CHAPTER 5 EQUIPMENT DESIGN

5.1 General Description

5.2 Mechanical Design

5.3 Electrical Equipment

CHAPTER 5 EQUIPMENT DESIGN

5.1 General Description

(1) Type and description

The pump shall be a vertical shaft, single suction, centrifugal type direct connected to a vertical shaft synchronous motor. The casing shall be of the diffuser type construction. The rotation of the pump shall be counterclockwise as viewed looking down on the unit.

The pump shall be the product of a manufacturer experienced in the design and manufacture of the type of pumps required by following mechanical design requirements.

The pump shall be designed and constructed to meet the following general requirements:

-The impeller shall be removable without disturbing the suction cover and the entire rotating element shall be able to removed from the casing when the top cover is taken away.

-Provision which the impeller and shaft shall be movable and enough space for adjusting and dismantling both the thrust bearing and clearing the motor shaft without coupling bolts, shall be made.

-An oil-lubricated thrust bearing as part of the motor shall be bearable against both the total weight of the rotating parts in pump and maximum unbalanced hydraulic thrust which is occurred in case that clearance between impeller and wearing expands more than two times of design value.

-All parts of the pump shall be designed for safety operation against the stress by the maximum reverse speed in power failure without consideration of unrestricted reverse flow, friction and windage.

-All major parts shall be provided with eye bolts lugs, or lifting devices to facilitate handling with a crane.

-The hydraulic design of the prototype pumps shall be homologous with the pump model approved by MED.

(2) Operating Condition

Normal starting and stopping of the unit shall be controlled from a control circuit specified in later section. The pump will be started with the discharge valve closed. Automatic opening of the discharge valve will be initiated by a contact which closes when the unit reaches synchronous speed. Under emergency conditions, including power failure, closure of the discharge valve will be initiated simultaneously with power interruption to the motor. Under normal shutdown conditions, the discharge valve will close, then power to the pump

motor will be interrupted.

The discharge pipelines shall be filled by the pipeline fill pumps provided in the pumping station.

(3) Head, Capacity, Speed and Efficiency

The minimum pump capacity, total head and speed at rated conditions are shown below. The maximum capacity of the pump shall not exceed 122 percent of the required minimum capacity at rated head. The expected range of total heads and the best efficiency head are also shown below. All pump losses shall be in addition to the specified head and shall be allowed for when computing the pump characteristics.

Rated capacity	(m^3 / s)	:	10.827
Rated head	(m)	:	99.6
Head range	(m)	:	aprox. 100 to 87
Best efficiency head	(m)	:	93.5
Speed	(r / min)	:	375

Suction sump water surface elevation (m)

max.	10.7	
design	9.9	
min.	9.7	(full unit operation)
min	8.8	(one unit operation)

Discharge tank water surface elevation (m)

max.	92.9	
min.	92.5	(pumps for stage I)
min.	92.6	(pumps for stage II)

Pump centerline elevation (m) : 1.60

Pump efficiency : The efficiency of the units supplied shall be as high as practicable consistent with the best modern design.

5.2 Mechanical Design

5.2.1 Main pump

(1) Impeller

(a) General

The impeller shall be of the enclosed type and shall be made in one piece entirely of stainless steel (ASTM designation ; A743M Grade CF-8) or equivalent, selected for and resistance to cavitation and abrasion. Impeller shall be equipped with replaceable wearing rings.

Austenitic stainless steel (ASTM A743M, previous A296, Grade CF-8) is selected as suitable material for the impeller in this project because fluid to be lifted contains slightly mild acid corrosives such as chloride, carbonate which discharged from upstream irrigation area.

This material is best known and widely used for most application. It is markedly superior in corrosion resistance compared to the chromium stainless steel, and may make unnecessary the high temperature water quench after welding. Following shows chemical composition and minimum mechanical properties of CF-8.

Carbon, max.	0.08
Manganese, max.	1.50
Phosphorus, max.	0.04
Sulphur, max.	0.04
Silicon, max.	2.00
Nickel	8.0 - 11.0
Cromium	18.0 - 21.0
Tensile, MPa	485
Yield, MPa	205
Elongation, min %	35

(b) Design and Fabrication

The impeller shall be thoroughly inspected by a non-destructive method (liquid penetrant examination). The impeller shall have sufficient strength to withstand forces due to runaway speed and to support its own weight and the weight of the main shaft when the latter is disconnected from the motor shaft and the impeller is resting on a ledge or shoulder in the suction cover or suction tube liner. The finished impeller shall be dynamically balanced.

(2) Shaft

(a) General

The pump shaft shall be made of forged, open-hearth carbon or alloy steel properly heat treated. The shaft shall be provided with integrally forged flanged couplings for connection to the impeller and to the intermediate shaft/ motor shaft.

(b) Design and Fabrication

The shaft shall be of ample size to operate at any speed up to full reverse runaway speed without excessive vibration or objectionable distortion. The size of the shaft and the construction of the main bearing support shall be such that any shaft deflection or unbalanced radial thrust on the impeller under any condition of speed up to full runaway speed or under any condition of discharge from maximum capacity to shutoff. Shall not cause contact between the impeller and casing ring.

(3) Casing

(a) General

The pump casing shall be of diffuser type construction as shown in figure 5.2-1 and shall be fully embedded in concrete. The casing shall be constructed in radial sections and shall have the least

number of sections practicable for shipment and handling. The casing shall be of welded plate steel.

The outlet of the casing shall be 1500 mm with a connecting flange to suit the discharge valve. The casing extension shall be provided a man hole of 500 mm diameter.

