FEATURE
1. Plant Design Data and Test Results	All performance data and charts over the full range of operation shall be provided for each plant feature. Table shall list all design clearances, settings, adjustments, voltages, currents, pressures, levels and flows together with the actual values measured or observed during manufacture, delivery, erection or testing as appropriate. All tests carried out at works and at site shall be described and the complete test records and results shall be included.	
2. Plant Photo- graphs	This volume shall include the photographs and descriptions required by Clause S1.09 for each plant feature.	
3. Erection Instructions	Erection instructions for each plant feature.	
4. Turbine Governor Inlet Valve and Ancillaries	4.1 Turbine 4.2 Governor 4.3 Turbine Inlet Valve 4.4 Turbine Control and Protection 4.5 Auxiliary Equipment	
5. Mechanical Auxiliary Equipment	5.1 Unit Cooling Water System 5.2 Compressed Air System 5.3 Ventilation and Air-Conditioning Systems 5.4 Water Drainage System 5.5 Powerhouse Crane 5.6 Diesel-driven Standby Electric Power System	
6. Generator and Auxiliaries	6.1 Generator 6.2 Shaft and Bearing 6.3 Signal Generator 6.4 Excitation System	
7. AC Station Service Trans- former and Switchboard	7.1 Oil – immersed, natural self-cooled, outdoor Station Service Transformer 7.2 High Voltage Fused Load Interrupter Switches	

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TABLE S1.07 (Cont'd)

VOL NO. & TITLE	PLANT FEATURE REF. NO.	PLANT FEATURE
8. Generator Terminal Cubicles, Bus Ducts and Neutral Cubicles	8.1 Generator PT, CT Cubicles 8.2 Generator Circuit Breaker Cubicles 8.3 Neutral Cubicles	
9. DC Station Service	9.1 125 V. Battery with Racks and Fuses 9.2 Instrument and Circuit Breaker Panel 9.3 Battery Charger 9.4 DC Distribution Panel Board	
10. Control, Protection and Alarm System	10.1 Main Control Board 10.2 Auxiliary Relay Board	
11. Main Transformer	See detail in section 12	
12. Line Protection Equipment 24 kV Switch- gear and Switchyard	12.1 24 kV. Switchgear Recloser 12.2 Switchyard	
13. Electrical Auxiliary Equipment	13.1 Cable Trays and Supports 13.2 Conduit, Boxes and Fittings 13.3 HV Cable 13.4 750 V Wire and Cable 13.5 Control Cable 13.6 Station Clocks 13.7 Motor Control Center 13.8 Single Side Band Transceiver and Antenna, VHF Communication system. 13.9 HV Cable End Treating Material	



S1.08 DRAWING

(1) General

All drawings produced by the Contractor or his sub-contractor for this Contract shall comply with the requirements of this Clause.

(2) Drawing Sizes and Standards

All drawings shall be drawn on the International Standards Organization (ISO) 'A' series of drawing sheets standardizing where possible on the A3 size. Information and details shall be written in English.

(3) Title Blocks

The Contractor or his subcontractors' title block shall show his name, the date, the title and number of the drawing and each new issue of the drawing shall be identified by a revision letter as part of the drawing number. A detailed description of the revision shall appear on the drawing. In addition each drawing shall show the following details in the lower right hand corner.

(4) Key-drawing List

The Contractor shall maintain a list of all drawings prepared for the Project and this list shall show, for each drawing which has been sent to the Engineer. The Contractor shall provide three copies of this list to the Engineer at three-monthly intervals.

(5) Quality

(a) Drawings for approval by the Engineer shall be supplied as prints in quadruplicate and shall be of suitable quality to permit reproduction. As-built drawings presented by the Contractor in accordance with Clause 4.06 of Volume 1 shall be the Contractor's original drawings in non-fading ink on durable plastic base film without any folds. Transparencies reproduced from the original will not be accepted as as-built drawings.

(b) As-built drawings shall be of quality suitable for the reproduction of clear legible full size prints and transparencies .

(6) Drawings on Site

Copies of the latest revisions of all drawings shall be sent to the Contractor site office as soon as possible after they are approved. The drawing shall be available at all reasonable times for inspection by the Engineer.



(7) Position Reference

Drawings indicating the position of any item of equipment shall use the system of grid lines and levels established by the Engineer as the reference datum.

S1.09 PACKING

- (1) All Plant shall be effectively protected against damage and corrosion during transportation from the place of manufacture to the site and during storage.
- (2) Immediately upon arrival at Site, the Contractor shall arrange for all packages to be checked against the shipping list for loss and inspected for damage during transit.
- (3) The Department will not provide covered storage at the Site. The Contractor shall ensure that all packages are suitable for the storage conditions provided.
- (4) If machined surfaces show sign of damage on receipt of shipment, the corrosion protection shall be removed, the rust and moisture eliminated, the defects repaired by approved means and the protection re-applied.
- (5) Electrical insulation shall be protected against sweating and entry of dust during transportation and storage.
- (6) Flange faces and openings shall be covered by metal blanks and gaskets. Rubber parts shall be protected against light and air. An approved drying agent shall be included with all items enclosed in plastic or other impervious material.
- (7) All packing material, except that required for storage of spare parts, shall remain the property of the Contractor and shall be removed from the Site. Only parts for immediate use shall be delivered from the works storage area and their packing material shall be removed quickly from the installation site and disposed of to the satisfaction of the Engineer.
- (8) All packages shall be clearly and indelibly marked with the dimensions, weight, slinging and load bearing points. Any packages which are not symmetrically loaded shall be marked with the position of the center of gravity.
- (9) Each package shall contain a packing list in a waterproof envelope. Two copies of the packing list shall be sent to the Engineer prior to dispatch.
- (10) The Engineer shall reserve the right to inspect and approved the equipment and the packing before the items are dispatched. Such inspection will not relieve the Contractor from responsibility for any loss or damage occurring during transportation and storage.



S1.10 PHOTOGRAPHS

- (1) The Contractor shall keep photographic records of the work during manufacture, factory assembly, delivery, erection, commissioning and rectification and as required by the Engineer.
- (2) The Contractor shall supply photographs which will:
 - (a) assist in training people , who may have no experience, in the operation, routine maintenance, major maintenance and testing of the plant; and
 - (b) record information which it may not be possible to obtain at a later date; and
 - (c) record details of how work, which is not frequently required, is done.

This will supplement the detailed instructions provided in the operation and maintenance instructions and reduce the need to rely on memory.

- (3) A volume of photographs shall be included with the operation and maintenance instructions. They shall be adequately edited and provided with captions and descriptions to the satisfaction of the Engineer.
- (4) All costs in this connection shall be included in the Contract Price.

S1.11 LABELS

- (1) Labels
 - (a) The Contractor shall provide labels in sufficient numbers, size and detail to permit rapid and positive identification to be made of all pieces of equipment whether enclosed in cubicles or separately mounted.
 - (b) Labels used indoors shall be engraved on double sided, engraving grade plastic laminate with black letters not less than 3.0 mm. high on a white background. Labels (used outdoors) shall be of matt stainless steel , with the letters filled with a suitable wax (Gravograph or equal). Pipe labels shall use adhesive markers. Labels over 100 mm. long and all labels fixed outdoors shall be fastened by nickel-plated brass screws. Indoor plastic laminate labels of length less than 100 mm. shall be fastened by means of an approved contact adhesive. Labels for cubicles and equipment mounted within 2.0 m above floor level shall be positioned so that they can be read by a person of average height standing in front of the cubicles.
 - (c) Labels for devices mounted on or in enclosures shall be provided on the inside of the enclosure adjacent to the device as well as on the device. Device labels shall not be located on removable covers of the device.



- (d) Warning labels shall be provided on or in all electrical equipment where terminals at voltages of 220 V and above may be exposed during maintenance, indoor warning labels shall be of plastic laminate with white lettering on a red background. Outdoor warning labels shall be of vitreous enameled steel with white lettering on a red background.
- (e) The text of each device label shall include the device number and a clear description of the function. Fuses, miniature circuit-breakers and links shall be identified by their function, voltage, polarity, phase color and fuse link (or circuit-breaker) rating. The wording for labels shall be in the English language.

(2) Rating Plates

A rating plate complying with the requirements of the appropriate standard shall be provided on each item of plant. Where the rating plate is affixed to an item of plant of a mass in excess of 1 ton, it shall also specify the mass of the item.

(3) General

Failure to complete the supply and fixing of labels and rating plates shall be sufficient reason for the Engineer to withhold the issuing of a Provisional Acceptance Certificate in accordance with the Conditions of Contract.

S1.12 PAINTING

Synthetic resin paint shall be used for the finish paint of all exposed portions of all the Equipment, except for the portion embedded in concrete, machined mating surfaces and galvanized surfaces.

The primary coat shall be of the kind matching the finish paint mentioned and shall be of rust preventive nature.

The exposed portions of all Equipment except those embedded in concrete shall receive shop finishes as detailed in this section.

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 supplier for application on any coat.

The paint shall be applied using brush or spray techniques. When painting on any surface has commenced, the painting operation shall be completed as soon as practicable, without delays. The drying time between coats shall not be less than 12 hours.

The Contractor shall supply touchup paint to match all shop-painted items. This quantity shall be at least 15 percent of the paint used to the original shop painting, except for the control cubicles for which at least 30 percent of the original quantity of paint shall be supplied.



The color schedule for the Equipment will be decided by Munsell color notation and included in the Award of the Contract.

The painting system referred to in these Specifications shall be as follows.

PAINT SYSTEM 1

Surfaces in Contract with Water

(a) General

All surfaces shall be painted with an inorganic, epoxy zinc-rich primer and three coats of coal tar epoxy. Final shop painting shall not be applied within 100 mm of field welding. These areas will only receive one coat of inorganic, epoxy zinc - rich 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, epoxy zinc-rich primer and three coats of a compatible coal tar system.

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

(ii) Film Thickness

The dry film thickness of the primer shall be between 0.05 mm and 0.09 mm. The dry film thickness of each of the coal tar epoxy coats shall be between 0.15 mm. and 0.20 mm.

(d) Final Film Thickness

The final thickness of the three coats shall be at least 0.45 mm. 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. A sufficient number of measurements shall be made to establish the final thickness.

The entire painted surface shall be subject to electrical inspection by a holiday detector, furnished by the Contractor.



PAINT SYSTEM 2

Surfaces in Contact with oil

(a) Surface Preparation

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

(b) Paint Application

(i) Materials

The painting system shall consist of two coats of a high built epoxy paint suitable for this purpose.

(c) Final Film Thickness

A sufficient number of readings with a gauge supplied by the Contractor shall be taken to ensure a minimum dry film thickness of 0.30 mm. is attained.

PAINT SYSTEM 3

Electrical 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 comprise two coats of inorganic, zinc-chromate primer and two coats of epoxy enamel.

(ii) Film Thickness

The dry film thickness of the primer shall be not less than 0.80 mm. and the dry film thickness of the epoxy enamel shall be not less than 0.10 mm.

(c) Final 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 0.25 mm. is attained.



PAINT SYSTEM 4 (FOR INDOOR STEEL WORK)

Mechanical Equipment, Prefabricated Piping

(a) Surface Preparation

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

(b) Paint Application

(i) Materials

The painting system shall comprise one coat of inorganic epoxy zinc-rich primer and two finish coats of acrylic latex, glossy finish paint.

(c) Final Film Thickness

A sufficient number of readings with a gauge supplied by the Contractor shall be taken to ensure a minimum film total thickness of 0.30 mm. is attained.

METAL COATINGS

(a) Galvanizing shall be applied by the hot-dip process to ASTM A120, ASTM A123 and ASTM A153. Materials (such as welding slag, paint and grease) likely to resist attack by the pickling liquid shall be removed prior to pickling. The surface after galvanizing shall carry an unbroken covering of zinc uniform in appearance and in thickness. The thickness shall be 0.09 mm. (0.6 kg/m².)

(b) Electroplating shall be either nickel plus chromium plating, cadmium plating or zinc plating shall comply with the following:

(i) Nickel plus chromium plating shall be in accordance with ASTM B456. Nickel plating alone shall not be used.

(ii) Electroplating of zinc shall be in accordance with ASTM B633 and ASTM A164.

