CHAPTER 3

TECHNICAL SPECIFICATION FOR GENERATORS

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SECTION 1

GENERAL SPECIFICATIONS

1.1 Scope of Works

The Contract for rehabilitation equipment and materials for the generators and ancillary facilities of the Da Nhim Hydroelectric Power Station is covered the designing, manufacturing, supplying, testing before shipment, finishing, painting, packing for transport, insuring, shipping, delivering to the Port of Saigon, and guidance service for erecting, Site testing and commissioning of the Plant as generally described below.

Rehabilitation of generators and Ancillary facilities to be rehabilitated

(1) Four 45,000 kVA alternating-current generators for direct coupling to the turbine.

(2) Four static thyristor excitation systems, control and protection equipment and accessories.

(3) Special Tools for rotor draw out and spare parts.

All Works shall be in accordance with these Specifications, the accompanying drawings and Tender Schedules, and shall be compatible with the other contractors' work.

1.2 General Description of the Project

The Da Nhim Hydro Power Project, which located at about 250 km northeast of Ho Chi Minh city, was constructed in 1964 with the installed capacity of 160 MW (4 units x 40 MW).

The Da Nhim basin which feeds water to the Project has a drainage area of about 1,400 km^2, and an annual rainfall of 1,700 mm, and the Da Nhim flows through this basin for a distance of 80 km. The lower half of the river course runs through the gradually opening fields at the elevation varying between 1,020 and 960 m, with an average discharge of 36 m^3/sec at its end.

The Da Nhim basin borders on the lower plain on the east coast beyong the divide mountains, and between the basin and the plain there is a large descent of about 800 m in a distance of less than 10 km. This favoured natural feature provides an ideal site for a valuable hydropower project which enables to develop huge water power at a low cost by diverting the water of the Da Nhim to the low plain through relatively short waterway.

1.3 Power Supplies

The power for auxiliary equipment shall be:

(1) Alternating current

(a) 3-phase 4-wire 50 Hz

Rated voltage between phases	380 volt
Rated voltage between phase and natural	220 volt
Voltage variation	± 10%
Frequency variation	± 5%
Neutral point	Solidly grounded

The 3-phase supply shall be used for power circuit and the single-phase supply for lighting, indication, motor controls and similar small power circuits. The single-phase supply within desks, cubiclesand panels shall be transformed down to 110 volt AC, if necessary.

(2) Direct current

220 volt, 2-wire for essential controls, indication, alarm, emergency lighting, circuit breaker tripping and closing circuit.

48 volt, 2-wire only for telecommunication set and/or intercommunication set only.

All equipment and apparatus shall be capable of satisfactory operation at 80% to 125% of the rated working voltage. All devices on DC operating circuit breakers shall also be capable of satisfactory operation even at 130% of the rated working voltage, considering equalizing charge of storage battery.

1.4 Climatic Condition

The climate is predominantly sub-tropical monsoon type, however, having it's long shape from north to south, the average annual temperature has notable variations. The average annual temperature in Hanoi is 23.5°C while that of Ho Chi Minh is 27.1°C. Winter in Hanoi (January) experiences cool weather of 16.5°C in average. Annual rainfall over the greater part of Vietnam's territory is around 1,600 mm, while in places where the mountain slopes are open to the winds, precipitation may exceed 2,500 - 3,600 mm and even reach 4,000 mm per year.

1.5 Seismic Coefficient

The seismic coefficient shall be taken as 0.10.

1.6 Water Conditions

The characteristic of sample water taken from the Dran Reservoir and tailrace is stated below for reference:

Date of sampling	:	7 August, 1994
Location of sampling	:	Dran Reservoir (Tailrace)

Result of analysis

Location of Sampling		Dram Reservoir	Tailrace
pH		7.12	(7.15)
Electrical Conductivity	µS/cm	31.0	(29.0)
Suspended solid	mg/l	26.8	(26.0)
Chloride (Cl^-)	mg/l	6.95	(6.84)
Sulphate (SO_4^{2-})	mg/l	1.34	(2.29)
Silica (SiO_2)	mg/l	29.31	(30.67)
Total hardness ($CaCO_3$)	mg/l	19.99	(19.77)
Carbonate hardness ($CaCO_3$)	mg/l	2.50	(6.25)

1.7 Changes in Specified Materials or Equipment

The Contractor shall not make any changes in the equipment or the materials to be incorporated in the equipment from those specified or implied by these specifications without the written approval of the Engineer. Such changes or alternations shall in no way be detrimental to the interests of the Employer and shall not result in any increase in the Contract price.

1.8 Unit of Measurement and Language

In all correspondence, in all technical schedules and on all drawings prepared by the Contractor, the metric units of measurement shall be used. On drawings or printed pamphlets where other units have been used, the equivalent metric measurement shall be added. All documents, correspondence, drawings, reports, schedules and instructions shall be in the English language, and nameplate of the equipment shall be in English or Indonesian language in accordance with the instruction of the Employer. Duty labels and instruction plates in/on cubicles and equipment shall be in the Indonesian language. The Contractor shall submit sentences and letters in English for duty labels and instruction plates to the Employer. Translation from English to Indonesian will be made by the Employer.

1.9 Standards and Workmanship

Materials shall be new, the best of their respective kinds and such as are usual and suitable for work of like character. All materials shall comply with the latest issues of the specified standard unless otherwise specified or permitted by the Engineer.

Workmanship shall be of the highest class throughout to ensure reliable and vibration free operation under all possible operating conditions. The design, dimensions and materials of all parts shall be such that the stresses to which they may be subjected shall not cause distortion, undue wear, or damage under the most severe conditions encountered in service.

Materials shall conform to the dimensions shown on and shall be built in accordance with approved drawings. All joints, datum surfaces and metallic components shall be machined and all castings shall be spot finished for nuts. Specific numerical machine finish designations shall be shown on the drawings. All screws, bolts, studs and nuts and threads for pipe shall conform to the latest standards of the International Organization for Standardization covering these components and shall all conform to the standards for metric

sizes. The Contractor shall never incorporate any standards or size system by his own account, regardless of that accepted and incorporated in this Contract.

All materials and works which have cracks, flaws or other defects or inferior workmanship will be rejected by the Engineer. All defective materials shall be promptly removed from the Site by the Contractor, and inferior workmanship shall be cut out and replaced.

(1) Standard specifications

The design, materials, manufacture, testing, inspection and performance shall, unless otherwise specified in the Special Requirements of these Specifications, conform to the authorized standards of the International Electrotechnical Commission (IEC) or equivalent national standards. The Tender shall include a statement of the standards which the Tenderer proposes.

(2) Assembly

Necessary items of equipment shall be assembled in the shop prior to shipment and such tests shall be performed by the Contractor as may be required to demonstrate to the satisfaction of the Engineer the adequacy of the equipment and its component parts. All tests should simulate normal operating conditions as closely as possible. All dismantled parts shall be properly matchmarked and doweled to ensure correct assembly in the field.

(3) Casting

Casting shall be true to pattern, of workmanlike finish and of uniform quality and condition, free form blowholes, porosity, hard spots, shrinkage defects, cracks or other injurious defects, and shall be satisfactorily cleaned for their intended purpose.

Major defect on castings shall not be repaired, plugged, or welded without permission of the Engineer. Distinction of major defect and minor defect shall be proposed by the Contractor. Such permission will be given only when the defects are small and do not adversely affect the strength, use, or machinability of the castings. Excessive segregation of impurities or alloys at critical points in a casting will be a cause for its rejection. The largest fillets compatible with the design shall be incorporated wherever a change in section occurs. All castings shall be stress-relieved before machinings and again after repair by welding.

(4) Forgings

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

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

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

(5) Welding

Wherever welding is specified or permitted, a welding process, including stress relieve treatment as required if necessary, conforming to an appropriate and widely recognized professional standard shall be used. All welders and welding operators shall be fully qualified by such a standard.

After the welding process has been approved by the Engineer, the Contractor shall record it on a special drawing which shall thereupon become one of the drawings of the Contract.

All defects in welds shall be chipped out to sound metal and such areas shall be magnetically or ultrasonically tested to ensure that the defect has been completely removed before repair welding.

Plates to be joined by welding shall be accurately cut to size and rolled by pressure to the proper curvature which shall be continuous from the edge. Flattening in the curvature along the edges with correction by blows will not be allowed. The dimensions and shape of the edges to be jointed shall be such as to allow through fusion and complete penetration, and the edges of plates shall be properly formed to accommodate the various welding conditions.

The surfaces of the plates adjacent to the edge to be welded shall be thoroughly cleaned of all rust, grease and scale to bright metal. All important weldings shall be stress - relieved by heat treatment before machining.

(6) Design of piping system and determination of heads for pumping units

Design, materials and installation of piping systems shall conform to ANSI Code for pressure piping B31-1, or an equivalent standard approved by the Engineer.

The Contractor shall prepare installation drawings for each piping system showing all fittings, valves, gauges, pressure relief valves, pressure reducers, types and sizes of pipe, pressures, flows, instruments, etc.

These drawings shall be submitted to the Engineer for approval.

The Contractor shall also prepare schematic diagrams of each piping system showing instruments, capacities, pressure settings, and all valves. These diagrams and drawings shall be designed to assist the operators in understanding the piping systems, in operating them correctly, and in identifying and correcting malfunctions.

Selection of pipe sizes and materials shall conform to specific requirements herein, or to normal practice where specific requirements are not given.

Rated head for pumping units (the head at which the pump discharges the required flow) shall be calculated by the Contractor using the static elevations given herein plus the energy losses not less than two times the calculated value in the associated piping for any probable deterioration of the piping. The pump motor shall be rated to avoid any overload over the full range of any probable operating heads.

(7) Pipe

Seamless steel pipe and/or copper tubing shall be used for all oil lines.

Carbon steel pipe and all fittings galvanized shall be used for water and air lines, unless otherwise specified. Where such pipes are used at the boundary between embedded and exposed portions and subjected to vibration due to rapid water flow, stainless steel pipes with at least one (1) meter in length shall be applied for such boundary portion. Drain pipes from the main strainer to the sump pit shall use the stainless steel pipe.

Copper tubing shall be used for air and gas lines, except generator braking piping.

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

(8) Hangers and supports

The Contractor shall supply all pipe hangers, brackets, nuts, clamping bars, holding springs, and other supports required for the support of the piping, including the drilling and caulking for expansion anchors, except as otherwise provided.

Unless otherwise specified, the pipe supports shall be spaced at maximum about 2-meter centers for steel and about 1-meter center for copper. Pipe hangers for copper tubing shall be copperplated and of an approved type. Vertical runs shall be supported by means of pie clamps or collars at each floor. Hangers and supports shall be painted.

(9) Hydraulic pressure tests

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

(a) Parts subject to air, gas, water and/or oil pressure:

1.5 times the maximum design pressure for 10 minutes.

(b) All other parts:

Twice the maximum working pressure, but not less than 5 kg/cm^2, for 10 minutes.

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

(10) Galvanizing

Unless specifically mentioned to the contrary, iron and steel shall be galvanized in the factory after shop fabrication is completed. The zinc coating is to be uniform, clean, smooth and as free from spangle as possible. Galvanizing shall be applied by the hot dip process for all parts other than steel wires. All steel wires shall be galvanized by a recognized trade standard.

The minimum quantities of zinc coating shall be 350 gram/sq. meter for bolts and nuts and 550 gram/sq. meter for all other parts except steel wires. The uniformity of zinc coating, tested by dipping the sample into a solution of copper sulfate, shall be such that no iron or steel surface shall be exposed until the surface has been dipped four times for bolts and nuts, and six times for all other parts.

The preparation for galvanizing and the galvanizing itself shall not distort or adversely affect the mechanical properties of the materials.

Special treatment during galvanizing to prevent the formation of "White rust" during shipment or storage is required. The Tenderer shall state in his Tender the treatment to be used.

(11) Nameplate

To facilitate operation and maintenance it is very important that all equipment, valves, instruments, switches, pipelines, etc., shall be clearly identified by nameplates showing the function and proper use of each item. Such identification shall be in English language and must be intelligently and carefully designed to minimize errors and to avoid maloperation in operation or maintenance.

The translation into Viet Namese will be done by the Employer.

The nameplates shall be permanently legible, clearly worded, weather proof when outdoors, and securely mounted in conspicuous and logical locations.

A table showing materials, dimensions, location, mounting and wording shall be submitted to the Engineer for approval.

(12) Phase indication of equipment

Coloured ferrules and code of phase indication shall be as follows:

Phase	Code	Colour
First phase	R	Red
Second phase	S	Yellow
Third phase	T	Black
Neutral	N	Blue
Ground	O	Green with yellow stripe
D.C. positive	P	Red
negative	N	Blue

The insulated wires to be used for control or metering circuit in the equipment shall be as follows:

Circuit	Colour
D.C. circuit	Blue
A.C. circuit	Yellow
C.T. circuit	Black
V.T. circuit	Red
Ground circuit	Green with yellow stripe
Carrier circuit	(will be informed later.)

1.10 Spare Parts

The Contractor shall furnish spare parts as listed in the Tender.

The spare parts supplied shall be packed or treated in such a manner as to be suitable for storage under the climate conditions at the Site for a period of not less than two years, and each part shall be clearly marked with the description and purpose on the outside of the package. The manner of storage shall be recommended by the Contractor.

Spare parts so provided shall be delivered into such stores as may be designated by the Employer. Delivery of spare parts will not be deemed to be complete until the packages have been opened by the Contractor, their contents checked by a representative of the Employer and the articles reprotected and repacked by the Contractor to the satisfaction of the Employer, or assembled into units at the Employer's option. The method of package and package materials shall be suitable for the satisfactory re-package.

1.11 Packing

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

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

All cases, packages, etc., shall be clearly marked on the outside to indicate the total weight, to show where the weight is bearing and the correct position of the slings and shall bear an identification mark relating them to the appropriate shipping documents.

Cases which cannot be marked as above shall have metal tags with the necessary marking on them. The metal tags shall be securely attached to the package with strong steel wire or equivalent.

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

The maximum weight and width of each packing of the cargo for the Project shall be limited to 18 tons and 4 meters respectively for inland transportation.

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

The shipping mark shall consist of the following information in sequence and in frame commensurate with the size of container:

(a) Consignee: _____

(b) Contract No.: _____

(c) Port of destination: _____

(d) Item number, if applicable, package number in sequence, and quantity per package: _____

(e) Description of contents: _____

(f) Net and gross weight, cubic measurement: _____

The shipping mark will be decided after the Contract.

1.12 Delivery

The Contractor shall deliver all materials supplied under the Contract to the Port of Saigon in adequate time for its preparation according to the Schedule.

Each notification shall include a complete shipping list of the contents of each package to be delivered and shall indicate the anticipated date of delivery and the serial number for each component to be used for identification and evidence of the insurance cost arranged for it.

1.13 Drawings and Data to be Supplied by the Contractor

Before starting manufacture of the equipment, dimensioned drawings and data showing all significant details of the equipment and materials to be used shall be submitted simultaneously to the Engineer and to the Employer for approval.

These drawings shall be submitted within the times mentioned hereunder measured in calendar month from the Date of Commencement. Time shall be allowed to permit changes to be made if required by the Engineer. The drawings shall be modified as necessary if requested by the Engineer, and resubmitted for final approval.

When the Contractor prepares his proposed construction schedule as for reference, as required herein, he shall make allowance for the drawing approval time and indicate it on the schedule. A period of at least six weeks should be allowed for such approval. Claims for extension of time will not be approved if they are related to the late submission of drawings to the Engineer or if they involve delays caused by drawings not being initially approved by the Engineer.

After approval of drawings by the Engineer, the Contractor shall supply the approved drawings to the Employer and the Engineer, according to the table given below.

It is to be understood, however, that approval of the drawings will not relieve the Contractor of any responsibility in connection with the work.

All drawing submitted for approval or sent to the Employer and the Engineer for any other reason shall be sent by registered airmail.

After all items of the work have been manufactured and erected, a complete sets of prints and negatives of the finally corrected drawings shall be furnished according to the following table.

Number of drawings to be submitted to the Employer and the Engineer shall be as follows:

	To the Employer	To the Engineer
During the work		
Drawings for approval	3 copies	5 copies
Approved drawings	6 copies	2 copies
After completion of the work (Final drawings)		
Complete set of reproducible originals	1 set	-
Complete set of bound prints	6 sets	1 set

Additional copies of particular drawings are to be provided if required, at the Contractor's expense.

The Contractor shall provide the following drawings and information within the times stated below (expressed in number of months after the Date of Commencement).

(1) Eight months

(a) Final detailed drawings of all major equipment

(b) Dimensioned drawings showing the detailed construction of all major equipment and parts

(2) Twelve months

(a) Final detailed drawings of all major equipment.

(b) Final circuit connection diagrams incorporated with changes as required by the Engineer

(c) Preliminary operating and maintenance instruction manuals

(d) Details of special tools to be provided

(3) Eighteen months

(a) Final operating and maintenance instruction manuals.

(4) At the time of shipment

Final drawings showing all changes up to the time of shipment.

1.14 Operating and Maintenance Instructions

The Contractor shall submit to the Engineer for approval, general instructions concerning the correct manner of assembling, operating and maintaining the work with special reference to any recently developed features. This instruction manual shall be submitted immediately following final approval of the drawings.

When finally approved, ten (10) copies of the instruction manual shall be furnished to the Employer and two (2) copies to the Engineer. The Contractor shall ensure that his erection supervisor has a copy in his office at the Site.

The instruction manual shall describe in detail the erection procedure and use of all erection equipment and measurement devices. The method of assembling, adjusting, operating and dismantling each device, system and machine shall be described and illustrated. The maintenance details of each component shall also be described, including the frequency of inspections and lubrication.

