Arun International

For Reliable Power

ARUN

POWER

SOLUTIONS

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INDEX

SECTION ONE

WHY AN ARUN INTERNATIONAL POWER STATION?

WHY AN ARUN INTERNATIONAL POWER STATION?

Arun International (Power) Ltd is structured to provide **real** power solutions that satisfy customer needs by providing the best **value** package available.

The company is structured to provide **total systems solutions** through standardisation and modularization.

A range of industrial base load designed generation equipment powered by proven Internationally recognised prime movers is used to ensure the total integrity of the plant.

Modern project management services are employed to ensure that **customer expectations are met.**

Some of the **BENEFITS** that Arun International brings are

LOW CAPITAL EXPENDITURE

featuring

- modern systems management
- modular design for reduced installation costs
- standardised products based upon extensive market research with power providers

HIGH AVAILABILITY

featuring

- simple maintenance
- operating and maintenance packages
- increased periods between services
- reduced maintenance downtimes
- remote monitoring

HIGH RELIABILITY

featuring

- high quality component selection
- in house power generation experience and expertise
- advance design technology reducing wear of critical components
- high station efficiency
- on going development to match customer needs

LOW OPERATING COSTS

featuring

- low maintenance costs
- flexibility of fuels
- low fuel consumptions
- reduced maintenance downtimes
- efficient station designs
- remote condition monitoring capability

LONGEVITY

featuring

- extensive applications experience
- advance equipment designs
- user friendly design consideration
- controlled operating philosophy
- tried and proven maintenance regimes

ENVIRONMENTALLY FRIENDLY

featuring

- advanced fuel technology for exhaust gas emission control
- waste management of fuels and oils
- modular plant designs for control of leakage and drainage
- sludge treatment systems

PEACE OF MIND

featuring

- operational overview and advice by remote monitoring
- long term maintenance contracts
- full product support

SECTION TWO

THE GENERATING SET

THE GENERATING SET

The generating set is a heavy duty, industrial unit featuring the **latest technology engine** coupled to a generating set of worldwide repute. The prime mover and driven alternator are connected through a flexible coupling carefully selected to take into account the site conditions and **torsional control**.

The generating set is mounted on to fabricated steel bases to provide a rigid construction and or mounted direct on concrete foundations.

The fitting of the units are designed to ensure correct alignment during the construction phase and to allow alignment adjustments through the life of the generating set.

THE ENGINE

The prime mover is normally of the turbocharged, charge air cooled, four stroke, compression ignition, industrial, heavy duty type designed and constructed for continuous base load applications for operation on a wide range of fuel oils.

The engine is designed to meet / exceed International standards using the latest analytical designs and test validation with **a minimum 25 year life span** based on **operating times in excess of 8000 hours per annum**.

The engine selection is made only after due consideration of the technical and commercial merits thus ensuring the best fit for the customer.

ALTERNATOR

General

The alternator is rated for continuous operation and complies with international requirements.

The alternator is of the two bearing, salient pole, air cooled rotating field type, the enclosure and insulation selected to suit the particular project requirements.

Stator

Stator windings are star connected. All phase ends are brought out as terminals into a terminal box. **Sufficient space is allowed** for to accept current transformers.

Terminals will incorporate locking devices to ensure that slackening due to vibration is controlled.

Rotor

The windings are designed and arranged such that relative movement between parts of a coil, and between coils and the poles, due to mechanical forces or thermal effects is reduced to a minimum. **Minimal wear and tear of insulation materials, windings, poles etc. is thus assured.**
The exciter is directly coupled to the rotor.

Anti-condensation Heaters

Anti-condensation heaters are fitted to **prevent condensation in the alternator and exciter.**

Excitation system

A complete brushless excitation system is provided complete with automatic voltage regulation.

The system is not reliant on any external power source for excitation power.

The exciter consists of a polyphase rotating armature machine with a directly connected rectifier assembly. Means are provided to electrically isolate the generator field winding for insulation test purposes without the need to dismantle the exciter assembly.
The exciter magnetising characteristics and effective time constants are designed to provide steady state and transient performance requirements to be adequately fulfilled. Silicon power diodes are employed in the rectifier rated at least twice the maximum continuous current in service.
The rectifier is designed to withstand without damage foreseeable abnormal operating conditions such as sudden short circuits. A fault detector is supplied to initiate an alarm and trip where necessary and protect the alternator.

Exciter cooling

The brushless exciter will be air cooled by air ducted from the generator cooling air inlet to the exciter unit.

Automatic voltage regulation

The automatic voltage regulation equipment is provided to ensure correct, safe and continuous operation of the alternator.

The regulator is of the fast response continuously acting type, responsive to three phase line to line terminal voltage and such other signals necessary **to improve stability** and overall dynamic recovery following sudden load changes or clearance of system faults. A potentiometer for manual regulation is provided.

The regulation system employs solid state electronic circuits and amplifiers with good linearity over the normal operating range of the equipment.

Means for adjusting the set point voltage for the voltage regulator is provided.
A 'soft start' facility is provided to ramp up the set point for **rapid response**.

Stabilising adjustable and lockable controls are provided to allow adjustment to compensate for changed operating conditions.

A quadrature droop circuit is provided for VAr sharing between alternators.

SECTION THREE

LUBRICATING OIL SYSTEM

LUBRICATING SYSTEMS GENERAL

Lubricating oil is used for two prime purposes, to act as a lubricant to load bearing surfaces and to transfer heat.

Types and grades of lubricating oil can vary in their properties and equipment manufacturers recommendations should be adhered to in order to obtain maximum benefits.

The operating temperature of lubricating oil should be controlled in accordance with the equipment manufacturers guidelines to ensure maximum efficiency.

Oil should be kept clean by the use of adequate filtration to protect load bearing surfaces from foreign objects that could destroy bearing surfaces. Good filtration greatly assists in extending component life.

When heavy fuel oil is used, lubricating oil centrifuges are employed to assist in the cleaning procedure to remove water and fine particulates that will pass through to the lubricating oil sump from the combustion area. The lubricating oil is centrifuged constantly over a 24 hour period the contents being centrifuged 4/5 times during this period.

Lubricants can deteriorate without any visible signs and it is therefore important that regular lubricating oil analysis is carried out.

When lubricating oil reaches a point that it must be changed, waste oil along with filters should be incinerated or disposed of through the appropriate waste oil professional services.

LUBRICATING OIL SYSTEM

The engine is designed on the wet sump principle with its own integral oil sump. The sump is of generous capacity to ensure a continuous full flow supply of oil with a capacity that allows sufficient dwell time thus allowing for longer lubricating oil life.

The engine lubricating oil pressure pump is directly driven from the engine to ensure positive oil pressure when the engine is running. A suction strainer is fitted in the engine sump to protect the pump.

Lubricating oil is circulated through the oil circuit to Duplex oil filters prior to entering the engine lubricating circuits. The design of the filter allows for full flow to pass through one filter and prevents both filter sides from being shut off at any one time. The Duplex filters are provided with manual changeover filters to allow for the **servicing of the oil filtration circuit without the need for shutting down the engine.**

Filtration is designed to remove any particulates in excess of 15 microns diameter and protect the engine bearing surfaces.

Replaceable cartridge element type filters are provided as standard.

Washable filters or automatic backwash filters are available as options.

A thermostatic control valve is fitted in the line between the pressure pump and the filter assembly to control the engine lubricating oil temperature. The control valve diverts oil through a plate type oil cooler which is cooled by the secondary cooling water system.

An electric driven lubricating oil priming pump is fitted in the line from the engine to assist in lubrication in start up conditions and the cooling of the engine during shut down operations. The priming pump is interconnected to a discharge line to allow the lubricating sump to be emptied.