S1.13 LOCKING FACILITIES

- (1) Where locking facilities are required to prevent unauthorized access to or operation of equipment, the facility shall be suitable of application of a padlock with 10 mm. shackle diameter and 35 mm. shackle opening.
 - (2) Integral locking facilities, e.g., of the key-in handle type will not be accepted and if normally fitted in proprietary equipment shall be removed or otherwise rendered inoperative.
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S1.14 TROPICALIZATION

- (1) General : All materials and equipment supplied under these Specifications shall be suitable for being delivered, stored and operated under tropical conditions of high temperature, high humidity, heavy rainfall, mildew and fungus conducive environment.

Process for tropicalization shall be in accordance with the best commercial and industrial practices.

- (2) Metals : Iron and steel shall generally be painted or galvanized or metal-sprayed as appropriate. Indoor parts may alternatively have chromium or copper-nickel platings, or other suitable protective finish. When it is necessary to use dissimilar metals in contacts, these shall be so selected that the potential difference between them in the electrochemical series is not such as to cause galvanic corrosion. If this is not possible, the contact surface of one both of the metals shall be electro-plated or otherwise finished in such a manner that the potential difference is reduced within the required limits or, alternatively, the two metals shall be insulated from each other by a suitable insulating material or a coating of varnish compound.
- (3) Bolts, Screws, Nuts, Washers: Steel bolts, screws, nuts and washers when used, shall be zinc, cadmium or chromium plated or, where plating is not possible due to tolerance limitations, of corrosion-resisting steel. All wood screws shall be dull nickel-plated brass or of other suitable finish. Corrosion-resisting steel, copper-nickel alloy or bronze, shall also be used for bolts and nuts when either or both are subject to frequent adjustment or removal, or are in contact with water and for bolts projecting from concrete with nuts to removal or vice versa.
- (4) Fabrics, Cork, Paper, etc.: Fabrics, cork paper and similar materials, which are not subsequently protected by impregnation, shall be adequately treated with suitable fungicide. Sleeve and fabrics treated with linseed oil varnishes shall not be used.
- (5) Adhesives: Adhesives shall be especially selected to ensure the use of types which are impervious to moisture, resistant to mold growth and not subject to the ravages of insects. Synthetic resin cement only shall be used for joining wood. Case in cement shall not be used.
- (6) Electrical Material and Equipment : Materials and components which are inherently fungus resistant or are protected by hermetic sealing or oil immersion need not be treated. Other elements shall be protected by additional varnish for high humidity and given an antifungal treatment.



S1.15 MISCELLANEOUS METALWORK

The Contractor shall provide and install in respect of the Plant in his supply, the following miscellaneous metalwork ;

- (a) soleplates, bedplates, foundation bolts and anchor bolts ;
- (b) floor plates and kerbing, including covers for pipe and cable trenches, required for completing the floors around and over the Plant ;
- (c) platforms, stairways, ladders, guards, handrails necessary for easy and safe access to the Plant requiring access for operation, maintenance and testing;
- (d) safety guards at each point where normal access would permit personnel to come within reach of any moving item of plant; and
- (e) lifting lugs, eyebolts or other lifting attachment points on each item having a mass of more than 40 kg.

S1.16 EMBEDMENT, FOUNDATIONS AND PLINTHS

- (1) (a) Except where otherwise stated, embedded supports and other embedded metalwork shall be provided by the Contractor. They shall be consistent with dimensioned concrete outline and structural metalwork drawings. The Contractor shall ensure that adequate provision has been made in the civil drawings for the complete installation of his Plant and shall inform the contractor for the civil works of:
 - (i) any required changes and the reasons;
 - (ii) location and outlines of all metalwork to be embedded in the concrete.
- (b) Any equipment to be embedded shall be supplied to the civil works contractor not less than 3 months before construction work is programmed to commence in the area concerned.
- (c) Unless the Contractor informs the civil works contractor of his requirements not less than 3 months before work is programmed to commence in the area concerned , such additions or alternations to the civil works shall be made by the Contractor or, if the Engineer so requires, by the Department at the expense of the Contractor.
- (d) The Contractor shall be responsible for ensuring that any items which he requires to have embedded and any agreed alterations to the civil works, are carried out on site.



- (2) All scrubbling to a depth of 15 mm. grouting in of plant, grillages and steelwork, adjustment to foundation levels, grinding of foundations, bedding on foundations and cementing into walls and floors, shall be carried out by the Contractor.
- (3) Equipment for mounting on floors shall be installed on concrete plinths to be constructed by the Contractor with the finished level up to 75 mm. above the floor level to cater for normal variations which will occur in foundations. With respect to his Plant, the Contractor shall supply all foundation bolts and packing plates between the concrete and the plant, equipment and bases.
- (4) Plant which is mounted on the floor and which does not require supporting steelwork grouted or embedded in the concrete foundation and plant which is surface mounted on concrete walls or the lower face of concrete shall be fixed in position by approved masonry anchors. Masonry anchors shall be expansion type or resin adhesive type, shall be of adequate strength and corrosion-proof. The Contractor shall provide the fastenings and shall forward to the Engineer full details of the proposed masonry anchors including typical pull-out values and if requested shall submit samples for approval. Wooden, fiber or plastic plugs or similar type fixings will not be accepted.
- (5) Embedded parts installed by the Contractor shall be accurately placed and secured by the Contractor. The placing of the concrete around such items will be by others.

S1.17 POSITION OF INSTRUMENTS, CONTROLS AND HANDWHEELS

- (1) Instruments shall be located conveniently for access and reading. Instruments which must be read frequently shall be located between 750 mm. and 1,800 mm. from the floor. Those which are read occasionally may be located between 500 mm. and 2,000 mm. from the floor.
- (2) Controls and valve hand wheels shall be located conveniently for access and operation. In general controls should be within the range 750 mm. to 1,500 mm. and valve hand wheels 1,000 mm. to 1,500 mm. above floor level.

S1.18 FABRICATION AND WELDING

- (1) General Requirements for Fabrication

The following requirements shall apply to all fabrication of components.

- (a) Plates and sections shall be free of all surface marks or damage exceeding 1 mm. deep.



- (b) Weld root gaps for partial penetration welds shall not exceed 1.5 mm. the dimensions of weld preparations, root gaps and plate alignment shall be to tolerances specified on the relevant drawings. All weld preparations shall be subject to examination for material flaws.
- (c) Before welding, the weld preparation and plate surface for 15 mm. on either side of the preparation shall be completely cleaned to base metal including complete removal of any surface coating by abrasive blasting.
- (d) Weld procedure and welder qualification tests shall be carried out in accordance with the approved standards. Where the standard does not specifically require weld procedure and/or welder qualification test, the Engineer may require the Contractor to submit details of the proposed weld procedure and of the qualifications of the proposed operator. The Engineer may at his discretion require that weld procedure and/or welder qualification tests be conducted in such cases. The Engineer reserves the right to call for further qualification tests and to withdrawn approval of any welder whose work is unseat is factory.
- (e) Weld procedure and welder qualification tests shall reproduce the production conditions including preheat, electrode treatment, interpass temperature, degree of restraint and stress relief.
- (f) Undercut not exceeding 1 mm. deep shall be removed by grinding; undercut exceeding 1 mm. deep shall be filled by welding.
- (g) The surface of welds shall be smooth and free of sharp contour changes. The Contractor shall grind the surface of any weld as necessary in the opinion of the Engineer to avoid affecting the interpretation of non-destructive examination.
- (h) Arc strikes on the place surface shall be avoided. Accidental are strikes shall be ground out and the area crack-detected.
- (i) Welded-on fabrication aids shall be kept to a minimum and shall be subject to the approval of the Engineer. They shall be attached only by approved welders using approved procedures and shall be removed by flame cutting not less than 1.5 mm. above the parent plate surface and then by subsequent grinding and crack-detecting of the weld area.
- (j) Butt welds shall be free from under filling and from reinforcement greater than one-tenth the face width of the weld. All undercut shall be filled by welding.
- (k) Wherever practicable, welding shall be carried out in the downhand position.



- (l) Weld spatter shall be completely removed. Machined surfaces and tapped holes shall be adequately protected from spatter during welding.
- (m) Joints not completely protected from the weather or in a corrosive environment shall be seal welded. Unless otherwise approved, welds between dissimilar metals shall be performed at the Contractor's premises.
- (n) Electrodes shall be stored and dried before use strictly in accordance with the electrode manufacturer's recommendation and welding code requirements.
- (o) Preheat and interpass temperatures shall be applied in accordance with the electrode and steel manufacturer's recommendation and with the weld procedure tests. Measurements shall be by temper sticks or surface pyrometer on the opposite side of the plate surface pyrometer on the opposite side of the plate surface from that to which heating is being applied.

(2) Further Requirements for Important Stressed Components

The important stressed components shall mean those components whose failure would endanger the operation of plant or the safety of personnel. They shall include but shall not necessarily be confined to:

- (a) components or parts thereof including welds which are stressed to greater than 40 percent of yield stress in normal or abnormal service conditions;
- (b) components which are stressed directly or indirectly by pressure conduit or tailwater pressure, operating oil pressure or air pressure;
- (c) all rotating parts of main plant (generator and turbine but excluding auxiliaries);
- (d) bearings and their support systems; and
- (e) lifting equipment, crane girders and crabs.

The following further requirements shall apply to the important stressed components in addition to the requirements in sub-clause (1) of this Clause.

- (i) All plate materials and sections shall be identified by heat number at all phases of fabrication and erection. They shall be checked ultrasonically for internal defects.
- (ii) As far as practicable, all shop-welded fabrication shall be stress relieved.
- (iii) As far as practicable, all welds shall be full penetration, back-gouged and of a configuration which lends itself to radiographic or ultrasonic examination.



(3) Non-destructive Testing of Welds in Steel Components

- (a) All full penetration welds in important stressed components shall be examined for their full length radiographically or ultrasonically. In general this examination shall be by radiography for butt welds and by ultrasonic for tee-welds. The examination methods and the standard of acceptability shall be in accordance with Section V of the ASME Code.
- (b) In addition a percentage of all other welds shall be examined ultrasonically or radiographically. The examination methods, extent of examination and standard of acceptability shall be in accordance with Section V of the ASME Code or AWS Code.
- (c) The toes of all fillet welds in important stressed components shall be subject to crack-detection.
- (d) Radiography of welds shall be carried out in accordance with Section V of the ASME Code.
- (e) The Contractor shall submit radiographs and reports to the Engineer within 7 calendar days of the taking of radiographs. The report shall contain complete identification of the component concerned, definition of the location of the radiographed areas, full description of the radiographic techniques and report on all indications of the film.
- (f) Ultrasonic techniques and acceptability of defects found by ultrasonic examination shall be in accordance with ASTM A435.
- (g) Welds in which unacceptable defects are found by radiography or ultrasonic examination shall be subject to re-examination by the same respective method after repair.

(4) Non-destructive Testing of Welds in Aluminum Components

Such welds shall be tested generally in accordance with Section V of the ASME Code. The actual scope of tests shall be to the approval of the Engineer, dependent on the design and function of the components concerned.

S1.19 PIPING, VALVES AND THREADED FASTENERS

- (1) General: All piping, valves and threaded fasteners shall be designed according to ANSI Standards; the pipes shall be in accordance with ANSI B 31.1; all flanges shall be of raised face (RF) designed according to ANSI B 16.5.

Screwed joints may be used for pipes up to 50 mm. diameter at working pressures not exceeding 7 kg/cm^2 . Pipes of 25mm. diameter and less for working pressures exceeding 7 kg/cm^2 shall be joined by unions of approved type.



The working pressure of a system shall be taken as the maximum pressure it can attain including water hammer and/or relief valve blow-off pressure.

The pipe diameters shall be calculated considering the following maximum allowable speeds:

- Air 15 m/s and 5 m/s in between compressors and receivers;
- Oil and water at the suction side m/s;
- Oil and water at the pressure side 2.5 m/s.

The thicknesses of the pipes shall be calculated following the ANSI requirements; at least 3 (three) millimeters for corrosion shall be considered for the water and air piping and 1 (one) millimeter for the oil piping.

All piping 100 mm nominal diameter and larger shall be completely prefabricated at Contractor's workshop with all fittings in place except that extra length for field cutting and welding shall be provided where required for field assembly.

Piping with flanged connections shall be furnished with gaskets, bolts, studs and nuts. All pipes up to 50 mm. nominal diameter shall be assembled by means of threaded or socket welded fittings. Threaded and socket welded pipe will be Site fabricated, as erection proceeds.