The Contractors shall, in preparing the instruction manual, take into account the lack of experience and familiarity of the operators with this type of equipment.

The manual shall give specific information as to oil, grease, or any other materials needed for maintenance operations. This information shall include brand names and manufacturer's members or designations, for at least two brands available in Viet Nam.

The manual shall include a complete list of all drawings prepared for the Contract, a spare parts list, and a parts list for each component of the equipment. The parts list shall include

manufacturer's name and serial number and ordering instructions. The parts list shall apply only to the equipment supplied and shall not include reference to or description of similar equipment which is of the same model but different only in detail. The manual shall be prepared in the English language.

1.15 Test Procedure Instructions

The Contractor shall prepare a testing program which will establish that specified requirements have been met and that the items furnished and installed with perform as specified and required.

The Contractor shall submit to the Engineer for approval, during or immediately following the submission of drawings, testing programmes describing each test to be performed during commissioning and performance tests. The programme shall establish the sequence of the tests, the equipment preparation and operation procedures to be followed and the detailed procedure for conducting each test. The programme shall also contain performance guarantees, design values, technical particulars, or other criteria for the evaluation of each test. These programmes shall be submitted for approval and distributed in the same manner as the drawings.

1.16 Attendance of Employer's Personnel at Factory Tests and Training

The Contractor shall arrange for the Employer's engineers or staff members to witness tests of major items of equipment in the manufacturer's plant as follows:

Two persons for a total time of twenty-four man-days

The Contractor shall submit the instruction for training with the schedule. After approval of the Employer, the Contractor shall invite the Employer's engineers and provide training at manufacturer's plant for them during manufacturing as below in order to erect and operate the power plant successfully:

Two persons for one months

Necessary expenses including round-trip international air ticket cost between Viet Nam and the Contractor's country, costs of flood and lodging and inland travel charge in the Contractor's country shall be borne by the Contractor.

1.17 Tests

(1) Factory tests

Tests at the factory shall be in accordance with the requirements of the appropriate clauses of Section 2 "Technical Specifications". The Contractor shall comply with any test requirements of the country of manufacture, such as testing or licensing of pressure vessels, and shall submit certificates showing such compliance.

(2) Field tests during erection and preliminary functional test

During the construction and after the installation of each item of equipment, control device, piping system, etc., tests shall be performed, as specified herein, to establish the accuracy of the assembly and to prove the adequacy of the materials and the workmanship. All tests and test procedures shall be approved by the Engineer.

The Contractor shall cooperate the following, tests for all items where applicable, to insure that the equipment has been correctly installed, all necessary adjustments and settings made, and that the item is in sound condition to run under load.

Generators and ancillary facilities

(A) Inspection during erection of equipment

(a) Deformation check of generator stator
(b) Clearance check of main bearings
(c) Center alignment check of generator with turbine
(d) Measurement of clearance between stator and rotor
(e) Hydraulic pressure test of air coolers, cooling coils and pipes
(f) Calibration of dial type thermometers
(g) Calibration of pressure gauges
(h) Calibration of temperature relays
(i) appearance check of electrical equipment and cable connection

(B) Preliminary function test

(a) Shaft oil lift operation check
(b) Field coil voltage balance check
(c) Insulation resistance measurement of stator and field windings

(d) withstand voltage test of generator windings
- Stator winding to earth : A.C. 16.5 kV, 10 minutes
- Field winding to earth : A.C. 1.5 times of the rated excitation voltage, 10 minutes, but in no case at less than 500V A.C.

(e) Measurement of stator winding tan δ
- Capacitance of stator winding
- Loss angle measurement of stator winding

(f) Resistance measurement of stator and field windings

(g) Excitation system
- Check of control motor operation
- Field breaker operation check
- Characteristics test of AVR components

(3) Performance tests

After the auxiliary and control equipment has been restored, tested and approved and the generating unit has been fully restored and adjusted and/or its mechanical has been successfully completed, each of the Contractors for turbine, generator, transformer and switchgear shall cooperate to carry out the performance tests in the presence of the Engineer to demonstrate that all guarantees and technical particulars as listed in the Tender and Contract Documents have been satisfied and that the entire work is properly installed, free from objectionable leakage and correctly adjusted to operate as specified. The Contractors for turbine, generator, transformer and switchgear shall jointly designate a test coordinator with authority to direct and control the tests.

Each of the Contractors for turbine, generator, transformer and switchgear shall cooperate as required to made all final adjustments and setting to the control, detection and protective devices.

SECTION 2

ALTERNATING-CURRENT GENERATORS

2.1 General

2.1.1 Scope

This section covers the design, manufacture, supply testing before shipment, finishing, painting, packing for transport insuring, shipping delivery to the Port of Saigon of the following equipment and materials for rehabilitation of generators.

(1) Four (4) sets of stator cores and stator windings
(2) Four (4) sets of static thyrist exciter including AVR
(3) Four (4) sets of main bearing metals with oil rings
(4) Four (4) sets of air coolers
(5) Four (4) sets of oil cooler
(6) Four (4) sets of lubricating oil pump
(7) Four (4) sets of oil lift pumps
(8) Four (4) sets of cooling water pipes
(9) Four (4) sets of pipes for lubricating oil
(10) Four (4) sets of pipes for oil lift
(11) Four (4) sets of housing, end-bells
(12) One (1) set of rotor lifting device
(13) Four (4) sets of meters, relays wirings
(14) Four (4) sets of oil seals
(15) Four (4) sets of air seals
(16) Four (4) sets of materials for overhaul
(17) One (1) lot of spare part
(18) One (1) lot of guidance services

2.2 Existing Generators to be Rehabilitated

2.2.1 Type and Rating

The existing generators are of three-phase, horizontal shaft, synchronous generator with a salient pole revolving field. The cooling system is of the self-ventilating and recirculating type with air coolers.

Each existing generator is rated as follows:

(1)	Duty	Continuous running duty
(2)	Rated	45,000 kVA
(3)	Rating voltage	13,200V
(4)	Rated current	1,968A
(5)	Rating frequency	50 Hz
(6)	Rated power factor	0.89 lagging
(7)	No. of units	4 nos.
(8)	Name of manufacturer	Mitsubishi Electric Corporation, Japan

2.2.2 Speed

The rated speed of the generator is 500 revolutions per minute. The generator has been designed to withstand the maximum runaway speed of 920 rpm for five (5) minutes.

2.2.3 Direction of Rotation

Direction of rotation is unti-clockwise when viewed from exciter.

2.2.4 Technical Data

The Tenderer shall refer to the following technical data on the existing generator.

A. Generator

*(1)	Fly-wheel effect of alternator and exciters (GD^2)	365.72 t-m^2
(2)	Maximum current density in stator winding	2.71A per sq.m/m
(3)	Maximum current density in rotor winding	2.02A per sq.m/m
(4)	Maximum induction in magnetic circuit - pole piece - stator tooth	 15,650 gauss 15,600 gauss
(5)	Inherent voltage regulation - 1.0 pf - 0.89 pf	 12.9% 23.1%
(6)	Maximum voltage rise when throwing off continuous maximum rated load at rated power factor under actual service conditions with speed control and voltage control equipment in operation	less than 30%
*(7)	Direct axis synchronous reactance	76.6% JEC method 89.0% AIEE method

*(8)	Direct axis transient reactance	23.6%
*(9)	Direct axis sub-transient reactance	17.2%
*(10)	Negative phase sequency reactance	20.5%
*(11)	Zero phase sequence reactance	9.24%
*(12)	Stator winding resistance per phase (75°C)	0.0079 ohm
*(13)	Open circuit wave form distortion	2.19%

*(14) Efficiency
Efficiency of alternator at normal speed and voltage, including excitation under the following conditions

(a)	100% load	- at 1.0 pf	98.4%
		- at 0.89 pf	98.14%
(b)	90% load	- at 1.0 pf	98.3%
		- at 0.89 pf	98.03%
(c)	80% load	- at 1.0 pf	98.17%
		- at 0.89 pf	97.88%
(d)	70% load	- at 1.0 pf	98.0%
		- at 0.89 pf	97.7%
(e)	50% load	- at 1.0 pf	97.42%
		- at 0.89 pf	97.6%
(f)	40% load	- at 1.0 pf	96.88%
		- at 0.89 pf	96.46%

*(15)	Short circuit ratio	1.304
*(16)	Line charging capacity at rated voltage	50,500 kVA

B. Exciter

(1) Main exciter

(a)	Type	Enclosed self vent.
(b)	Rated output	160 kW
(c)	Rated voltage	220
(d)	Maximum ceiling voltage across brushes	355V
(e)	Response ratio	1.72

(2) Pilot exciter

(a)	Type	Enclosed self vent.
(b)	Rated output	1 kW
(c)	Rated voltage	110V

(3) Lubricating oil pump

(a)	Discharge	100 liter per min.
(b)	Pressure	3 kg/cm^2
(c)	Discharge diameter	50 mm
(d)	A.C. motor	
	Output	3.7 kW
	Voltage	380 V
	Current	7.3 A
	Frequency	50 Hz
	No. of pole	4 P
	Speed	1500 rpm
(e)	DC motor	
	Output	3 kW
	Voltage	220 V
	Current	17A
	Speed	1450 rpm

(4) Automatic voltage regulator

(a)	Regulating system	Magnetic amplifier system

C. Bearing

(1) Main bearings

(a)	Type	Sleeve bearing
(b)	Inner diameter	650 mm for exciter side 850 mm for turbine side
(c)	Weight	8.0 ton for exciter side 13.0 ton for turbine side

(2) Oil pump for oil pressure of bearing

(a)	Pressure of oil	100 kg per sq.cm
(b)	Capacity	8.5 liter per min.
(c)	Motor	
	Type	Enclosed drip proof type
	Output	1.5 kW (DC)

D. Parts

(1)	Diameter of stator core	3,700 mm
(2)	Length of stator core	1,995 mm

(3)	Type of stator winding	Single star, one turn with rebel transposition
(4)	Number of bearings on each alternator	2
(5)	Maximum diameter of rotor	2,889 mm
(6)	Maximum diameter of shaft	1,080 (at the flange parts)
(7)	Length of shaft	8110 mm
(8)	Number of poles	12
(9)	Type of pole damper windings	Non-connected damper
(10)	Quantity of air circulating in alternator	2,300 cu.m per min.
(11)	Quantity of water required by air coolers	3,100 lit. per min.
(12)	Heaters	27 kW
(13)	Materials of air cooler tubes	Albrac tube (aluminum blass)
(14)	Materials and strength of following parts:	
	(a) Stator frame	Steel plate
	(b) Main shaft	Forged steel
	(c) Yoke (Spider rim)	Steel plate or forged steel
	(d) Spider	Forged steel and steel plate

E. Nature of insulation

(1)	Stator conductors	
	(a) to earth (b) between turns	Mica tape with "DIARESIN" impregnated Coils are one turn coil type and there are no turn insulation
(2)	Stator end windings	Mica tape with "DIARESIN" impregnated
(3)	Stator core plates	Silicon steel with special varnish insulation on both side
(4)	Rotor windings	
	(a) to earth (b) between turns	Flexible mica with glass and asbestos cloth Asbestos paper

Note: The figures for items marked with star mark (*) have been taken from test records at the factory.

2.3 Basic Requirement

The materials and equipment to be used for the rehabilitation of the generator shall be conformed with the latest Japanese Standard such as JIS, JEC, JEM, IEC or equivalent International Standard such as IEC.

The parts and equipment to be provided for the partial rehabilitation work are essentially required to have same dimension and performance of the former parts and equipment.

The overall performances of generator after rehabilitation shall be not less than those at the initial operation.

2.4 Generators

2.4.1 Guaranteed Items

The Tenderer shall guarantee and state the following items on the generators for after rehabilitation in the Tender Schedule:

(1) Capacity

The generator capacity not less than 45,000 MVA shall be guaranteed and stated in the Tender.

(2) Efficiency

Efficiencies shall be guaranteed at loads of 100%, 90%, 80%, 70%, 50% and 40% rated output of the generator, at the rated frequency, rated voltage, rated power factor of 89% and unity power factor respectively.

All losses shall be corrected to 75°C. The losses to be considered in the efficiency calculations shall be in accordance with IEC 34-2 and 34-2A (Methods for determining losses and efficiency of rotating electrical machinery from tests).

The generator shall conform to the efficiency curves submitted with the Tender for the rated and unity power factors, over the range from 25 to 100% of the rated output at the rated voltage.

(3) Short circuit ratio

The short circuit ratio shall be not less than 1.1 and the designed value is to be stated in the Tender.

(4) Wave form

The open-circuit wave form shall be sinusoidal. The deviation factor of wave form shall be guaranteed to conform to that stated in the Tender, and not be more than 5 percent.

The deviation factor is the ratio of the maximum difference between corresponding ordinates of the wave and of the equivalent sine wave to the maximum ordinates of the equivalent sine wave when the waves are superposed in such a way as to make this maximum difference as small as possible.

(5) Inherent voltage regulation

The inherent voltage regulation of the generator at the rated power factor shall be not greater than 30 percent, and guaranteed values at the rated and unity power factors shall be stated in the Tender.

(6) Line charging capacity

The line charging capacity of the generator shall be guaranteed and stated in the Tender.

(7) Temperature rise and maximum temperature

(a) Temperature rise

The following limits of temperature rise shall be applied to the generator, when the generator delivers the rated output continuously at the rated voltage, power factor and frequency, with air temperature entering the generator air coolers of not more than 40°C:

Part of Generator	Method of Measurement	Limits of Temperature Rise
- Stator windings	Resistance	80°C
- Ditto	Embedded temperature detector	80°C
- Magnetic cores and other parts in contact with windings	Thermometer	80°C

(b) Maximum temperature

The maximum temperature of each bearing shall not exceed 65°C, when measured by an embedded temperature detector in the bearing metal.

2.4.2 Insulation

The windings of generator shall be insulated with class F materials.

2.4.3 Connections

Each generator shall be star-connected with three (3) terminals brought out at the neutral side and three (3) terminals at line side of the stator winding. Both the line and neutral terminals shall be insulated for full line voltage.

The neutral point of stator winding shall be grounded through a grounding transformer.

2.4.4 Temperature Detectors

Each generator shall be provided with embedded temperature detectors for indication on the temperature recorder to be provided by the contract and mounted on the main control board. Each embedded temperature detector shall be of resistance type search coil having a resistance of 100 ohm at 0°C of platinum element.

Temperatures to be measured shall be as follows:

Twelve (12) in stator (six as spares)

One (1) in cooling air inlet.

One (1) in cooling air outlet.

Two (2) in main bearing.

2.4.5 Stator

The stator frame of the existing generator shall be reconstructed in one piece and provided jack pads for rotor drawing out and shall be used for new stator together with new cores and coils.

The stator core shall be built up with thin, high-grade, nonaging-silicon-steel laminations; each lamination coated on both sides, after punching with an insulating varnish or other materials to minimize eddy current losses. The core laminations shall be adequately keyed or dovetailed to the stator frame and securely held in place by clamping flanges at each end. To insure uniform tightness of laminations, full and final clamping pressure shall be applied to successive layers of laminations while being stacked. There shall be no perceptible buzzing in laminations during operation. The air ducts shall be arranged in the stator core to make smoothly and quietly radial flow of air and to minimize windage and friction losses.

The stator winding shall be of one-turn coil and be connected as stated in Clause 2.4.3. Line ends of the winding shall be suitable for connection with conductors of the power cables through flexible conductors. The neutral ends shall be bussed through the current transformers in the generator housing, ready for connecting to the neutral grounding transformer cubicle. Terminals shall be copper and shall be of the bolt-clamped connection type.

The coil insulation shall be of non-inflammable and be properly vacuum and pressure impregnated with high-grade insulating synthetic resin. The insulation shall become reasonably plastic by the application of heat or shall otherwise be of such nature that the coil can be placed in or removed from slot without injury. The entire coil shall be able to withstand exposure to dampness without injury, shall have adequate corona shielding with a semi-conducting compound, and shall withstand specified continuous temperature without injury. The coil shall be form-wound and interchangeable. All coil ends shall be capped with non-inflammable material filled with suitable compound free from air pockets or other suitable method approved by the Engineer.

Stator coil conductor shall be electrolytic copper with a conductivity not less than the value for annealed copper specified in the approved standard. Connection shall be made with silver or copper phosphorus brazed.

If it becomes necessary during erection to lift coils from the stator slots after their ends have been finally connected, the permission of the Engineer shall be obtained. Such coils lifted

may be replaced only once in the slots, and those lifted more than once shall be replaced with new coils.

The Contractor shall make provisions to secure the winding firmly in the slots so that horizontal sliding of windings shall be avoided. The end portions of the coils and the connections shall be rigidly supported and braced to prevent vibration and distortion under stresses caused by the most severe circuit condition to which the generator may be subjected.

2.4.6 Rotor

The existing rotor will be used with cleaning and minor repairing.

2.4.7 Bearings

The existing generator main bearings are of sleeve type direct water cooled with oil rings. In addition, a forced-oil-circulated with external oil cooler system has been also applied to the main bearing lubrication.

The existing main bearing metals, oil rings, oil seals, lubricating oil pumps and external oil cooler shall be renewed together with related oil and water piping. Those dimensions, capacities and performances shall be the same as existing ones except an external oil cooler which is required 120% capacity of existing one.

The existing high pressure oil pumps for shaft lift at the generator starting for main bearings of turbine and exciter sides shall be renewed together with pressure relays, relief valves, filters and piping, but, driving motors, control panels shall be used for new pumps.

2.4.8 Generator Cooling

All existing air coolers shall be replaced with new ones having sufficient capacity. Each air cooler shall be made of straight tubes with fins to provide adequate thermal conductivity. The headers or water boxes shall be constructed to permit access to all tubes for inspection or cleaning with minimum disturbance to water pipe connections.