(b) Design and Fabrication

Unless otherwise specified, the pump casing shall be designed and fabricated in accordance with a pressure vessel code approved by MED.

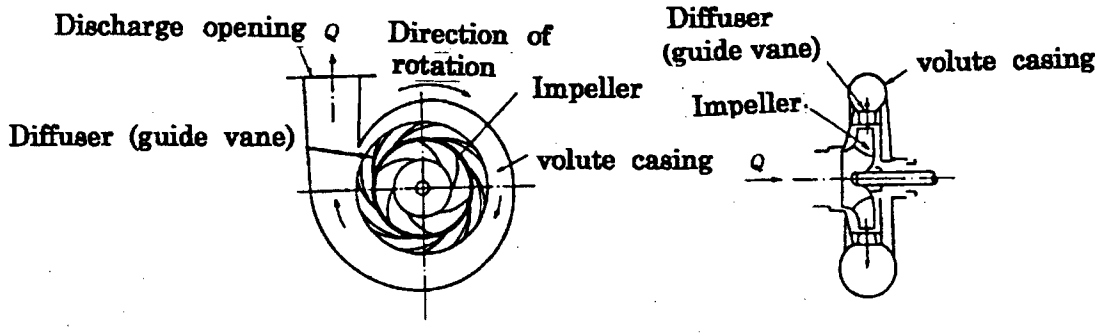


Figure 5.2-1 Diffuser type pump

(4) Guide Bearing

The main guide bearing shall be of the babbitt-lined oil lubricate type, and shall consist of a bearing housing and a removable bearing shell. The bearing shall be located above the stuffing box and as close to the impeller as possible and shall be suitable for contiguous operation with the shaft rotating in either direction.

(5) Casing and Impeller Wearing Ring

Removable and renewable wearing rings shall be provided where there are close running clearance between the impeller and the stationary parts of the pump.

To avoid biting each other, one of each pair of wearing rings shall be made of stainless steel with Brinell hardness approx. 300. And the other wearing ring of each pair shall be made of aluminum bronze with Brinell hardness of approx. 160.

(6) Stuffing Box

A stuffing box, designed so that it can be repacked and adjusted without disturbing the guide bearing or dismantling any other part of the pump, shall be provided where the shaft passes through the casing cover. The stuffing box shall be constructed to permit minimum seal water flow without excessive pressure on the packing and shall be packed with high-grade, Teflon type, hydraulic packing.

(7) Suction Elbow Liner

A steel suction elbow liner extending from the pump suction cover to the point to be connected with the suction pipe shall be provided as shown on drawing PSM-201. The connection between the suction cover and suction elbow shall be by either field welding or use of a flange.
The Suction elbow liner shall be provided with a man hole approximately 600 x 900 mm in size.

(8) Pit Liner

The pit liner shall be provided to permit removal of the casing cover in one piece, and be made integral with the equipment alcove which have opening for conduit and pipe chases.

(9) Platforms, and Handrail

A walkway shall be provided around the circumference of the guide bearing for convenience in inspection, operation, and maintenance. A safety guard shall be provided around the pump shaft.

(10) Instruments, Electrical Control and Alarm Switches

The pump shall be provided with the instruments, electrical control panels, and alarm switches.

5.2.2 Valves

(1) Discharge Valves

(a) Type and Description

The type of valves placed in the discharge lines from pumps must be carefully selected to give the most economical installation while providing the desired operating conditions. Hydraulically cylinder-operated butterfly valves, electrically controlled, in the discharge lines from vertical type centrifugal pumps should be selected for automatic start and stop of pumps and automatic closure following power failure or shutdown of the units.

(b) Structural General

The bi- plane type butterfly valve with nominal bore of 1,500 mm (rated flow speed will be approx. 6 m/s) should be selected for high head in this project, which is suitable for operating system using hydraulic oil. Valve size, maximum unbalanced pressure expected at the discharge valves, and time of opening or closing the discharge valves should be suitable to operate under the most severe normal and abnormal operating conditions including emergency shutdown for water hammer protection.

Valve body : The valve body shall be designed to withstand the maximum occurring combined forces of operating cylinder or counterweight, pump suction head, pump shutoff head, and the bulkhead load imposed by the full discharge pipe line. The valve body shall be provided with a structurally adequate base and mating sole plates which will be embedded in a concrete pier.

Valve shaft : The valve shaft shall be made of stainless steel and be of sufficient size to transmit the forces imposed on the shaft by the disk, cylinder operator and counterweight without distortion or undue stress. The valve shaft shall be of the stub shaft type, which comprises two separate shafts inserted into the valve disk hubs or be combination of a separate shaft and a shaft combined with the valve disk.

Valve disk : The valve disk shall be of welded plate steel or cast steel.

Valve seat : The valve seats shall be of a design that permits removal, replacement and adjustment without removing the valve from the discharge line. The valve seats shall provide tight shutoff with full discharge line pressure of 9.1 bar max. on the downstream face of the valve and 0 bar on the upstream face of the valve. The valve seat shall be mechanically held in place by the metal retainers. The valve seat which are epoxied in place or the rubber seat inflated behind by epoxy without the metal retainer are not acceptable. The mating seat surface shall be 18.8 stainless steel.

Bearings : The valve shall be fitted with sleeve type self-lubricating bearings in the hubs of the valve body. The inside bearing support shall be designed to allow ready access to the stuffing box. Either two thrust bearings or a two-way thrust bearing shall be provided to insure centering of the disk.

Operator : The rated torque capability of the operator shall be sufficient to seat, unseat and hold the valve disk rigidly in any intermediate position under any operating condition.