Piping systems shall be complete with fittings, valves, supports and all necessary accessories. Piping arrangement shall be neat in appearance and shall allow a convenient operation. Items requiring periodic attention shall be easily and readily accessible from floors or platforms. Pipes shall neither obstruct passways nor interfere with access to valves and equipment.

The piping buried in the concrete shall be sloped for drainage and provided with 25 mm. diameter drain valves at all low points in the system.

The supports, hangers, anchors and clamps necessary to support and restrain all pipes and valves shall be designed, selected and located in order to ensure uniform continuous slopes for draining and minimize stresses in the piping material, and to let the piping system be safely supported, guided and anchored especially for the pipes to be laid in the pier trench.

All items to be site welded to the piping shall be of the same material as that of the relevant piping.

As far as practicable, the supports shall be grouped and of consistent design throughout.

The Contractor shall submit for approval drawings showing;



- the piping flow diagram;
- the piping P. and I. diagram;
- the piping layouts.

The Contractor's calculations of the piping diameters and thickness shall be available for approval at the Engineer's request.

Asymmetric sketches shall be supplied for site erection.

- (2) Pipes: Pipes shall be in accordance with the ASTM A 53 Grade B standard specification or approved equivalent for welded and seamless steel pipe. Type S, seamless pipes will be preferred. Longitudinal welded pipes type E, electric resistance welded pipes are subject to approval.

All pipes shall be shipped with the ends plugged by plastic covers.

The beveled ends to be welded at site shall be protected by a special paint compatible with the welding.

Elbows having radius at least 1.5 nominal diameter shall be used for changes in the direction of piping having 75 mm nominal diameter and over. For piping having 50 mm. nominal diameter and below commercial fittings shall be used. Bends having radius not less than 5 nominal diameter instead of ells may be used.

Minimum wall thickness at any point of the elbows, bends and ells shall not be less than the minimum wall thickness allowed for pipes.

Shop prefabricated pieces may be employed for tee reducers, drain and other special pieces. Materials and thickness shall be the same as for the straight pipe. Branch connections shall be reinforced where necessary in accordance with the requirements of ANSI B 31.1 "Code for Pressure Piping"

For piping having 50 mm. nominal diameter and over, seamless type fittings such as tee, reducers and cap shall be used for intersection of piping, piping branches, changes in size and end closure. Metered fittings and metered bends will not be accepted.

- (3) Valves: All the valves shall be of the flanged type, made of carbon steel with stem and sealing rings of stainless steel; all valves shall be provided with back seated items.

Valves nominal diameter shall always be equal to the relevant pipe diameter.

Seals and seats shall be positively fixed so that they cannot become loose in service. The fixing of seals and seats by an interference fit only is not acceptable.



The operating mechanism shall have means of lubrication and position indicators and, in the case of isolating valves, the means of padlocking in the open and closed positions together with approved padlocks and keys.

All hand-operated valves shall close by clockwise rotation of the hand wheels which shall be marked to show the direction of closing. Valve hand wheels shall be located for safe and convenient operation with extended spindles where necessary to achieve this. All hand operated valves shall be capable of being opened and closed against their maximum working pressure fully unbalanced with a force at the hand wheel not exceeding 100 N. If necessary to achieve this, reduction gearing, ball or roller bearings shall be provided.

As far as practicable, all valves for similar service shall be of the same make and type and be interchangeable.

All gate valves for water and air service shall be of a type in which the operating mechanism is not subject to the working fluid.

Valves other than needle type shall not be used permanently if the need for throttling is foreseen, such as to adjust flow subdivision in a system, orifice plates or needle valves with fixed stops shall be provided.

Valves for water and oil service may be gate, butterfly, ball, plug or needle type, whichever is most suitable to the particular service and operating pressure.

Valves for air service may be ball, plug or needle type whichever is most suited to the particular service.

Non-return valves shall be of a type specifically designed to avoid impact and water hammer on closure. The closing member shall be pivoted from the valve body, not from a lid cover.

Relief valves for pumps shall be of direct spring loaded, angle body type.

For identification each valve of 150 mm. N.D. and over shall be provided with stainless steel identification disc on the hand wheel.

On this disc the following shall be etched:

- manufacturer;
- catalogue number;
- size inches;
- rating and fluid;
- trim material;
- body and bonnet material.



Valves below 150 mm. N.D. shall be identified with size and ANSI class. The disc shall be written in English.

- (4) Threaded Fasteners: The threaded fasteners shall comply with ISO metric system and with the following requirements:
- steel bolts shall be forged unless otherwise approved;
 - mild steel fasteners shall be zinc or cadmium plated;
 - all parts shall be spot-faced or machined for nuts or bolts except in the case of clearance bolts in structural steelwork;
 - tapped holes shall not be used in sheet metal less than 6 mm. thick;
 - fasteners of less than 6 mm. diameter shall not be used except in instruments and relays;
 - threaded fasteners of more than 8 mm. diameter shall have hexagon or socket hexagon heads;
 - all threaded fasteners subject to vibrations and/or installed in a position which is unable to be inspected during operation shall be locked in an approved manner.

S1.20 CASTING AND PATTERNS

- (1) All steel castings shall be annealed in accordance with the relevant standard. All iron castings shall be mild annealed in a suitable annealing furnace to relieve casting strain before being machined.
- (2) The Contractor shall retain all patterns required for the production of the Plant at least until the end of the maintenance period.

S1.21 LUBRICATION

- (1) The Contractor shall submit, for the approval of the Engineer, a complete list of the lubricants recommended for each part of the Plant; this list shall give the type and grade of each lubricant in sufficient detail to permit the correct lubricant to be supplied from normal commercial domestic sources. As far as possible the number of different types of lubricant required for the plant shall be reduced to a minimum.
- (2) All lubricants and flushing oils required for the plant up to the time of taking over shall be provided by the Contractor.
- (3) The Contractor shall nominate a minimum number of standard size grease nipples which shall be used for all Plant.
- (4) The filling points for lubricating oil systems shall be provided with fine gauze filters beneath the filling caps to prevent the entry of dust.

- (5) Drip trays shall be provided beneath oil filling and drain points and any other locations subject to oil leakage or spillage.
- (6) The filling and drainage points shall be located so that they are conveniently accessible. Adequate working space shall be provided for the positioning of buckets, hoses and other appliances used for filling and drainage.

S1.22 SELF-LUBRICATING BUSHES

- (1) Where self-lubricating bushes are specified, they shall be as follows:
 - (a) For applications subject to immersion or to weather, - bronze with lubricating insert ('Lubrite' by Merriman, Hingham USA or equivalent). The lubricant shall have long-term resistance to deterioration when exposed to atmosphere and water in a tropical climate.
 - (b) For indoor, nominally dry application - as in paragraph (a) of this sub-clause or epoxy resin with glass mesh reinforcement and hard chromium plated and ground journals.
- (2) The use of 'Teflon' or similar materials and the use of materials which promote electrochemical action, is not acceptable.

S1.23 TEST, GENERAL REQUIREMENTS

- (1) Test During Manufacture-General:
 - (a) All Plant materials and components shall be subject to type, sample and routine tests and inspection while in the process of and upon completion of manufacture at the Contractor's premises in accordance with this Specification and the Conditions of Contract. Tests listed in the Standards as optional tests (to be performed if specified at the time of ordering) are required to be performed unless otherwise stated.
 - (b) The Department, its representative and/or the Engineer will visit the factory of the Contractor during manufacturing and factory tests. The attendance to the Contractor's factory for any purpose by The Department, its representative and/or the Engineer shall not in any way release the Contractor of any of his obligations under the Contract until the final acceptance certificate is issued. Some factory tests, if so permitted by prior approval of the Engineer, may be performed without the presence of The Department, its representative and/or the Engineer.



- (c) The Contractor shall bear the cost for receiving the following engineers from the Department for a period of 12 days each, which shall include round-trip economy class air fare from Bangkok to the factory, local transportation cost, lodging and meals and other miscellaneous expenses necessary for the purpose of the trip. The costs for receiving the Department's engineers at the Contractor's factory shall be included in the prices bid in the Schedules.
- | | |
|--------------------------------|-------------------|
| (i) for turbines | two (2) engineers |
| (ii) for generators | two (2) engineers |
| (iii) for associated equipment | two (2) engineers |
- (d) It is the intention of the Department. to acquire the services of a qualified inspection company to conduct expediting services, inspection company to conduct expediting services, inspection during manufacture and attendance at factory tests. The Contractor is required to provide all reasonable facilities including advance notice (at least thirty (30) days) of all testing dates in order that the said inspection company may fulfill all of its duties as required under the contract to be made between the Department and the inspection company. The attendance of the inspection company at the Contractor's factory during fabrication and at factory tests shall not relieve any of the obligations of the Contractor under this Contract.
- (e) Type, sample and routine tests shall be to the relevant American Standards or other approved standards for equipment where the test requirements are not specified in this Specification.
- (f) The Contractor may offer type test results for identical equipment in lieu of the type tests specified, in which case the specified type tests may be waived by the Engineer. If type test results for identical equipment are offered in lieu of the specified type tests, the Contractor shall also provide evidence as to the similarity of the equipment tested and the Contract Plant.
- (g) The Contractor shall submit evidence to the Engineer that the instruments used for the tests have been calibrated at an approved testing laboratory within a period of up to 3 months for a portable instrument and 6 months for a fixed instrument.
- (h) The Contractor shall submit to the Engineer 4 certified copies of all results of all tests required under the Contract. The results of each test shall be recorded in the form of test certificates or test reports.
- (i) The results of tests shall be submitted to the Engineer within 1 month of the tests being carried out.
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- (j) In the event of any test piece failing to comply with the requirements of the Contract, the Engineer may reject the whole of the material represented by the test piece.

(2) Tests at Site - General

(a) Responsibility for Tests

- (i) The Contractor shall conduct the Tests at Site
- (ii) The Contractor shall provide everything required to carry out the tests, including the provision, installation and removal of all test instruments and obtaining of all records. The Contractor shall provide certified test certificates to prove that all instruments have been calibrated by an approved laboratory not more than 3 months prior to carrying out the tests. The Contractor must specify items of testing equipments to be handed over to the Department.
- (iii) The Contractor shall prepare and submit the program to the Engineer for approval, schedules for each test together with a program for the Tests on Completion.
- (iv) The Contractor shall submit one copy of the results of each of the Tests at Site to the Resident Engineer at Site within one week of the tests being carried out. Four copies of the certified results of each of the Tests at Site in the form of test reports or test certificates shall be provided to the Engineer within one month of the tests being carried out.
- (v) The Department's staff may observe or participate in the Tests on Completion.

(b) Scope of Tests

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

- (i) 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 ancillary Plant under test.
- (ii) The Tests on Completion which are tests to progressively prove the correct operation of complete ancillary systems and of the main Plant items.

The Tests on Completion shall include, immediately following all other tests, a test of service performance including 50 hours running. Where appropriate, the plant shall be connected to the PEA power system. The test shall include a total of 50 starting, and stopping sequences. The service performance tests shall be completed without adjustment and without fault. This shall be a prerequisite for taking-over.



S1.24 ELECTRICAL EQUIPMENT

(1) Motors

All motors shall be totally enclosed, fan-cooled type with provision for lubrication, suitable for operation in high ambient temperatures and high humidity conditions. Motors up to and including 1/2 hp shall be 220 V, single-phase. The exception to this will be motors on the emergency "essential services" but that must be 380 V, 3-phase. All motors above 1/2 hp shall be 380 V, 3-phase.

Unless otherwise specified, induction motors shall be of the direct-line starting, drip-proof type, and when operated, shall not develop trouble under a voltage fluctuation of +10 percent. The induction motors shall not be affected by a rise of 30 or 40 percent in voltage and frequency due to a full load rejection of the unit.

Motors shall be

- normal starting torque
- low starting current
- squirrel-cage induction type
- designed for full voltage starting
- drip tight or weatherproof
- totally enclosed.

Would rotor motors will be acceptable only if a squirrel-cage type were not satisfactory for the duty. The motors shall have Class B, 80°C temperature rise and continuous rating at 40°C ambient temperature and class F insulation. Motor lead insulation shall be Class B and cable terminal boxes shall be provided preferable with stud type connectors.