Each cooler shall be provided with a drain valve and pipe connection at the bottom which shall allow complete drainage of cooler for inspection, and which shall be connected to a common drainage header draining to the sump pit. air vents shall be provided at the top of each cooler and other high points in the pressure piping. Each air vent shall be connected to the drainage header.

The piping in the generator housing and on other necessary places, where deemed to be necessary, shall be provided with drip-proof protection.

Each cooler shall be fastened directly to the stator frame or to base frame embedded in the concrete. Lifting lugs shall be provided on each cooler.

2.4.9 Generating Housing and Generator End-bell

The existing steel made generator housing shall be reconstructed the top of housing to remove the main and sub end-bells when the coil ends are inspected. The main and sub end-bells at the both stator ends shall also be renewed.

The sound proof panels shall be mounted on the inside of the generator housing to reduce the noise produced by the generator.

2.4.10 Control and Protection for Generator

The following instruments shall be replaced for each unit.

(1) Dial type thermometers with alarm and trip contracts

Two (2) nos. for main bearing metals mounted on the turbine control panel.
Two (2) nos. for air cooler inlet and outlet.

(2) One (1) temperature recorder of 12 elements for resistance of 100 ohms at 0°C mounted on the main control board.

(3) Flow relays

One (1) no. for air cooler mounted in the generator pit.
Two (2) nos. for main bearing metals mounted in the generator pit.
One (1) no. for bearing oil cooler mounted in the turbine room.

(4) Four (4) nos. of thermo sensing detectors for generator fire protection mounted in the generator housing.

2.5 Excitation System

2.5.1 Type and Performance

The existing excitation system shall be replaced completely with a static and potential-source rectifier type one. The static and potential-source rectifier type excitation system shall consist of an excitation transformer, thyristor rectifiers, field circuit brakers, filed flashing equipment and automatic voltage regulating equipment, compete with all the necessary accessories, and housed in metal enclosures.

The excitation system shall be designed to have the nominal voltage response time not more than 0.05 second and the ceiling voltage not less than 150 percent of the rated value, and shall be capable of supplying full generator field current with an A.C. input from the excitation power transformer whichever value is the larger of 50% rated voltage or that voltage resulting from a three-phase short-circuit at the high voltage terminals of the main transformer, of which impedance voltage is 11%.

The field flashing for initial excitation shall be made by 220V D.C. from the station battery.

The excitation system shall have a sufficient capacity so that the generator is capable of supplying continuous rated load at 110% rated voltage, rated power factor and rated frequency, and capable of charging single circuit of the 230 kV single circuit transmission line with ACSR 410 mm^2 conductor for about 260 km to the Saigon Substation.

The excitation system shall be designed to operate stably on manual control at 25% rated voltage and shall have a function to charge the transmission line from this partial to the rated voltage gradually by manual control.

2.5.2 Thyristor Rectifier

The excitation rectifier shall be of three-phase, full bridge thyristor type. Each thyristor unit comprising a positive (+) side thyristor and a negative (-) side one, to form single branch of the thyristor bridge shall be contained in a steel tray. Each thyristor tray shall be possible to be drawn out from the front of panel to permit easy removal and replacement while the generator is operating at the rated output. The rectifiers shall be so designed that even when one thyristor tray is out of service, the generator shall be able to keep running safely with the guaranteed generator ratings. One spare thyristor tray shall be provided in the excitation control cubicle for each generator.

Power for operation of the rectifier shall be supplied by an excitation transformer connected to the generator terminals.

Mimic diagram for the rectifier bridge shall be provided on the front of each tray panel with signal indicators in order to indicate any failure of the thyristor. Test terminals shall also be provided on the front of the tray to permit measurement of thyristor voltage.

A current limiting fuse shall be provided in each thyristor circuit for overcurrent protection. The fuses shall not be blown within the overload capacity of the thyristor element, however, when the fault current exceed the overload capacity, the fuses shall be blown quickly before the thyristor is damaged. The fuses shall be provided with alarm contacts for remote annunciation.

The rectifier equipment shall be provided with overvoltage protection devices to protect the thyristor from surge voltage and transient overvoltage originated in the A.C. system and in the field circuit.

The rectifier equipment shall also be provided with protection system for abnormal current which may flow in the thyristors through the generator field due to the abnormal current on the generator armature circuit in the event that the generator becomes out of step or short-circuit fault occurs on the generator circuit. A protection system using fuses for the rectifier equipment will not be acceptable.

Cooling fans shall be provided for cooling the rectifiers. Stand-by fans shall also be provided and arranged to automatically be switched on in the case of failure of the normally used fans. All fans shall be possible to operate continuously at rated load. All control equipment for the fans shall be equipped complete with circuit breakers, starters, protective devices and automatic changeover system.

2.5.3 Excitation Transformer

The excitation transformer shall be of three-phase, 50 Hz, dry or dry molded type, self-cooled. It shall have an ample capacity for the operation of excitation system and full rated capacity taps shall be provided on the high voltage winding to accommodate the complete range of regulator operation. The transformer shall be provided with an interwinding grounded shield plate to prevent surge transmission from the high- to the low-voltage winding. The transformer shall be equipped with standard accessories including a transformer temperature indicator with adjustable high temperature alarm contact as approved by the Engineer. The contacts of all gauges, relays and thermometers shall be

normally open and shall close in the event of abnormal conditions, and shall be insulated from ground and suitable for use at 220 V D.C. All contacts shall be wired to terminal blocks for interconnection to external circuits. The excitation transformer and accessories shall be installed in an metal enclosure, installed near new excitation control cubicles.

2.5.4 Voltage Regulating Equipment

The voltage regulating equipment shall consist of an automatic voltage regulator, a manual voltage regulator, under- and over-excitation limiting devices, an automatic reactive power regulator and a power system stabilizer, and shall be complete with all the necessary auxiliaries and their controls for full voltage regulation.

The automatic voltage regulator shall be of the high speed, quick response, solid-static amplifier type and shall continuously respond with high speed to correct any change in generator voltage and maintain the terminal voltage, under steady state condition, within plus or minus 0.5 percent of normal value without hunting, for any excitation setting within the normal operating range.

Voltage control shall be accomplished by the continuous comparison of the average three-phase voltage of the generator with a reliable and stable reference voltage source provided in the control system.

The automatic voltage regulator shall adjust the filed voltage for generator so that transient changes in the terminal voltage and effectively suppressed, and sustained voltage oscillations shall not be produced.

The manual voltage regulator shall be provided to regulate the field voltage stably from about 25% of the rated generator terminal voltage to the rated voltage for generator operation at the rated output, rated power factor and rated frequency, and 110% of the rated voltage.

The manual voltage regulator shall also be designed for trial charging operation of single circuit of the 230 kV transmission line with ACSR 410 mm^2 conductors of about 260 km long. For purpose of the line charge operation, the generator voltage shall stably controlled at any position from about 25% to 100% of the rated generator voltage for any duration up to 10 minutes, with the power source of the excitation system connecting to the station-service circuit. The line charge operation shall be available by the selector switch (#43CH) with two positions of "USE" and "LOCK" to be mounted on the operator console in the control room.

While the line charging operation, the charge-over of power source from the station-service circuit to the excitation transformer supply or vice versa shall be performed smoothly without interrupting the line charging state. Upon recovery of excitation transformer power supply, the change-over of the switch to "LOCK" position shall result in the restoration of normal generator voltage control under the automatic voltage regulator. Necessary interlock for safety shall be provided as required.

A power system stabilizer shall be provided for protection against electro-mechanical oscillations resulting from a system disturbance.

The device shall operate to supplement the voltage regulating action by adding a controlled signal into the excitation system input.

On overvoltage resulting from sudden load rejection and successive overspeed up to 120% of the rated speed, the automatic voltage regulator shall limit the instantaneous output voltage change to plus 205 of the voltage held before the occasion of sudden load rejection.

The under- and over-excitation limiting devices shall be used to maintain the operation of generator within its capacity limit. such devices however, shall allow the regulator to reduce the excitation voltage to zero to prevent overvoltages during line charging operation or over-speed of the unit.

Provision shall be made for rapid field de-magnetization whenever the generator lockout relays operated.

Devices shall be furnished for cross-current compensation among the generators in parallel operation. The voltage adjusting device shall provide a voltage control range from minus 20% to plus 10% rated voltage. It shall be provided with a limit switch to stop the voltage adjusting device at each end of travel with indicating lamps.

Necessary current transformers and potential transformers for AVR shall be used existing ones provided in the existing 13.2 kV cubicles.

The voltage regulating equipment shall be suitable for remote control from the main control board and shall provide the following functions:

(1) Placing the regulator in manual or automatic operation
(2) Placing the regulator in or out of service during automatic starting or stopping control sequence of the turbine generator unit.
(3) Automatic positioning or follow-up of the excitation system manual regulation to the proper setting from no load to full load during automatic voltage regulation.
(4) Indication of field voltage and current, and all other quantities pertinent to operatin.
(5) All necessary indication euqipment.

2.5.5 Protection for Excitation System

The protection for the excitation system shall be classified into two groups by the nature and extent of failures or troubles. When heavy troubles or faults occur, the excitation system shall be tripped its output and the relevant generating unit shall be brought to emergency stop operation. When troubles or faults are not so serious, the faulted devices shall be isolated from the system without interruption of the generator excitation and only alarm and annunciation shall be given.

The protection system shall be designed to meet with the protection system for the main generating unit.

The protection shall be provided for, but not limited to, the followings:

(1) Protection

i) Excitation transformer overcurrent
ii) Two (2) or more rectifier cooling fans, fault
iii) Two (2) or more rectifier protection fuses, melted
iv) Initial excitation failure
v) Firing pulse, failure
vi) Thyristor power source, failure

(2) Alarm

i) One(1) rectifier cooling fan, fault
ii) One(1) rectifier protection fuse, melted
iii) Automatic follower, fault
iv) Voltage setter for automatic voltage regulator, fault
v) Voltage setter for manual voltage regulator, fault
vi) Excitation transformer temperature, high
vii) Under-excitation limiter, operated

viii) Over-excitation limiter, operated

ix) Power system stabilizer, fault

All protection and alarm items shall also be indicated on the group fault annunciator mounted on the excitation control cubicles.

2.5.6 Excitation Control Cubicles

The excitation control equipment shall be housed in the self-supporting metal enclosed cubicles. Doors with locks shall be provided for easy access to the equipment. all measuring and control instruments shall be mounted in a convenient location on the front of the cubicles.

The following equipment shall be furnished and mounted in the excitation cubicles:

(1) Power rectifier equipment.

(2) Automatic voltage regulator equipment.

(3) One (1) control switch (#7-90R) with two positions of "RAISE" and "LOWER" for the automatic voltage regulator. The control switch shall be of momentary contact type with spring return to neutral position.

(4) One (1) A.C. voltmeter 0-18 kV for generator terminal voltage.

(5) One (1) set of group status indicator for indication of "CENTRAL", "LOCAL", "EXCITATION MANUAL", "LINE CHARGE", "AVR", "MVR (manual voltage regulator)", "OVER EXCITATION", and "UNDER EXCITATION".

(6) One (1) set of group fault indicator.

(7) Manual voltage regulator equipment.

(8) One (1) selector switch (#43-90) with two positions of "AVR" and "MANUAL" for generator voltage regulation mode. The selector switch shall be of maintained contact type.

(9) One (1) control switch (#7-70G) with two positions of "RAISE" and "LOWER" for the manual voltage regulator. The switch shall be of momentary contact type with spring return to neutral position.

(10) One (1) balance meter.

(11) One (1) D.C. ammeter for field current.

(12) One (1) D.C. voltmeter for field voltage.

(13) One (1) generator field circuit breaker with auxiliary switches. The circuit breaker shall be designed for remote 220V D.C. operation and rated for not less than the maximum continuous current of this circuit under any specified operating condition of the generator. The circuit breaker shall be provided with arc extinguishers, and the operating mechanism shall be trip free on all positions.

(14) One (1) field discharge contact and resistor.

(15) One (1) selector switch (#43-41) with two positions of "AUTO" and "MANUAL" for field circuit breaker control. The switch shall be of maintained contact type.

(16) One (1) control switch (#3-41) with two positions of "ON" and "OFF" for manual control of the field circuit breaker control. The switch shall be of maintained contact type.

(17) One (1) field flashing contactor and resistor.

(18) Power system stabilizer (P.S.S.)

(19) All equipment necessary to protect the generator and excitation system from overvoltage caused by generator overspeed.

(20) One (1)D.C. shunt mounted in the excitation system field leads.

(21) Necessary relays and control transformers.

(22) Terminal blocks and other necessary accessories to make a complete working excitation control system.

2.5.7 Other Materials

The power cables between the excitation transformer and 13.2 kV generator bus shall be of 8.7/15 kV, single-core 200 sq.mm. copper, crosslinked polyethylene insulated, PVC sheathed type and shall be supplied with suitable cable ends.

After removal of an existing 50 kVA, 13.2 kV/380 V power transformer installed in the 13.2 kV cubicle for high frequency motor-generator of AVR, this bus branch circuit shall be used as the cable terminal for the excitation transformer circuit with necessary modification. Necessary materials required for this modification shall also be supplied.

2.6 Accessories

The Contractor shall supply the following accessories:

(1) All necessary foundation and anchor bolts for the generator and associated equipment.

(2) All necessary lifting lugs and eyebolts required for installation or removal of machines and equipment.

(3) A name plate of metal (except aluminium) attached to each component of plant giving the name of the manufacturer, the date of manufacturing, serial number and complete rating data in English.

(4) All necessary oil level indicators.

(5) All necessary relays for detecting cooling water flow for the bearings.

(6) All necessary bolts and nuts of each size used.

2.7 Special Tools and Equipment

2.7.1 Mandatory Special Tools and Equipment

The Contractor shall supply one complete set of rotor draw out device including the following items:

- One (1) set of stator stands and jacks
- One (1) set of rotor stand and jacks
- One (1) extension shaft with coupling bolts and nuts
- One (1) set of truck and rails
- One (1) set of pulling device with fitting

2.7.2 Recommended Maintenance Tools and Equipment

The Contractor shall itemize and quote the recommended maintenance tools and equipment for four units of the generators.

2.8 Spare Parts

2.8.1 Mandatory Spare Parts

The following mandatory spare parts shall be furnished and quoted separately for the main equipment for four units.

(1) One (1) set of turbine side main bearing, habitted and machined, but not scraped.

(2) One (1) set of exciter side main bearing, habitted and machined, but not scraped.

(3) Two (2) oil circulating pumps for main bearing with accessories.

(4) Two (2) oil lift pumps for main bearings with accessories

(5) Two (2) air coolers

(6) One (1) set of oil cooler for bearing lubricating oil

(7) Forty-eight (48) pcs. of diode for brushless exciter

(8) One (1) set of spare cards for AVR

2.9 Tests

2.9.1 Tests at Works

All tests shall be carried out in accordance with IEC-34.

(1) Routine tests

All generators shall be subject to the following tests:

(a) Material test
(b) Check of the dimensions
(c) Insulation resistance measurement
(d) Power frequency withstand voltage test for stator coil
(e) Loss angle test
(f) Hydraulic pressure test for air coolers and bearing oil coolers

For the excitation system the following tests shall be carried out prior to shipment:

(a) Check of dimensions
(b) Insulation resistance measurement
(c) Power frequency withstand voltage test
(d) Determination of excitation system response
(e) Sequential operation test
(f) Power frequency withstand voltage tests and performance tests of the excitation transformer
(g) Excitation system loss

2.9.2 Tests at Site

The generators and their auxiliary equipment furnished and installed by the Employer shall be tested in accordance with the requirements of the Preliminary and Performance tests specified in Clause 1.17 of the General Specifications.

SCHEDULE

PERFORMANCE GUARANTEES

Section ____: Alternating Current Generators

I. Alternator Current Generator

1.	Maximum continuous rating	45,000 kVA
2.	Rated voltage	13,200V
3.	Frequency	50 Hz
4.	Rated power factor	0.89 lagging
5.	Synchronous speed	500 rpm

6. Efficiency with all losses including thrust bearing, excitation system and rheostat losses corrected 75°C

	Power factor 0.89 lag	Power factor 1.0
100% rated output	%	%
90% rated output	%	%
80% rated output	%	%
70% rated output	%	%
50% rated output	%	%
40% rated output	%	%

7.	Short circuit ratio	
8.	Deviation factor of open-circuit wave form	%
9.	Inherent voltage regulation - 1.0 P.F.	%
	- 0.89 P.F. lagging	%
10.	Line charging capacity at rated voltage	kVA

11. Maximum temperature rise at rated output as defined in ____

	Method of measurement	Method of measurement
(a) Stator windings	℃	℃
(b) Stator core	℃	℃

12.	Maximum temperature of bearings	℃
13.	Direct axis transient reactance at rated current, unsaturated	%
14.	Direct axis sub-transient reactance at rated current, unsaturated	%
15.	Excitation at 75°C and rated speed and (a) 45,000 kVA, 0.89 P.F. lagging, 13,200V	V
		A
	(b) No load, 13,200V	V
		A

16. Maximum voltage rise when throwing off continuous rated load at rated power factor under actual service conditions with speed control and voltage control equipment in operation _____ %

17. KVAR capability of the generator for rated temperature rise
    (a) Zero power factor leading _____ KVAR
    (b) Zero power factor leading _____ KVAR

II. Excitation System

1. Nominal rating _____ kW
2. Nominal voltage _____ V
3. Ceiling voltage _____ V
4. Response ratio _____
5. Response time _____ sec.

SCHEDULE

TECHNICAL PARTICULARS

Where one of the tendered prices is for a number of parts, the Tender shall attach hereto a list of such parts.

