



งานปรับปรุงประสิทธิภาพและเพิ่มกำลังผลิต
โครงการไฟฟ้าพลังน้ำห้วยประทาว (เขื่อนล่าง)
ตำบลท่าหินโงม อำเภอเมืองชัยภูมิ จังหวัดชัยภูมิ

โครงการปรับปรุงเพื่อเพิ่มประสิทธิภาพเขื่อนห้วยประทาว
HUAH PRA THAO DAM EFFICIENCY ENHANCEMENT PROJECT

เอกสารหมายเลข 2
VOLUME 2
ข้อกำหนดทางด้านเทคนิค
TECHNICAL SPECIFICATIONS

ส่วนที่ 2
PART 2
งานอุปกรณ์เครื่องจักรกล-ไฟฟ้า
ELECTRO-MECHANICAL EQUIPMENT

งานปรับปรุงประสิทธิภาพและเพิ่มกำลังผลิต
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เอกสารประมูลจ้างด้วยระบบอิเล็กทรอนิกส์
เอกสารหมายเลข 2 : ข้อกำหนดทางด้านเทคนิค
ส่วนที่ 2 งานอุปกรณ์เครื่องจักรกล-ไฟฟ้า

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อุปกรณ์ไฟฟ้า&เครื่องกล ที่โรงไฟฟ้าพลังน้ำเขื่อนล่ง

SECTION 1 - GENERAL

1.1 GENERAL REQUIREMENT

- (1) These General Specifications apply to all Volume 2/2 equipment, materials, devices & components, including pre-engineering or bought-out items, procedures, methods, techniques, and workmanship contained in the Volume 2/2 Technical Specifications whether referred to specifically or not.
- (2) Where the other Technical Specifications in Volume 2/2 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 DEDE.
- (6) Old equipment that needs to be dismantled and moved out in order to install new equipment as listed in scope of work will be collected, tabled and delivered to DEDE.

1.2 SERVICE CONDITIONS

All the equipment shall be designed and manufactured for its particular location for continuous operation at the extremes of climate as

All equipment to be installed indoors shall be designed and manufactured for satisfactory continuous operation at an ambient temperature of 40° C

All equipment to be installed outside but under roof shall be designed and manufactured for satisfactory continuous operation at an ambient temperature of 45 ° C.

Equipment supplied outdoor shall be designed for satisfactory operation at an ambient temperature of 60° C.

1.3 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
PEA.	Provincial Electricity Authority of Thailand

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.

1.4 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 Celsius	°C	
Force	Gram	g	
(weight)	kilogram	kg	
	tonne	t	kg x 10 ³
Pressure	kilogram per square centimeter	kg / cm ²	
Material Strength	Kilogram per square centimetre	f (y) f (u)	minimum yield point 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

1.5 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) any tools necessary for changing lamps for instruments of control panels; (ix)
 - (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) Thermal infrared camera 320*240 High-Resolution, Temperature range: -20 ~300 oC or better.
 - (g) One (1) set of disc grinder 100 mmØ, AC 1Ø, 230 V, 50 Hz.
 - (h) One (1) set of cordless drill machine Quick lock 13 mmØ DC.
 - (i) One (1) set of electric hammer drill rotary lock 20 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.
- (l) One (1) charging kit for connection to a standard nitrogen gas bottle.
- (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.

1.6 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.

1.7 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 use Thai or English 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 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 S1.07, 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 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.

1.8 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.

1.9 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.

1.10 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.

1.11 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.

1.12 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.

1.13 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.

1.14 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 conductive 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 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.
- (7) Rubber seal :Store rubber objects in airtight avoid exposure to UV light containers. Keep Rubber From Cracking; Protect and Preserve.

1.15 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 with in 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.

1.16 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 scrabbling 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 of 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.

1.17 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.

1.18 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 there of 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.

1.19 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/cm². Pipes of 25mm. diameter and less for working pressures exceeding 7 kg/cm² 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.

1.20 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.

1.21 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.

1.22 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.

1.23 TEST, GENERAL REQUIREMENTS

(1) 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.

1.24 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
- (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 near 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 area 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 m². 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

1.25 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.

The Contractor shall provide a lecture working and operation to other relevant parts about 25 persons at Bangkok or province THAILAND for 2 days. The cost of these services shall be included in the Contract Price.