The engine would be provided with a lubricating oil centrifuge module to remove solids and water from the lubricating oil. This would draw oil from and return oil to the engine sump. The centrifuge module would be designed for continuous operation to centrifuge the sump contents 4/5 times per day

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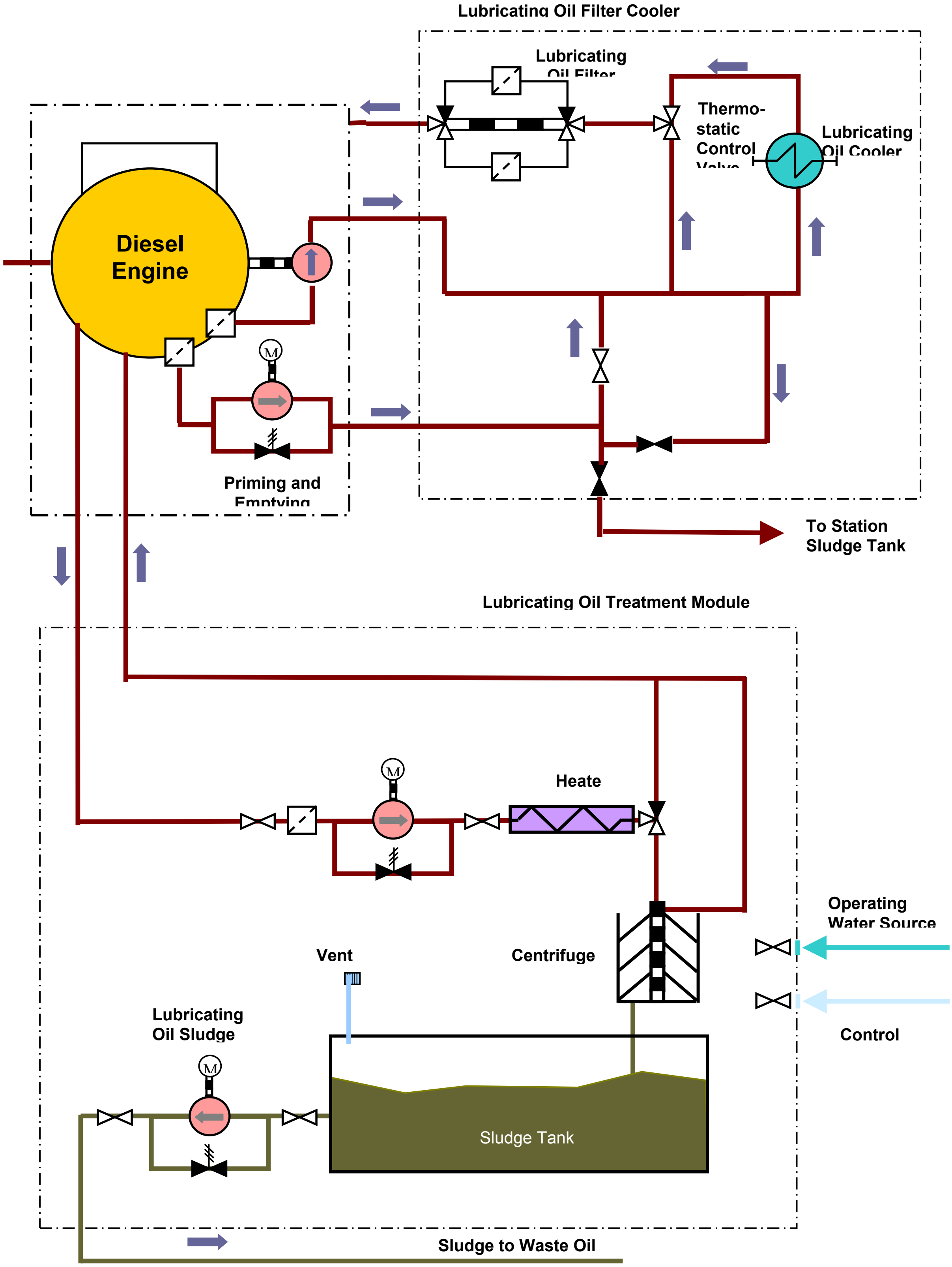
Typical Lubricating Oil System Process Diagram



SECTION FOUR

FUEL OIL SYSTEMS

FUEL OIL SYSTEMS GENERAL

The selection of the fuel oil to be used in a power station requires serious consideration.

In general, high quality distillate fuel oil is expensive in comparison to the heavy fuel oil options. The higher the fuel viscosity, the less expensive the fuel oil becomes.

The environmental requirements should be considered at an early stage to determine whether the fuel being considered will suit the environmental needs without extensive and expensive ongoing treatment.

Heavy fuel oils delivered to power stations can contain up to 2% sludge. Through treatment, much of this is recoverable (up to 98%), however there will always be a small amount of sludge that will require disposal. Waste fuel oil incineration or removal by professional disposal companies needs to be taken into account when looking at the power station build and through life costs.

Sulphur in fuel oils can exceed that accepted by Environmental Authorities (SOx) and its removal is expensive with ongoing process and maintenance costs.

It is now common practice to ensure that NOx levels meet Environmental Authority standards and the engines need to be capable of running within these limits to avoid the need to install NOx level control plants.

Most base load power stations now run on a grade of less expensive heavy fuel oil.

Heavy fuel oils require treatment to remove water and suspended solids and this is normally carried out by centrifuging. Adequate reserve capacity should be considered to allow servicing of the centrifuges without having to revert to distillate fuel oil operation.

Heavy fuel oils need to be heated to control the fuel viscosity at the supply side to the engine. The temperature required is dependant upon the normal viscosity of fuel purchased and temperatures required at the engine will vary from 110^{0}C to 145^{0}C. The engine fuel oil system components must be able to operate at such temperatures without deterioration.

The normal practice employed in operation of a power station on heavy fuel oil is to start the engine on distillate fuel oil, change over to heavy fuel oil operation and shut down on distillate fuel oil. This allows for the fuel system small pipe work to be flushed out and prevents the pipes from clogging during shutdown.

FUEL OIL SYSTEM

The heavy fuel system is designed in accordance with the project requirements, and capable of being supplied to run on a range of heavy fuels up to 600cst viscosity.

The heavy fuel oil system is divided into four main systems

a. Tanker unloading system
b. Bulk fuel oil storage system
c. Treated heavy fuel oil system
d. Engine fuel oil system

The system is designed to provide for maximum reliability and efficiency taking into account the operating conditions and constructed to conform to modern **environmental requirements.**

a. Tanker unloading system

In the event that the supply to the tank farm cannot be provided under pressure, ie from tankers without their own pumps, then a tanker unloading system is provided.

Should the lubricating oil be supplied in bulk, a lubricating oil unloading pump is provided to pump the oil from the supply source to the lubricating bulk storage tank.

Two pumps (one duty and one stand by) are provided to pump distillate from the supply source to the distillate bulk storage tank.

Two pumps (one duty and one stand by) are provided to pump heavy fuel oil from the supply source to the heavy fuel oil bulk storage tank/s.

The pumps are designed such that isolation is provided at the supply connections with blanks fitted when not in use to **minimise any spillage** and the pumps fitted with cut outs to prevent overfilling of the tanks.

The unloading pump systems are fitted within a bunded area to prevent any spillage from spreading.

b. Bulk fuel oil storage system

The bulk fuel oil storage system (tank farm) is constructed within a concrete bunded area to ensure that any spillages are contained within international environmental standards.

The heavy fuel oil storage tank/s are designed to hold the station full load running operation capacity requirements required to suit the specific project needs (normally one week or one month supply). The tank/s are fitted with heating for the heavy fuel to hold the temperature of the fuel at a level such that the fuel can be efficiently transferred to the heavy fuel oil pre-treatment tank.

Two pumps (one duty and one stand by) are provided to pump heavy fuel oil from the bulk storage tank to the heavy fuel oil pre-treatment tank ensuring a reliable supply.

The tank/s are insulated to prevent heat loss, thus increasing the efficiency of the plant.
The distillate bulk fuel oil storage tank is supplied with a minimum capacity of 24 hours full load operation of the power station. The distillate fuel oil is required for the starting and stopping of the engines and provides a secondary temporary source of fuel to the station in the event of a major problem with the heavy fuel oil heating or pumping system increasing the reliability of the plant.

Two pumps (one duty and one stand by) are provided to pump distillate fuel oil from the bulk storage tank to the distillate station ringmain ensuring a **reliable supply**.

The ringmain provides a constant pressurised supply of distillate fuel within the station to allow immediate transfer of fuel supply for starting / stopping the engine and provides an emergency supply **capable of carrying the station full load**.

c. Treated heavy fuel oil system

Heavy fuel is received in the heavy fuel oil pre-treatment tank from the bulk fuel oil transfer pump unit.

The tank is designed with a capacity of four hours station full load capacity heavy fuel oil. The tank is insulated to prevent heat loss, thus increasing the efficiency of the plant.

An outflow heater in the tank raises the fuel temperature further and provides a supply to the heavy fuel oil centrifuge plant.