(2) Magnetic Motor Starters

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

- (a) molded case circuit breaker disconnect with thermal time delay and instantaneous trips
 - (b) a 380 - to 220-V individual fused control transformer
 - (c) a 220 - V ac operating coil
 - (d) thermal overload protection in each phase - temperature compensated with thermal elements correctly related to motor nameplate, current and type of enclosure
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- (e) auxiliary contacts for the control of related auxiliary devices such as motor heating, indicating lights, inter-locks, etc.

All starters shall be suitable for across-the-line starting of motors with manual resetting and under voltage release features.

All motors of 25 hp and above shall be provided with ammeters with suppressed scale for starting current and have motor full-load current deflection at roughly two-thirds of the scale.

All motors shall be provided with quick-break molded case circuit breakers 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.

Magnetic contactors used in various switches shall be made of arc-resistant metal and have sufficient capacity against current onrush. The contacts shall be designed to obtain high contact pressure and positive seating to reduce contact bounce.

(3) Relays and Devices

Electric contacts of dial type thermometers, thermal relays, oil level relays, oil pressure relays, air pressure relays, limit switches, etc., shall be able to safely break a current of possible maximum inductive load (2 A) and 125 V dc.

The contact surfaces (both male and female) for a transistor sheet (printed card) shall be gold plated. All printed cards shall be suitably treated to prevent damage to connection or components by hydrogen sulfide gas.

The relays (control, protection and auxiliary relays) and meters shall be air-sealed to prevent corrosion by hydrogen sulfide gas which will probably occur after water is impounded in the reservoir.

Mechanical targets (operated at 125 V dc) 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.

(4) Molded Case Circuit Breakers

All molded case circuit breakers shall have 2 or 3 poles as required, having thermal time delay and instantaneous trips with ON-TRIP-OFF indicating operating mechanisms. Circuit breakers used in conjunction with motor starters or contractors 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.



Circuit breakers shall be bolt-in type, interchangeable, temperature compensated, quick-make, quick-break type and shall comply with NEMA standards.

A group alarm contact shall annunciate an open breaker and each breaker shall have an individual light which shall come on when the breaker is open.

(5) 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 environmental. Local stop buttons neat the motors shall be lockable in pressed position for maintenance.

(6) Indicating Lights

All indicating lights shall be of LED type (E12) long life and service under conditions of shock, vibration and rough handling unless otherwise specified.

(7) Instruments and Meters

All instruments and meters shall have approximately 110 mm. dials, shall be of heavy duty industrial type, suitable for withstanding extreme shock and severe vibration.

(8) Convenience Outlets

Convenience outlets in the control cabinets shall be duplex 3-pin type rated for 15 or 20 A at 250 V, suitable for Thailand pattern plug as approved by the Engineer.

(9) Pressure, Level and Flow Switches

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

(10) Electrical Enclosures

Unless indicated otherwise in this Specification, electrical enclosures, except junction boxes and pull boxes 4 inches trade size and smaller shall be as follows:



<u>Location</u>	<u>Enclosure type</u>
Indoor (nonhazardous)	
Dry area	NEMA 12
Areas where moisture conditions are more severe than those for which enclosures are intend	NEMA 12 NEMA 4
Outdoor (nonhazardous)	NEMA 4
Hazardous areas	In accordance with the requirements of the National Electrical Code for the location

The construction of electrical enclosures located in areas subject to conditions classified in the National Electrical Code as hazardous shall be of a type designated by NEMA as suitable for the environment in which they are located.

Electrical switchboards, panels, and cabinets, except those of cast metal, shall be constructed from steel plate reinforced as required to provide true surface and adequate support for devices mounted thereon. Thickness of the steel plate shall conform to the requirements of UL50. Switchboards, panels, and cabinets shall be of adequate strength to support mounted components during shipment and to support a concentrated load of 91 kilograms on their top after erection.

Anti-condensation heaters, 220 V a.c., complete with isolating switch, shall be provided in enclosure containing control or relay equipment, except when the external surface area is less than 0.5 m^2 (excluding the bottom).

The rating of the heaters shall be 20 W for each square meter of exposed surface are of the enclosure. Where the heat produced by the equipment during normal operation is equal to or greater than the output of the heater a thermostat shall be provided to control the heater.

All enclosures fitted with anti-condensation heaters shall have ventilation openings in the doors which shall be screened with vermin-proof and insect-proof fine brass gauze or a suitable filter and arranged to minimize entry of dust and prevent entry of water. Sealing of doors and covers shall be by closed cell neoprene foam sections on to surfaces at least as wide as the sealing section; water absorbent materials is not acceptable for seals.

Lighting shall be provided inside each enclosure large enough for a man to work inside. Luminaries shall be controlled by a fully enclosed door-actuated switch.

Where an enclosure contains fluids under pressure, compartments shall be provided to prevent damage to equipment by fluid leakage or discharges.



Finish painting inside enclosures shall be gloss white. The finished surfaces outside shall present a first class appearance of uniform color to adjacent enclosures. Equipment contained in enclosures shall be finish painted as if it were exposed to view.

A label showing the cubicle abbreviation shall be provided on the outside rear or cabling side of each enclosure.

(11) Ground Buses

A 6 mm. by 25 mm. cross-section bars copper ground bus shall be provided at the bottom of each enclosure to which the metallic cases of meters, instruments, relays and grounding circuits of all other equipment shall be connected. The ground buses shall be solidly bolted to the steel framework so as to make good electrical contact. Solderless lug or terminals shall be provided on the ground buses for terminating the copper ground cables from the grounding systems.

(12) Wiring

The wiring of the control cabinets, control boards, cubicles and control boxes for auxiliary equipment shall conform to the NEC and NEMA standards, shall be tinned, stranded copper switchboard wire, PVC insulated. All wiring shall be 2.5 mm² except for current transformer circuits which shall be 6 mm². All hinged wiring shall be extra flexible. The small wiring used in the semiconductor circuit will be excluded. The wiring for all instruments, relays and auxiliary devices of equipment and accessories shall be connected by ring tongue, crimp style terminals (amp terminal). All wiring shall be neatly and carefully installed in suitable wiring ducts with removable covers and complete to conveniently located terminal blocks for connecting to incoming and outgoing leads.

The terminal arrangement shall group all leads to facilitate connections to the incoming cables. Not less than 20 percent spare terminals shall be provided on each group of terminal blocks for terminating spare conductors in control cables and for future use.

Both ends of all wires shall be provided with terminal number rings and the number shall be recorded in the wiring diagram.

The interior wiring shall be concentrated on terminal blocks installed at a convenient height in the equipment or control cabinets in order to facilitate external cable connections. Wire runs shall be neatly trunked inside the switchgear or in wiring troughs. Conductor connections shall not be soldered except for essential requirements.

The terminals of motors or other equipment shall have pressure compression type terminal lugs.



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

- Secondary circuit of potential transformer - red
- Secondary circuit of current transformer - black
- dc circuit - blue
- ac circuit except power circuit - yellow
- Neutral - green

Three-phase outgoing cables shall be color coded as follows.

- Phase 1 - black
- Phase 2 - white
- Phase 3 - red
- Neutral - green

Direct current shall be color coded as follows.

- Positive - white
- Negative - black

(13) Terminal Blocks

Terminal blocks shall be of the 600-V molded block type with insulating barrier between terminals. Terminal blocks for current transformer secondary circuit shall be of short-circuit type. Terminal blocks shall be attached with a cover and the terminal number. Each terminal block shall have marking strips and shall be equipped with crimp style terminals for 2.5 mm² or more. Terminal blocks shall be provided with at least 25 percent surplus terminals as spares for each control board and cabinet. No more than two wires shall be connected to one terminal.

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.

(14) Cables and Conduits

The Contractor shall furnish all control and power cables which will be used for controlling, operating and supplying power for Equipment of the power plant. The Contractor shall supply all conduits, accessories and fittings which will be required for laying the cables.

The Contractor shall allow for the following minimum of spare cores in each multi-core control cable.



NUMBER OF CORES IN CABLE	MINIMUM NUMBER OF SPARE CORES
Up to 5	-
Up to 12	2
Up to 20	4
Over 20	6

S1.25 OPERATOR TRAINING

The Contractor shall instruct the Administration's nominated staff in the operation and maintenance of the Plant during installation and commissioning and for a period of one month after completion of all site tests. The Contractor shall satisfy himself and the Engineer that the Department's staff are fully capable of operating and maintaining the Plant before leaving the Site. The cost of these services shall be included in the Contract Price.



<i>SECTION 2</i> <i>TURBINES AND GOVERNORS</i>
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SECTION 2 - TURBINES AND GOVERNORS

S2.01 SCOPE OF WORK

The scope of work under this clause shall consist of design, manufacture, shop test, supply, delivery, and installation, field test, placing in successful operation, commissioning, and guarantee of the following turbines, governors, and auxiliary equipment.

- (a) Two single-runner, Vertical, 5 jets Pelton type turbines.
- (b) Two electronic PID type governors complete with pressure oil system.
- (c) The spare parts for turbine, governor, and auxiliary equipment.

The Contractor shall supply all the necessary switches, contactors, magnetic starters and relays with the turbine, governor and electrical auxiliaries. All electric items supplied by the Contractor shall be standard manufactured items available from stock. The Contractor shall provide all terminal boxes required and shall provide all wiring and conduit from the electrical components to these terminal boxes.

Hill curve showing efficiency curve (or) Turbine Prototype Performance Curve indicating Allowable Operating Range, turbine prototype efficiency at each Nozzle opening relative to head and flow and output indicating relative to head and discharge **shall be submitted with the bid**

Oil Pressure System Diagram for Governor including Component Arrangement, **shall be submitted with the Bid.**

Failure to submit the above information will subject to rejection of the Bid Proposal.

S2.02 TURBINE

(1) Type

Single runner, 5 Jets Vertical type Pelton Turbine and the mono block Pelton runner shall be directly mounted on the generator shaft

(2) Design Data

The main design data of the turbine shall be as follows:

- (a) Net Head (m)
Design 179.43
- (b) Discharge (m^3/sec)
Design (each) 2 x 1.574
- (c) Capacity (kW)
Guaranteed Values under net head:
Design (each) not less than 2,521 kW

- (d) Efficiency (%)
Minimum guaranteed values under
Design net head and design kW: 91
- (e) Frequency of Rotation (rpm)
Rated To be proposed by the Bidder
- (f) Direction of Rotation
View from the top Clockwise
- (g) Couple to Generator
Runner directly mounted on
generator shaft

(3) Requirements for Design and Characteristics

- (a) General: The turbine shall operate at any gate opening, under any head and under tail water level as specified without unacceptable torque and/or pressure oscillations and without unacceptable cavitation. Non-embedded turbine casing and distribution pipe. Use turbine case as generator support. Non embedded distribution pipe. Distribution piping placed on power house floor. External servomotor for jets control.

Best turbine efficiency shall be obtained between 80 percent and 100 percent of full gate opening under 179.43 m design net head and rated flow given. The derivation of guaranteed efficiency shall be fully substantiated in the Bid preferably by certified results of tests on prototype and/or model turbine homologous with those offered, together with a full account and justification of the method used in translating these results to the efficiencies guaranteed for the turbines offered for this project.

- (b) The total stored energy constant of the generator and turbine shall be not less than the minimum necessary for stable governing and the attainment of the specified and guaranteed pressure rise and speed rise.

The Bidder shall submit with the Bid for calculation of transient state, including total penstock length, unit speed rise, pressure rise and GD^2 needed for operating with shock load of 125 kW and parallel operation verifying that the Bidder's proposed equipment is suitable and can be operated with the existing Grid system without any problem to the supplied equipment during emergency shutdown as well as without any hunting when synchronizing and connecting to the existing 3.3 kV grid system.

Failure to submit this will subject to rejection of Bid Proposal.