Section ____: Alternating Current Generators

1.	Manufacturer's name	_____
2.	Number	4 units
3.	Type	_____
4.	Direction of rotation when viewed from exciter	Unti-clockwise
5.	Reactances based on 45 MVA	
	(a) Direct axis synchronous	_____ %
	(b) Negative phase sequence	_____ %
	(c) Zero phase sequence	_____ %
6.	Stator	
	(a) Weight of core per unit	_____ tons
	(b) Outside dimension of stator frame	_____ m
	(c) Stator winding resistance per phase at 75°C	_____ ohms
	(d) Current density in conductors at the rated output and voltage	_____ A/sq.mm
	(e) Maximum flux densities in teeth	_____
	(f) Number of parallel circuits per phase	_____
7.	Air coolers	
	(a) Number of unit cooler	2 nos.
	(b) Number of tubes	_____ nos./unit
	(c) Internal diameter of tubes	_____ mm
	(d) Material of tubes	_____
	(e) Cooling water required (cooling water temp. 30°C)	_____ liter/min.
	(f) Loss head of water through the air cooler	_____ kg/cm^2

8. Material of insulation

   (a) Stator conductors in core _____

   (b) Stator core plates _____

9. Excitation system

   (a) Capacity of the static exciter _____ kW

   (b) Capacity of the excitation transformer _____ kVA

   (c) Connection of excitation transformer _____

   (d) Required initial excitation - current _____ A

10. Largest package

   (a) Item _____

   (b) Weight _____ tons

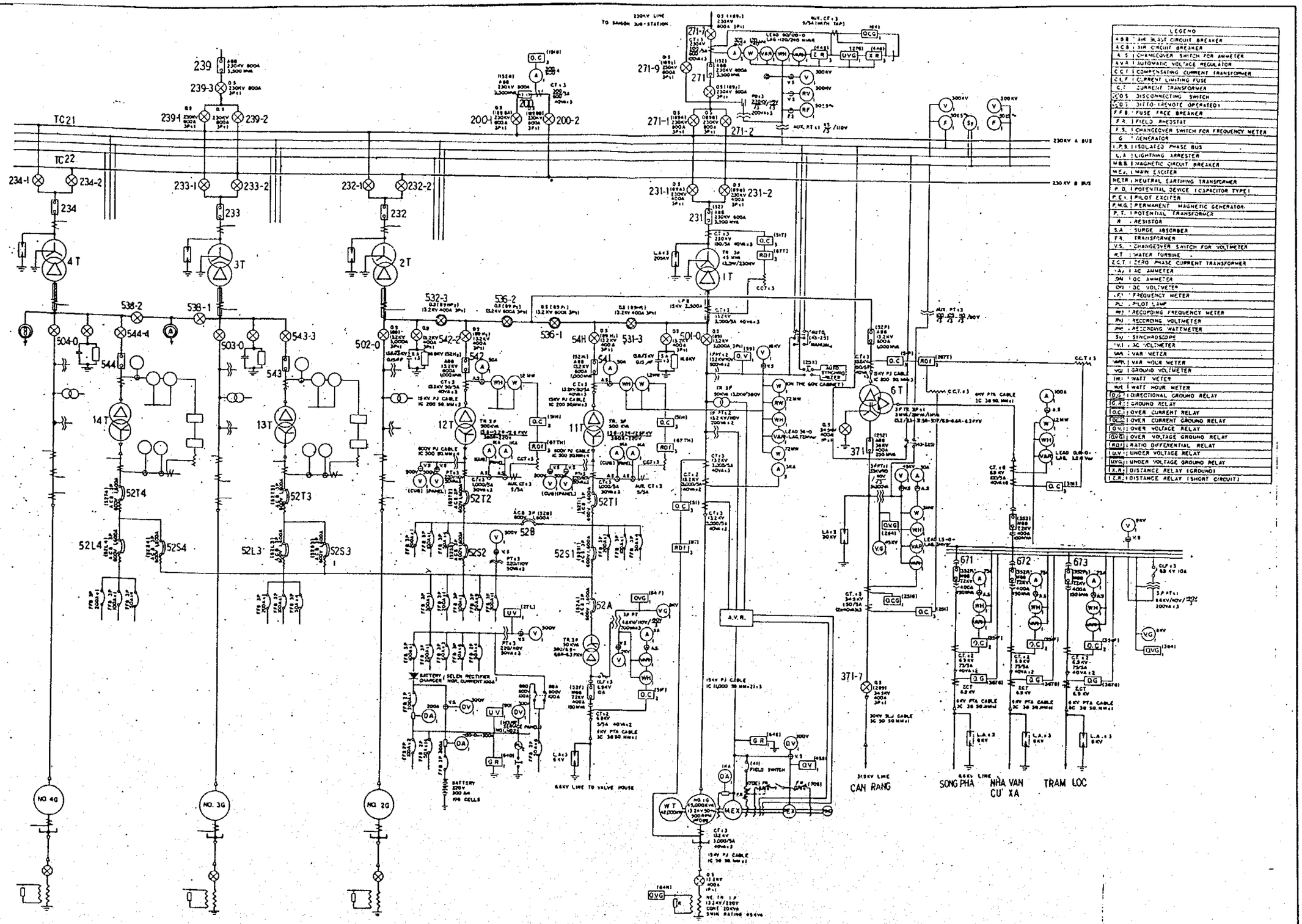
   (c) Dimension (L x W x H) _____ m

11. Heaviest package

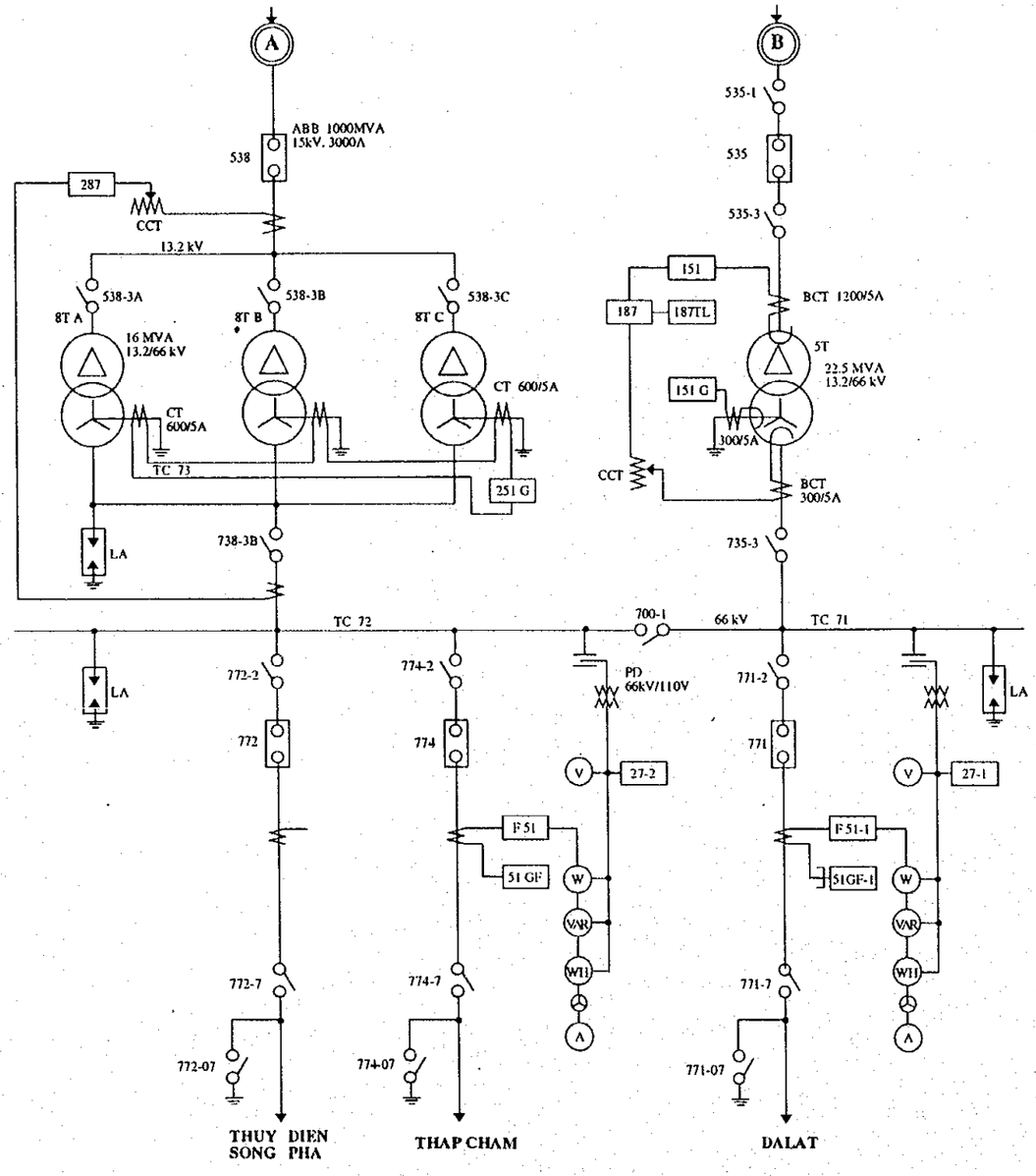
   (a) Item _____

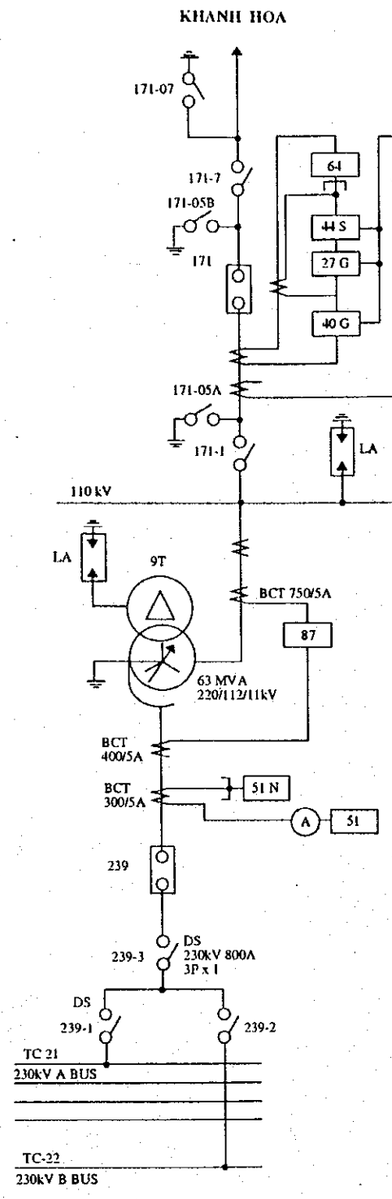
   (b) Weight _____ tons

   (c) dimension (L x W x H) _____ m

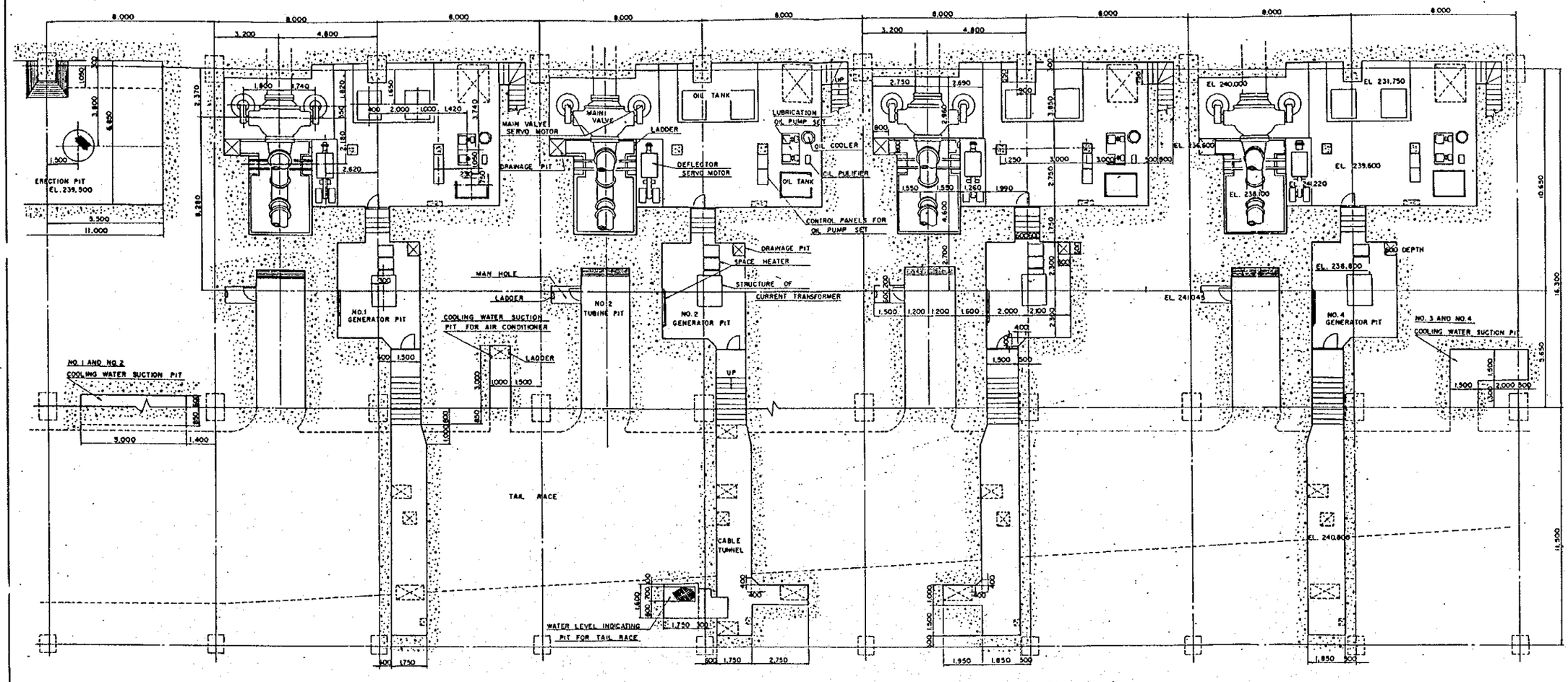


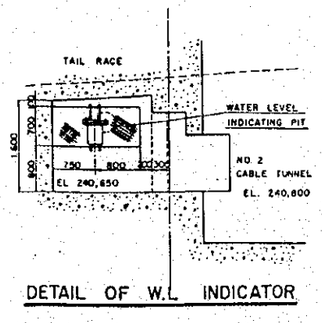
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.1 Skeleton Connection Diagram 1/2





FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.2 Skeleton Connection Diagram 2/2

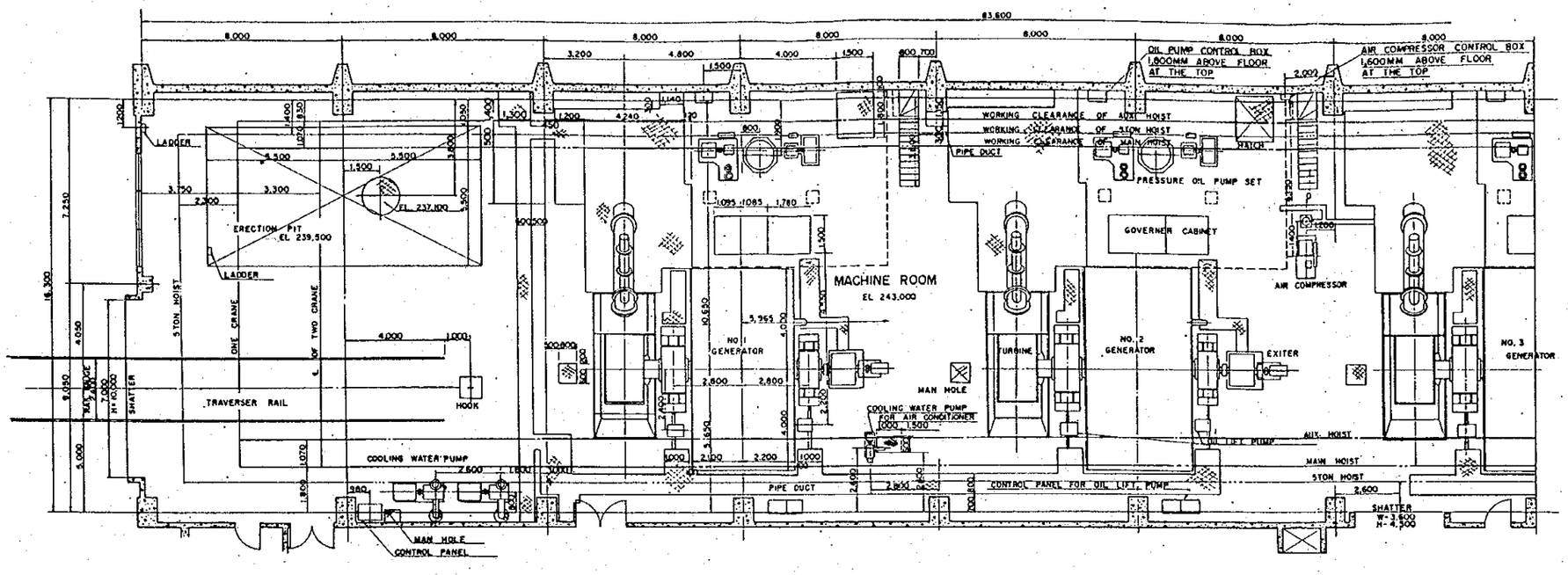


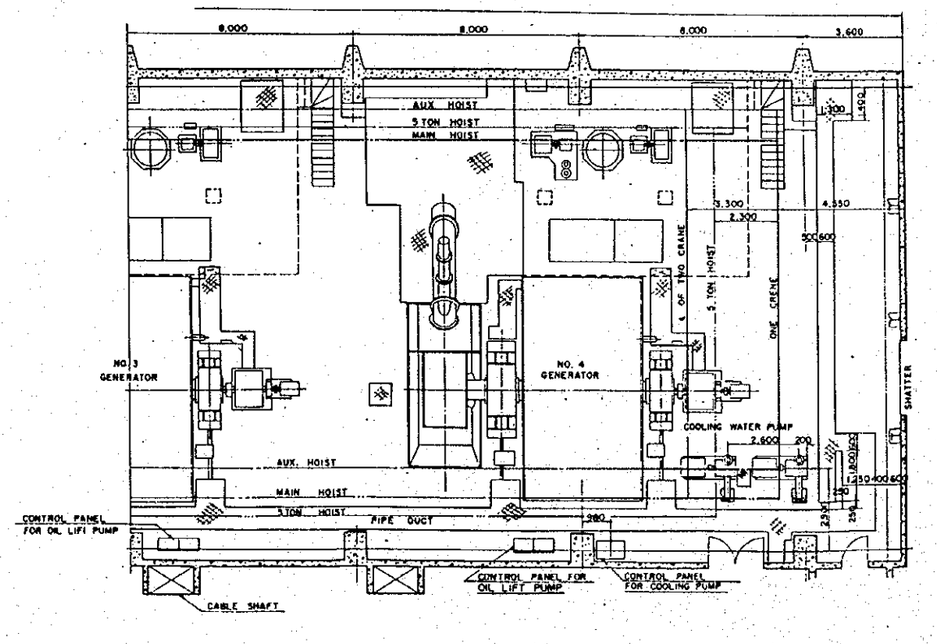


DETAIL OF W.L INDICATOR

SCALE (MM) 1 : 50
0 1,000 2,000 3,000 4,000 5,000

FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.3 Arrangement of Generator and Turbine Pit