The centrifuge plant draws fuel oil from the tank, through a heater unit to provide a positive pressure supply at the temperature required for centrifuging. The centrifuge removes water and solids from the fuel and discharges the clean fuel to a heavy fuel oil treated storage tank. The waste from the centrifuging operation (water and sludge) is collected in a sludge tank within the centrifuge module and then pumped under pressure to the station bulk sludge storage tank for disposal, ensuring that **no waste product of the process can cause an environmental problem.**

The heavy fuel oil treated storage tank is designed with a capacity of eight hours station full load capacity heavy fuel oil. The tank is insulated to prevent heat loss, thus increasing the efficiency of the plant.

Two pumps (one duty and one stand by) are provided to pump heavy fuel oil from the treated storage tank through the heavy fuel oil station ringmain ensuring a **reliable supply**.

The ringmain provides a constant pressurised supply of heavy fuel oil within the station ensuring adequate supply under all station load conditions.

e. Engine fuel oil system

Each engine is fitted with its own final heating, pumping and filtering module to increase the efficiency of the plant. In the event that one engine heating, pumping and filtering module develops a fault, only the engine in question reverts to distillate fuel operation, the remainder of the station continuing to run on the heavy fuel oil thus keeping the maximum possible station load running on the most economical fuel.
Two pumps (one duty and one stand by) are provided to pump distillate fuel oil from the bulk storage tank to the distillate station ringmain ensuring a **reliable supply**.

The ringmain provides a constant pressurised supply of distillate fuel within the station to allow immediate transfer of fuel supply for starting / stopping the engine and provides an emergency supply capable of carrying the station full load.

Each module is fitted with flowmeters to register the usage of distillate and heavy fuel oil.

The station ringmains provide a positive pressurised supply of distillate and heavy fuel oil to each engine module.

A controlled three-way valve supplies distillate or heavy fuel oil (depending upon the monitored state of the engine) through a mixing/de-gassing tank to the engine pressurising pump. The pump ensures that a constant supply of fuel at the required pressure for maximum efficiency is supplied to the engine. The fuel is further heated to the final temperature required for maximum combustion efficiency and is controlled by individual viscosity controllers. The fuel is then filtered before passing to the engine.

Duplex oil filters are fitted prior to entering the engine fuel circuits. The design of the filter allows for full flow to pass through one filter and prevents both filter sides from being shut off at any one time. The Duplex filters are provided with manual changeover filters to allow for the servicing of the heavy fuel oil filtration circuit without the need for shutting down the engine.

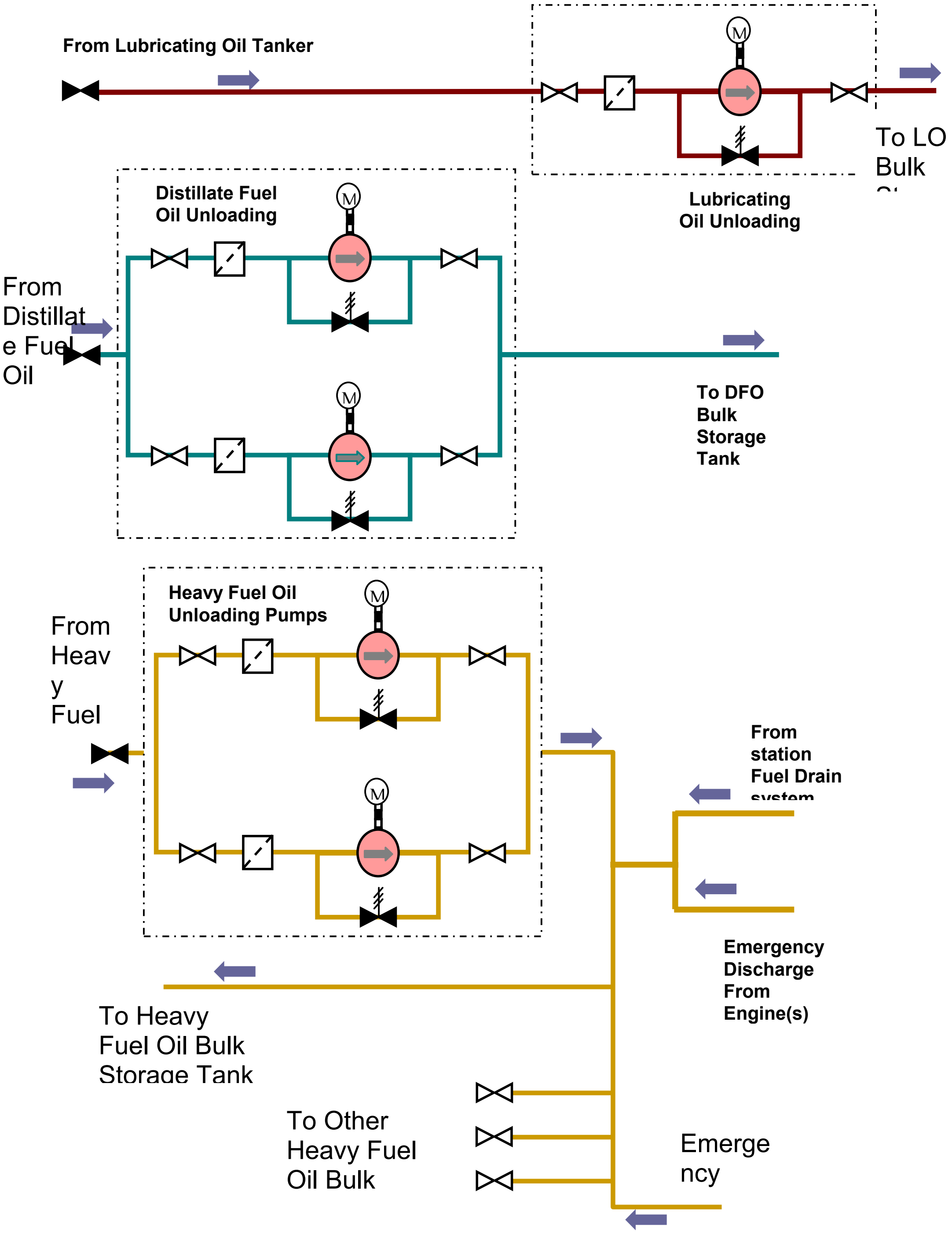
Filtration is designed to remove any particulates in excess of 15 microns diameter and protect the engine fuel pump and injector components.

Replaceable cartridge element type filters are provided as standard.

Unused fuel is circulated back to the mixing/de-gassing tank forming a closed circuit.

Fuel oil drains on the engine and the module are piped through to a fuel oil drain tank where the waste oil is pumped to the heavy fuel oil bulk storage tank **minimising fuel spillage/waste** in the station.