SECTION 1

GENERAL

SECTION 2 – อุปกรณ์ไฟฟ้า&เครื่องกล ที่โรงไฟฟ้าพลังน้ำเขื่อนล่าง

2.1 หม้อแปลงไฟฟ้า

2.1.1 ทัวไป

หม้อแปลงไฟฟ้าต้องผลิตและทดสอบตามมาตรฐานของ IEC และเป็นไปตามมาตรฐานของประเทศไทย

2.1.2 ขอบเขต

ผู้รับจ้างต้องจัดหาและติดตั้งหม้อแปลงไฟฟ้าตามชนิดที่ระบุในแบบและอุปกรณ์ประกอบการติดตั้ง จะต้องจัดให้มีหม้อแปลงไฟฟ้า เพื่อรับพลังงานไฟฟ้าจากระบบจำหน่ายไฟฟ้า 22 kV ของ กฟภ. แปลงเป็นระบบไฟฟ้าแรงต่ำ 400 V จ่ายไฟให้กับอาคารควบคุมน้ำเข้าโรงไฟฟ้า และอาคารควบคุมน้ำลงลำน้ำเดิม ผู้รับจ้างจะต้องจัดหาและติดตั้งหม้อแปลงไฟฟ้าชนิด Oil Immerse Type สำหรับใช้ภายนอกอาคาร ติดตั้งบนนั่งร้านเสาคู่ ตามตำแหน่งที่ระบุในแบบและให้เป็นไปตามมาตรฐานของการไฟฟ้า ขนาดของนั่งร้านจะต้องสามารถรองรับขนาดและน้ำหนักตามหลักวิศวกรรม

2.1.3 ความต้องการทางเทคนิค

พิกัด หม้อแปลงต้องมีคุณสมบัติและสมรรถนะดังต่อไปนี้

- Number of units: 3
- Rated output: 100 kVA 1 set สำหรับจ่ายไฟให้กับระบบไฟฟ้าในอาคารควบคุมน้ำ
- Rated frequency: 50 Hz
- Rated voltage: HV side 22 kV, LV side 400 V
- Insulation level of winding and accessory equipment: as per IEC standard
- Efficiency: as per IEC standard
- Transformer winding: Copper
- Cooling type: Oil Cooled, Self-Cooled
- Transformer tank: steel plate or corrugated tanks
- Transformer type: Conservator or Hermetically Seal tank
- Vector group: Delta-Wye
- Impedance: not more than 6 %
- Top oil temperature rise: 60°C (design value)
- Winding temperature rise: 65°C (design value)
- Tap changer: Off-circuit tap change on HV side, $\pm 2 \times 2.5$ %
- Audible sound level: as per IEC standard
- Applicable standards for design, manufacturing and testing: IEC standard

คุณสมบัติและสมรรถนะอื่นๆ ดังนี้

- แกน ฉนวน แคลมป์ ฯลฯ จะต้องมีการออกแบบที่ทันสมัยที่สุดในขณะที่ขดลวดทองแดงจะต้องได้รับการออกแบบให้มีแรงดันอิมพัลส์และความเค้นของไฟฟ้าลัดวงจร วัสดุจะต้องได้รับการยอมรับหลังจากได้รับการอนุมัติจากผู้ควบคุมงานของผู้ว่าจ้าง
- ขั้วต่อสายแรงสูงต้องทำสำหรับใช้ต่อกับสายไฟฟ้าแรงสูง ตามมาตรฐานของการไฟฟ้าฯ