Operating system : A schematic diagram of the hydraulic portion of the valve-operating system is shown on the drawing PSM-203.
The oil hydraulic unit shall be provided complete with two 7.5 kw motor operated oil pumps, a hand oil pump, an oil reservoir, a single oil-level switch, an armored gauge glass with valves, external bypass relief valve, and all necessary connecting piping and wiring completely assembled as a unit.

A free standing, semi-enclosed, sheet steel control panel, shall be provided to house the pushbuttons, selector switch, indicating lamps, terminal blocks and three solenoid valves, two flow control valves, a accumulator, a pressure switch, a discharge pressure gauge and all necessary connecting piping and wiring completely assembled as a unit.

The electrical facilities incorporated in the unit shall be designed based on the electric sources AC, 380 V, 3 ϕ , 50 Hz.

The arrangement of the discharge valve and valve operating systems shall be as shown on the drawing PSM-206.

(2) Isolating Valves

Manually and 5.5 kw motor operated bi-plane valve with nominal bore of 1,500 mm shall be selected for maintenance shutoff service and positioned at down stream side of the discharge valve. And spare parts shall be interchangeable with the discharge valve spares. Structural design of the valve shall be same as the discharge valve.

The electrical facilities incorporated in the unit shall be designed based on the electric sources AC, 380 V, 3 ϕ , 50 Hz. The arrangement of the isolating valve shall be as shown on the drawing PSM-206.

(3) Pipeline Valves

Manually and 7.5 kw motor operated bi-plane valve with nominal bore of 2,400 mm shall be selected for maintenance shutoff service and positioned at the valve chamber apart from the pumping station. Structural design of the valve shall be same as the discharge valve.

The electrical facilities incorporated in the unit shall be designed based on the electric sources AC, 380 V, 3 ϕ , 50 Hz.

The arrangement of the pipeline valve shall be as shown on the drawing PSM-207.

5.2.3 Gates

(1) Bulkhead Gate for Suction Sump

(a) Type and Functions

One set of vertical lift bulkhead gate shall be provided to close inlet of the pump suction pipe for inspection and maintenance purposes. The bulkhead gate shall be constructed so that the closing member can be completely removed from the water passageway when the gate is full opened. The gate shall be selected the fixed roller gate which the operating member moves on rollers to engage with the sealing element.

The bulkhead gate shall be raised under balanced head condition after the suction pipe has been refilled by using unwatering valves in the pumping station, also will be lowered under balanced head condition. The arrangement of the bulkhead gate is shown on drawing PSM-208.

(b) Structural general

The fixed roller gate consists primarily of a skin plate supported by horizontal beams which in turn are supported by vertical girders at the sides. Four main rollers are mounted around the vertical girders and transmit the load to tracks in the face of the structure. Frames consist of tracks and seal seats mounted on structural beams, and guides. These frames are erected in blockouts in the concrete face and are aligned by anchor bolts embedded in the original pour. After alignment, the blockouts shall be filled in with concrete.

(2) Stop-logs for Suction Sump

A multi-stage steel log should be used. The height of a stop log should be about 1 to 1.5 m to facilitate installation, removal, transportation, and storage. The stop log is inserted and lifted by a lifting beam with a connect/disconnect device. Three sides should be watertight for open waterway. Stainless steel should be used for embedded guides faced with water. The arrangement of the stop log is shown on drawing PSM-209.

(3)Radial Gate for Spillway

(a) Type and Functions

Two set of the radial gate shall be provided to close outlet of the spillway. The radial gate shall be constructed so that the closing member can be completely removed from the water passageway when the gate is full opened.

The radial gate shall be raised under unbalanced head condition of 4.34 m. And also, will be lowered by own weight.

The general arrangement of the radial gate is shown on drawing SPW-110.

(b) Structural General

The water load shall be applied to the convex side and carried by horizontal beams, which are supported by two end beams. The end beams are supported by radial arms, emanating from the pin bearings located at the axis of the cylinder. The gate members shall be consisted as below.

- Leaf, including faceplate, horizontal beams, and vertical side beams
- Two arms
- Four or six guide rollers
- Two pin bearings consisting of pin, bracket, and anchor bolts
- Rubber seals, sides, bottom, and corner, with cramp bars
- Wall plates, one each side, with anchor bolts
- Gate sill, with anchor bolts
- Hoist with anchor bolts

Arrangement of radial gate shall be as shown on the drawing SPW-110.

(4) Stop-logs for Spillway

Same specification as (2) shall be applied.

(5) Stop-logs for Box Culvert

Same specification as (2) shall be applied.

(6) Roller Gate for Sand Settling Basin

(a) Type and Functions

Two set of vertical lift roller gates shall be provided to close inlet of the sand settling basin for inspection and maintenance purposes. The roller gate shall be constructed so that the closing member can be completely removed from the water passageway when the gate is full opened. The gate shall be selected the fixed roller gate which the operating member moves on rollers to engage with the sealing element.

The roller gate shall be raised under unbalanced head condition of 3.5 m. And also, will be lowered under balanced head condition.

The arrangement of the roller gate shall be shown on drawing SSB-203.

(b) Structural General

The fixed roller gate consists primarily of a skin plate supported by horizontal beams which in turn are supported by vertical girders at the sides. Four main rollers are mounted around the vertical girders and transmit the load to tracks in the face of the structure. Frames consist of tracks and seal seats mounted on structural beams, and guides. These frames are erected in blockouts in the concrete face and are aligned by anchor bolts embedded in the original pour. After alignment, the blockouts shall be filled in with concrete.