- (c) Frequency Regulation

The Contractor shall guarantee the maximum transient frequency change which will result from an instantaneous change of 50 Hz in any initially steady isolated load having a self regulation coefficient of 1.0, being

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supplied by one turbine, or both with the permanent speed droop of 3 percent. **The Bidder shall submit calculation to justify the regulation.**

(d) Speed Regulation

The Contractor shall guarantee the maximum momentary speed rise which can occur when the generator output corresponding to 100 percent gate opening at maximum gross head is instantaneously rejected from both units with a permanent speed droop of 3 percent. The maximum momentary speed rise shall not exceed 40 percent. **The Bidder shall submit the calculation to justify the regulation.**

(e) Pressure Regulation

The Contractor shall guarantee that the maximum gauge pressure which can occur in the pressure conduit or turbine on instantaneous rejection of any load of which the units capable, shall not exceed 269 m of water at the elevation of turbine nozzle center. This guarantee shall apply under all conditions of normal operation, (i.e., all plant functioning correctly). **The Bidder shall submit the calculation to justify the regulation.**

(f) Turbine housing/casing

Turbine housing and base frame shall be designed to support the base static loads and dynamic forces due to operation and installed independently on the power house floor without embedded in concrete structure not to occur any correction or modification works for the civil work structure

Turbine housing shall be used as Generator support and all nozzle distributor pipe and external servo motor for needle and jet deflector control shall be installed and located above power house floor.

It shall be made of welded steel structure with reinforcement. Turbine housing and nozzle pipes shall be installed above in the power house floor and fabricated with anchors to power house floor, stiffening ribs for support in order to mount synchronous generator frame from the top in vertical

Maintenance hole shall be installed with cover for access to runner, nozzle jets and deflector for maintenance

(g) Operating Mechanism and components

(a) Operating Mechanism of the turbine shall be controlled by hydraulic servomotor (or) hydraulic cylinder for opening and closing of needle and deflectors

(b) Nozzle pipe injector (or) water injector shall be fabricated with steel. It shall be provided with flange connection between nozzle elbow joints and shut-off devices. Nozzle pipe injector, elbow and flange shall be made of steel.



(c) Nozzle elbow joints

Nozzle elbow joints shall be made of steel. It shall be welded with unilaterally arranged length guide of nozzle needle bar so that is no possibility of clogging.

(d) Nozzle mouth, Needle and Needle bar

Nozzle mouth piece and nozzle needle shall be made of hardened stainless steel to maximize abrasion protection, including replaceable wear ring

Needle and needle bar shall be made of stainless steel fixing in maintenance free slide bearing bushing and it shall be sealed with two sealing rings to prevent leakage. Needle shall be equipped with thread and it can easily be replaceable.

Nozzle needle shall be operated and actuated via externally mounted and position controlled hydraulic cylinder

The nozzle needle controlled shall be actuated by hydraulic cylinders (or) servo motor. Each nozzle shall be equipped with each actuation system including electrical position feedback as well as a mechanical position indicator with scale in mm.

(e) Jet Deflector

Jet Deflector shall be made out of a special hardened stainless steel to achieve maximum strength protection against wear and abrasion

In case of operated/actuated by hydraulic cylinder, It shall be guided with maintenance free slide bearing (made of bronze) and limit switch shall be provided for end position

Counter weighting acting shall be provided in case of power failure and emergency stop condition of safety

The pivot joints of the deflector mechanism shall be provided with self-lubricated bushing and the pin shall be stainless steel. Jet deflector shall be equipped with stainless steel bolts and easily to be replaced

(f) Servomotor/ Hydraulic cylinder

The body shall be well machined and polished over full internal surface. The piston shall be with guide ring and seal and the rod shall be made of stainless steel over it full length

(g) Turbine shaft and bearing

Pelton runner shall be direct mounted at generator shaft so that the turbine shaft is not applicable

Heavy duty industrial type roller ball bearings shall be provided at synchronous generator and it shall be lubricated with automatic greasing unit



(4) Turbine Dismantling Arrangement

All major turbine parts shall be provided with eyebolts, lugs or lifting devices. Provision shall be made to support the turbine shaft and runner during erection and dismantling.

(5) Runner

- (a) The runner shall be made of forged mono-block in single piece having wear and corrosion resistance Chrome-Nickle-steel (X3CrNiMo 13-4) or higher material for strength shall be used
- (b) The runner shall be manufactured by using minimum 5-axis CNC milling machine for highest precision profile with lowest manufacturing tolerances so that any welding or casting is not allowed. Furthermore the final the proper polishing process shall also be applied to achieve smooth surface condition.
Evidence for proofing this shall be submitted with the Bid proposal.

- (c) Each runner shall be statically and dynamically balanced and the runner material verification and balancing report shall be submitted to DEDE during manufacturing period and before delivery. The runner and generator shaft shall be designed properly precisely to be fitted together during engineering stage and delivered separately to project site.

- (d) They shall be aligned and assembled at site during installation period under manufacturer's supervision at the Contractor's premises.

(6) Turbine Setting

- (a) Each runner shall be statically and dynamically balanced and the runner material verification and balancing report shall be submitted to DEDE during manufacturing period and before delivery. The runner and generator shaft shall be designed properly precisely to be fitted together during engineering stage and delivered separately to project site.
- (b) They shall be aligned and assembled at site during installation period under manufacturer's supervision at the Contractor's premises.

(7) Turbine Control Instrument Cubicle

(a) Construction

The cubicle shall be made of steel plate not less than 3.0 mm thickness. A hinged door shall be provided on one side of the cubicle and, on the other side, the cubicle shall be installed adjacent to the governor cubicle described in Clause S2.03. Front and rear hinged doors, all necessary piping and wiring shall be provided. The turbine Control Instrument Cubicle shall be installed nearby Turbine-Generator and shall be equipped with instrumentation and operating devices used for start and stop of turbine and closing and opening of inlet valve during operation of Unit.



(b) Instruments to be mounted on the Cubicle

The following instruments shall be mounted in front of the cubicle and shall send their output signals and data values to Unit PLC (or) Governor PLC for control and monitoring purpose:-

Dial type vapor pressure thermometer with alarm output and trip contacts

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|--------------------------------------|------------------|
| 1) Generator DE bearing Temperature | One (1) for each |
| 2) Generator NDE bearing Temperature | One (1) for each |

Pressure gauge with analog signal (4-20mA) output

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|-------------------------------|---------|
| 1) For penstock | One (1) |
| 2) Governor Oil Tank pressure | One (1) |

- | | |
|--|---------|
| Digital Speed Indicator | One (1) |
| Emergency Shut-down Device (if applicable) | One (1) |
| Intel valve position indicator in % | One (1) |
| Gate position indicator in % | One (1) |
| Lubricating Oil Tank Temperature (if applicable) | One (1) |
| Lubricating Oil Tank Level (if applicable) | One (1) |

(8) Protection and Alarms

- (a) The Contractor shall provide protection functions for Generating Unit as per the "Protection and Relaying Functions" specified under Control, Protection and Alarm Section as well as the applicable international standards.
- (b) In addition to the devices listed, the Contractor shall provide such other protection and alarm devices of all of them necessary for the safe operation of the turbine, governor, inlet valve and ancillaries and shall include for these in the Bid Price.

S2.03 GOVERNOR

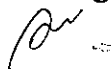
(1) Type

- (a) The turbine shall be provided with the digital type automatic PID controlled governing system with the oil pressure tank (or) oil pumping system. The system shall be independent, adjustable and control the Unit to operate with an adequate margin of stability under all steady state and transient load conditions without hunting and shall cause the Units to operate stably and satisfactorily in parallel with each other and/or the interconnected with Grid system.
- (b) The governor shall be of the PID controlled electro-hydraulic type with an established reputation of satisfactory and reliable service. Evidence of using PID Controlled Governor with product catalog/ information shall be provided with the Bid.
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- (c) The speed signal for the governor shall be derived from an approved source which shall not be used for other functions. The source for the speed signal shall be wired directly to the governor without fuses or other electrical protection devices and it shall not be damaged by short-circuits. The source for the speed signal shall be sufficiently free from interference or distortion to ensure stable speed control of the unit and it shall have sufficient resolution to ensure accuracy of speed control. The Contractor shall also provide suitable frequency and load reference sources for the governor.
- (d) The proposed location for the major items of governing equipment in the station is shown on Drawing. The Bidder shall advise whether or not these locations are suitable for the governing equipment that has been offered so that **the Layout and Dimensional Drawings for both Electrical and Hydraulic oil pumping system shall be indicated inside powerhouse and the dimensional drawing shall be attached with the Bid.**
- (e) The governor control system shall be provided with high precision speed-controlled components measuring speed of turbine by two locations to secure turbine speed detection all the speed switches required for its **operation and control diagram for which Operation and Control Sequence Diagrams (Start/ Stop) for Governor Control System shall also be submitted with the Bid.**

(2) Governor capabilities

- (a) The governing system shall be suited to and afford all facilities necessary to meet the monitoring and control system requirements as per Section 11.
- (b) The Unit will be connected with PEA Grid at 33kV network so that governor shall be capable for operating responding to deviation in frequency of 0.05 Hz and greater. It shall be capable of responding to load changes greater than 5 percent of rated capacity of initiating servomotor movement within 0.2 s and also load fluctuations of 5 to 10 percent rated capacity by damping the fluctuation to 10 percent of the initial fluctuation within 10.0 s.
- (c) The governor shall include the facilities listed below:
 - (i) Means for adjusting and locking the damping time constant between zero and 4.0 s;
 - (ii) Means for adjusting the temporary speed droop from 10 to 60%;
 - (iii) Means for adjusting and locking the accelerometer time constant between zero and 3.0 sec;
 - (iv) Means for adjusting the governor speed setting over at least the range +5 percent to -10 percent of normal speed while operating or stationary;
 - (v) Means for adjusting the load set point from 0 to 110 percent of rated generator load for electro-hydraulic governor only
 - (vi) A guide vane stroke limiting device;



- (vii) Means for adjusting permanent speed droop to any valve between 0 and 6%;
 - (viii) Provision for adjusting and locking the openings and closing times of the guide vanes within a range incorporating a minimum time of 3.0 sec. If a stepped rate of guide vane closure is used there shall be provision for the independent adjustment of the position and timing of the step (s); and
 - (ix) A device for closing the guide vane as part of the stop and shutdown sequences.
- (d) Governor Cubicles

For an electro-hydraulic governor, the electronic equipment and governor controls and indications shall be located close to Turbine Control Instrument Cubicle. The cubicle for Governor Hydraulic Parts and PLC Controlled Electronic Parts shall be separately provided therefore the evidence for this such as **Location Layout of Equipment with detail Component List descriptions shall be submitted with the Bid.**

(3) Governor Oil Pumping System

- (a) A complete governor pumping system shall be provided for each unit. Each system shall supply hydraulic oil for the opening and adjusting guide vane servomotor and the inlet valve servomotor. The governor system shall be suitable for the same grade of oil as the bearings.
- (b) A separate oil and accumulator tank shall be designed and included in Governor Oil Pumping System as per ASME Boiler and Pressure Vessel Code, Section III to resist the maximum allowable operating pressure including pressure switches, level control devices, pilot control valves, adjustable unloader valves, oil strainers at suction line of each pump, safety relief valves, check valves, temperature relay and hand operated valve for the complete operation for both governor oil pumping system and inlet valve opening hydraulic unit.

The hydraulic P&I diagram showing the above components shall be submitted in the Bid indicating oil cooling equipment.

- (c) Duplicate AC motor-driven vertical pumps with motor suitable for operation at 380Vac, 50Hz shall be provided for normal and standby duty respectively complying with IEC standards IP 54 Class F Insulation. The duties shall be interchangeable while in service setting via Governor PLC (or) Lead/ Lag selector switch. The rated capacity of each pump shall be not less than 1.5 times of total oil volume of servomotors sufficient for all requirements of the system. Each pump shall be complete with at least its own components as per item (b) so that either pump may be withdrawn for maintenance without affecting operation of the other. The strainer shall be fitted with a differential pressure indicator to give indication of the need for cleaning.



The preliminary equipment layout arrangement drawing shall be submitted in the Bid to verify that Bidder complies the above requirements.