- ขั้วต่อสายแรงต่ำ ต้องทำสำหรับใช้ต่อกับสายไฟฟ้าแรงต่ำ และขั้วต่อสายศูนย์ต้องทนกระแสได้เท่ากับขั้วสายเฟส
- ตู้หม้อแปลงไฟฟ้าต้องออกแบบให้สามารถระบายอากาศ และป้องกันฝุ่นได้เป็นอย่างดีโดยไม่ทำให้เกิดของหม้อแปลงลดลงหรืออุณหภูมิสูงเกินกว่าที่กำหนด ในกรณีที่ตู้หม้อแปลงทำภายในประเทศต้องประกอบตามแบบและคำแนะนำของผู้ผลิตหม้อแปลงทุกประการ
- หม้อแปลงแต่ละตัวต้องมีอุปกรณ์ลดแรงดันทางกลที่ติดตั้งฝาครอบซึ่งออกแบบมาเพื่อบรรเทาแรงดันที่เป็นอันตรายซึ่งอาจสร้างขึ้นภายในถังหม้อแปลงไฟฟ้า และจะกระตุ้นสัญญาณเตือน AndGetฐานต้องมีชุดล้อเลื่อนให้สามารถเคลื่อนที่ได้ หรือสามารถหมุนได้อย่างน้อย 90 องศา
- ต้องมีตัวปิดวงจรที่ดำเนินการได้จากภายนอก สำหรับการเปลี่ยน HV taps ภายใน ในกรณีเมื่อหม้อแปลงไม่มีไฟฟ้าผ่าน
- หม้อแปลงไฟฟ้าแต่ละตัว จะเป็นต่อกล่องขั้วสายไฟแบบระบบปิด ทนต่อสภาพอากาศ สามารถมีการเชื่อมต่อได้ ทั้งสำหรับไฟฟ้าแรงสูงและแรงต่ำ
- น้ำมันฉนวนต้องเป็นไปตามข้อกำหนดทั้งหมดของมาตรฐาน ASTM (ASTM D3487 และ D1275) ซึ่งจำกัดค่าปัจจัยการกัดกร่อนที่มีฤทธิ์กัดกร่อนคือ 1A หรือ 1B) และต้องมีปริมาณสารยับยั้งการเกิดออกซิเดชันสูงสุด 0.3% โดยมวล หม้อแปลงไฟฟ้าจะต้องมีปริมาณน้ำมันเพียงพอ เพิ่มร้อยละ 10 เพื่อเติมถังหม้อน้ำและบุชชิงแต่ละถังให้อยู่ในระดับที่เหมาะสม น้ำมันจะต้องจัดส่งในถังเหล็กและจะต้องเป็นผลิตภัณฑ์ปิโตรเลียมกลั่นที่เป็นไปตามข้อกำหนดที่เท่าเทียมกันหรือได้รับการรับรองต่อไปนี้เมื่อทดสอบตามมาตรฐาน ASTM D-117 หรือ IEC 60296
- เกจวัดระดับน้ำมันชนิดแม่เหล็ก มีเตือนระดับน้ำมันต่ำและสูง มาตรฐานต้องสามารถอ่านได้จากระดับฐานของหม้อแปลงไฟฟ้า และช่วงระดับน้ำมันต้องสอดคล้องกับอุณหภูมิน้ำมันระหว่าง 15°C ถึง 90°C โดยมีระดับน้ำมันที่ 30°C ระบุไว้อย่างชัดเจน
- ถ้ามี การรวมตัวของก๊าซและแรงดันน้ำมันกะทันหัน รีเลย์ Buchholz, ฟันลอยคู่, ตัวเตือนแผ่นดินไหว ข้อกำหนดนี้ควรจะใช้สำหรับหม้อแปลงรูปแบบดั้งเดิม ตามมาตรฐานผู้ผลิต
- อุปกรณ์สำหรับการเตือนภัยทั้งหมด ควรจัดไว้ 2 ส่วนที่ไม่ได้ลิงกราวด์ วงจรแบบปิด แบบอิสระทางไฟฟ้าเหมาะสำหรับ 125 VDC ต้องใช้ความระมัดระวังเพื่อป้องกันอุปกรณ์เหล่านี้ จากสภาพอากาศและจากความชื้น อุปกรณ์ไฟฟ้าจะต้องเดินสายในท่อเหล็กกับตู้ขั้วต่อบนหม้อแปลงแต่ละตัวซึ่งสามารถเชื่อมต่อกับวงจรภายนอกได้อย่างสะดวก จะต้องระบุการเดินสายขั้วต่อบนแผงขั้วต่อที่ติดตั้งแยกกำหนดและติดตั้งในกล่องขั้วต่อแบบแยกเดี่ยวที่ด้าน LV ลิงค์ที่ถอดออกได้หรืออุปกรณ์ตัดการเชื่อมต่ออื่น ๆ จะต้องจัดเตรียมตามความจำเป็น วงจรที่มีแรงดันไฟฟ้าต่างกันจะต้องแยกจากกันโดยแยกสิ่งกีดขวาง ต้องจัดให้มีฉนวนท่อร้อยสายไฟภายนอกหรือต่อสายเคเบิลจากกล่องขั้วต่อ
- แผ่นป้ายบอกรายละเอียดต้องเป็นเหล็กกล้าไร้สนิมที่ติดอยู่กับหม้อแปลงแต่ละตัวในตำแหน่งที่มองเห็นได้ชัดเจนแก่ผู้ใช้เครื่อง การทำเครื่องหมายแผ่นป้ายต้องเป็นไปตามมาตรฐาน IEC ที่เกี่ยวข้องและต้องเป็นภาษาอังกฤษ