5.2.4 Auxiliary Equipment

(1) Water Supply and Drainage System

(a) Cooling Water Supply System

The piping diagram for cooling water supply system, drain and dewatering system is shown on the drawing PSM-202.

The cooling water shall be supplied to the coolers and bearings of motors, pump bearings, intermediate shaft bearings and pump shaft ground packing. The cooling water is taken from the discharge pipe by a motor operated valve provided for unit individually and then must be passed through the strainer and sand separator. The system will also be provided a pressure reducing valve, a safety valve and flow relays with necessary pipes and valves. The cooling water shall be return to the suction sump. The chemical precipitation system shall be used if creation of the moss in cooling pipe under rest for long period is concerned. Specification of main equipment is shown below:

- Cooling water intake motor operated valve — Nom. dia. 200 mm, 0.75kw
- Automatic strainer — Nom. dia. 200 mm, 0.2 kw
- Sand separetor (with motor operated desand valve) — 128 cu.m/hr 0.2 kw

(b) Drainage and Dewatering System

Drainage and dewatering system shall be provided with facilities for unwatering any leakage of water flow into the sump pit from either inside or outside the pump station and suction pipe.

These facilities shall be consisted with the bulkhead gate, isolating valve, dewatering valves and a sump with installed sump pumps. The sump pumps shall be enough capacity for unwatering the sump pit or the unit from the sump pit in the pumping station to the suction sump.

Specification of sump pump is shown below:

Type : Submersible volute pump
Number : 3 units (including stand-by unit)
Nominal size : 125 mm
Capacity : 1.3 cu.m / min
Head : 14 m
Output : 7.5 kw

(c) Pipeline Fill and Drain System

The pipeline fill pumps shall be provided in the pumping station for filling water into pipeline before initial operation of main pumps or after the pipelines is drained. Drain pipeline with 400mm dia. fill/drain pipe shall be provided with the valves.

Specification of pipeline fill pump is shown below:

Type : Horizontal double suction volute pump
Number : 2 units (including stand-by unit)
Nominal size (suc. / des.) : 250 / 300 mm
Capacity : 0.15 cu.m / sec
Head : 90 m
Output : 240 kw

5.2.5 Ancillary Equipment

(1) Pumping Station Trash Removal Equipment

The general arrangement of fixed trash screen and trash car shall be as shown on the drawing PSM-210.

(a) Screen

The screen shall be designed to install at 75° inclined angle for mechanical raking at upstream side and at 60° inclined angle for guard at downstream side.
The upstream side screen shall be constructed from steel bar 90 x 9 mm thickness and the bar pitch which held in accurate spacing with spacers to give a maximum clearance of 50 mm between bars. and the downstream side screen shall be constructed from steel bar 75 x 9 mm thickness and the bar pitch which held in accurate spacing with spacers to give a maximum clearance of 100 mm between bars.

(b) Trash Rake

The trash car type rake shall be used since the amount of trash is small and the water velocity is low.

Specification of trash car should be as below.

Type : Mobile weed screen cleaning machine
Number of unit : 1 set
Rake length : 2,000 mm
Hoisting speed : 10 m / min
Raking capacity : 0.5 cu.m
Travelling speed : 10 m / min
Travelleing distance : about 30.5 m
Motor power : Hoisting 5.5 kw
Opening 0.75 kw
Travelling 1.5kw

(2) Gantry Crane

The general arrangement of gantry crane shall be as shown on the drawing PSM-211.

Gantry crane shall be used to serve for unloading and loading the bulkhead gate or stop logs in chamber at suction side and have a hoist of lifting capacity 1.25 times of the maximum

expected load required to lift the bulkhead gate. The gantry crane shall have two speeds, normal and inching in the three directions, which be controlled longitudinal, traverse and hoisting motion.

Specification of gantry crane shall be as shown .

Hoisting load : 13 tons
Crane span : 3.50 m
Lifting speed : 2 m / min
Travelling speed : 20 m / min
Power source : 3ϕ, AC 380V 50Hz
Motor output for hoisting : 7.5 kw
Motor output for travelling : 2 x 2.2 kw

(3) Overhead traveling crane

The general arrangement of overhead travelling crane shall be as shown on the drawing PSM-205.

The overhead travelling crane shall be provided in the pumping station for serving the area of the main pump units, valves and station auxiliaries for unloading and loading, and installing and maintaining of the equipment. It shall be electrically operated cab controlled type and be complete with main traverse girders, cab, main and auxiliary hoists, shafting, gearing, complete electrical equipment and necessary components for proper and efficient operation of the crane. The capable of lifting weights shall be of 25% above the weight of the heaviest parts.

Specification of the overhead travelling crane shall be as shown.

Main hoisting capacity : 100 tons
Auxiliary hoisting capacity : 20 tons
Lifting speed for main hoist : 1.2 m / min.
Lifting speed for Auxiliary hoist : 3.0 m / min.
Traveling speed of girder : 20 m / min.
Traverse speed of trolley : 10 m / min.

5.3 Electrical Equipment

5.3.1 Design conditions and Standards

General design conditions and standards for the electrical equipment shall be as described in Chapter 4, Clause 4.11 "Electrical Design".
Specific conditions and standards for major equipment shall be described in this Clause.

