4.4. Feedwater System

4.4.1. General

A. The feedwater system shall include LP drum integral deaerator, feedwater pumps, desuperheating spray water feed system, minimum flow recirculation system, and necessary piping which consists of the required valves, hangers and supports, insulation, etc.

B. The necessary instrumentation and controls(including all required installation materials) shall be supplied.

The flow from the section of each pump shall be monitored with the flow element of flow nozzle or ventri tube type.

The V-cone type flow measuring element on upstream of each pump with all accessories, including flange and root valves, cone support, etc. shall be provided. Venturi cone and flanged meter tube shall be provided by same manufacturer.

According to the ISO 5167 and Appendix J1, flow measurement (high/low pressure steam, water application) considering the best efficiency shall be applied.

C. The feedwater pump within all pump operation range shall be not exceed the vibration specified at ISO 10816-7.

4.4.2. Feedwater pumps

A. The feedwater pumps supply feedwater from LP drum to the HP/IP economizer.

The feedwater system shall be provided with motor driven Three(3) × 50% (per unit) capacity(including spray water requirements for superheater and reheater) feedwater pumps. The feedwater pumps shall be applied without any trouble.

Pressure transmitter for sensing lubricating oil pressure shall be provided to prevent operation without oil to pump bearings. The Supplier shall also provide lubricating oil pressure transmitter for alarm and trip. Lube oil skid

shall be equipped with space heater.

B. The pumps shall be inherently stable when running in parallel at all loads. The pumps shall be of motor driven with coupling and the water flow to the HRSG shall be controlled by the control valves.

C. The pump design flow have a appropriate margin based on the maximum capacity under all operating heat condition as follows. The pump run-out flow shall be not less than 130% of pump rated flow and be covered with ST bypass operation.

Step 1. System surge allowance : The maximum system requirement (including spray water requirements for superheater and reheater) is to be increased by 5 percent to allow for flow surges.

Consideration must also be given to the additional head required to attain 5 percent flow increase.

Step 2. Pump wear allowance : The design flow is to be increased by 6 percent to compensate for pump wear. This is in addition to the flow increase stated in step 1.

The 50% x two(2) pumps shall be stably able to operate during steam bypass operation within run-out flow.

D. When pump trip, the stand-by pump shall be operated to full load within 10 seconds to protect plant trip.

E. The NPSH required shall not exceed the available for the full operating flow range up to steam blowing-out condition.

F. The pumps shall be horizontal, centrifugal, ring sectional, multistage, diffuser or volute type, with impellers arranged in series specially designed for feedwater pumping service. The pumps shall be mounted on a suitable baseplate and supported at the horizontal axis such as to permit free expansion both axially radially while maintaining alignment. The noise level of each pump shall be guaranteed in accordance with performance sheet.

G. The pumps shall be of a design and construction that has been proved reliable and satisfactory for continuous operation. Design and workmanship shall be such that the pumps are readily assembled or dismantled and that

they will operate satisfactorily under all operating conditions without undue wear, vibration, cavitation or overheating.

H. The feedwater pumps may, under severe transient conditions, be momentarily subject to moderately cavitating conditions.

I. The feedwater pump shall be capable of 'dry running', and of accepting a complete loss of water due to incidents such as suction loss of feedwater pump. In such an extreme case it is recognized that the pump should be shut down and restarted after it has been reprimed. The pumps must however be capable of being shut down in a controlled manner and brought to restart safely in a short time.

J. The first critical speed of each pump shall exceed the operating speed of the pump by at least 25 percent. Critical speed is rotative speed corresponding to lateral natural frequency of rotor including effect of its support conditions(stiffness, mass, fluid film and etc) and the rotative speed at which the pump set is in a state of resonance.

K. Shaft seals shall be the cartridge mechanical type with their cooling water system.

Internal system consisting of shaft seal cooling water cooler, piping, valves, filter, temperature elements, sight flow gauges for a complete system.

L. A hydraulic balancing drum (balance disc not acceptable) shall be capable to operate any condition and furnished with local pressure indicator and additional tap. The axial thrust of the rotor shall be carried by a balance drum and external oil lubricated thrust bearing. The Supplier shall provide the pump speed vs balancing drum leak off outlet pressure and tie in point pressure with the balancing drum leak-off line (New/worn condition).

M. A simplex basket type suction strainer suitable for off-load cleaning shall be provided with differential pressure transmitter for each pump. Separate fine strainers shall be provided for use during commissioning phase. All strainer elements shall be stainless steel.

N. Each pump shall be connected to LP drum with individual suction line. The pumps shall also be provided with separated arrangements to automatically

recirculate water back to the LP drum for protection of pumps low and no load conditions.

O. The boiler feedwater pump shall be designed with a sufficient margin for required NPSH in considering the reduction of available NPSH due to the deaerator decay and shall be designed so that there is no problem in suction performance in considering of conditions such as start-up, normal operation, max. operation and load variation.