2.1.4 การติดตั้ง

ต้องเป็นไปตามคำแนะนำของบริษัทผู้ผลิต ตามมาตรฐานการติดตั้งสำหรับประเทศไทย และของการไฟฟ้าฯ และตามที่ได้แสดงไว้ในแบบทุกประการ โดยติดตั้งบนนั่งร้านเสาคู่ เมื่อติดตั้งแล้วเสร็จให้ตรวจสอบฉนวนไฟฟ้า รวมทั้งตรวจสอบโดยการไฟฟ้าฯ ถ้าหากมีสิ่งใดที่ต้องแก้ไขเพื่อให้ผ่านการตรวจสอบดังกล่าว ผู้รับจ้างต้องแก้ไขให้ถูกต้องโดยไม่คิดค่าใช้จ่ายใดๆทั้งสิ้น

2.1.5 การทดสอบที่โรงงาน

หม้อแปลงต้องผ่านการทดสอบมาจากโรงงานผู้ผลิต และมีหนังสือรับรองผลการทดสอบจากโรงงานผู้รับจ้างต้องรายงานผลการทดสอบดังกล่าวต่อการไฟฟ้าฯ และผู้ว่าจ้างเพื่อพิจารณาอนุมัติ ให้ผู้รับจ้างส่งหนังสือรับรองดังกล่าวให้ผู้ว่าจ้าง 3 ชุด ให้ทำการทดสอบต่อไปนี้กับหม้อแปลงแต่ละตัว

- a. Leak test for 24 hours
- b. Resistance measurement of each winding.
- c. Turn ratio at all taps.
- d. Polarity and phase relation.
- e. Audible sound level.
- f. Efficiency. (25%, 50%, 75% and 100% rated load)
- g. No-load losses.
- h. Excitation current.
- i. Temperature rise test on main transformer.
- j. Dielectric tests on windings
- k. Impulse tests on all line and neutral terminals.

ผู้รับเหมาต้องจัดให้มีหลักฐานว่าหม้อแปลงที่มีการออกแบบ ความจุ และชั้นฉนวนเหมือนกับที่ระบุไว้ในที่นี้ ได้รับการทดสอบแรงกระตุ้นสำเร็จแล้ว และหากหลักฐานดังกล่าวพิสูจน์ได้ว่าไม่เป็นที่พอใจต่อผู้ว่าจ้าง การทดสอบแรงกระตุ้นตามมาตรฐาน IEC จะต้องดำเนินการโดยผู้รับเหมา โดยไม่มีค่าใช้จ่ายใดๆ เพิ่มเติมทั้งสิ้น

2.1.6 การทดสอบที่สถานที่ก่อสร้าง

การทดสอบต่อไปนี้จะต้องได้รับการตรวจสอบบนหม้อแปลงแต่ละตัวหลังการติดตั้ง

- a. Damage incurred in shipment
- b. Inspect bushings for chips or cracks
- c. Inspect all gaskets, fittings and radiators for leaks
- d. Check liquid level
- e. Check out and test control wiring
- f. Check no-load tap changer for proper movement
- g. Check operation of temperature indicator, pressure relay and other devices
- h. Check operation of pressure relief valve as recommended by the manufacture
- i. All transformers shall be subjected to one-minute megger tests
- j. The high-potential tests shall be applied only if the megger tests pass minimum requirement
- k. All control, alarm and metering circuits shall be checked

2.2 GATE ACTUATOR

SCOPE OF WORK

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

- 2 (two) : Gate Actuator joint with vertical lift stem screw.

PURPOSE AND FUNCTION

The first actuator is installed with gate valve diameter 600 mm. at intake penstock house. The gate used with bypass pipe supply some water to irrigation.

Another actuator is installed with slide gate stem long about 6 meters size of gate 500 mm. and this is distance full open. The gate used to letting some water bay into the canal for ecosystem.