Typical Station Tanker Unloading System



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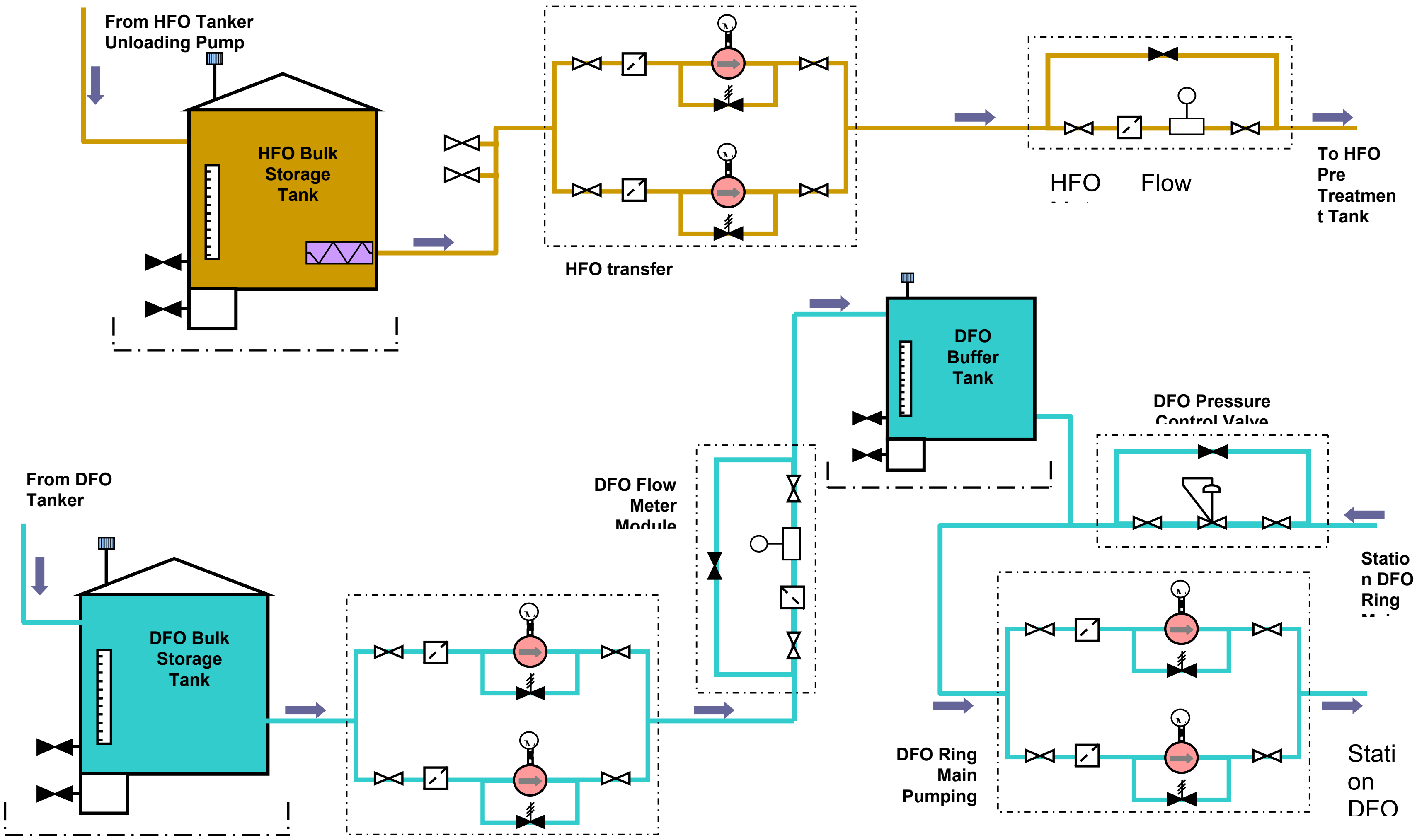
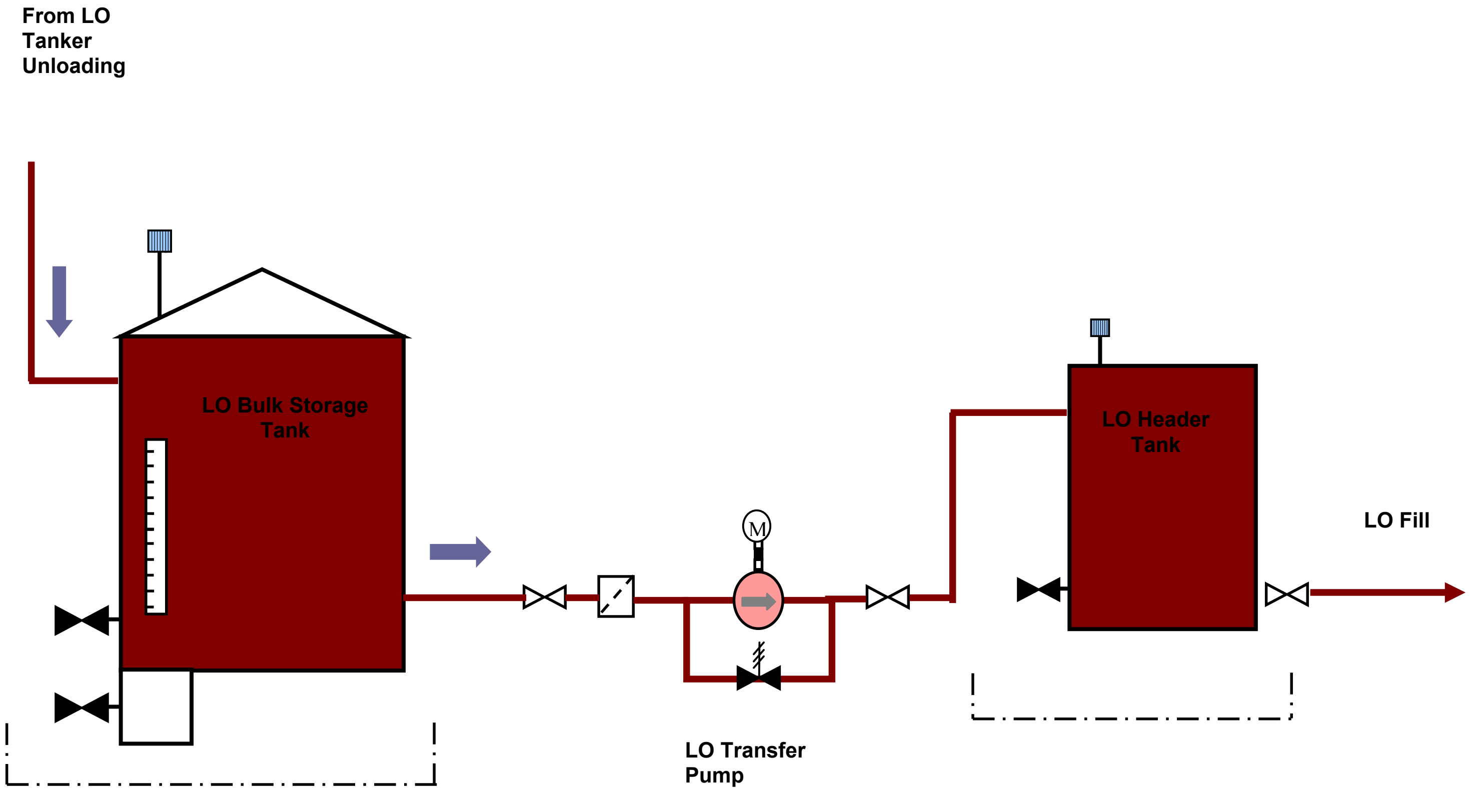
Typical Station Bulk Fuel Storage System



Typical Station Bulk Fuel Storage System (continued)



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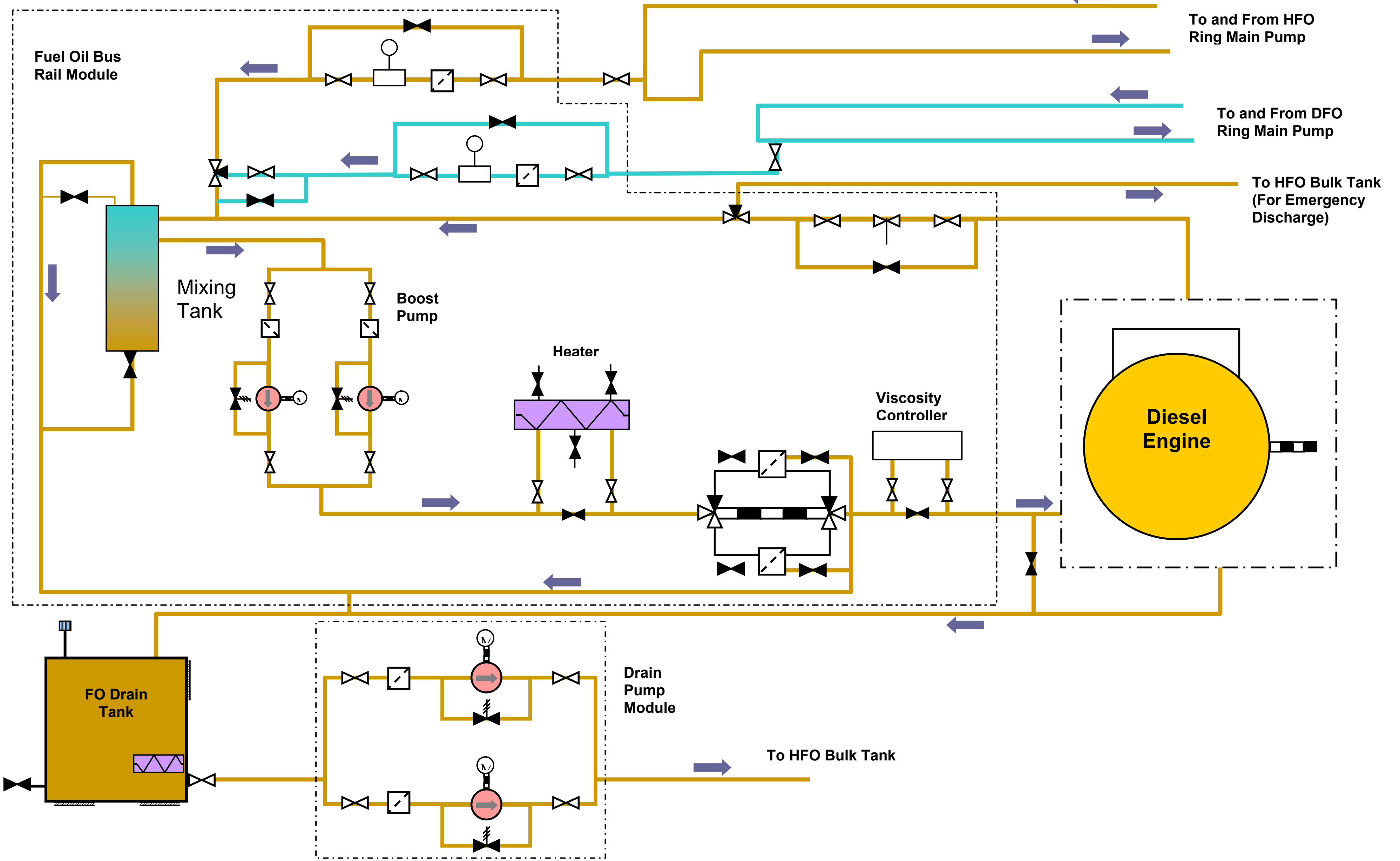
Typical Engine Fuel Oil System