- (d) The governor pumping system shall include a pressure receiver and oil sump tank, each with oil level gauge (or) sight glass, one service manhole of dia 500 mm with suitable oil resistant gaskets, means for maintenance purpose. Charging and make-up air shall be provided by the compressed air system pursuant to Clause S5.02 where applicable. The pressure receiver tank shall be 25 times of the total volume of guide vane servo motor cylinder and inlet valve servomotor having sufficient capacity to the turbine to be started and brought to full speed at any time within 8 hours after the loss of electric power supply to the standby governor oil pump and with the normal pump not commencing to rotate until the unit reaches normal speed and in addition to one complete closing stroke from low oil level or low pressure shutdown with the oil pump not operating.
- (e) The governor and inlet valve oil pipework shall be arranged so that oil cannot drain from the servomotor cylinders, control valves or pipework when the oil pressure supply is off. Air release points shall be provided on the servomotors and where necessary, on the pipework. The oil pressure supply shall be automatically isolated from the governing and inlet valve systems when the unit is stopped.
- (f) The oil sump shall be fitted with a suction and return connection for oil centrifuge equipment.
- (g) Twin cartridge type strainers or an 'auto-clean' type strainer shall be fitted in the main oil pressure supply from the receiver. Each strainer shall be fitted with a differential pressure indicator to give indication of the need for cleaning. They shall be of sufficiently fine filtering capacity to prevent damage to any portion of the governing system by foreign matter. Cartridge type strainers shall be capable of being individually removed for cleaning without shutting down the governor.
- (h) A float valve or similar shall be fitted to the oil pressure supply connection in the pressure receiver to prevent release of air in the event of abnormally low oil level in the receiver. The float valve shall be arranged to permit oil to be delivered into the receiver when the oil is at any level.
- (i) Portable Oil Centrifuge Unit

One portable oil centrifugal unit of 400 L/h capacity shall be supplied to use in the station. The oil centrifuge unit shall be suitable for removing water, metal particles and other foreign matter from all lubricating and regulating oil systems. The unit shall be mounted on a rubber tyre trolley, shall be suitable for unattended operation and shall be supplied complete with:

- Motorized centrifuge unit, with all wetted parts of corrosion resistant material. All wearing parts shall be renewable.
 - Motorized pumps to feed dirty oil and to discharge treated oil from the centrifuge.
- 

- Electrical heaters with thermostatic control to bring the oil to the correct temperature for centrifuging.
- Regenerative heat exchanger to heat incoming oil and cool outgoing oil.
- Control panel with all necessary starter and heater controls.
- All necessary thermometers, pressure gauges, sight glasses and flow indicators.
- All necessary piping, valves, flexible suction and delivery hoses and tools.

The operation of the centrifuge unit shall be such as to minimize aeration, frothing and foaming of the oil.



SECTION 3
INLET VALVES

SECTION 3 - INLET VALVES

S3.01 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 0.8 m. diameter.
- (2) The main elements of the valve shall be of cast, forged or fabricated steel. 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 solid, rubber 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 leakage under a head of 179.43 m. 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 pipe line.
- (7) The Contractor shall provide steel pedestals to support the valve and transmit all loads from the valve to the floor slab.
- (8) The Bidder shall submit the layout dimensional arrangement of Inlet Valve and bypass valve together with dismantling pipes and drain pipe with the Bid.

S3.02 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 counter weight.



- (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 interests 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.

S3.03 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. The valve controls shall be kept as simple as possible consistent with their function.
- (2) Position indicators visible from the floor of the Machine Bay shall be provided for the by pass valve, inlet valve rotor and mechanical lock.

S3.04 BYPASS VALVE

- (1) The inlet valve shall be provided with a bypass valve, pipes and fittings, preferable around 100 mm diameter. The purpose of by-pass valve is to fill water into the nozzle and to balance the pressure between upstream and downstream side across the inlet valve, and the bypass valve shall be operated by AC motor when the nozzle and inlet valve are closed before starting the turbine-generator. A manually operated gate valve (normally open) shall also be provided together with bypass valve.
- (2) The bypass valve shall be mounted directly on the connecting pipe (or) valve body and shall be complete with a pipe connection to the isolating valve which shall be mounted directly onto the penstock. The bypass valves shall be operated automatically operate electrically using AC from PLC Control Command and



manually operated by hand wheel of gate valve. Means shall be provided to ensure positive segregation of oil and water circuits.

- (3) All wearing parts of the bypass valves including those susceptible to erosion or cavitation shall be renewable and those in contact with water shall be of stainless steel or bronze.

S3.05 DISMANTLING JOINT AND CLOSING PIECE

- (1) A flanged stub pipe and a welded closing piece shall be provided to connect the inlet valve to the terminal point of the penstock. The closing piece shall be compatible for welding to the penstock and shall be designed in accordance with the criteria used for designing the spiral case. For inspection and maintenance of the inlet valve, the penstock will be closed with a blind flange and the operation of the other unit can resume after a short interruption.
- (2) The closing piece shall include 150-200mm trimming allowance and shall incorporate connections for all equipment required to be connected to the pipeline under the Contract. The Contractor shall be responsible for trimming and fitting the closing piece and also for the making of the welded joints between the pipeline and the closing piece. These welds shall be subject to a 100 percent radiographic inspection.
- (3) A flanged dismantling joint shall be provided between the nozzle set and inlet valve. The dismantling joint shall be complete with nuts, bolts and jointing suitable for attaching to the inlet valve and nozzle set, 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.

S3.06 PRESSURE CONDUIT AND TURBINE DRAIN SYSTEMS

- (1) A 100 mm diameter manually operated gate valve and connecting pipes shall be provided with each turbine for draining water from penstock upstream to the tailrace. The conduit connection to penstock tappings shall be located upstream of the inlet valve in the stub pipe or closing piece. The embedded pipework provided by the civil works contractor shall be as shown on the Drawing.
- (2) **The Bidder shall submit the layout arrangement of Turbine, Inlet Valve, bypass valve and pipe arrangement shall be submitted with the Bid.**



SECTION 4

***TESTS FOR TURBINE, GOVERNOR INLET VALVE
AND AUXILIARIES, TURBINE MODEL TEST,
TURBINE FIELD EFFICIENCY TEST***

SECTION 4 - TESTS FOR TURBINE, GOVERNOR INLET VALVE AND AUXILIARIES, TURBINE MODEL TEST, TURBINE FIELD EFFICIENCY TEST

S4.01 TESTS FOR TURBINE, GOVERNOR, INLET VALVE AND AUXILIARIES

(1) Tests During Manufacture

Turbines, governors, inlet valves and auxiliaries shall be subject to the following tests at the Contractor's premises and according to manufacturer's standards with IEC regulations.

Contractor shall provide manufacturer's internal test reports such as balancing reports, material test reports (or) certificates during the factory witness test so that Witness Test Attendees shall verify comparing with shop drawings approved during engineering stage.

Calibration Certificates of testing instruments shall be provided together with Witness Test Reports.

Material Tests

- (i) Material tests on all important stressed components as defined in Clause S1.17 (2).
- (ii) Radiographic examination or ultrasonic examination of all major castings and forgings. The areas proposed for such examination shall be nominated by the Contractor when he submits drawings of the components concerned in accordance with Clause 4.06 of Volume 1 and shall be subject to the approval of the Engineer. The decision as to whether further examination is required shall be determined on the incidence of defective materials disclosed by the initial examination. The acceptability of the material shall be judged in accordance with American Society for Testing Materials, cracks and hot tears being 'unacceptable', severity level 2 for all other forms of defect being 'borderline', as defined in those Standards. Any areas found by these examinations to contain unacceptable defects shall be subject to re-examination after repair.
- (iii) Radiographic, ultrasonic examination and crack detection of welded components in accordance with Clause S1.17
- (iv) Crack detection of all castings and forgings.

(a) Hydrostatic Tests

- (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 in no case less than 7 kg/cm^2 .
- (ii) Leakage and deflection tests on all equipment stressed by pipeline pressure.
- (iii) Leakage tests with kerosene under gravity for all sump tanks.



(b) Tests on Unit Auxiliaries

- (i) Motors for unit auxiliaries shall be subjected to type and routine tests.
- (ii) All motor-driven auxiliary machines shall be run as complete units and tested for starting current, running current, power factor, bearing performance, gland tightness, noise and vibration.
- (iii) One auxiliary machine of each type for connection to the unit auxiliary system shall be tested to demonstrate satisfactory operation over the range of voltage and frequency which may occur in service including full-load rejection of the generator.

(c) Tests on Governors

Governor shall be tested as per IEC publication 308 for the governor. And test items to be submitted for approval by DEDE.

(2) Tests at Site

(a) Preliminary Tests

The preliminary tests for the turbines, governors, inlet valves and ancillaries shall include the following:

- (i) Radiographic (or) ultrasonic examination of all site welding parts as defined in Clause S1.17.
- (ii) Hydrostatic pressure tests on all pressure pipe systems. (The test pressures shall be respectively the same as specified in Clause S4.01 (1) (b) for the tests during manufacture).
- (iii) Insulation and continuity tests on wiring including tests for correctness of connection.
- (iv) Checking for correct operation of each control, protection and indication device.

(b) Tests on Completion

For the turbines, governors, inlet valves and ancillaries, the Tests on Completion shall include the following:

Tests for correct operation, control, indication and protection of all ancillary systems required to be in service for the operation of the turbine/generator units including:

- Oil Pumping System (Governor)
- PLC Controlled Governor system
- Unit PLC Control
- Inlet valve and bypass valve operation
- Cooling water supply system
- Drainage System
- Brake System
- Final alignment check for rotation parts
- All instruments feedback signals from field to Control Systems

When water from penstock available for test, Contractor shall start drain for penstock to assure that there is no external pieces inside penstock which may be harmful and cause damage to Turbine parts and Inlet Valve

No Load Heat Run Test, Load Heat Run Tests with Load rejection for different load % for 25, 50, 75 and 100% respectively and 50 Hours PEA Grid Connected Heat Run Test shall be performed for completion of Contract.

Contractor shall perform the followings during Commissioning Wet Test:-

- (i) Speed, pressure and frequency regulation tests.
- (ii) Check of pressure and output fluctuations.
- (iii) Tests of correct functioning of controls, protection and indicating equipment.
- (iv) Test to prove that the delivered turbine and related equipment are complying with the guaranteed efficiency and output as specified in the Contract.

(v) The relevant sections of the 'International Code for the Field Acceptance Tests of Hydraulic Turbines' IEC Publication 41 in so far as this code is consistent with this Specification and the conditions at Site, except that the tolerance shall be as stated in subparagraph (ii) of this paragraph.

(vi) Tolerances allowing for inaccuracies of measurement, the following tolerances shall be applied to performance figures ascertained from Tests on Completion.

- Momentary speed rise - $N \pm 2.0$ percent absolute.
- Maximum pipeline pressure - $N \pm 2.0$ percent of the ascertained figure.
- Power output - $N \pm 0.5$ percent of the ascertained figure.
- Inaccuracy of efficiency for field test of turbines shall not exceed ± 1.5 percent.

Tolerance according to IEC standards shall also be considered.

S4.02 TURBINE FIELD EFFICIENCY TEST

Field testing to verify the turbine efficiency and outputs shall be done by the Contractor after completion of all installation works and dry test. The test procedures, instrument used and date for the test shall be submitted to DEDE for approval.

Tests shall be carried out in accordance with the provisions set forth in "International Code for the field Acceptance Test of Hydraulic Turbines" (IEC Publication 41) and **the method, diagram and the instruments used for the test shall be submitted with the Bid.**

The Bidder shall indicate in his Bid at least two methods for measuring flow and shall submit drawings with located indication including necessary provisions for the penstock.

Failure to provide information may subject to the rejection of Bidder's Proposal.

All instrument and cost required for performing the test shall be at the Contractor's expenses. Testing instrument shall be calibrated by an independent institute/organization and it shall be submitted to DEDE for approval.

Should the result of the test show that the efficiency or the output is lower than the corresponding guaranteed value, all the liquidated damage costs relevant to the test shall be deducted from the Total Contract Price.



SECTION 5
MECHANICAL AUXILIARY EQUIPMENT

SECTION 5 - MECHANICAL AUXILIARY EQUIPMENT

S.5.01 UNIT COOLING WATER SYSTEM

(1) General Description

- (a) The Contractor shall provide one unit a separate cooling water system for supply to, and where necessary, the generating equipment of this plant during the unit is operating. The cooling water shall be close loop system in which the cooling water flow in the close system and exchange heat via plate heat exchanger for release heat to the tail water. The envisaged schematic arrangement of the unit cooling water system is shown on the Drawing. The details shown on the Drawing shall be taken as the minimum requirement. The items of Plant to be supplied by the unit cooling water system shall be for:
 - (i) bearing lubricating oil system(if required)
 - (ii) turbine shaft sealing (if required) and
 - (iii) Any other unit auxiliary requires a supply of cooling water while that unit is operating
- (b) The Contractor shall design and specify the flow requirements, size of piping required and the operating head of the system.
- (c) The Contractor shall submit the cooling water system diagram showing valves, and instrument and pipe sizes together with the Bid.