5.3.2 Main Motors Type and Ratings

The main electric motors shall be vertical solid shaft, brushless excitation and Salient Pole type synchronous motor. The motors shall be designed for indoor use and the enclosure shall be totally enclosed of the water-cooler heat exchanger type. The stator terminal box shall be IP55 with cable grand. Ratings of the main motors are as follows:

Numbers of units	:	4
Output (MW)	:	13
No. of phase	:	3
No. of poles	:	16
Synchronous speed (rpm)	:	375
Rated Voltage (kV)	:	11
Frequency (Hz)	:	50
Power factor	:	1.0
Insulation Class	:	F

(1) Service Factor

The motor shall be required a 10% margin at the design point on the loading curve. The locked rotor current values at rated volts and frequency of the motors shall not exceed 600% of full load current.

(2) Temperature Rise

The motor shall be operated in an ambient air temperature 45°C. The temperature rise limits of the windings when the motor is running its rated output at rated voltage and frequency shall not exceed 75°K at service factor 1.0 and 95°K at service factor 1.1
Insulation of the rotor and stator windings of the motors shall be use Class F type materials with temperature rises limited to Class B.
Motors shall be provided with embedded resistance temperature detectors (RTD) in the stator windings. A minimum of six detectors (2 detectors per phase) shall be

embedded. The RTD shall be PT-100 resistance type having a resistance of 100 ohm at 0°C. The RTD shall be provided with self-contained surge protecting devices in the terminal box.

Each motor shall be provided with anti-condensation space heaters in the terminal box of IP55, to prevent condensation in the windings or oil reservoirs when the motor is shut down for long periods.

(3) Bearings

The motor shall be equipped with its own thrust bearing and three guide bearings (intermediate shaft / motor lower / motor upper). The bearings shall be oil bath water cooled lubricating type and shall be provided with lubricant draining and filling devices without any hindrance.

Two (2) RTD for the thrust and one (1) each RTD for the guide bearings shall be provided and a vibration detector on the thrust bearing.

(4) Protection System

The protection system for the main pumps units shall be designed taking the sequential interrelations into consideration. Protection system shall be as shown in the following table.

Table 5.3-1 Protection System for Main Pump Unit

Abnormal condition	Pump Stop	Main Motor C.B Trip	Alarm/ Indication
(1) Major Fault			
a. Pump			
Suction Well Low Water Level	○	○	○
Guide Bearing/Thrust Bearing High Temp.	○	○	○
Guide Bearing Low Oil Level	○	○	○
Shaft/Frame Vibration	○	○	○
b. Motor			
Over Current / Over Load	○	○	○
Phase Fault / Reverse Phase	○	○	○
Out of step Relay	○	○	○
Differential Relay	○	○	○
Field Current Fault	○	○	○
Electric System Fault (under voltage, DC Control Source)	○	○	○
(2) Minor Fault			
a. Pump			
Starting failure	—	—	○
Pump Impeller High/Low Pressure	—	—	○
Low Cooling Water Flow	—	—	○
Shaft/Frame Vibration	—	—	○
b. Motor			
Stator winding high temp.	—	—	○
Cooling water high temp.	—	—	○
Low cooling water flow	—	—	○
Aux. machine fault	—	—	○

A single diagram of the synchronous motor is shown in Figure. 5.3-1.

The power supply system to the main pump units, auxiliary equipment and common used equipment is shown on the Drawing PSE-202, PSE-203 and PSE-204.

5.3.3 Starting Equipment of Main Motors and Motor Exciting Panel

(1) Starting Equipment

The MED and JICA team discussed the starting system of the main pump motor based on the recommended plan and comparison table of motor starting systems provided by the Team.

From a technical and economical point of view, the Kondorfer starting system shall be used for the main pump motors this was agreed by MED.

The Kondorfer starting system shall consist of the Autotransformer and vacuum type circuit breaker starting panels.

Ratings of the starting equipment are as follows:

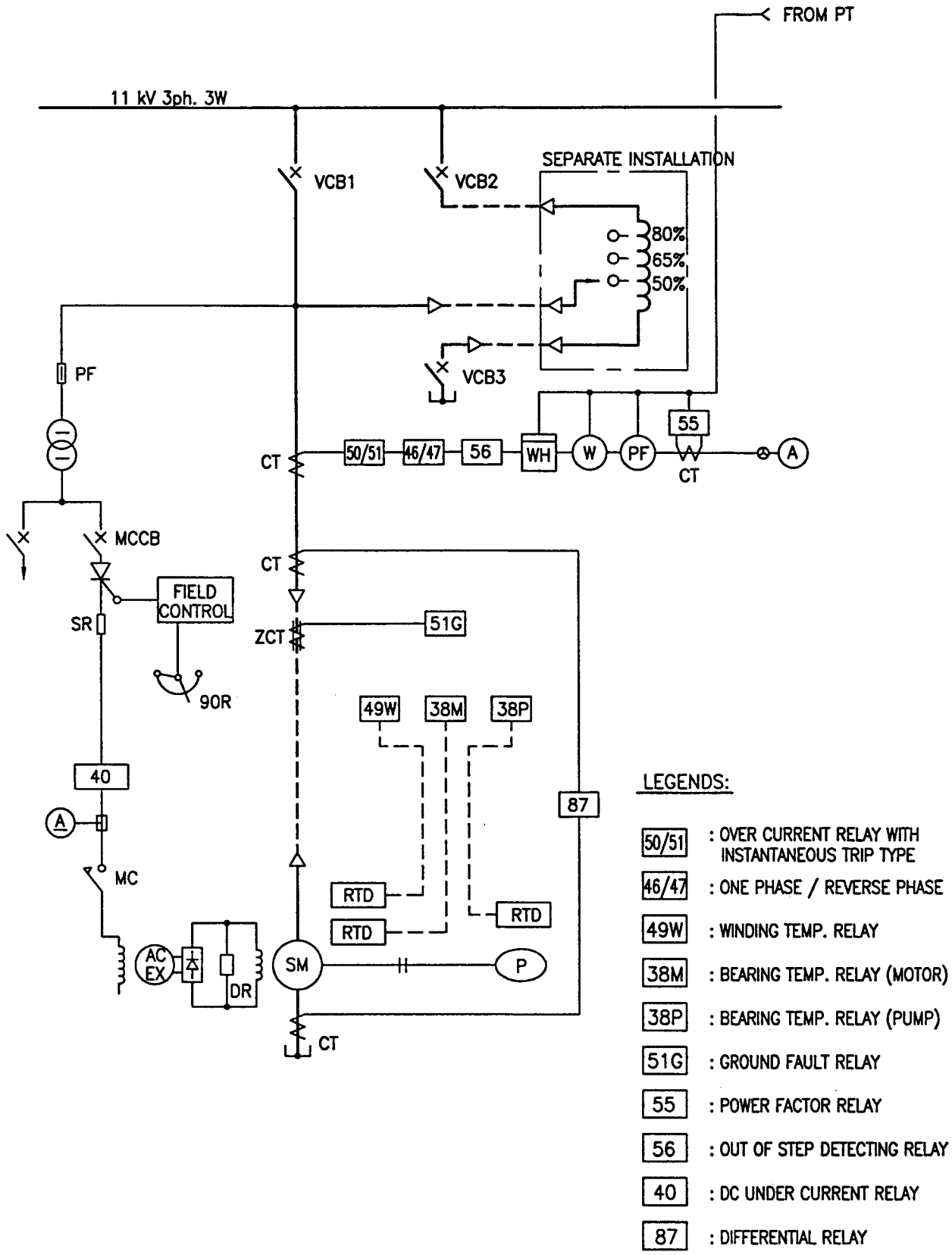


Figure 5.3-1 Single – Line Diagram of Synchronous Motor (Typical)

(a) Auto-transformer

Numbers of required	4
Type	Auto-transformer
Service	Indoor use
Rating (min)	3
Numbers of phase	3
Rated voltage (kV)	11
Frequency (Hz)	50
Rated capacity (kVA) (max)	57000 kVA (approx.) at 80% tap
Numbers of tap (%)	80, 65, 50
Insulation class	H
Outline dimension (mm)	2600 (W) x 2800 (H) x 2500 (L) (approx.)

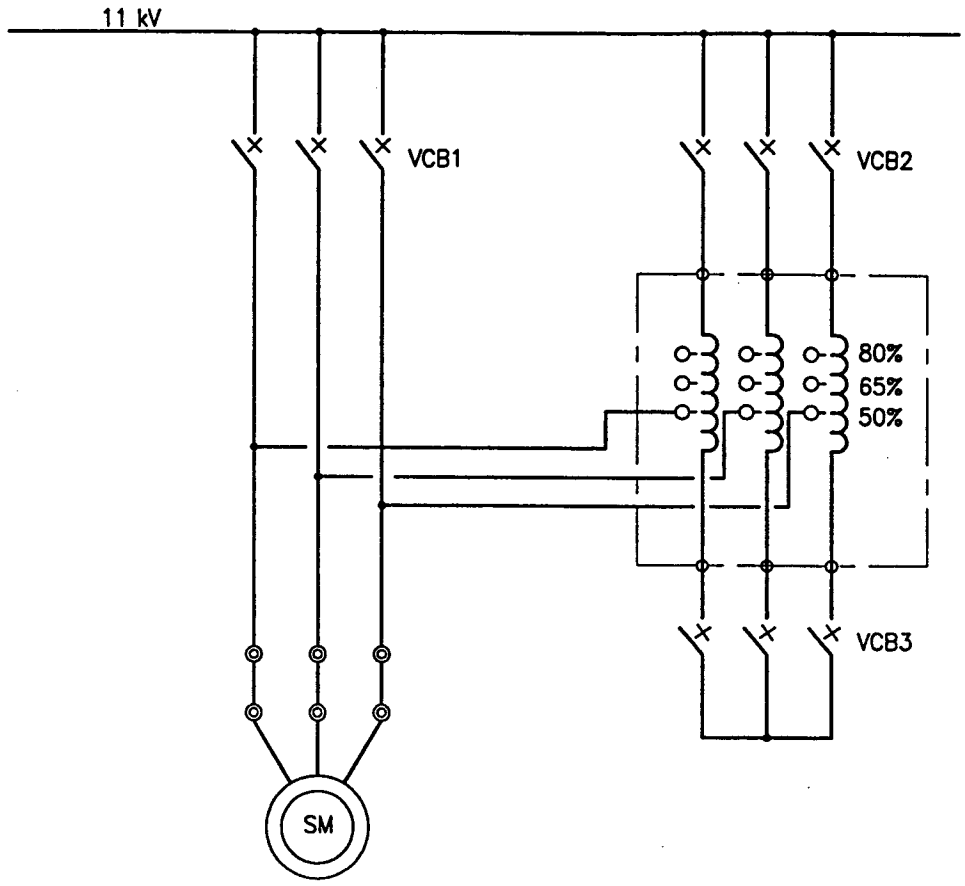
(b) Main motor starting panel

Required Numbers (per auto-transformer)	3
Nominal voltage (kV)	11
Rated voltage (kV)	12
Rated frequency (Hz)	50
Rated current (A)	1200
Insulation level impulse (kV)	75
Insulation level (kV)	28
Breaking current (kA)	40

The electrical circuit for the Kondorfer starting method is shown in Figure 5.3-2. The principal of the Kondorfer starting method is as follows:

	C.B Activity	Function of Kondorfer Unit
Step-1	VCB2/VCB3 – on VCB1- off	Unit is operated as starting transformer.
Step-2	VCB2 – on VCB3/VCB1 – off	Unit is operated as reactor
Step-3	VCB1 – on VCB2/VCB3 – off	Unit is released from main circuit. motor put into normal running.