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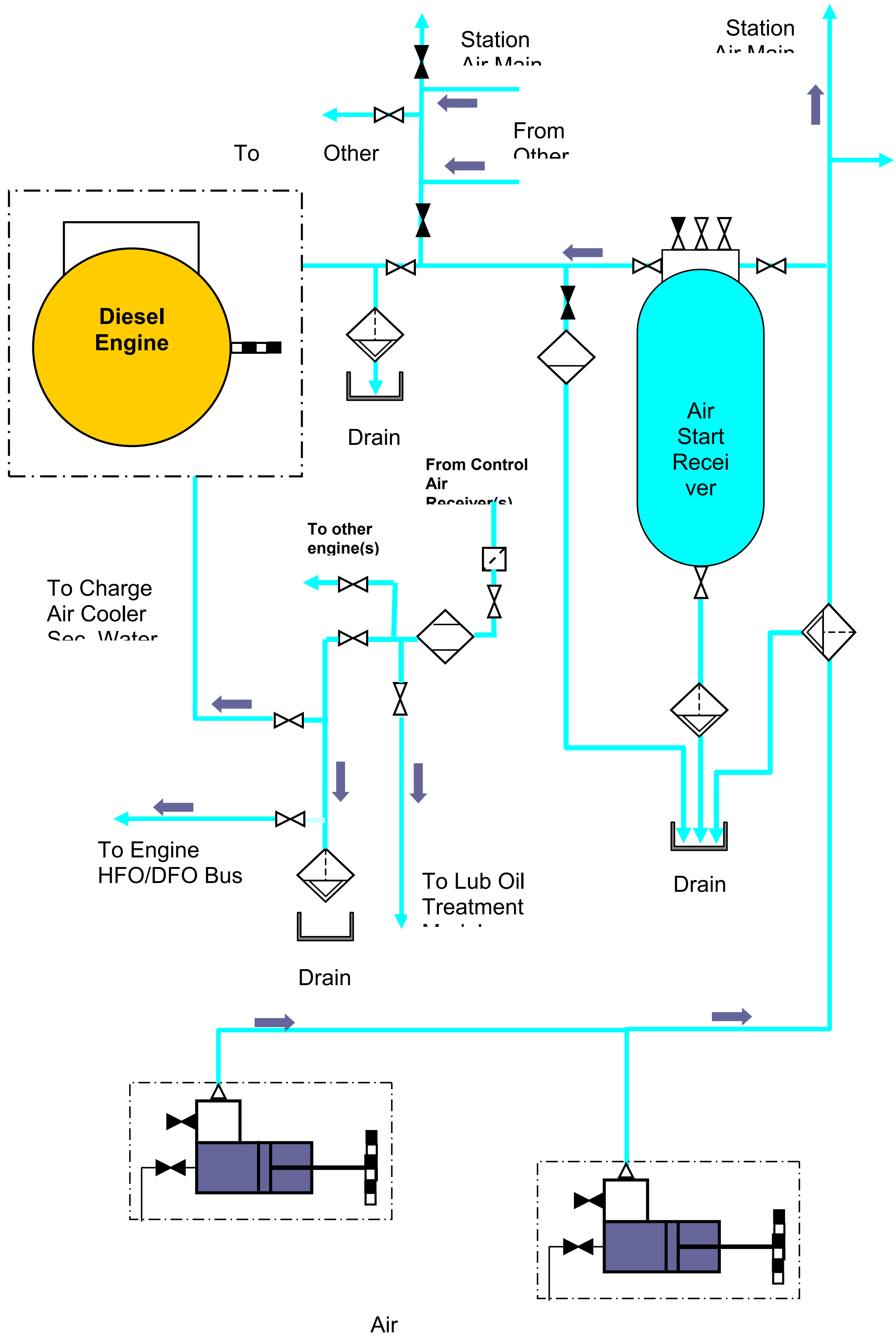
Typical compressed Air System Process Diagram



SECTION FIVE

STARTING / COMPRESSED AIR SYSTEMS

COMPRESSED AIR SYSTEMS GENERAL

Most medium speed engines employ compressed air to start the engine.

Compressed air systems should be designed to ensure that they conform to the requirements of high pressure air storage and transfer. Lloyds certified receivers are used as a standard to ensure that the integrity of the system is assured.

Compressed air supplies through compressors should be sized to ensure that the station requirements are catered for during normal maintenance operations and allows for black start operation of the station.

Air should be filtered and dry to ensure that pneumatic valves and controls operate reliably at all times.

Consideration should be given to the compressed air required for workshops, tools etc. during the design stage.

STARTING / COMPRESSED AIR SYSTEM

The engine is arranged for starting by compressed air and various controls are air operated.

Two motor driven air-cooled air compressors are provided to provide **a reliable supply** of compressed air at 30-bar pressure to air receivers, the receivers being sized sufficient to start the engine three times without recharge.

The compressed air is filtered both on the inlet to and discharge from the air receivers.

Compressed air at 30-bar pressure passes from the receiver to the main start air valve on the engine. When a signal is given to start the engine, a main start valve is opened. Compressed air is passed to one bank of the engine via an air distributor, and is injected into the combustion chamber. This causes the engine to rotate at speed. When the engine fires, the main start valve is closed and the air supply to the engine isolated.

Compressed air is taken off the main air manifold of the station and reduced to 7/9-bar pressure to provide air to various controls in the station such as centrifuges and control valves. This air is filtered and dried to ensure that **high quality air** is used.

NOTE:

In the event that compressed air is used in the station for general purposes such as compressed air workshop tools, this requirement is either provided for through a separate system or the compressed air system increased in size to cater for this requirement.

SECTION SIX

COOLING SYSTEMS

ENGINE COOLING SYSTEMS GENERAL

Cooling water for the supply of the station requires careful consideration.

Water supply availability is the key element and will determine what type of cooling system can be best used.

There are three main types

a. Unlimited supply, namely canal or sea water

This type gives a limitless supply and can be used by pumping the supply through large heat exchangers instead of radiators or cooling towers. Unfortunately, it is not a supply that is available in most cases.

b. Limited supply, namely underground water tables or reservoirs

This type gives a limited supply of water and is normally the source of supply when using cooling towers.
It is however important to ensure that the water supply can sustain the long term draw off from the station. As a guide, the supply required will be up to 4% of the cooling flow rate to make up for cooling evaporation and drift and that for the centrifuges and general consumption.

c. Scarce supply

In this event radiators are supplied. When selecting radiators careful analysis of the working conditions ie dusty or salt laden air, parasitic loads and construction needs to be made. Many owners of power stations have suffered from inefficient operation and high costs of maintenance by lack of understanding of these issues.