Actuators utilize the station electrical supply of 400/3ph/50Hz. for local and remote operation and is fitted with 2 torque limit and 4 position limit switches, compact design, IP54. Manual forward and reverse operation of the actuator is achieved through local SPDT Switch or remote manual system activating the forward and reverse motor contactors built into the actuator. The status of actuator show indicator

Gate level indicator, Speed setting, Torque limit setting, stop position setting, reset point.

Hand wheel operation of actuator is also provided when cut off joint with motor.

2.3 HYDRAULIC PRESSURE CONTROL VALVE



Hydraulic pressure control valve control open – close penstock intake valve and bypass most valves are manual operating valve. The contractor shall be replace with proportional valves with electronic card matching with control cubicle in section 14.15

2.4 LIFT HOIST AND INTAKE TUNNEL GATE (GATE SHAFT)

SCOPE OF WORK

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

- 1 (One) : Replace old fix electrical sling hoist with new one. Full lift distance about 26 meters.
- 1 (One) : Maintenance gate shaft, Chang rubber seal, roller bearing and painting intake tunnel gate

2.5 MEASUREMENT AND PAYMENT

The Contractor shall supply and install the following permanent equipment as shown on the Drawings, and/or proposed by the contractor and the Engineer approval.

The scope of work shall include the design manufacture, supply, delivery, erection, commissioning, production of operation and maintenance manuals and defect liability as described hereunder

(1) Furnishing and Installing of mechanical auxiliary equipment

Payment for supply and installation of mechanical auxiliary equipment will be made as the applicable rate per set bid therefor in the schedule. These rates shall include the cost of all labors and materials required to perform the Works specified.

(2) Payment shall be as follow:

- (1) 10% of total price of each unit after approval of calculation sheet and detailed drawing by the Engineer
- (2) 50% of total price of each unit after acceptance of the delivery at site
- (3) 25% of total price of each unit after installation
- (4) 15% of total of each unit after commissioning and completed as-built

SECTION 3

สถานีสูบน้ำ

SECTION 3 – สถานีสูบน้ำ

3.1 PUMPING STATION (LOWER DAM)

3.1.1 ท่อไป

เนื่องจากระดับน้ำเขื่อนล่างส่วนมากจะมีปริมาณน้ำมากกว่า เขื่อนตอนบน ดังนั้นเพื่อการบริหารจัดการน้ำ ทั้งเพื่อการผลิตไฟฟ้าและการชลประทาน จึงกำหนดตั้งสถานีสูบน้ำเขื่อนล่างกลับไปในด้านบน ที่ความสูงผิวน้ำต่างกันโดยประมาณ 30 เมตร ปริมาณน้ำออกแบบสูบกลับประมาณ 960 ลบ.เมตรต่อชั่วโมง ข้อกำหนดด้านเทคนิคในบทนี้ จะเป็นข้อกำหนดเฉพาะด้านเครื่องกลและไฟฟ้า ในส่วนอุปกรณ์ใน สถานีสูบน้ำ โดยข้อกำหนดทั่วไป มาตรฐานที่ใช้ ให้เป็นไปตาม Section 1 GENERAL ยกเว้นหัวข้อ Test During Manufacture-General

3.1.2 จำนวนและชนิดของวัสดุที่ต้องจัดให้

- 1) ป้อนน้ำ ขับด้วยมอเตอร์ไฟฟ้า จำนวน 5 ชุด ใช้งาน 4 ชุด สำรอง 1 ชุด
- 2) วาล์วต่างๆ ตามแบบ (GATE VALVE ,AIR VALVE FOOT VALVE ANTI SURGE VALVE, GAUGE & FITTING)
- 3) ตู้ควบคุมปั๊ม ระบบป้องกัน และการแจ้งเตือน (CONTROL PUMP CUBICLES, PROTECTION AND ALARM SYSTEM)
- 4) รอกใช้ไฟฟ้า (HOIST)
- 5) ระบบ Ground ของอาคารและอุปกรณ์ (GROUNDING SYSTEM)
- 6) ถังดับเพลิง PORTABLE FIRE EXTINGUISHERS
- 7) แผงเซลล์แสงอาทิตย์ พร้อมโครงสร้างรองรับ และรั้ว