Usually the Kondorfer unit shall be provided with starting taps of 50, 65 and 80% of line voltage, and selection of the starting tap shall be recommended by the pump unit supplier take considering the starting torque and the time required for the pump unit. Each main motor shall have its own individual Kondorfer unit.



CIRCUIT BREAKER ACTIVITY			
STEP	1	2	3
VCB1	OFF	OFF	ON
VCB2	ON	ON	OFF
VCB3	ON	OFF	OFF

Figure 5.3-2 Diagram of Kondorfer Starting Method (Typical)

(2) Exciter Panel

The main motor exciter panel shall consist of static thyristor exciter circuit, power factor relay, pull out relay, and accessories all mounted on metal frames, complete with all electrical connections and completely enclosed within sheet metal housings. The motor exciter panel shall be of the following type and ratings:

(a)	Type:	Indoor, self-supported, metal-enclosed type
(b)	Rated voltage:	380/220 V AC, 3-phase, 4-wires
(c)	Rated insulation voltage:	600 V AC
(d)	Rated frequency:	50 Hz
(e)	Power frequency withstands voltage:	2.5 kV rms

All equipment, materials and fabrication shall conform to the latest applicable IEC 439, 473, 521 and 541 standards or equivalent. The motor exciter panel shall be fabricated from flat rolled steel panel, reinforced where necessary, in such manner that the complete structure is rigid. The panel shall be fabricated from not less than 2mm thick steel sheets. Each exciter panel shall be equipped with a space heater to prevent moisture and heater shall be controlled by thermostat.

The brushless excitation system shall consist of AC exciter and silicone rectifier. Exciting capacity of the static exciting device is very small.
The exciting devices shall be mounted on the shaft of the main motor.
The AC exciter is the revolving-armature type.
The field poles mounted on the stator is excited by a static exciting device and AC power generated in the revolving armature windings is rectified by the silicone rectifiers and then it is fed to the field windings of the main motor.
Therefore, the excitation system has no sliding or energized parts, thereby it is possible that making both of the main motor and AC exciter is completely brushless construction.

5.3.4 Medium and Low Voltage Switchgear

(1) Medium voltage switchgear

This switchgear specification shall applied to the voltage 11KV Main Motor starting panel and exciter transformer panel.
All switchgear together with the control and relay boards shall be of the totally enclosed type. The switchgear shall be metal-clad with IP42 protection for enclosure and compartments. Cubicles shall be vermin proof and insect proof.

Each switchgear shall be arranged for MV cable and Control cable entry at the bottom of the panel. The switchgear earthing common bar hall be have a minimum section of 150mm^2.
The metal thickness shall not be less than 2.0mm for structural members and 1.6mm for side panel and doors.
Each switchgear shall be equipped with a space heater for prevent of moisture within the switchgear. The heater shall be thermostatically controlled.
The circuit breaker operating mechanism shall be motor spring stored-energy operated and shall be electrically and mechanically trip-free.
In order to afford security for operation and/or maintenance staff, and to ensure the correct operation, mechanical and electrical interlocking devices shall be provided to prevent mal-operation of circuit breaker.
In addition to the above interlocking requirements, padlocking facilities shall be provided for the selector mechanisms on circuit breakers, at "Disconnected" and "Service" positions.
All switchgear shall be designed and manufactured in accordance with IEC56, IEC298, IEC632 and IEC694.

(2) Low voltage switchgear

This switchgear specification shall applied to the voltage 380/220V Load Center, Motor Control Center (MCC) and other panels.
The low voltage switchgear shall be totally enclosed IP42, completely dust proof and assembled in a steel housing. The equipment shall comprise the busbars, circuit breakers, switches, etc., necessary for the power supply to the main pump units, auxiliaries and common used equipment.
The low voltage switchgear shall employ air circuit breaker (ACB) for the incoming transformer feeders and mode case circuit breaker (MCCB) for the outgoing circuit to the downstream switchboard.
Low voltage switchgear and motor control centers (MCC) shall be constructed on a modular basis allowing for each extension and modification as required.
Low voltage feeder circuit shall be provided with over current and earth fault protection either as separate protection or as an integral protection in the case of MCCB.
Each motor starter unit of the MCC shall be provided with a circuit breaker, control transformer, magnetic starter and protection. The starter shall be the normal means of stopping and starting the motor. Each unit shall be contained in an individual compartment having a front access door.

5.3.5 Appurtenant Equipment

(1) DC Power Supply Equipment

The DC power supply equipment is used for switchgear control, instrumentation, protection and alarm circuits, emergency lighting, etc., independently of the main power system.

The DC power supply system shall consist of:

- Nickel-Cadmium Alkaline batteries with adequate capacity for supplying the continuous DC load and emergency DC load.
- Battery chargers capable of supplying the DC load and maintaining the batteries fully charged.
- D.C. distribution panel
  The branch circuit breaker handles shall be accessible from the front of the cubicle without the necessity of opening the hinged panel.