As a guide, the following gives a comparison between the three types of cooling

	RADIATOR	COOLING TOWER	CENTRAL COOLING (Heat exchanger)
Capital cost	High	Low	Medium
Parasitic loads	High	Low	Medium
Water make up	Low	High	Low
Noise level	High	Medium	Low
Water treatment	High	Medium	Low

All water in primary circuits and secondary circuits in radiators and cooling towers must be of good quality and will require some form of chemical treatment. Always treat water to the standards stated by the equipment supplier.

ENGINE COOLING SYSTEMS

The engine is cooled in three main ways

a. Radiator cooling
b. Cooling tower cooling
c. Central cooling

Central cooling varies dependent upon the type of cooling medium ie salt water, and the system specifically designed to suit the individual project needs.

RADIATOR COOLING

Cooling of the engine is of the closed circuit type using horizontal air blast radiators with electric motor driven fans.

Jacket water system

A jacket water pump, mounted on the front of the engine, pumps water through the first stage of the charge air coolers and then through the engine cooling waterways. Water leaving the engine is fitted in a closed circuit passing back to the suction side of the pump. A thermostatic control valve is fitted in the line to divert hot water leaving the engine, through a cooling matrix in the radiator, to provide the engine with coolant at the correct temperature.The radiator matrix is designed to resist fouling and designed with a **fouling reserve**. The matrix is designed to provide optimum performance with the minimal motor load thus **reducing the parasitic loads** required.

Cooling of the first stage of the charge air coolers allows for rapid control of charge air temperature to the combustion chambers in cold start and varying load conditions resulting in **high combustion performance**.

In cold climates, a jacket water priming and heating circuit is provided to warm the engine through for **rapid start and load acceptance** and to assist in cooling the engine after shut down.

A header tank is provided to allow for expansion and top up.

Secondary cooling water system

A secondary cooling water pump mounted on the front of the engine pumps water through the second stage of the charge air coolers and then through the lubricating oil heat exchanger. Water leaving the heat exchanger is fitted in a closed circuit passing back to the suction side of the pump. A thermostatic control valve is fitted in the line to divert hot water through a cooling matrix in the radiator to provide the engine with coolant at the correct temperature to provide maximum efficiency. The radiator matrix is designed to resist fouling and designed with a **fouling reserve**. The matrix is designed to provide optimum performance with the minimal motor load thus **reducing the parasitic loads** required.

A header tank is provided to allow for expansion and top up.

COOLING TOWER COOLING

Cooling of the engine is of the open circuit type using cooling towers with electric motor driven fans.

Jacket water system

A jacket water pump mounted on the front of the engine pumps water through the first stage of the charge air coolers and then through the engine cooling waterways. Water leaving the engine is fitted in a closed circuit passing through a jacket water heat exchanger back to the suction side of the pump.

Cooling of the first stage of the charge air coolers allows for rapid control of charge air temperature to the combustion chambers in cold start and varying load conditions resulting in **high combustion performance**.

In cold climates, a jacket water priming and heating circuit is provided to warm the engine through for **rapid start and load acceptance** and to assist in cooling the engine after shut down.

A header tank is provided to allow for expansion and top up.

Secondary cooling water system

A secondary cooling water pump mounted on the front of the engine pumps water through the second stage of the charge air coolers and then through the lubricating oil heat exchanger and to the cooling tower. The cooling tower provides cooled water back to the suction side of the secondary cooling water pump.

The cooling tower is fitted with blow down facilities and designed to provide for easy maintenance.

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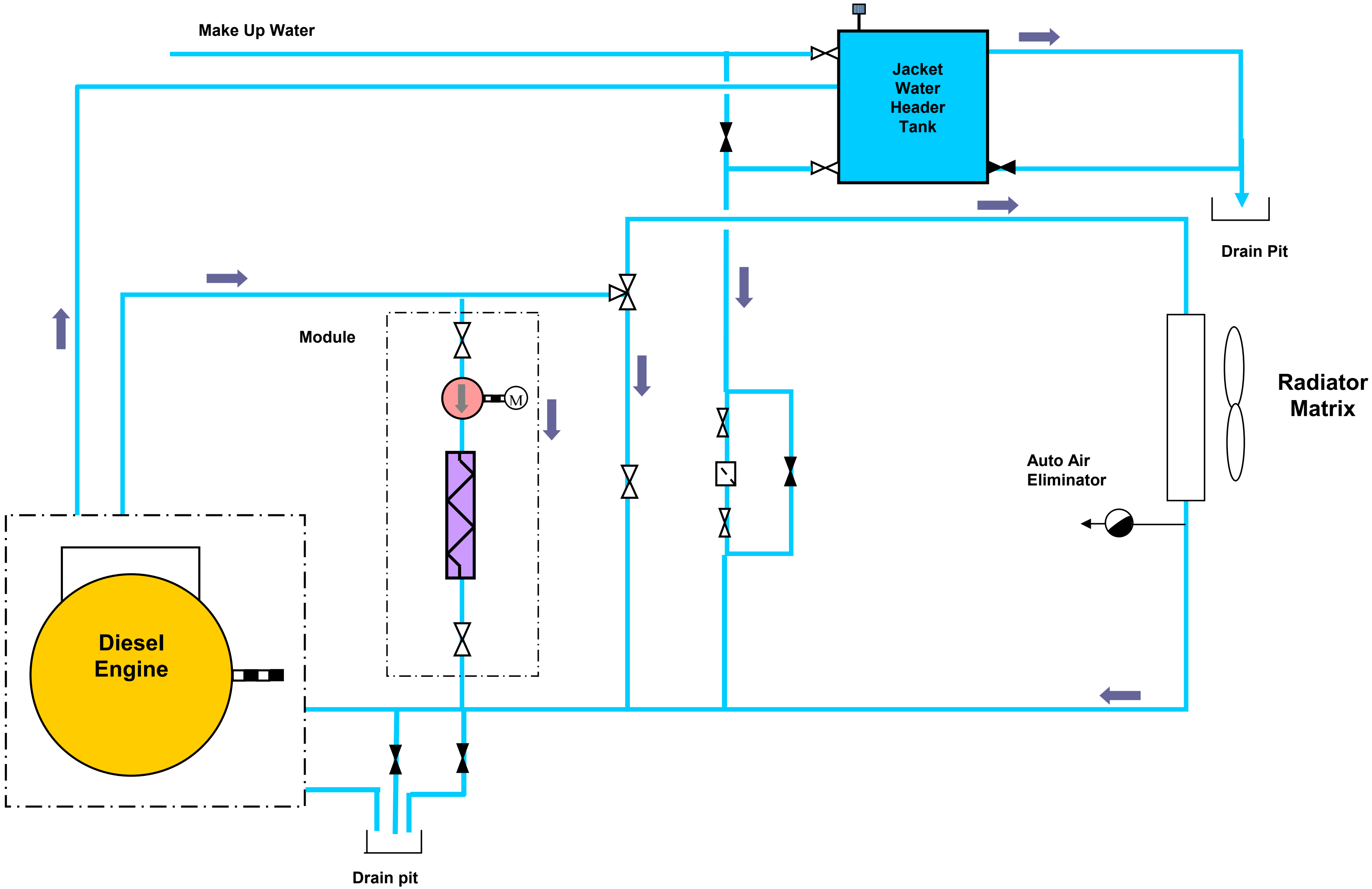
Typical Jacket Water System