SCALE (MM)
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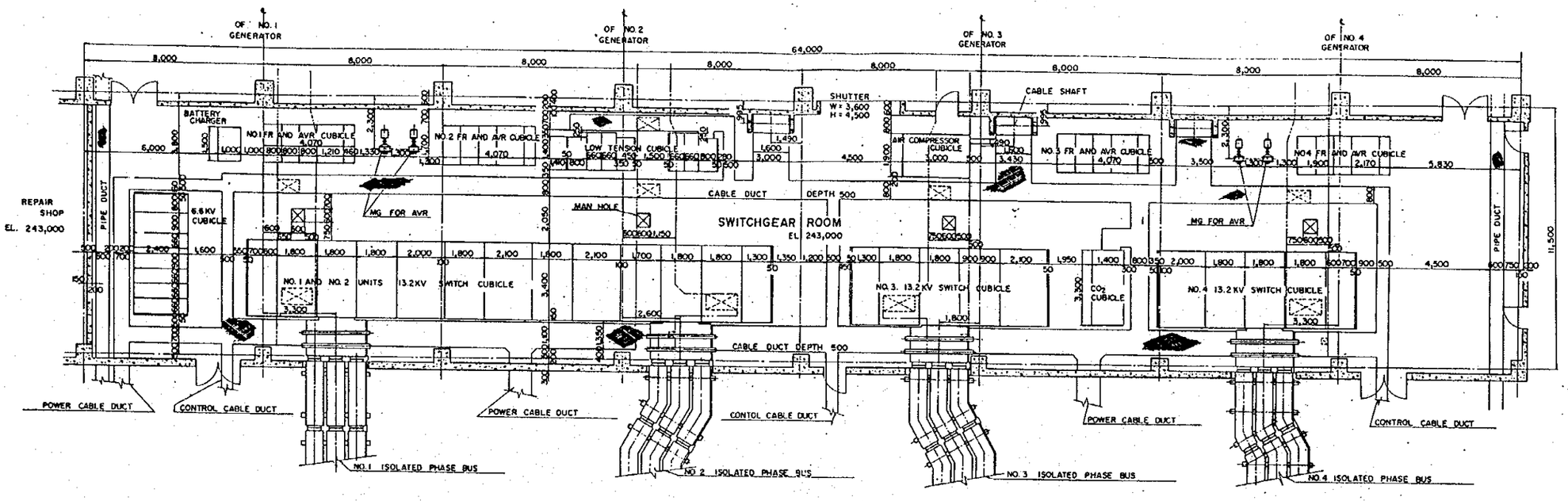
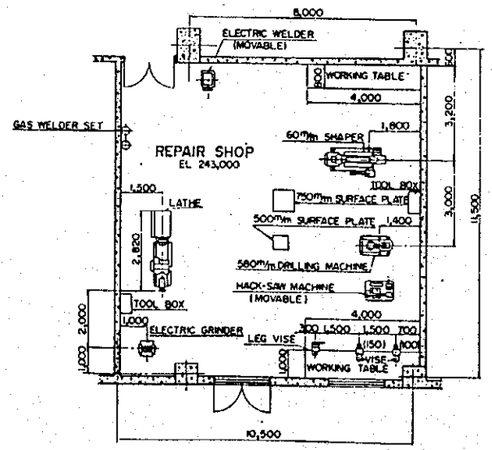
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.4 Arrangement of Machine Room

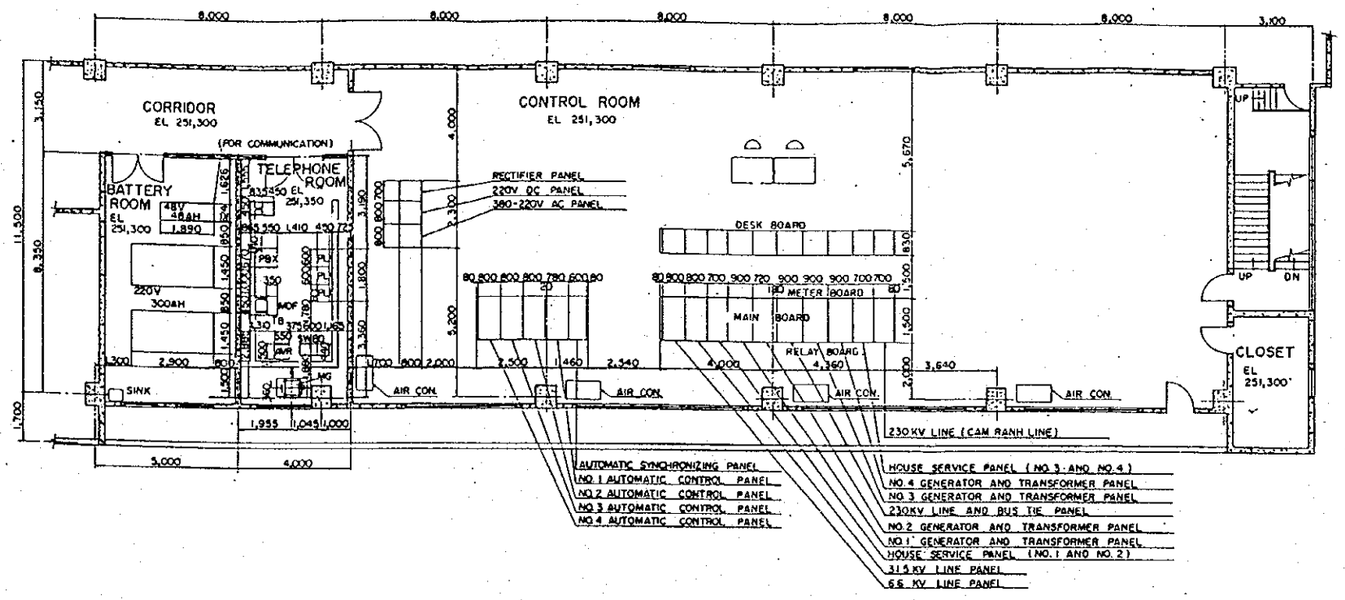




SCALE (MM)

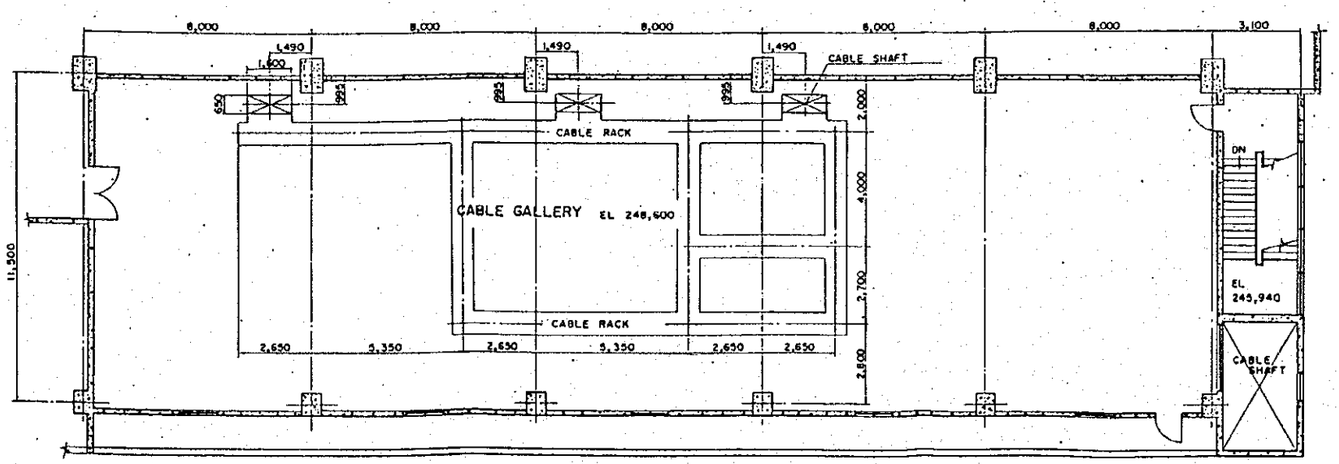
0 5,000 10,000

FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.5 Arrangement of Switchgear Room and Repair Shop



3RD FLOOR

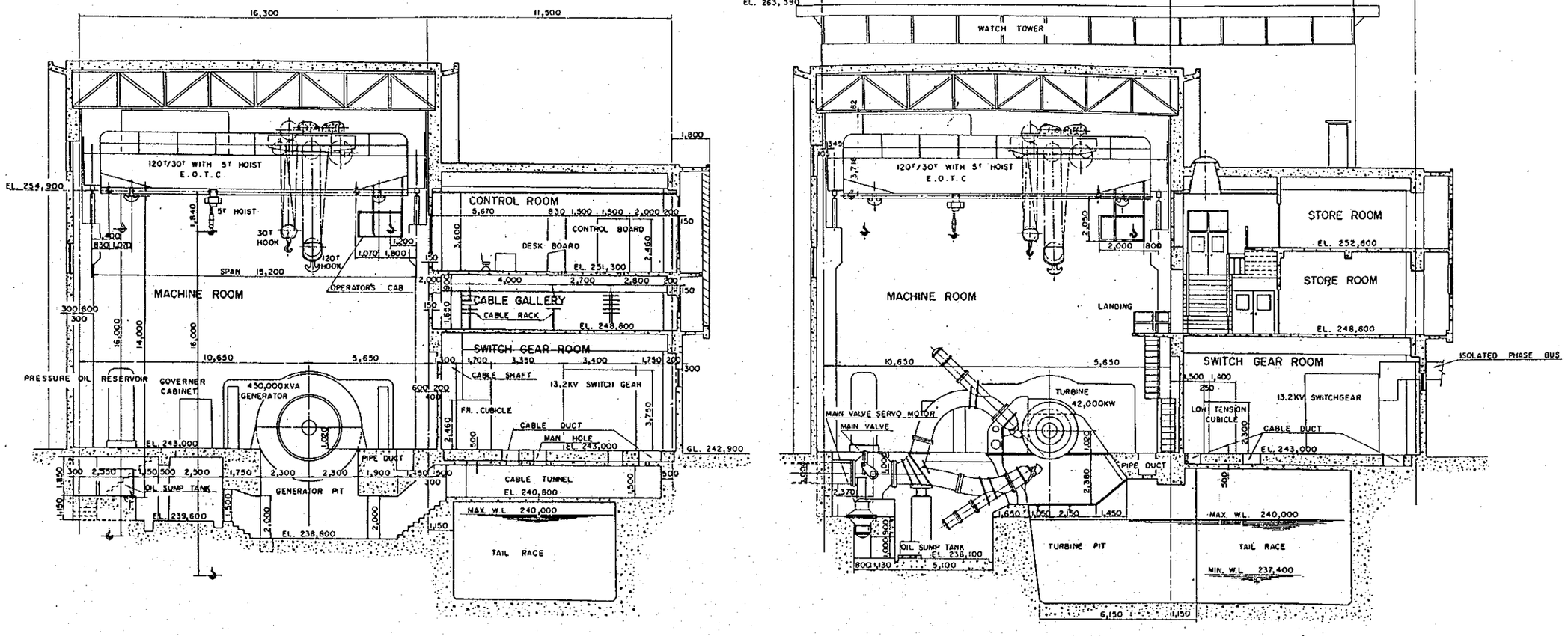
LEGEND	
A V R	AUTOMATIC VOLTAGE REGULATOR
C G	BATTERY CHARGER FOR P8X
M G	MOTOR GENERATOR
M D F	MAIN DISTRIBUTING FRAME
P B X	AUTOMATIC TELEPHONE SWITCH BOARD
P L	POWER LINE CARRIER TELEPHONE SET
SW BD	CONTROL SWITCH BOARD
T B	TERMINAL BOX FOR TELEPHONE



2ND FLOOR

SCALE (MM) 1:100

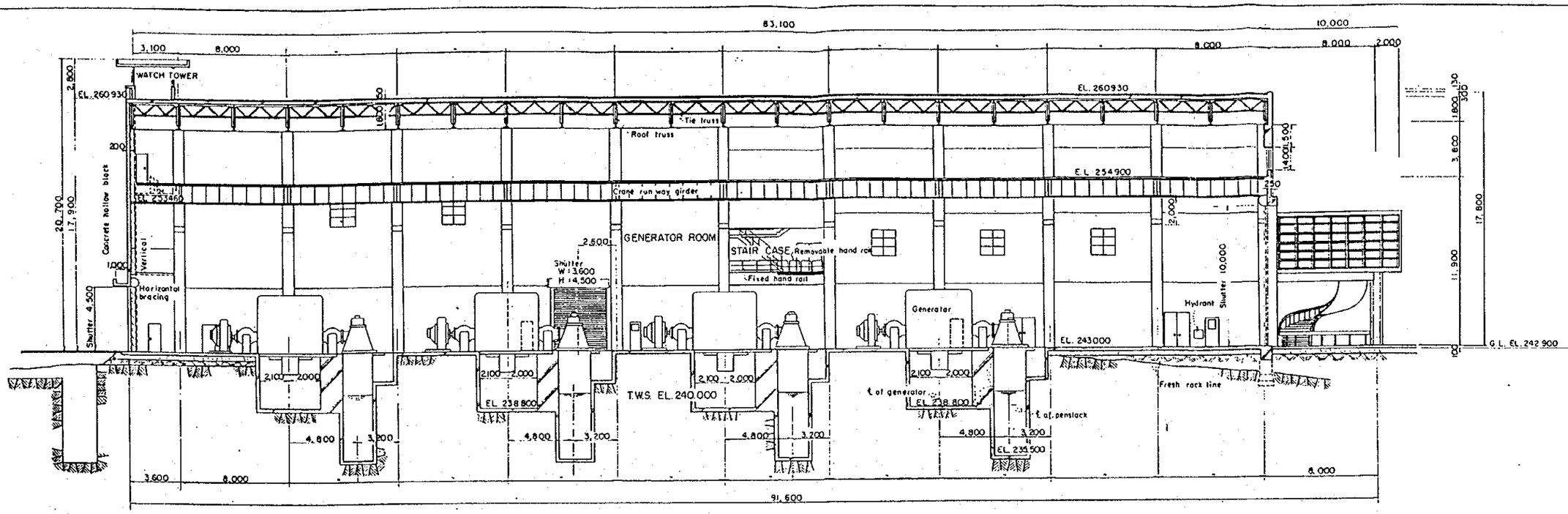
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.6 Arrangement of Control Room and Cable Gallery



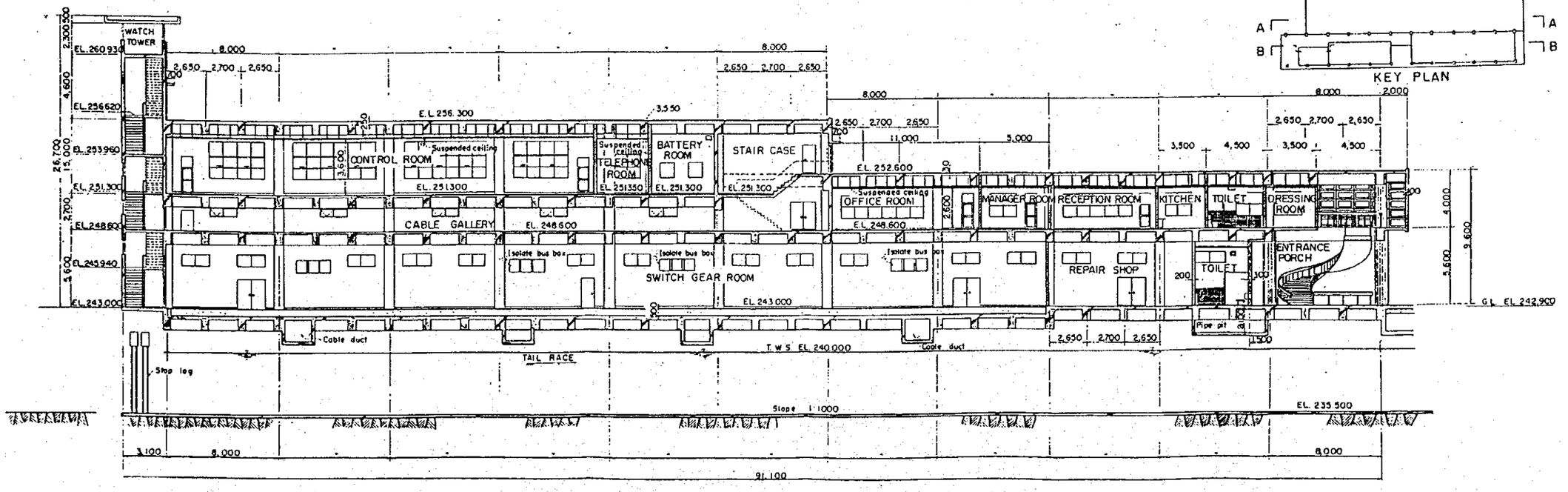
SCALE (MM) 1 : 100

0 5,000 10,000

FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.7 Cross Section of Indoor Equipment