3.1.3 ปั๊มน้ำ ขับด้วยมอเตอร์ ไฟฟ้า

ปั๊มแบบ Submersible Pump ขับด้วยมอเตอร์ 3 phase 380 V. ขนาด 37 kW. รับไฟฟ้ามาจากระบบผลิตพลังงานแสงอาทิตย์ เดินเครื่องได้ต่อเนื่อง ติดตั้งจำนวน 5 ชุด ใช้งาน 4 ชุด สำรอง 1 ชุด น้ำออกผ่าน เช็ควาล์ว เกจวาล์ว เข้าสู่ท่อรวมขนาด 700 มม. และเกจวาล์วรวม ส่งน้ำ ไม่น้อยกว่า 240 ลบ.ม./ชั่วโมง ต่อเครื่อง ผ่านท่อ 700 มม. ระยะ 482 เมตร สูง 30 เมตร จนข้ามสันเขื่อนบน

ผู้เสนอราคาต้องแนบ Catalog และ Performance chart พร้อม Dimension รุ่นที่เสนอมาพร้อมเอกสาร ประกวดราคาด้วย

3.1.4 วาล์วต่างๆ ตามแบบ (GATE VALVE ,AIR VALVE FOOT VALVE ANTI SURGE VALVE, GAUGE & FITTING)

ท่อ suction ขนาด DN 500 เป็น ท่อน้ำ เหล็ก carbon steel ชุบ มาตรฐาน ASTM A 53 STD ด้านล่างจุ่มน้ำติด Foot valve ข้องอ 90 องศา ก่อนหักเข้าปั๊ม ติด eccentric reducer และ vacuum gauge 1 ตัว ท่อออก ติด concentric reducer, pressure gauge ,check valve และ shot gate valve 500 มม. ก่อนต่อเข้า ท่อ Header ขนาด 700 มม. แต่ละช่วงของท่อก็มี Support ที่เหมาะสมรับป้องกันการสั่น

ท่อ Header หรือท่อร่วม ของปั้มน้ำทั้งสามชุด เป็นท่อ DN 700 STD ทำสี อีพริกซี หนา 300 ไมครอน ขึ้นไป ติดตั้ง Air valve ขนาด 50 มม., pressure gauge และด้านล่างติดท่อ Drain valve ขนาด 150 มม.ระบายน้ำกลับเข้าบ่อดูด ปลายท่อ Header ปลายด้านหนึ่งปิด ส่วนอีกด้านต่อเข้า shot face to face Gate valve 700 มม. หลังจากนั้นต่อเข้าท่อแยกสามทางลด 350 มม. ใส่ Short gate valve และ anti-surge valve เพื่อระบายความดันในท่อเมื่อปั้มตัวหนึ่งหรือทั้งสองตัวหยุดกระทันหัน ไม่ให้เกิน 35 เมตรของน้ำ น้ำจะระบายกลับไปทั้งบ่อดูด หลังจากนั้นท่อส่ง จะต่อเข้ากับ ท่อ HDPE ขนาด 700 มม. ส่งน้ำขึ้นไปลงที่ หลังเขื่อนบน

3.1.5 ตู้ควบคุมปั้ม ระบบป้องกัน และการแจ้งเตือน (CONTROL PUMP CUBICLES, PROTECTION AND ALARM SYSTEM)

เป็นตู้แยกควบคุมปั้มน้ำแต่ละ ตัว รวม 5 ชุด มีคุณลักษณะดังนี้

- 1) ตู้ควบคุม ควบคุมการจ่ายไฟ 380 V ให้มอเตอร์ พร้อมชุดควบคุมการสูบน้ำ ด้วยพลังงานแสงอาทิตย์และอุปกรณ์ป้องกัน
- 2) สายเคเบิลไปมอเตอร์ NYY/VCT มาตรฐาน มอก.
- 3) ท่อร้อยสายไฟ IMC& HPDE
- 4) ระบบควบคุม Automatic
- 5) ดัชนีการป้องกันน้ำ IP45
- 6) ความหนาตู้ไม่น้อยกว่า 1.5 มม. ได้รับการออกแบบ รับรอง จากวิศวกรไฟฟ้า
- 7) อุปกรณ์ประกอบตู้ ประกอบไปด้วย
 - ตู้ที่ติดตั้งพื้น มีช่องระบายอากาศและตะแกรงกันแมลง
 - สวิตซ์ตัดตอนอัตโนมัติ มีอัตราการทนกระแสไฟฟ้าและแรงดัน
 - ชุดสตาร์ท ใช้ตามมาตรฐานมอเตอร์
 - โอเวอร์โวลต์รีเลย์
 - อุปกรณ์ป้องกันไฟไม่ครบเฟส พร้อมกันแรงดันตก
 - ขดลวดไล่ความชื้น
 - รีเลย์กันไฟรั่วลงพื้นดิน
 - มาตรวัด กระแสและแรงดันไฟฟ้า
 - มาตรวัด ชม. การทำงาน
 - ชุดปุ่มกด ไฟแสดงสถานการณ์ทำงาน และป้ายแสดงรายละเอียดปุ่มกด
 - ขั้วหลักต่อสายเข้าและออก