P. The characteristics of the pumps must be such that the shut off head is not greater than 130 percent of the duty point head. The flow from the section of each pump shall be monitored with the flow element of flow nozzle type.

Q. Soft start capability shall be provided for the feedwater pump in order to protect the piping system from the high pressure transients of a feedwater pump suddenly coming on line.

R. The Supplier shall perform and submit a transient analysis and stress analysis due to water hammering for the design of feedwater piping and hangers/supports.

S. The Supplier shall provide a complete common forced feed lube oil system for the bearing of feedwater pump and motor.

1) A lube oil system and all associated instrumentation

The reservoir shall have sufficient free volume above the normal operating range level to accommodate full system flowback without in the high level alarm regardless of oil temperature. The supplier shall furnish and install the following equipment on each oil reservoir.

(1) One(1) Shaft driven 100% capacity main lube oil pump, per unit

(2) One(1) AC motor driven 100% capacity auxiliary lube oil pump, per unit

(3) One(1) 100% lube oil cooler for use with closed cooling water at the inlet temperature and pressure. Coolers shall incorporate tubes of minimum 16 mm outside diameter and 18 BWG minimum wall gauge Oil side of the coolers shall be designed for maximum oil pressure. The temperature control of the coolers shall be performed by the three way valve in the oil side.

(4) Duplex type oil strainers with differential pressures transmitter

(5) Pressure, flow, temperature, level instruments and others as necessary

T. Materials

1) All materials used in constructing the equipment shall be the best suitable for the specified service and shall be subject to acceptance by KOEN. For the specific materials identified in the following list, the materials shall be supplied to be suitable for the service intended. The Supplier will supply alternative materials of equal or superior properties for KOEN's consideration.

Feedwater pump

o Casing	13% Cr, 4% Ni Stainless Steel
or volute/diffuser	(A743 Grade CA6NM or eq.)
o Impellers	13% Cr, 4% Ni Stainless Steel
	(A743 Grade CA6NM or eq.)
o Shaft	13% Chrome Stainless Steel
	(A276 Type 410 or eq.)
o Balance drum & sleeve	13% Chrome Stainless Steel
	(A743 Type CA40 or eq.)

2) The Supplier shall identify the materials used on major parts as to the ASTM standards, or equivalent standards (including DIN for FWP Fluid Coupling).

U. Casing

1) Pump casings shall be designed to withstand any possible thermal shock.

2) The suction and discharge nozzles shall be machined for butt weld connection in accordance with Appendix W2. The suction and discharge

nozzles of the main and startup boiler feed pumps shall project upward from the pump casing. Design stress levels in the barrel, head, and bolting of the boiler feed pump shall not exceed the limits of the ASME Code for Pressure Vessels, Section Ⅷ, or equivalent. Welding shall be in accordance with ASME Section Ⅷ, Ⅸ or equivalent.

3) Casing wear rings shall be of groove or serrated type and of hardened stainless steel alloy that will be compatible with the impeller material, will result in prolonged life, and will be free of galling tendencies. The ring shall be rigidly positioned to prevent rotation under any conditions of operation. Impeller wear rings shall not be acceptable.

4) The casing shall be adequate for easy reassembly and maintenance. The Supplier shall adopt some device to guide the casing and take-off tube to the proper position during re-assembling work, along with checking horizontal balance for fine alignment.

V. Impellers and Diffusers

1) Impellers shall be the single or double suction enclosed type for boiler feed pump. All surfaces shall be machined or hand finished to a smooth surface. Impellers shall be keyed and individually positioned on the shaft. Each impeller shall be statically balanced after completion of all machining and rebalanced after any alteration. After assembly, the complete rotating element shall be dynamically balanced.

W. Bearings

1) Thrust bearings shall be the tilting pad double action type.

2) Sleeve bearings shall include "E" type thermocouples in contact with the bearing metal. Thrust bearings shall include "E" type thermocouples which, if design permits, shall make contact with one of the thrust shoes or shall be placed to give the most direct indication of actual bearing temperature.

3) The Supplier shall state the method of measurement that will be used to determine correct balancing of the pump and coupling before shipment. The Supplier shall state the maximum limits of vibration that should be used for alarm and trip points during plant operation. In no

case shall these limits exceed HI standards, or equivalent.

X. Shaft, Sleeves

1) The boiler feed pump shafts shall be rolled steel of the type specified on para 4.3.2 U, accurately machined and ground and of adequate size and strength to withstand safely and continuously all stresses resulting from startup, operating and transient conditions to which it will be subjected. The shaft extension shall be tapered to facilitate coupling removal.

2) Shaft sleeves and bushings, as required for the proposed shaft seals, shall be of suitably hardened stainless steel materials in accordance with the Supplier's standard construction for the specified service. Materials shall be free of galling tendencies.

Y. Shaft Seal and Jacket Coolings

1) The seal type for feedwater pump shall be cartridge mechanical type.