A-A SECTION



B-B SECTION

SCALE (MM)
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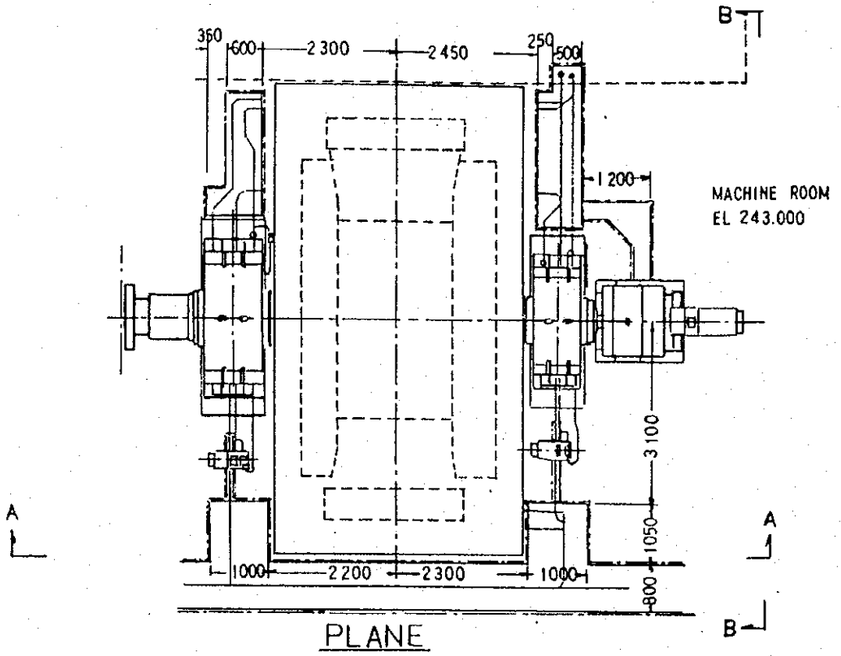
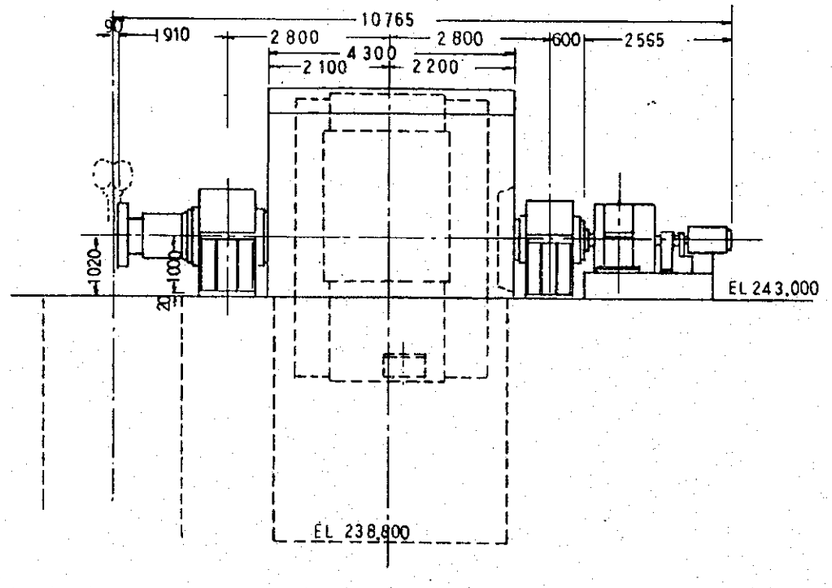
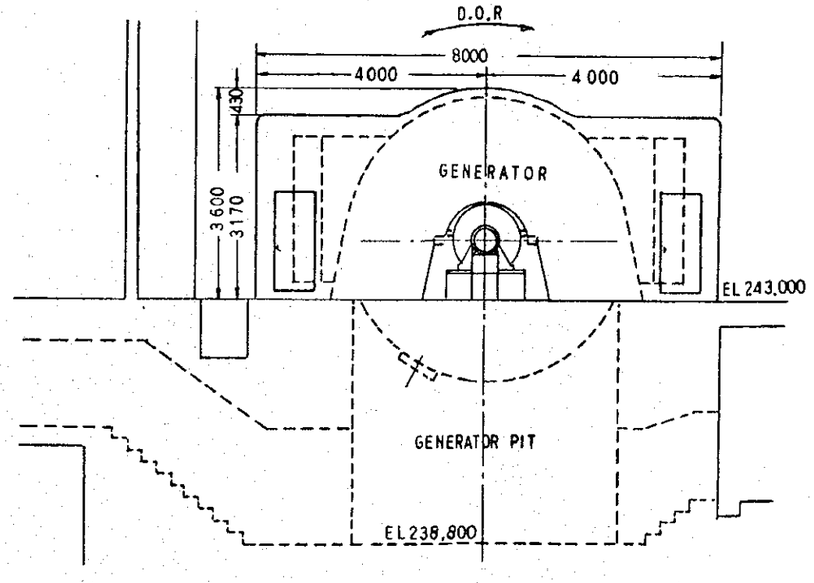
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.8 Longitudinal Section of Power House



PLANE

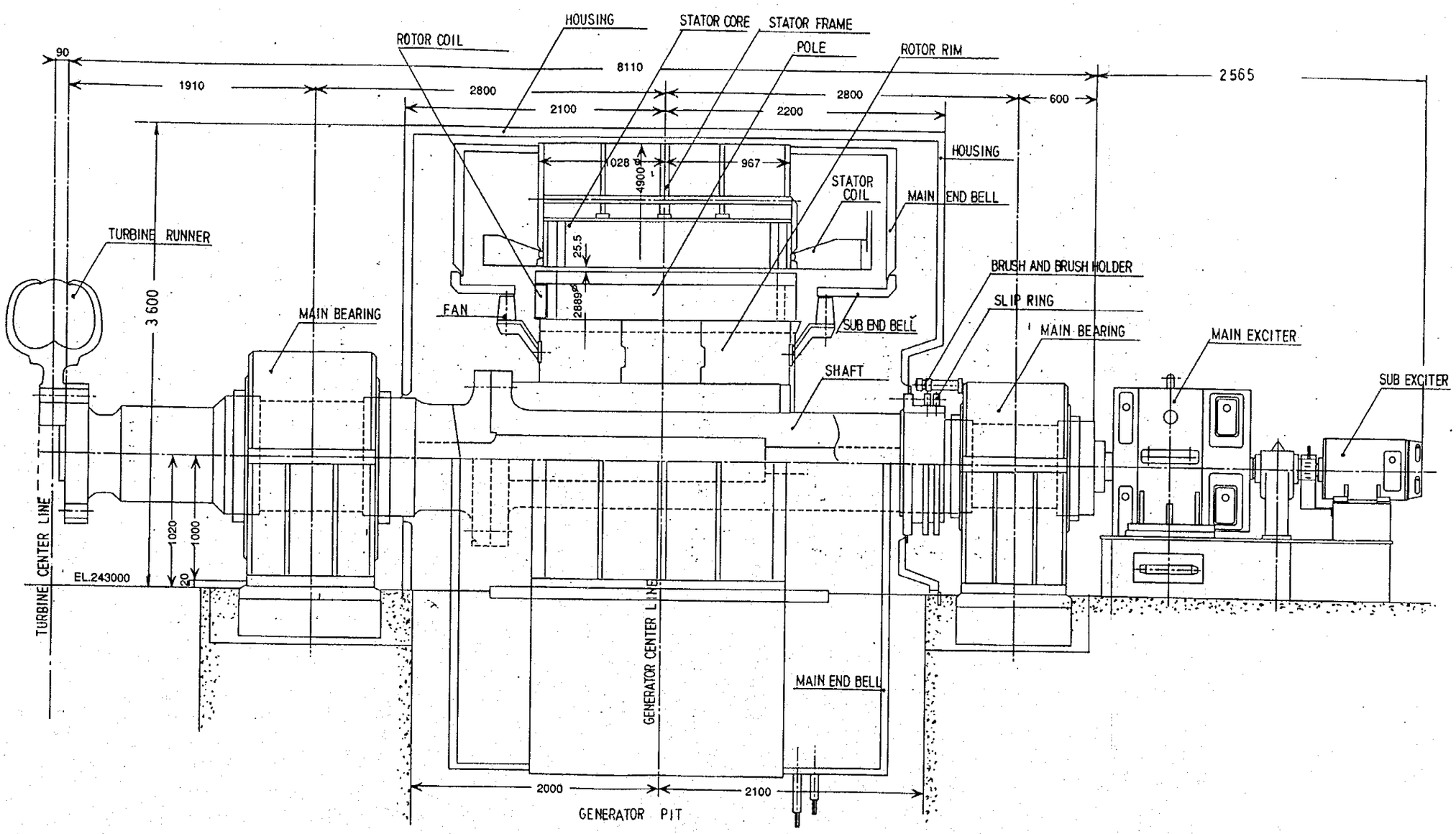


SECTION A-A

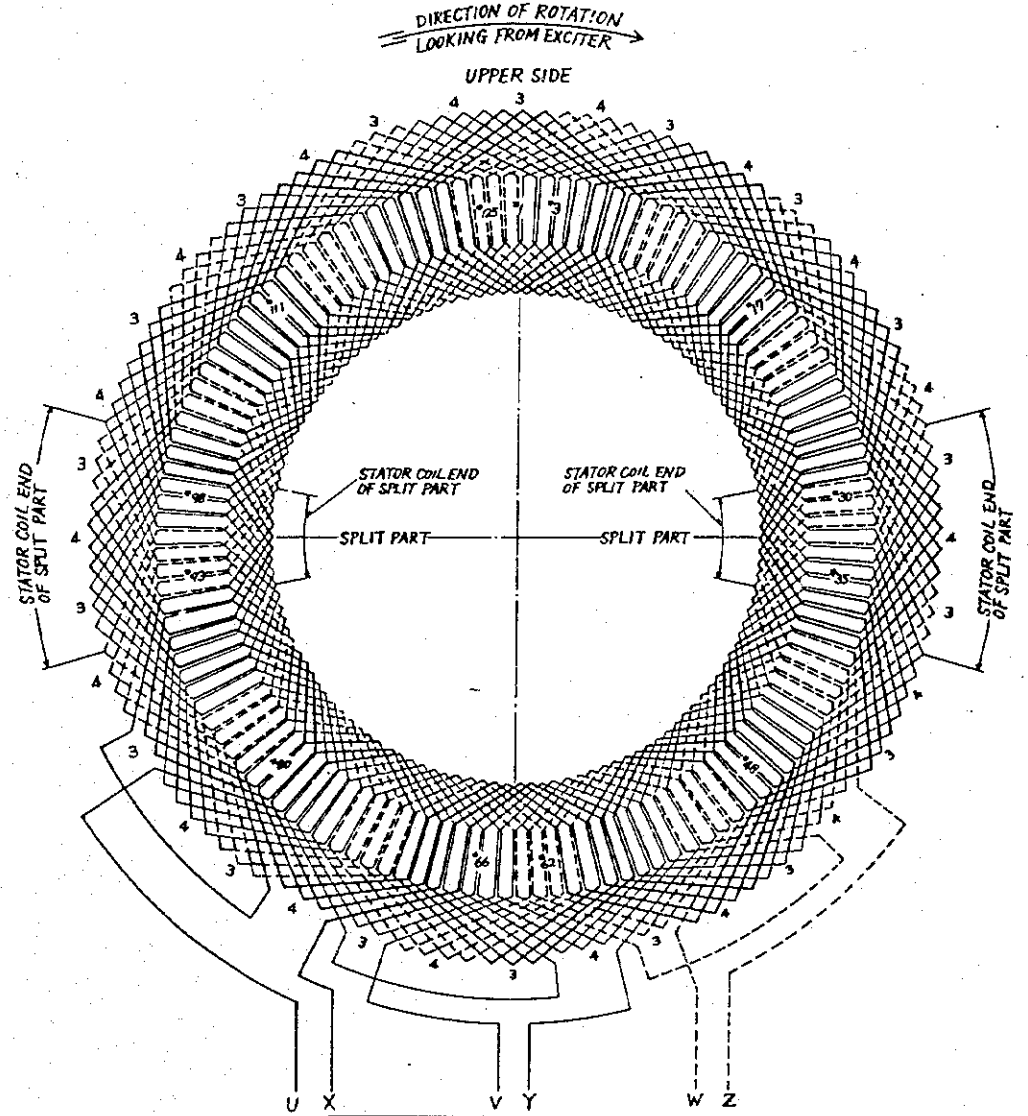


SECTION B-B

FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.9 Generator Outline



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.10 Generator Section



3 PHASE 12 POLE 126 SLOTS

SINGLE STAR CONNECTION

WAVE WINDING

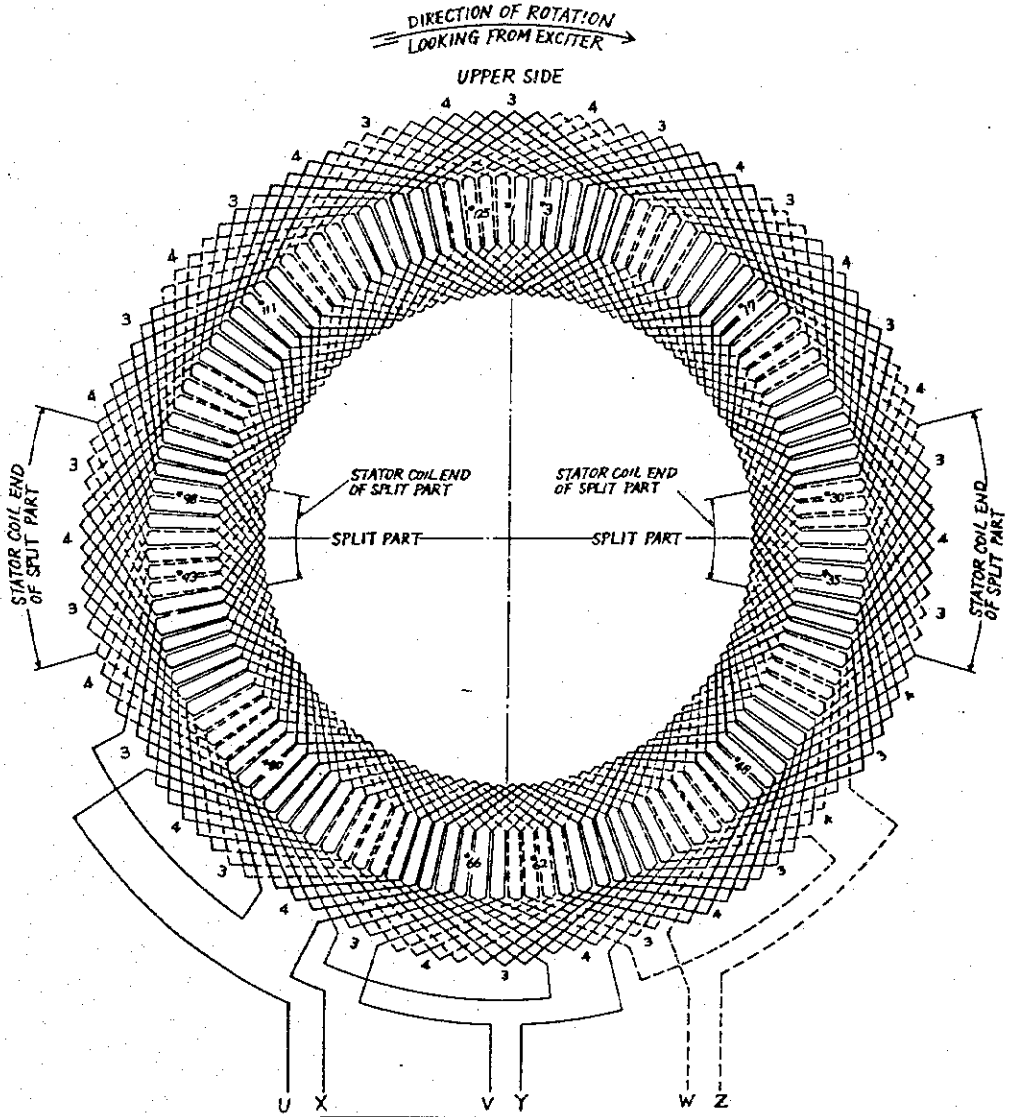
COIL THROW FRONT PITCH 1 TO 13
BACK PITCH 1 TO 10

COIL GROUPING 3½

12 SEARCH COILS FOR TEMPERATURE DETECTOR ARE LOCATED BETWEEN COILS SPECIFIED BELOW.

NO. OF SLOT	NO. OF SEARCH COIL (NORMAL)	NO. OF SLOT	NO. OF SEARCH COIL (SPARE)
3	1	17	7
30	2	35	8
48	3	62	9
66	4	80	10
93	5	98	11
111	6	125	12

FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.11 Stator Winding Diagram



3 PHASE 12 POLE 126 SLOTS

SINGLE STAR CONNECTION

WAVE WINDING

COIL THROW FRONT PITCH 1 TO 13
BACK PITCH 1 TO 10

COIL GROUPING 3½

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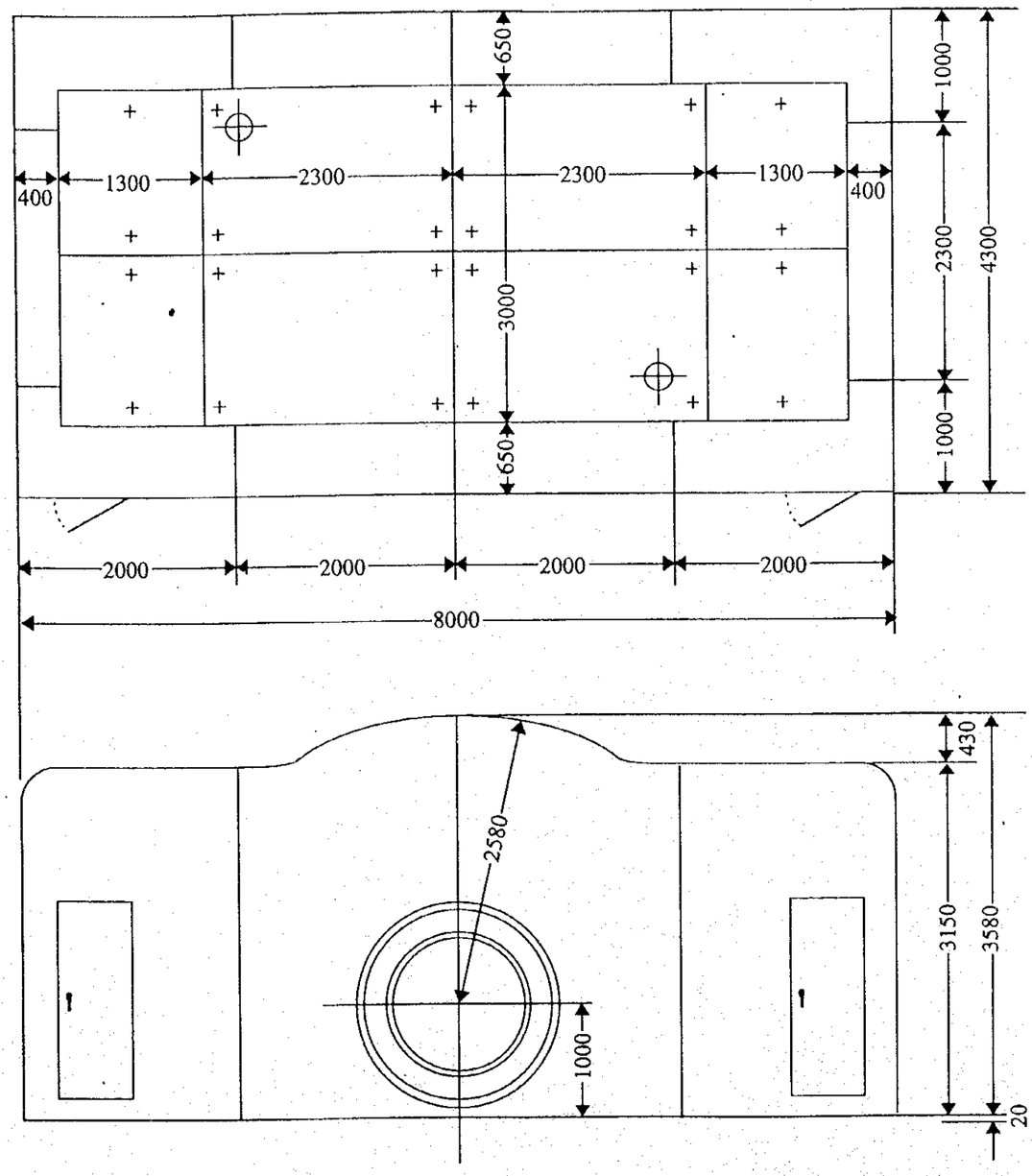
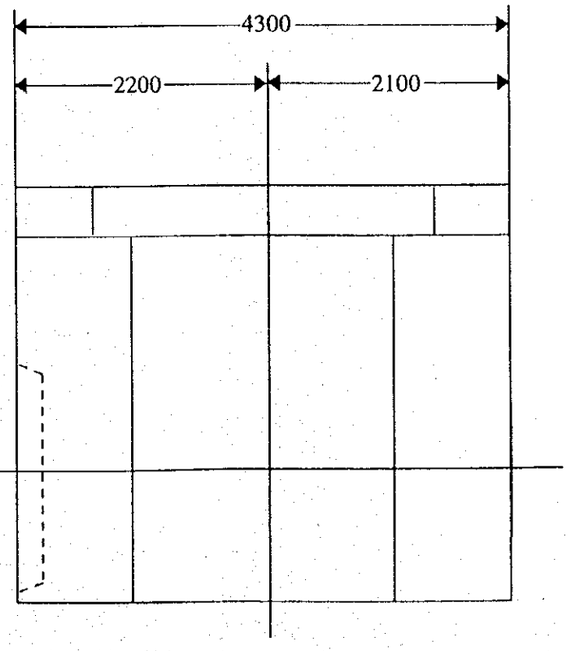
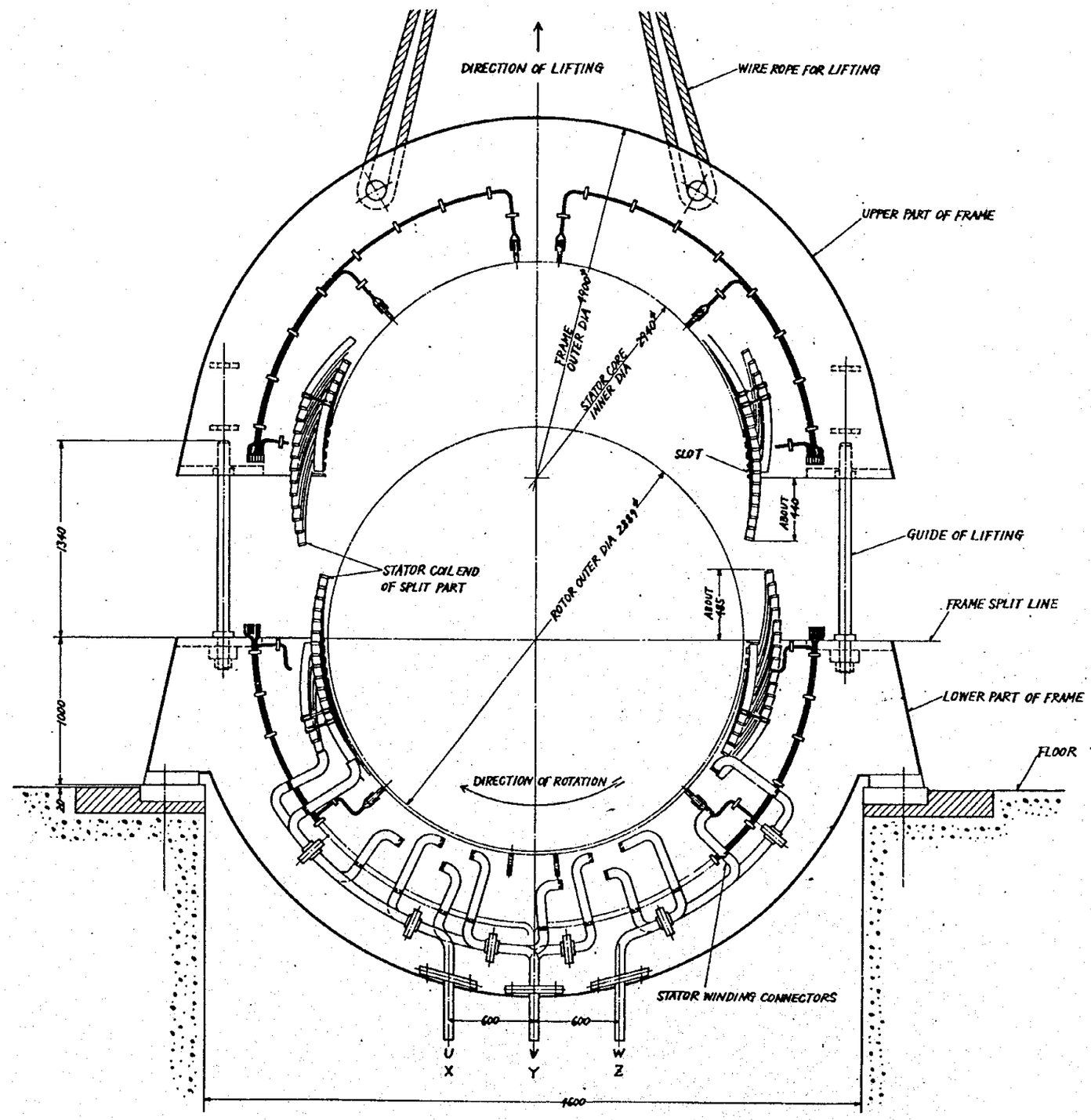
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.11 Stator Winding Diagram

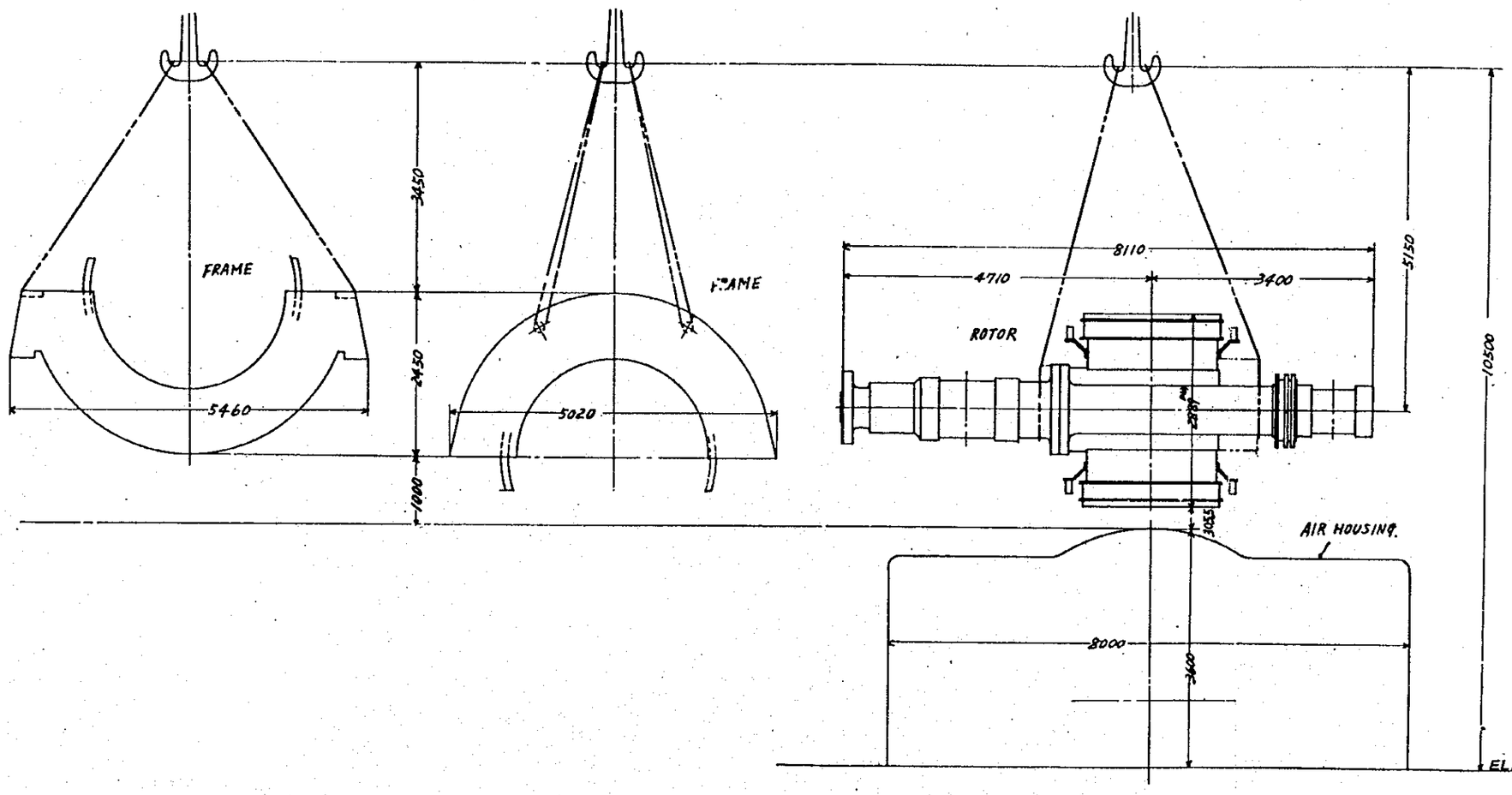




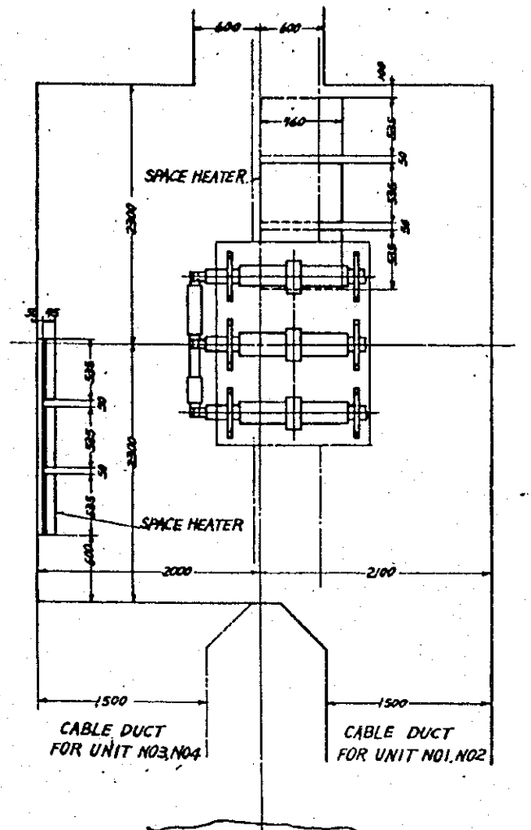
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.12 Assembly of Generator Housing

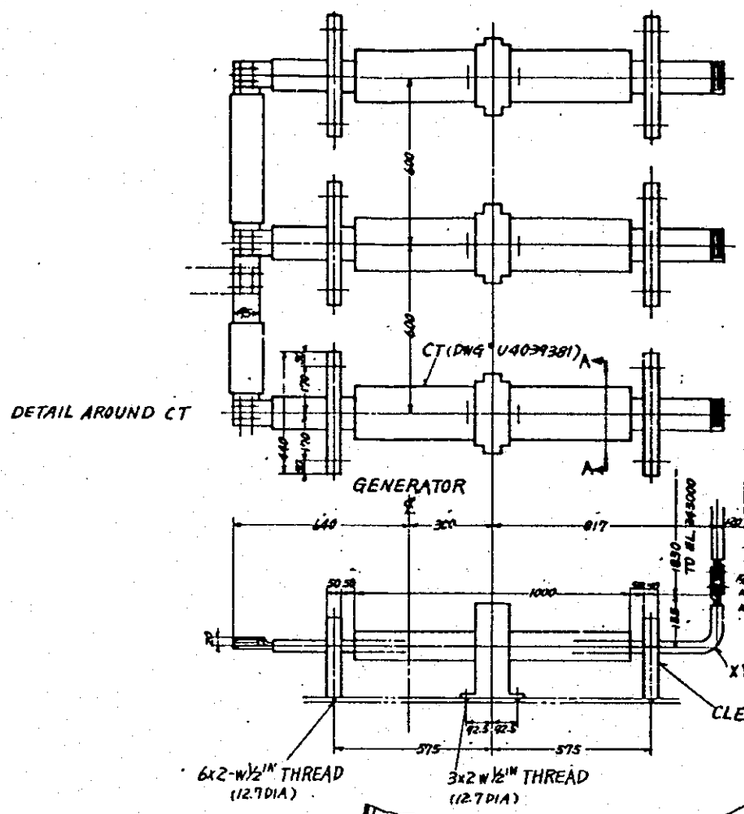


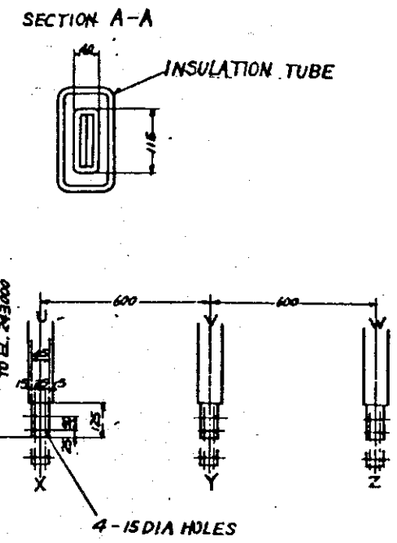
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.13 Assembly of Stator Split (before Improvement)