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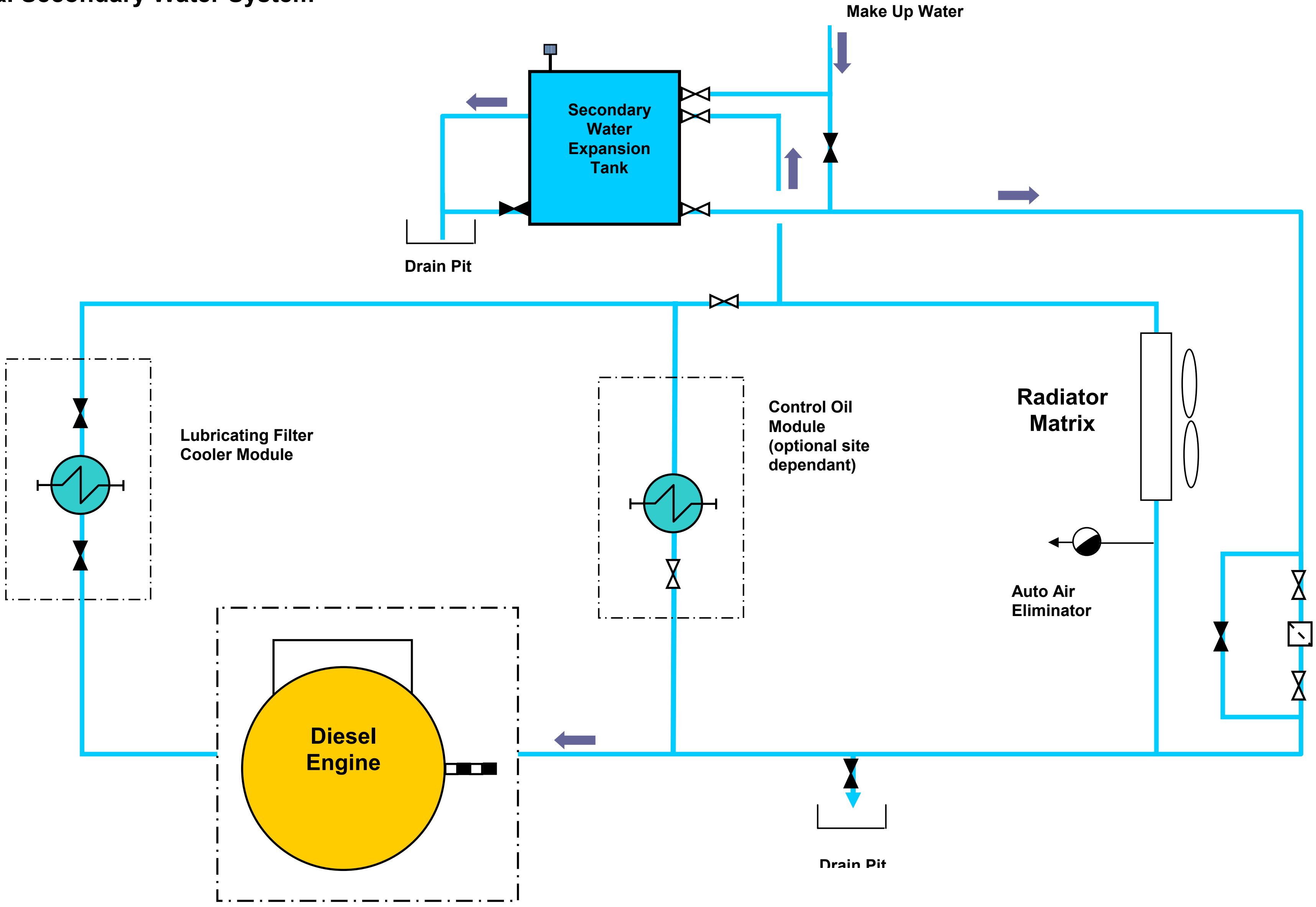
Typical Secondary Water System



SECTION SEVEN

WASTE HEAT RECOVERY

WASTE HEAT RECOVERY GENERAL

The diesel engines take fuel and converts this into mechanical power to generate electricity. In doing this, heat is expended to water cooling, lubricating oil cooling and exhaust systems.

In some cases this waste energy can be recovered to supply heat to other process systems ie hot water and steam

This is normally achieved via heat exchangers in the water and lubricating oil systems for low temperature recovery and the exhaust for hot water oil heating and low pressure saturated steam.

The exhaust gases hold the greatest amount of waste heat and is normally used for process systems associated with the power station and for heating heavy fuel oil.

The decision on the type of heat recovery to be used, if any, depends upon the individual project circumstances.

Hot water recovery from the exhaust system will provide a supply of hot water in a closed circuit at temperatures up to 120^{0}C.

Steam recovery will provide a supply of saturated steam at pressures between 7 and 10 bar.

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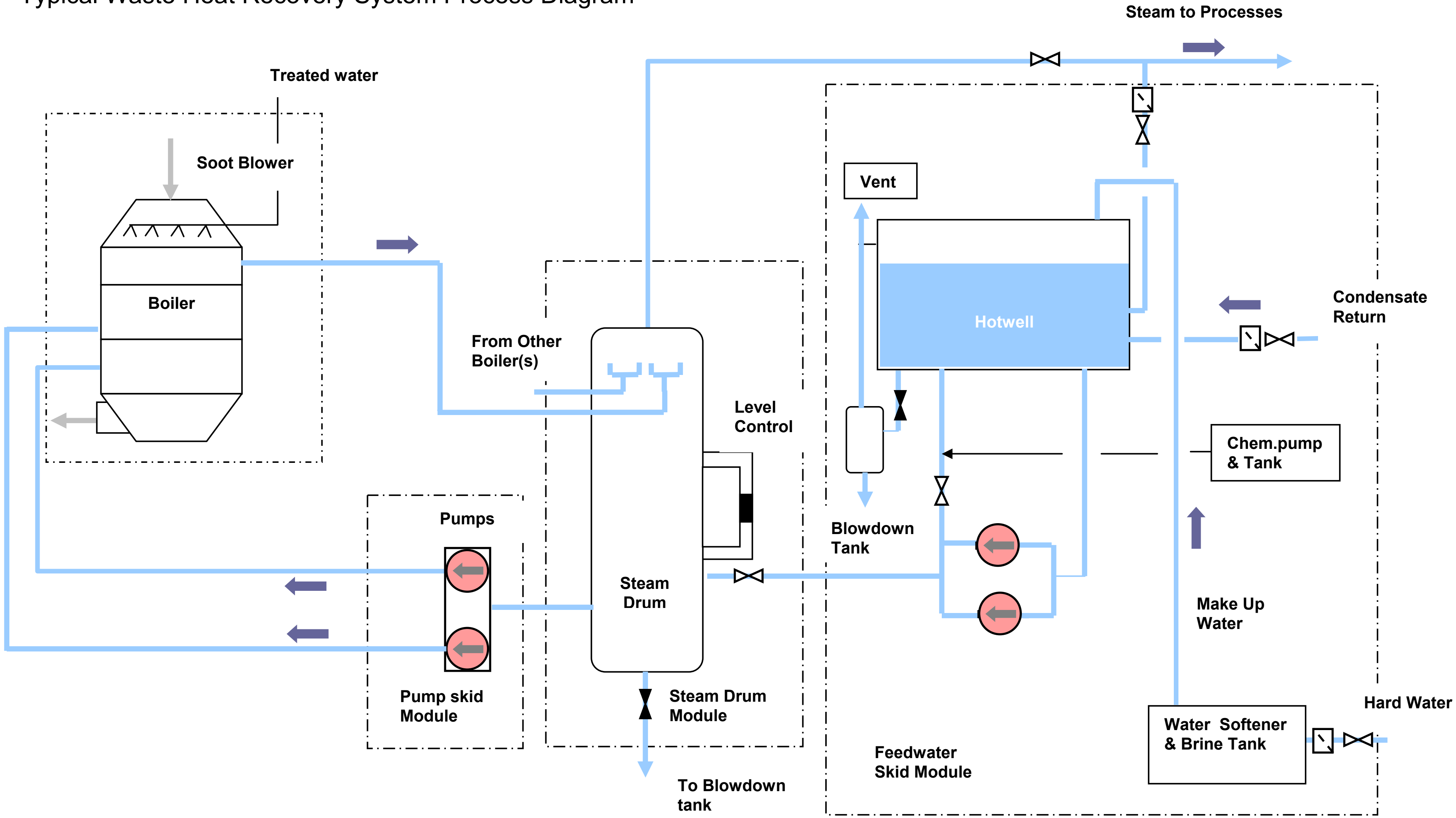
Typical Waste Heat Recovery System Process Diagram



SECTION EIGHT

AIR INTAKE AND EXHAUST SYSTEMS

AIR INTAKE AND EXHAUST SYSTEMS GENERAL

Air Intakes.

The engines require high quality filtered air in large quantities for the combustion process.

Since the air within the power station will increase by up to 10^0C above the outside ambient temperature due to radiated heat from the equipment, drawing air from within the station may result in the equipment guaranteed output having to be derated.

It is therefore now common practice to duct air to the turbochargers through ducting from outside the station. This air has to be filtered and self cleaning oil bath curtain or heavy duty dry type filters are normally used. The filter units are designed to minimise air pressure drop and thus exposes the outside to turbocharger noise. To reduce this noise level, air intake silencers are normally employed.