(2) Arrangement of Equipment

- (a) A stainless steel orifice for flow distribution adjustment, and a flow relay for flow indication and flow failure alarm, shall be provided. The system shall be complete with all pipes, valves, pressure gauges, flow control valves, air releases and drains.

(3) Type and Construction of Equipment

- (a) A.C. Motor Driven
A.C. motor driven isolating valve shall be controlled during turbine start and stop sequences.
- (b) Strainers (or) Filters (if applicable)
 - (i) The strainers (or) Filters shall be of the automatic and manually operated self-cleaning type, with mesh openings of not more than 3 mm and in any case small enough to exclude any foreign matter large enough to cause damage (or) blocking in any part of the system.
 - (ii) Any discharge from the strainers (or) Filters resulting from a backwash of flushing cycle shall be piped to drain. The mesh shall be of corrosion resistant material and the strainer bodies and covers shall be galvanized internally and externally.
 - (iii) The strainers (or) Filters shall each have an automatic air release valve with discharge piped to drain. The head across the strainer when 30 percent blocked shall not exceed 1.5 m of water.

- (c) Portable Chemical Feeder (Not applicable)
 - (i) Cooling water conditions may produce bacterial growth in the water passages of the various heat exchange systems.
 - (ii) A portable chemical feeder shall be provided to enable periodic injection of suitable concentration of hydro-chloric acid or sodium hypochlorite into each unit cooling water system in order to control the bacterial growth. It is expected that approximately ten parts per million residual chlorine will be required in the cooling water systems, however the chemical feeder shall provide for a range of feed rates which shall be fully adjustable.
 - (iii) The chemical feeder shall consist of a tank, pump, filter, check valve, pipes, swivel type injection connections for pipe coupling and other necessary instruments and shall be provided with a control panel, electrical cord and plug. The pump shall be of the positive displacement type driven by an electric motor. Two (2) flexible tubes shall be provided to connect the chemical feeder to the injection point in the cooling water system. The chemical feed unit and tank shall be mounted on a four wheel hand truck with pull bar and lifting eyes at each corner. The equipment shall be neatly arranged and provision shall be made for storing flexible tubes and electrical cord.
 - (iv) The chemical injection points for each unit cooling water system shall be located upstream of the Unit cooling water system and accessible from the machine hall floor level.
- (d) All piping for unit cooling water system shall be of seamless steel pipes with bolted flange connection.

S5.02 COMPRESSED AIR SYSTEM

(1) General Description

- (a) The common compressed air system will be used to supply operation air to the following equipment:
 - (i) Turbine governor pumping set oil/air pressure receivers (N₂ is applicable)
 - (ii) Maintenance service points at erection bay and machine bays and generator brakes.
- (b) The Contractor shall determine the capacity of compressor, primary chamber and air receiver, the normal operating pressure and pipe size so that the charging of a governor pressure receiver from atmospheric to working pressure can be achieved in 0.5 hours.

(2) Arrangement of Equipment

The system shall comprise two motorized air cooled compressors for normal and standby duty respectively. The duties shall be interchangeable while in service. Each compressor shall be included a silencer, intake, filter, governor type drainage valve, primary chamber, after-cooler, non-return valve and isolating valve delivering into the air receiver. The compressor shall be controlled by air pressure in the high pressure air receiver, connection of high and low pressure air receiver



shall be made by pressure reducing valve and solenoid valve which shall be controlled by the air pressure of low pressure air receiver. (N₂ is applicable)

The compressors shall be arranged to operate by automatic and manual control. The system shall be complete with all pipes, fittings and connections, manual valves, temperature and pressure gauges.

(3) Compressors

- (a) The compressors shall be continuously rated and of a reciprocating, air cooled pattern.
- (b) All working parts shall be replaceable.
- (c) The compressors shall be provided with after-cooler and, where necessary inter-coolers. They shall be air cooled and the tube nests shall be replaceable. The tubes shall be of corrosion resistant material. Each cooler shall be complete with moisture separator and automatic trap fitted with sight glass assembly.
- (d) Main bearings, and for reciprocating compressors, connecting rod and crosshead bearings shall be oil pressure lubricated by a pump mechanically driven from the compressor. Where separate cylinder or rotor lubrication is provided, the oil pump shall be mechanically driven from the compressor.
- (e) The pressure oil system shall include a suction strainer, sump level indicator and full flow strainer of either the replaceable cartridge or cleanable edge filtration type.
- (f) Crankcases shall be enclosed when the compressor is operating. Cooling jackets, air cowlings and crankcases shall have adequate access for cleaning and inspection.
- (g) Intake shall be provided with suction silences and an air cleaner of either the oil bath or replaceable cartridge type.
- (h) Compressors shall be fitted with protective devices to stop the compressor in the event of low oil pressure or high air delivery temperature.
- (i) Compressors shall be fitted with starting unloaders such that the unit reaches full speed before air delivery commences.
- (j) Motors and compressors shall be rigidly mounted on a common base plate to maintain correct alignment. All moving parts shall be enclosed. The base plate shall minimize the transmission of vibration to the foundation.

(4) Air Receivers and Air/Oil Receivers (N₂ is applicable)

- (a) Compressed air receivers and air/oil receivers shall be designed and constructed in accordance with ASME Standard.
- (b) The receivers shall be fitted with safety valves, pressure gauges and automatic and manual condensate drains.
- (c) The Contractor shall provide detailed shop drawings and calculations for the design of the receivers sufficient for the DEDE Engineer to check compliance with ASME requirements.



S5.03 VENTILATION AND AIR-CONDITIONING SYSTEMS (Not applicable)

General

- (a) The Contractor shall design, supply and install the ventilation and air-conditioning systems in the power station. The system shall comprise:
 - (i) Three (3) air conditioning split type ceiling mounting, each for the Control Room, 24,000 BTU-HR Sealed Energy Save No. 5.
 - (ii) Three (3) air conditioning, spit type for office 24,000 BTU-HR Sealed Energy Saving No. 5.
 - (iii) Individual ventilation systems for the following rooms:
 - Toilets - window mounted exhaust fan
 - Diesel Room - exhaust fan
 - Battery Room - exhaust fans
 - Control Room - supply/exhaust fans
 - Office Room - supply/exhaust fans
 - Switchgear Room - exhaust fan
- (b) Each system shall include control and indicating instruments and all electrical wiring.

S5.04 POWERHOUSE WATER DRAINAGE SYSTEM

(1) General Description

- (a) The station drainage pumping system shall consist of two sump pumps and motors each of 4 L/s capacity when operating in the drainage pit. Schematic arrangement of pumps and pipework is shown on Drawing.
 - (b) The drainage pumps will be used to remove normal seepage, drainage water, and spiral casing drainage water which will be directed by gravity drains into the drainage pit. The pumps shall be supplied with quick release couplings such that a pump can be removed and used as a portable pump for drainage of a draft tube. The pumps will also be used to drain the inlet valve pits under emergency conditions such as a burst connection from a pressure conduit. The Contractor shall determine the size of piping required and the head against which the pump must operate to enable complete drainage of a turbine draft tube.
 - (c) The drainage water may vary from the normal site 'clean' condition to a condition where it contains silt, small suspended material and contaminants such as lubricating oil, kerosene and grease in concentrations up to approximate 150 ppm.
- (2) Arrangement of Equipment: The system shall comprise two drainage pumps each with its own discharge piping, pressure gauge, check valve, and gate valve. The pumps shall operate under both manual and float switch control. The float switches shall be arranged to operate in accordance with levels. The duties of the two normal drainage pumps shall be interchangeable by manual controls.



(3) Type and Construction

- (a) The pumps shall be submersible, bottom suction, vertical shaft units with quick release coupling suitable for operating while submerged for indefinite periods and after being stationary for long periods. The design and construction of the motors shall prevent the entry of external water, foreign material or contaminants into the motors or their cooling systems under all conditions.
 - (b) The pumps shall be held with guide rail in the pit and can be remove by sliding up along the guide rail.
 - (c) The pumps shall be driven by 230Vac, single-phase motors. Provision shall be made for replenishing the cooling lubricant if required.
 - (d) The float switches shall be suitable for submerged operation. They shall be mounted in a vertical steel pipe which shall be located in the drainage pit. Off takes from the sump to the float switch pipe shall be equipped with mesh strainers. The float switch pipe complete with float switches shall be arranged so that it may be easily removed form the drainage pit.
- (4) Piping and Fittings: The Contractor shall supply duplicate galvanized piping together with all steelwork and fittings for locating the pumps and float switch pipe within the drainage pit.

S5.05 PORTABLE FIRE EXTINGUISHERS

- (1) The Contractor shall supply portable fire extinguishers complying with accepted standards. Each extinguisher shall be mounted on suitable bracket on the wall at location to be advised by the DEDE Engineer.
- (2) Extinguishers shall be red with a glossy baked enamel finish, chrome-plated trim and safety pin.
- (3) The following table lists the quantities of portable fire extinguishers required. For those type of extinguishers where it is possible to supply either a model which can be refilled on site or a model which must be returned to a factory for refilling, the model which can be refilled on site shall be supplied, fully charged on complete with one (1) spare refill for each extinguisher.

TABLE S5.05-1
FIRE EXTINGUISHERS

Location	Minimum Capacity	CO ₂	Dry Chemical
Erection bay	6 kg	1	1
Control room	6 kg	2	1
Office area	6 kg	1	-
Diesel room	6 kg	1	1
Machine bay	6 kg	2	1
Battery room	6 kg	1	-
Store room	6 kg	1	1
Switchgear room	6 kg	1	1

S5.06 OVERHEAD TRAVELING CRANE

(1) Type and Rating

- (a) The Contractor shall provide an electrically driven, pendant controlled, overhead traveling, and top running bridge type crane for the Powerhouse, together with a set of crane rails, longitudinal travel collector wires and associated equipment, four end buffers for the longitudinal travel and permanently fixed ladder and platform for routine maintenance.
- (b) The capacity of the crane shall not be less than 25 tons however the Contactor shall design and supply depending on the heaviest part of equipment to be lifted during erection and maintenance of the equipment inside this station.
- (c) The crane shall be design, constructed, erected and commissioned in accordance with CMAA or equivalent standards.
- (d) The height of lift of the crane and the limits of traverse and travel of the crane hook shall be determined by the Contractor and shall be sufficient for all erection and maintenance operations on the Plant in the Powerhouse Machine Bay.
- (e) The limits of lifting traverse and travel of the crane hook shall give the maximum possible coverage within the Powerhouse.
- (f) The crane will constitute a prominent feature of the Powerhouse and shall be designed to present an appearance aesthetically in keeping with this role and with the interior architecture of the Powerhouse.

(2) Operating Requirements

- (a) The crane shall have electrically driven hoisting (two speeds), traversing and traveling motions controlled by a low voltage push-button pendant. The pendant shall be movable horizontally along the crane bridge and located vertically for operation from the machine bay floor.
- (b) The operating speeds of the crane shall be within the following ranges:

Hoist	Normal	0.050 m/s
	Creep	0.005 m/s
Traverse	Normal	0.33 m/s
	Creep	0.08 m/s
Travel	Normal	0.60 m/s
	Creep	0.16 m/s
Minimum Height of Lift		10 m (approx.)

(3) Crane Runway

- (a) General
The Contractor shall supply and install all sole plates and anchor bolts for the crane rails, longitudinal travel buffers and limit switch strikers.
- (b) Span
The span of the crane runway rails measured centre to centre shall be $9.0 \text{ m} \pm 2 \text{ mm}$.
- (c) Rails
The crane runway shall consist of jointed flat bottom rail and shall be installed to within $\pm 2 \text{ mm}$ of level for its full length. Each section of each crane runway

10'

rail shall be interconnected and the rails shall be connected by grounding conductors to the Powerhouse grounding system.

(d) Longitudinal Travel Buffers

Four longitudinal travel buffers complete with soleplates and holding down bolts shall be supplied and installed by the Contractor, one set for each end of the runway.

(e) Longitudinal Travel Limit Switch Strikers

Two longitudinal travel limit switch strikers shall be supplied and installed by the Contractor. These shall be positioned to provide a possible overrun of 150 mm when the limit switched trip.