3.1.6 รอกโซ่ไฟฟ้า (HOIST)

รอกโซ่ ไฟฟ้า ขนาด 5 ตัน 2 Speed มีระบบเบรกแบบกล วิ่งได้ในทุกทิศทางของโรงปั้มน้ำ เพื่อใช้ในการติดตั้ง ซ่อม ปั้มน้ำ ความยาวของโซ่ไม่น้อยกว่า 6 เมตร มีระบบคลัทช์สำหรับการป้องกันการโอเวอร์โวลต์ มอเตอร์ไฟฟ้าได้มาตรฐาน CE

ระดับการป้องกันชั้น (IP Grade): รอกที่ IP เกรด: IP54 ,ปุ่มกด Bottom IP Grade: IP65

3.1.7 ระบบ Ground ของอาคารและอุปกรณ์ (GROUNDING SYSTEM)

ไม่มากกว่า 5 Ohm

3.1.8 ถังดับเพลิง PORTABLE FIRE EXTINGUISHERS

Location	Minimum Capacity	CO ₂	Dry Chemical
พื้นที่ติดตั้งปั๊มน้ำ	6 kg	1	1
พื้นที่ติดตั้งตู้แผง	6 kg	-	1

3.2 ระบบผลิตพลังงานแสงอาทิตย์

3.2.1 แผงเซลล์แสงอาทิตย์

ผู้รับจ้างจะต้องจัดหาระบบผลิตพลังงานแสงอาทิตย์ชนิดติดตั้งบนพื้นดินขนาดกำลังผลิตติดตั้งตามบัญชีแสดงปริมาณวัสดุและราคา (BOQ) พร้อมอุปกรณ์ประกอบ พร้อมติดตั้งทดสอบให้สามารถใช้งานได้เป็นอย่างดี โดยมีคุณสมบัติเฉพาะทางเทคนิคดังนี้

- (1) แผงเซลล์แสงอาทิตย์แบบซิลิกอนผลึกเดี่ยว (Mono Crystalline)
- (2) แผงเซลล์แสงอาทิตย์จะต้องให้กำลังไฟฟ้าสูงสุดไม่น้อยกว่า 450 วัตต์ต่อแผง โดยทำการทดสอบ ณ Standard Test Condition (STC) ที่ค่าความเข้มแสงอาทิตย์ 1,000 วัตต์ต่อตารางเมตร ที่อุณหภูมิแผงเซลล์ฯ 25 °C และ Air mass 1.5 และกำลังไฟฟ้าของแผงมีค่าความคลาดเคลื่อนได้ไม่เกินร้อยละ 5 เพื่อให้เป็นไปตามมาตรฐานของเซลล์แสงอาทิตย์
- (3) โลหะหุ้มขอบแผงเซลล์แสงอาทิตย์เป็นอลูมิเนียม เพื่อให้มีน้ำหนักเบา ทนทานไม่เป็นสนิม และทำการเจาะรูเพื่อต่อสายดิน (Ground)
- (4) กล่องต่อสายไฟหลังแผง ทำจากวัสดุที่มั่นคงแข็งแรง ทนต่อสภาพอากาศและสภาวะแวดล้อมได้ดี สามารถป้องกันการซึมเข้าของน้ำได้ ทนทานต่อสภาวะการใช้งานภายนอกและมีอายุการใช้งานยาวนานเทียบเท่าแผงเซลล์แสงอาทิตย์ มีแยกการต่อเป็นขั้ว (MC4) บวก - ลบ มีฝาเปิด - ปิด เพื่อความปลอดภัยและสะดวกในการใช้งาน
- (5) ระบบผลิตไฟฟ้าจากเซลล์แสงอาทิตย์ต้องสามารถทำงานร่วมกับอุปกรณ์ควบคุม Inverter และส่วนประกอบของระบบผลิตไฟฟ้าได้เป็นอย่างดีและมีประสิทธิภาพ
- (6) แผงเซลล์แสงอาทิตย์จะต้องได้รับมาตรฐานผลิตภัณฑ์อุตสาหกรรม มอก.61215 เล่ม 1(1)-2561 และ มอก.2580 เล่ม 2-2562
- (7) แผงเซลล์แสงอาทิตย์จะต้องผลิตจากโรงงานที่ตั้งอยู่ในประเทศไทย และได้รับมาตรฐาน ISO 9001 หรือ ISO 9002
- (8) แผงเซลล์แสงอาทิตย์จะต้องมีประสิทธิภาพไม่น้อยกว่าร้อยละ 20