The maximum and minimum battery voltages are based on 1.10V per cell for charge equalization and 1.00V per cell end of load cycle discharge voltage, respectively, using alkaline battery type. The batteries shall be rated for 10-hour discharge rate. The battery chargers shall normally float charge the batteries and shall also supply the D.C. load. The battery chargers shall equalize the batteries when needed. They shall also be capable of recharging their respective batteries to 80% capacity in 1 hour at the end of the battery discharge load cycle while supplying the load of their respective batteries.

Battery charger shall be a full wave silicone controlled rectifier type with fully automatic controls or thyristor controls.

Input power sources for the battery charger shall be of 3-phase, 380 volts, 50Hz and output of the DC equipment shall be of 110 volts DC.

The battery charger and distribution panel shall be a floor mounted, free standing cubicle. The batteries shall be mounted on a steel rack and installed in a cubicle. The cubicle shall be constructed of heavy gauge steel, suitably braced, vermin-proof, with a degree of protection equal to indoor IP 31 to IEC or equivalent.

(2) Central Control Equipment

The central control system is used for remote operation, supervision and data acquisition of the main pump unit running. The equipment shall be located in the central control room.

The central control system shall consist of the following equipment:

- Operator console with color CRT (Personal Computer Type)

- Printer desk
- Uninterrupting power supply unit (UPS).

Layout of the central control equipment is shown on DWG. No. PSE-208 and CRT display, supervision and data acquisition plan is shown on DWG. No. PSE-209.

(3) Emergency Diesel Generator

Emergency generator set shall be provided for the essential loads as listed below to supply of the emergency power in case of a power failure at the main substation. The emergency power supply system shall be designed to transfer of the emergency power within 10 seconds.
Loads connected to the emergency power shall be as follows:

- Actuator for guard valve	5.5 kW x 1
- Pipe line guard valve	7.5 kW x 1
- Sump pump	7.5 kW x 2
- D.C power source	8 kVA
- Control/Instrumentation	3 kVA
- Lighting	17 kW

From above loads, the emergency generator output to be selected of 100 kVA and diesel engine horse power to be a minimum of 120 P.S., to meet generator's output (See APPENDIX D.5.3). The revolution speed of the diesel engine shall be 1500 rpm. Single line diagram, location and layout plan of Emergency Generator set is shown on DWG. No. PSE-211 and PSE-212.

5.3.6 Main Pump Units Operation

(1) Starting Conditions

The starting conditions for main pumps and motors are as follows:

(a) For Pumps
- Higher than the prescribed water level in the suction well
- Greater than the prescribed water pressure in the water-supply to the stuffing box and the bearing
- Greater than the prescribed oil level at the oil reservoir of the guide bearing
- Greater than the prescribed cooling water flow from the heat exchanger of the bearing (Intermediate and guide bearing)
- Greater than the prescribed water flow for the pump shaft seal water
- Closing position of discharge valve
- The other pumps are not in a starting condition

- No working for the protection relays of the pump (Refer to item (2) protection system)

(b) For Motors

- Greater than the prescribed oil level at the oil reservoir of the bearing
- Greater than the prescribed cooling water flow from the heat exchanger of the bearing (Thrust, upper guide and lower guide bearing)
- Greater than the prescribed water pressure for the bearing
- Greater than the prescribed cooling water flow from the cooler of the motor
- No working for the protection relays of the motors (Refer to item (2) Protection system)
- 11 kV power "ON"

(2) Protection Systems

The main pump units and related equipment shall be equipped with the following protection systems.

		Abnormal condition
Major Fault	Pump	(1) Low water level in the suction well (2) High temperature at the following bearings a. Inter mediate guide bearing b. Pump guide bearing (3) Low oil level at the pump guide bearing
	Motor	(4) Over current / over load (5) Phase fault / reverse phase (6) Out of step-detecting (7) Differential (8) Field current fault (9) Major electric system fault (Under voltage, DC control source off etc.) (10) High temperature at the following a. The thrust bearing b. The upper and lower guide bearings
Minor Fault	Pump	(1) Starting failure (2) High/Low pressure above the pump impeller (3) High cooling water temperature at the inlet / outlet of the bearing oil heat exchanger (4) Vibration on guide bearing (5) Low cooling water flow on the following a. The heat exchanger of the bearing b. The pump shaft seal water
	Motor	(6) High stator winding temperature (7) High cooling water temperature at the following a. The cooler of the motor b. The inlet / outlet of the bearing oil heat exchanger (8) Low cooling water flow from the cooler of the motor (9) An auxiliary machine fault (over load, etc.) (10) Minor electric system fault

Note 1: In case of major fault, the main pump shall be automatically stopped.
Note 2: In case of minor fault, the operator shall check the fault and determine whether or not to stop the main pump.

(3) Main Pump Operation Procedure

The operation of the main pump units shall be in accordance with the outline procedure shown on DWG. No. PSE-206.

5.3.7 Emergency Generator Set Operation

(1) Starting Conditions

Emergency generator set shall be start automatically at the following conditions:

- Normal power failure at the 380 V busbars in the Low voltage load center panel that the Generator connected to, and/or,
- When the under voltage relay on the normal power line is working (excess line voltage drop).

(2) Protection Systems

The emergency generator set shall be equipped with the following protection systems.

PROTECTION DEVICE	ENGINE STOP	CP TRIP	ALARM	INDICATION
LUBICATE OIL PRESSURE LOW	O	O	O	O
COOLING WATER ABNORMAL	O	O	O	O
OVER SPEED	O	O	O	O
INCOMPLETE STARTING	O	O	O	O
OVER CURRENT	–	O	O	O
EMERGENCY STOP	O	O	O	O

(3) Operation Procedure

The emergency generator set shall be automatic sequentially controlled as shown on DWG. No. PSE-211.