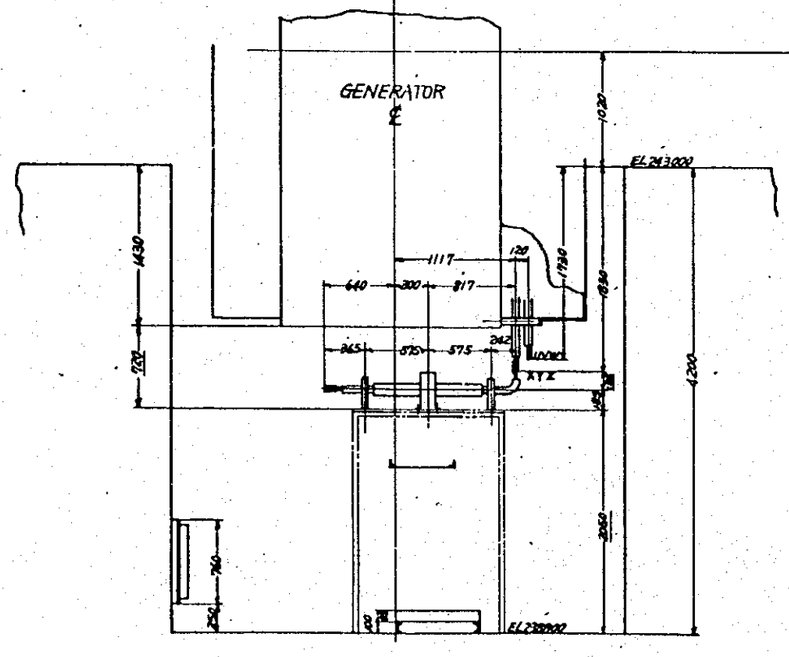


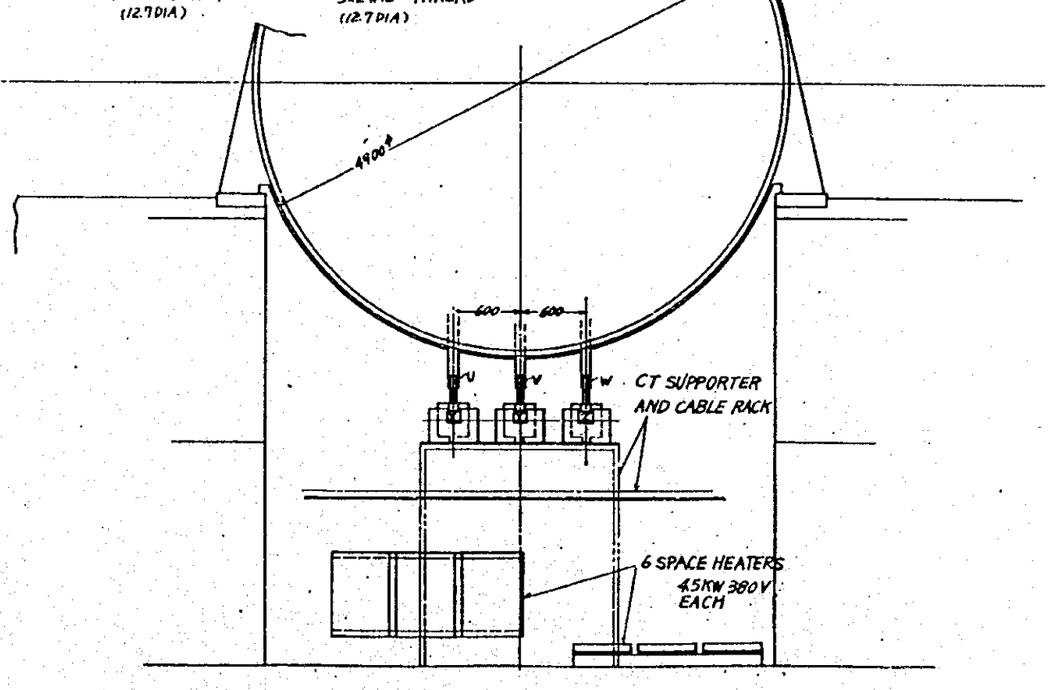
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.14 Generator Lifting (before Improvement)









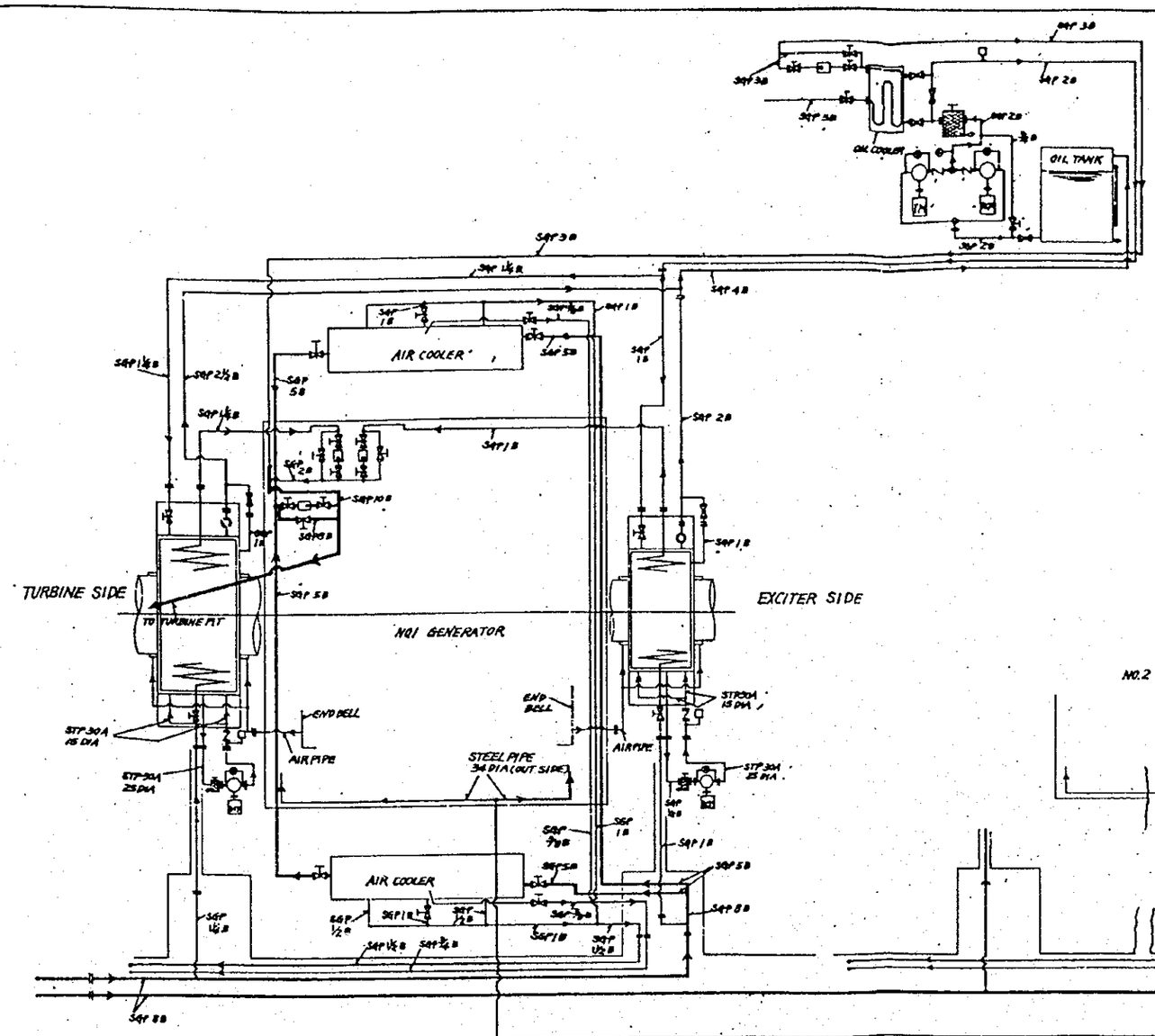


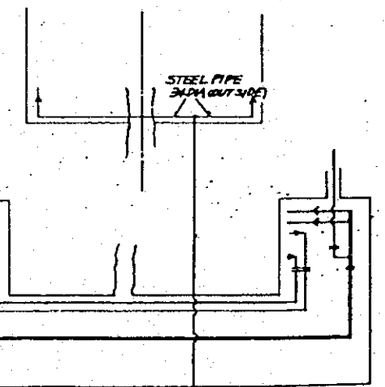
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.15 Arrangment of Current Transformer and Space Heater

NOTE

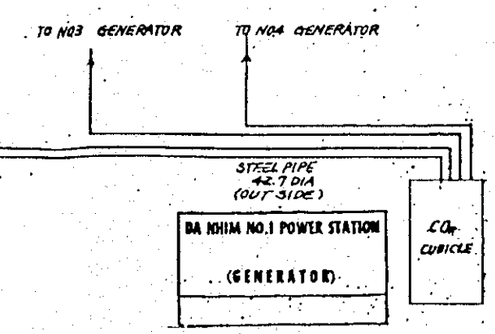
THIS DRAWING IS THE SCHEMATIC DIAGRAM OF LUBRICATION, COOLING WATER AND CARBON DIOXIDE SYSTEM THEREFORE. THIS DOES NOT SHOW THE ACTUAL POSITION.

THE PIPES WHICH ARE DISTINGUISHED BY CHAIN LINES SHALL BE FURNISHED BY THE WATER WHEEL MFR.

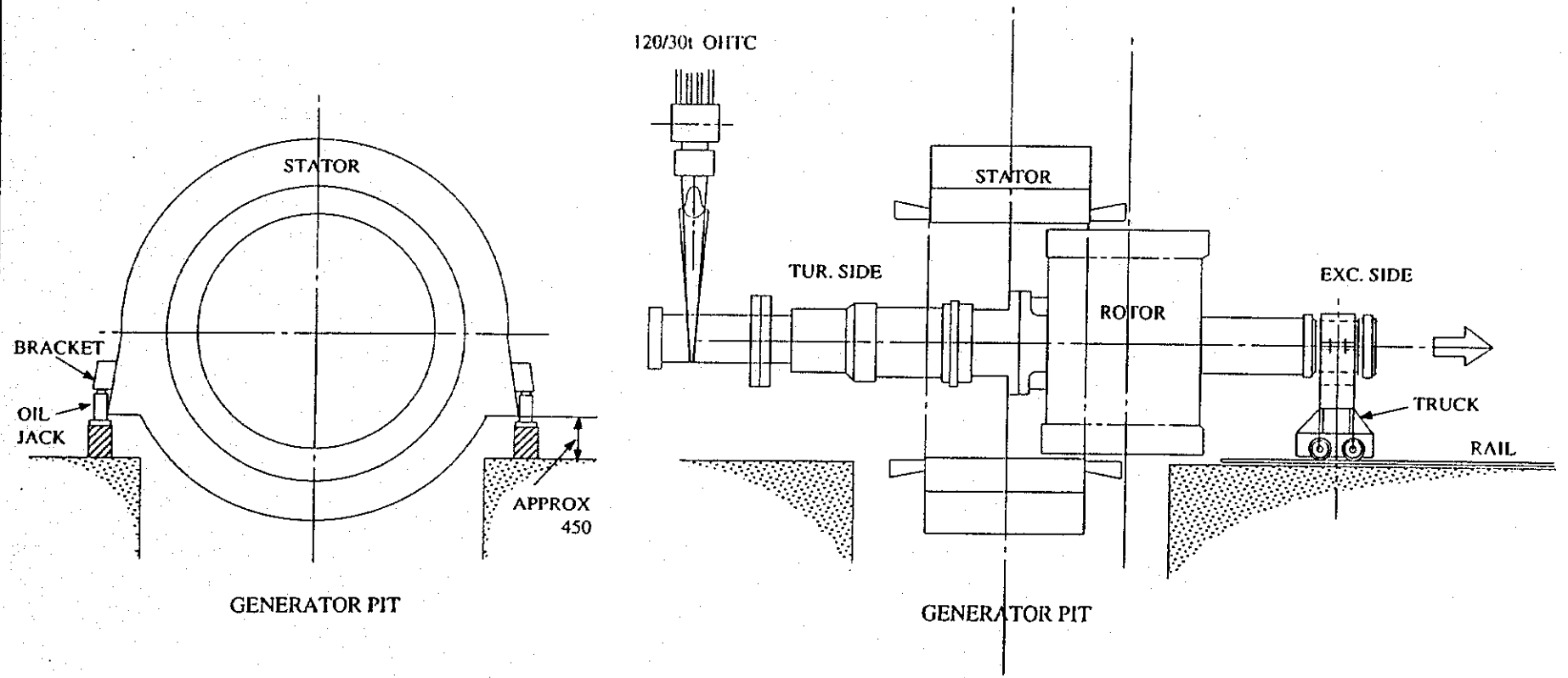




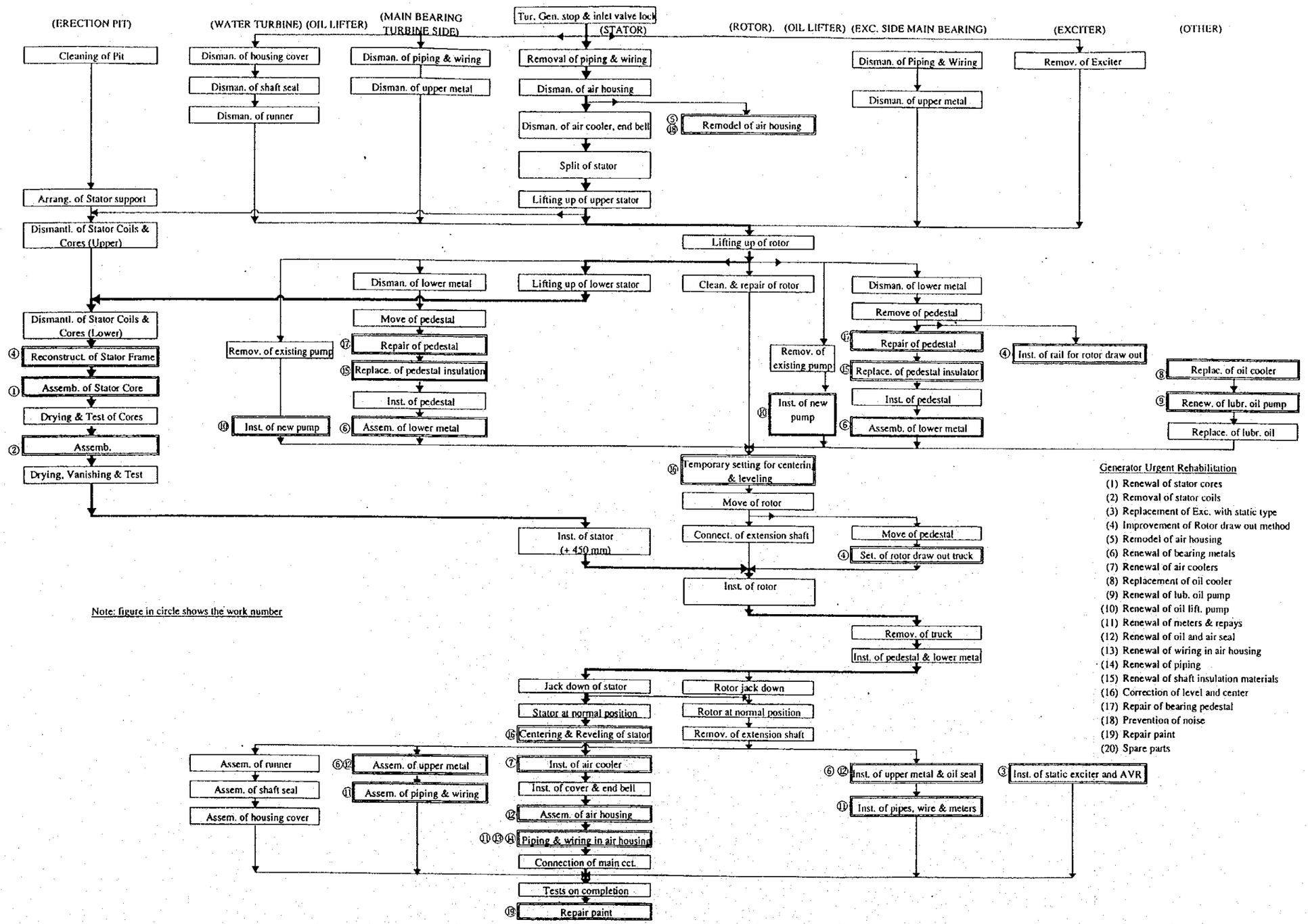
EXPLANATION OF MARK	
MARK	NAME
	GLOBE VALVE
	SLUICE VALVE
	TWO-WAY COCK (SCREWED TYPE)
	THREE-WAY COCK
	TWO-WAY COCK
	CHECK VALVE (SCREWED TYPE)
	CHECK VALVE
	FLANGE
	INSULATION FLANGE
	WATER FLOW RELAY
	SAFETY VALVE
	PRESSURE GAUGE
	STRAINER
	DIRECTION OF FLOW
	OVER FLOW
	OIL PRESSURE RELAY
SGP 1/8	13.8 DIA STEEL GAS PIPE
SGP 1/4 B	21.7 DIA
SGP 3/8 B	27.2 DIA
SGP 1B	34 DIA
SGP 1 1/4 B	42.7 DIA
SGP 1 1/2 B	48.6 DIA
SGP 2B	60.5 DIA
SGP 2 1/2 B	76.3 DIA
SGP 3B	89.1 DIA
SGP 4B	114.3 DIA
SGP 5B	139.8 DIA
SGP 8B	216.3 DIA
SGP 10B	267.4 DIA STEEL GAS PIPE
STP 30A	CARBON STEEL PIPES FOR HIGH PRESSURE SERVICE



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.16 Piping Diagram



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.17 Rotor Carrying out Method



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 3.18 Flow Chart of Urgent Rehabilitation Works of Generator