2) Shaft seals with pumping ring, external and internal shaft seal cooling water system.

3) The jacket cooling water will be supplied from the closed cooling water system.

Z. Shaft Seal Cooling Water System

1) The Supplier shall supply a complete shaft seal cooling water system for each pump.

2) Internal system consisting of shaft seal cooling water cooler, piping, valves, filter, temperature elements, sight flow gauges for a complete system.

3) The shaft seal cooling water system shall, under all conditions of operation, maintain the outflowing seal water temperature sufficiently below 100℃ to prevent flashing. No cold injection water shall flow into the pump inside.

4) The shaft seal cooling water will be cooled by the tube side cooling

water supplied from the KOEN's closed cooling water system.

5) The shaft seal cooling water system shall include a magnetic separator or filter that will protect the seals from damage due to solids. The screen shall be of type 316 stainless steel or approved equal, and shall be of a type that is readily cleaned by flushing. A differential pressure indicating transmitter for local and remote indication of fouled strainer shall be incorporated.

AA. Couplings

1) The coupling for feedwater pump supplied by the Supplier shall be the non-lubricating flexible type.

2) Coupling selection shall consider the vibration and thermal conditions.

3) Coupling service factor should be selected not less than 2.0.

AB. Strainers

1) The Supplier shall supply the suitable fine/coarse mesh size for start up and normal operation. The perforated plate for reinforcement of mesh shall be installed for start up and normal operation. The basket strainer shall be designed so that it cannot be damaged from two way flow both to pump and reverse to as well. The basket strainer is suitable to be installed in a vertical pipe run. (Tee type strainer is not acceptable)

2) The strainer shall be constructed of stainless steel for mesh and carbon steel for body and [300lb RFWN] ASME flanges including counter flanges. The strainer shall be hydrostatically tested per ASME B16.5 or an equivalent code.

4.4.3. Feedwater pump minimum flow control

This control system shall be designed to prevent overheating of the feedwater pumps.

Minimum flow control valves shall be provided to minimize disturbance to the feedwater control, while operating at low pump loads.

The V-cone type flow measuring element on upstream of each pump with all accessories, including flange and root valves, cone support, etc. shall be provided. Venturi cone and flanged meter tube shall be provided by same manufacturer.

The minimum (recirculation) valve of boiler feed pump shall be designed as a flow control valve. In addition, the flow control valve shall be designed so that there is no problem under all conditions such as start-up, normal operation and pre-operation(low load etc).

The accuracy of the V-cone type flow measuring element shall be ±0.5% of flow. The selection of flow range, corresponding differential pressure and rangeability shall be fully engineered with minimum flow requirement and allowable pump maximum flow limit taken into account.

A. Each pump shall be provided with vibration sensors.

The Supplier shall provide the vibration monitoring devices consisting of probes with protective housing, keyphasor, extension cables and transducers with housing for accurate, reliable vibration monitoring.

1) Motor

a) DE (X, Y) : X, Y Each 1ea (Proximity Type)

b) NDE (X, Y) : X, Y Each 1ea (Proximity Type)

2) Pump

a) DE (X, Y) : X, Y Each 1ea (Proximity Type)

b) NDE (X, Y) : X, Y Each 1ea (Proximity Type)

3) Axial Position(Z) : 2ea (Proximity Type)

4) Keyphasor : 1ea

5) Reverse rotation detector : 1ea

The manufacturer and specification of vibration sensor should be subject to approval of KOEN. And the vibration sensor shall be supplied to the same manufacturer with the one supplied by plant VMS in order to have a

good availability by site operator.

The transducer output signal shall be useful for vibration monitoring system supplied by the KOEN.

The vibration measuring devices including installation bolt, nut shall be insulated to cut off the ripple caused by ground and short circuits.

B. Each pump shall be provided with a motor operated isolating valve and a non-return valve on the pump discharge. The shut-off valve shall be installed on the suction line of feed water pump.

C. Electrical motors shall be designed in accordance with appendix E1.

4.4.4. Feed Water Deaerating System

The feedwater deaerating system consists of direct contact normal deaerating heater, not bypass (partial flow) deaerator, mounted on the top of the LP drum.

The deaerating & pegging steam shall be taken from the heat recovery steam generators or auxiliary steam header. With load of the plant a minimum allowable pressure in the LP drum shall be maintained with a supply of pegging steam.

The water level in the LP drum shall be controlled by the level control valve on the feedwater supply line, which shall be with the bypass line with the block valve of inching type MOV.

A. Deaerator

1) The deaerator shall be consists of spray-tray deaerator including vent condenser with internal spray distribution system and tray banks, connecting downcomers and pressure equalizing pipe between deaerator and LP drum.

2) The deaerator shall be capable of reducing the oxygen content of the feedwater discharge according to HEI standard at maximum load and normal quantity of make-up water depending on load and preheating the incoming condensate/make-up water to the required feedwater