(4) Construction Requirements

(a) Crane Structure

(i) The crane shall be of fabricated steel construction. The bridge shall consist of one main girders connected together at each end by means of a substantial cross beam. The vertical deflection caused by the rated load plus the trolley shall not exceed length/ 1,000 of span. Floor plate walkways and steel handrails shall be provided, and shall be suitable for routine maintenance of crane parts. The securing of the main girders to end carriages shall be by high tensile bolts and nuts to assure correct alignment and easy erection.

(ii) The complete bridge structure shall be mounted on end carriages. Each end carriage shall contain wheels which rotate on antifriction bearings mounted on simply supported axles. The design of each end carriage shall be such that easy inspection and wheel removal is possible. In the event of a wheel shaft breaking it shall not be possible for the crane and carriage to drop more than 33 mm.

(iii) Four travel buffers shall be attached to the outer bogies; one for each can stop at the end of each crane runway.

(b) Longitudinal Travel Mechanism

The longitudinal travel drive units shall be identical motorized geared units ensuring smooth operation of the longitudinal travel. The high precision gears of these units are run in the oil bath. Each drive unit shall be equipped with the electro mechanical brake operators according to the sliding rotor principle which shall be capable of being replaced without removing other components. The brakes shall be capable of being applied gradually to minimize swaying of the load and shall operate automatically when the supply to the motor is interrupted. The travel motor is designed as a drive unit for acceleration and safe deceleration of high-inertia load.

(c) Low Headroom Monorail Hoist

(i) The hoist motor shall drive the hoist drum by central drive. The hoist drive shall be fitted with an automatic, spring applied, energized to release, brake. The hoisting drum shall be steel or cast iron and shall have accurately machined grooving to accommodate the hoisting rope in single layers. The hoisting rope shall be performed, non-rotating construction.

(ii) The hook of the crane fall block shall be of swiveling type, supported on a ball or roller thrust bearing. The fall block shall be provided with shrouded



sheaves. The fall block sheaves, compensating sheaves, and reeling return sheaves shall have machined grooves and shall be mounted on ball or roller bearings.

- (iii) The motor torque is transmitted to the reduction gear through a flexible coupling to cushioning high starting torque peaks.

The minimum breaking strength of the rope shall be not less than five (5) times the hoist's rated load.

(d) General

- (i) All gearing other than final drives, shall be enclosed in gear cases. The gearboxes shall be fitted throughout with ball or roller bearings. Gearing shall be designed in accordance with the AGMA Class II with a minimum service factor of 1.25.
- (ii) All shafting to which gears, pinions and other similar parts are fitted, shall preferable be provided with a raised portion and/or shoulder where such parts are carried. Any change of section of shaft shall be effected with fillets of ample radius.
- (iii) All bearings and other wearing surfaces shall be provided with means for lubrication, preferably by automatic circulation. Points for lubrication by grease gun shall be suitable for the same make and grade of grease and shall each be provided with a separate grease nipple of the all steel, one piece button-head type. All grease nipples shall be readily accessible and grouped wherever possible. Removable; sheet steel guards shall be provided for open gearing.
- (iv) All gear boxes, motors, bearings, etc. shall be positively located after alignment, other than by their holding down bolts.
- (v) All platforms shall have 75 mm high kick strips at their edges.

(e) Electrical Equipment

- (i) All electrical equipment shall be suitable for operation from the 400 V, 50 Hz three-phase four-wire supply from the AC Station Service Distribution Board. The Contractor shall provide, on the crane, adequately rated single phase transformers, suitable for continuous operation for the supply of power to the control circuits, lighting and power outlet circuits and 'POWER ON' indicator light circuits.
- (ii) The electrical power supply to the crane shall be by means of three shrouded hard drawn copper collector wires supported by brackets, attached to the building above crane runway level. Red indicator lights shall be installed between phases at the end of the collector wires to show that collector wires are energized. The Contractor shall supply and install the collector wires, three collectors or renewable carbon head type, and all necessary and strainers, brackets, insulators, collector wire guards, and other fittings, together with a 'lock-off' type isolating switch and all wiring and conduit from this switch to the point of connection to the three longitudinal collection wires. The isolating switch shall be labeled 'CRANE ON/OFF'.
- (iii) All motors shall be half-hour rated for the required duty cycle.
- (iv) A control and protection panel enclosed in a cabinet, of dustproof, sheet metal construction, incorporating a hinged door and hinged panel, shall be mounted on the crane bridge. The equipment shall include an



externally operated triple-pole main isolating switch, triple-pole main contactor, triple-pole ganged magnetic overload relays for each motor and all necessary fuses, control switches and wiring for the motors, control circuits, and one single-phase switched socket outlet. A 'POWER ON' indicating light shall be fitted to the cabinet.

- (v) A fall block operated, whole current over hoisting limit switch shall be provided for the hoist. In addition, a shunt type limit switch shall be fitted to the hoist to limit the travel in the 'raise' and 'lower' directions. Shunt type limit switches shall be provided also for the cross-traverse and longitudinal travel motions. All limit switches shall be self-resetting and shall be electrically connected in a manner permitting 'backing out' after tripping.
- (vi) The traverse power take off shall consist of an approved trailing cable system. An isolating switch shall be provided at the point of entry to the crab platform. This switch shall isolate the cross-traverse motion and shall be labeled "CROSS TRAVERSE-ON/OFF".
- (vii) All crane wiring shall be installed in screwed conduit.
- (viii) The control pendant shall preferable operate at 24 V but not more than 50 V. The push buttons shall return to the off position when pressure is released. The pendant shall include a power on/off switch. The buttons for each motion shall be grouped together and shall be logically identified. The electrical conductors to the pendant shall not be used to support its weight. The pendant shall incorporate a 'power on' indicating light.

S5.07 DIESEL-DRIVEN STANDBY ELECTRIC POWER SYSTEM

(1) Scope

The work to be done under this section includes the design, manufacture, supply, shop testing, delivery, and the installation, testing, initial operation and complete with auxiliaries, capable of fully automatic black start and loading.

The work to be finished by the Contractor shall include the following.

- (a) Diesel Engine
 - Diesel engine
 - Governor
 - Fuel oil system
 - Lubricating oil system
 - Cooling system
 - Air intake system
 - Exhaust system
 - Engine starting system, including battery and automatic charger
 - Engine protective devices and instruments and control panel
 - (b) Generator
 - Generator
 - Excitation system
- 

- Generator protective devices
- Generator instruments, and control panel
- (c) Steel Base for Unit Mounting
 - Steel base
 - Vibration dampeners
 - Oil drip pan covering full length of base

(2) Application

In the event of a failure of the incoming power, the diesel engine driven generator set will automatically start and be used to provide standby electric power to assist in starting hydro-generating unit. The ambient air has H₂S present and equipment shall be designed accordingly.

(3) Requirements for Design

The rating of the generator, and thus the diesel, shall be suitable for the following duties.

- (a) The base continuous load that the diesel shall carry at all times will be the essential and emergency lighting, communication equipment, 2 battery chargers, cooling water system supply, 1 control building air conditioner and condenser unit, the town site water pump, guardhouse power supply and 1 station air compressor.
- (b) The diesel generator must be capable of starting the largest motor on the essential services distribution panel board with a base continuous load as specified in (a).

Preliminary sizing of the diesel generator indicates that 125 kVA at 0.8 PF is required. Final rating selection shall be made by the Contractor based on detailed load calculations.

The unit shall be capable of starting and loading automatically, as required, and of supplying an isolated load. Final design and rating shall be approved by DEDE.

(4) Diesel Engine and Auxiliaries

(a) Diesel Engine

The diesel engine shall be capable of operating on normal diesel fuel and shall not require premium diesel fuel for satisfactory performance. The engine shall be rated to produce required output at 45°C ambient temperature and 99 percent relative humidity.

The diesel engine may be either normally aspirated or supercharged.

The engine and generator shall be supplied complete with a common bedplate suitable for mounting on a concrete foundation. Adjustable steel spring type vibration isolators with sound pads shall provided for mounting between the unit base and concrete foundation. A suitable oil drip pan shall be provided under the full length of the diesel and generator to catch oil leakage.



(b) Governor

The engine shall be equipped with a suitable governor for 50 Hz operation.

The engine shall have a separate overspeed trip device to stop the engine in the event of the engine exceeding its safe speed.

(c) Fuel Oil System

This system shall include for one 120 L, standard indoor fuel tank complete with fill-connecting piping, vent pipe, level indicator, low-level alarm, cradles and supporting structure, mounted for gravity feed to the engine pump. The system shall be complete with all interconnecting fuel oil piping and flexible connections. One hand-operated fuel pump shall be provided for pumping fuel from barrels to fuel tank.

(d) Cooling System

The cooling system shall be air-cooled or oil cooled with shaft driven air fan.

(e) Air Intake System

This system shall include an engine air cleaner, complete with support structure, intake piping, flexible connections and piping supports as required. The filter elements of the air cleaner shall be of a washable type. A differential pressure indicator shall be provided across the filter to indicate when the filter elements require cleaning.

(f) Exhaust System

This system shall include a muffler, complete with support structure, exhaust piping, flexible connections, pipe supports, and insulation for exhausting from building. The muffler is to be located inside the building. The exhaust system inside the building shall be suitably insulated over its entire length. Noise is a critical factor and the Contractor shall include the best muffler system available.

(g) Starting System

This system shall include a heavy-duty starting motor, regulator, batteries of ample capacity, battery rack, jumpers, cables and 2-rate automatic battery charger.

(h) Protective Devices

The engine shall be provided with all necessary protective devices, safety features and controls which shall include, but not be limited to:

- Low oil pressure cutout
- Automatic over speed shutdown
- Over crank shutdown

(i) Control Panel

The engine control panel shall be mounted on the unit and shall include, but not be limited to, the following instruments and controls.

- Complete engine automatic starting controls, including a test switch
- Safety devices
- lubricating oil pressure gauge
- lubricating oil temperature gauge
- Tachometer/hour-meter
- Start-stop automatic switch
- Automatic-manual control selector switch
- Cranking limiter
- Individual signal lights, manual resets, and common alarm terminal.

Remote alarm annunciator shall be provided in the control room.



(j) Special Tools

The Contractor shall supply one set of any special tools necessary for the complete servicing and maintenance of the engine and all auxiliaries. The Contractor shall provide one barrel hand pump with all hoses, connectors and fittings to fill the storage tank from standard fuel oil barrels. .

(5) Generator and Exciter

(a) Generator and Exciter

The generator shall have a continuous rating of 125 kVA, 0.8 PF, 400/230V, 3-phase, 4-wire, 50 Hz, and shall be capable of operating at 110 percent load at rated power factor and frequency for a minimum of 1 hour.

The unit shall be suitable for operation in a tropical climate, as stated in previous sections of the Specifications.

The generator shall be equipped with a direct coupled, brushless or static exciter, designed and rated to match the generator characteristics.

(b) Construction

The generator and exciter shall be air-cooled, self-fan, ventilated type, in a drip-proof enclosure.

Winding insulation shall be Class F.

The generator shall be provided with a full amortisseur winding.

(c) Voltage Regulator

A solid-state voltage regulator shall be supplied, capable of maintaining the output voltage within 1 percent of the rated voltage over the full operating range of the generator. Provision shall be made for manual adjustment of the regulated output voltage from 10 percent below to 10 percent above the nominal rated voltage.

(6) Generator Control Panel

A totally enclosed sheet steel control panel with front hinged access door shall be supplied to house the following generator control equipment:

- AC voltmeter and ammeter with selector switch
- Automatic voltage regulator
- Frequency meter (48 to 52 Hz)
- Protection relays
- Battery, Charger with charging ammeter and voltmeter
- Automatic control and timing relays as required performing the functions of start/ stop diesel generator, closing generator breaker (located in AC station switchgear) when generator is up to normal frequency and voltage



The starting and stopping functions shall be controlled through separate timing relays to permit adjustable delay in starting and stopping over a range of 0.1 seconds to 10 minutes by both Locally or HMI PLC.

(7) Equipment Bases

The Contractor shall supply and install all equipment concrete bases. Final setting on bases shall be cement grout. The Contractor shall provide connecting bolts, gaskets, leveling shims and washers, and shall supply the anti-vibration mounts for the diesel-generator unit and auxiliaries.

Each piece of equipment shall be installed strictly in accordance with the manufacturer's instructions. The complete initial lubrication of all equipment, including all gear cases, sump, and other oils shall be provided by the Contractor.

All equipment shall be factory painted in keeping with the requirement of Clause S1.11.