3.2.2 โครงสร้างสำหรับรองรับแผงเซลล์

ผู้รับจ้างจะต้องจัดหาพร้อมติดตั้งโครงสร้างสำหรับรองรับแผงเซลล์อาทิตย์ตามบัญชีแสดงปริมาณวัสดุและราคา (BOQ) ทำด้วยวัสดุเหล็กชุบกัลวาไนซ์ (Galvanize steel) หรือ สแตนเลส (Stainless steel) ให้ครอบคลุมพื้นที่ติดตั้งแผงเซลล์แสงอาทิตย์ เพื่อใช้ในการบำรุงรักษาแผงเซลล์แสงอาทิตย์

3.2.3 สายไฟฟ้าเชื่อมต่อระหว่างเซลล์

ผู้รับจ้างจะต้องจัดหาพร้อมติดตั้งสายไฟฟ้าที่ใช้เชื่อมต่อระหว่างเซลล์แสงอาทิตย์ ต้องเป็นชนิด PV1-F เท่านั้น และได้ มาตรฐาน TUV หรือ UL หรือ VDE เป็นอย่างน้อย

3.2.4 ตู้ PV String Combine Box

ผู้รับจ้างจะต้องจัดหาพร้อมติดตั้งตู้ PV String Combine Box พร้อมอุปกรณ์ประกอบ ให้มีขนาดเหมาะสมกับแผงเซลล์แสงอาทิตย์

3.2.5 อินเวอร์เตอร์

ผู้รับจ้างจะต้องจัดหาพร้อมติดตั้งอินเวอร์เตอร์คุณสมบัติดังนี้

- (1) แบบ Off grid 380V แบบ 3 เฟส 50 Hz ขนาด 37 kW จำนวน 5 ชุด
- (2) มีหน้าจอแสดงการทำงานของ Inverter
- (3) ประสิทธิภาพเฉลี่ยไม่น้อยกว่าร้อยละ 98
- (4) สามารถทำงานได้ที่อุณหภูมิสูงสุดไม่น้อยกว่า 60 องศาเซลเซียส
- (5) ระบบป้องกันน้ำและฝุ่นไม่น้อยกว่า IP65

3.2.6 การติดตั้งและทดสอบ

ผู้รับจ้างจะต้องทำการทดสอบและปรับตั้งระบบผลิตไฟฟ้าจากพลังงานแสงอาทิตย์พร้อมอุปกรณ์ประกอบให้สามารถใช้งานได้เป็นอย่างดี โดยผู้รับจ้างเป็นผู้รับผิดชอบในการจัดหาอุปกรณ์ที่ใช้ในการทดสอบ

3.3 MEASUREMENT AND PAYMENT

The Contractor shall supply and install the following permanent equipment as shown on the Drawings, and/or proposed by the contractor and the Engineer approval.

The scope of work shall include the design manufacture, supply, delivery, erection, commissioning, production of operation and maintenance manuals and defect liability as described hereunder

- (1) Furnishing and Installing of mechanical auxiliary equipment

Payment for supply and installation of mechanical auxiliary equipment will be made as the applicable rate per set bid therefor in the schedule. These rates shall include the cost of all labors and materials required to perform the Works specified.

- (2) Payment shall be as follow:

- (1) 10% of total price of each unit after approval of calculation sheet and detailed drawing by the Engineer
- (2) 50% of total price of each unit after acceptance of the delivery at site
- (3) 25% of total price of each unit after installation
- (4) 15% of total of each unit after commissioning and completed as-built