It is important to ensure that the ducting has been carefully designed to withstand the effect of being coupled to the turbochargers. Engine vibration is controlled by the use of expansion joints, and the ducting systems (due to the effect of varying temperatures), by the use of drains and traps within the system.

Exhaust systems

Exhaust from the engine must be safely carried away from the engine and discharged in a safe manner and within the guidelines laid down by Environmental Authorities.

Design must take into account the expansion of the exhaust system in each plane by the use of adequate expansion bellows pieces and personnel safety through thermal insulation.

Noise must be reduced by the use of exhaust silencers whilst ensuring that no excess back pressures are placed on the engine thus limiting the performance.

Drains should be fitted in the system to drain off condensate that may collect during shutdown.

AIR INTAKE AND EXHAUST SYSTEMS

Charge air intake

Air from outside the station is drawn into the engine air intake through an air intake filter. The filter is normally of the continuous self cleaning oil bath curtain type, however in certain cases of extreme dust, dry type cleaners may be provided.

Air silencers are fitted in the air manifold between the engine and the filter to reduce the noise to the outside of the building to acceptable limits.

The charge air ductwork is fitted with drains to remove condensate.

The air passes through the two exhaust gas driven turbochargers to two stage charge air coolers. The primary side is cooled by the jacket water system and the second stage by the secondary cooling water system to provide for **optimum combustion air temperature** during cold and varying load conditions, benefiting in higher efficiency and exhaust emission control.

Exhaust system

The exhaust from the turbochargers is connected into a single duct using a transition piece and discharged to the outside of the building. An industrial exhaust silencer is fitted to provide for noise control and discharged to atmosphere through vertical exhaust tail pieces.

If waste heat recovery exhaust gas boilers are supplied these are fitted in the exhaust line after the silencers and fitted with a by pass ducting system.

A chimney may be provided if the design requires, **to meet environmental legislation**, dependent upon the type of fuel being used.

In the event of high sulphur fuels being used a De-SOx plant may be fitted, which is designed for the individual project needs to limit pollution.

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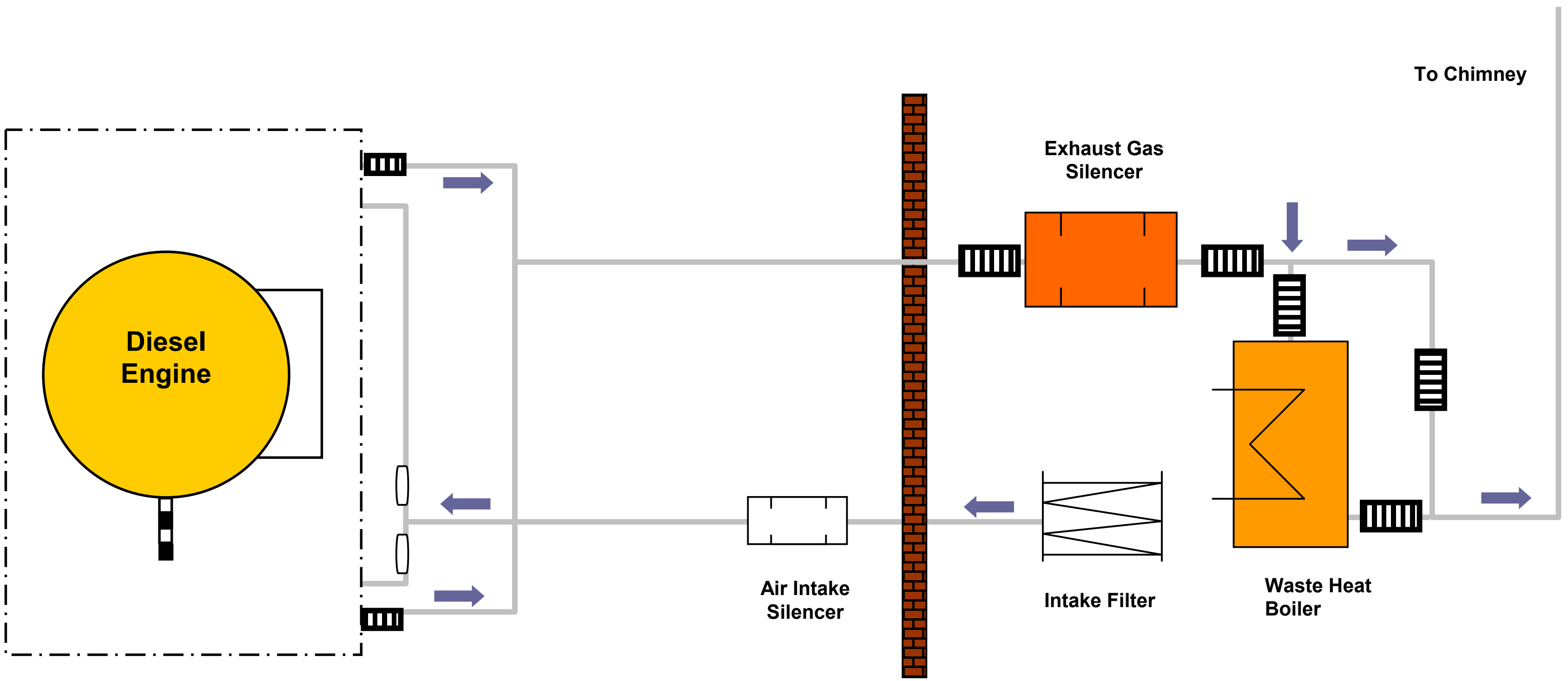
Typical Charge Air Intake and Exhaust System Process Diagram



SECTION NINE

ELECTRICAL CONTROL SYSTEMS

ELECTRICAL CONTROL SYSTEM

Operating Philosophy

General

The following description applies to a station which has been correctly sized **to take into account reserve spinning load, standby set and maintenance set requirements.**

The generating sets are normally controlled from the central control desk with local start / stop control at the set for **emergency and maintenance purposes**.
Control of the generating set auxiliaries is normally automatic from the unit control panels. For test purposes these are controlled from the individual motor control panels.

All status and measurement data necessary for the safe normal operation of the station is available at the central control desk.

Normal operation

The medium voltage bus bar is supplied by the main generating sets operating in parallel.

The generators are earthed by a single earthing resistor when operating in parallel unless a bus coupler is employed and open, in which case two resistors are employed.

The medium voltage bus bar supplies power via a main feeder/s to the outgoing transmission system. Where individual project requirements require the station voltage output to change to suit the main transmission supply a step up transformer/s is supplied.

Power is drawn from the medium voltage bus bar to the low voltage bus bar through a step down transformer. To ensure the supply of the low voltage supply a stand by step down transformer is offered as an option.

The station supplies including the generator auxiliary supply are supplied from the low voltage bus bar as required.

The central control desk automatically regulates the number of generators in operation to ensure that a **suitable spinning reserve is available** to allow for fluctuations in load or the loss of a main generating set**. Load sharing between sets is automatic** under the control of the engine speed governors and the central control desk.

Each engine has a comprehensive alarm / shut down system to protect the integrity of the station. In the event that a sub critical alarm develops and remains unattended to, further deterioration results in a critical shutdown fault and stops the engine and causes the appropriate circuit breakers to trip. Faults are indicated on the unit control panels with a common fault indication on the central control desk.

Each generator has a **comprehensive electrical relay protection system**. Operation of one of these relays results in the tripping of the associated circuit breaker and, in some cases, tripping of the engine and alternator excitation. Any relay operation is indicated on the central control desk as well as at the relays.

Should a first stage fault occur on any of the running generators, then if another generator is selected to its automatic operational status, the stand by unit will start, synchronise and take over the load. With an immediate second stage fault on the main generator, the standby generator will start immediately and take over the load.

NOTE:

In the event that it is known that large loads are to be placed on line it is necessary for the station operators to ensure that sufficient spinning load is available to cater for this foreseen occasion to ensure that load demands can be met.

When a generator is started from the central control desk, either automatically or by the operator, the sequential starting of auxiliaries, the engine start, alternator excitation, synchronising, and loading of the set is fully automatic under the control of the central control desk and the unit control panel.

The engines will start up using distillate fuel and automatically switch to heavy fuel oil operation when conditions are satisfactory. The operator is also able to inhibit the change to heavy fuel oil operation if required. In this event, certain first stage alarms trigger automatic reversion to distillate fuel operation.

When a generator is shut down from the central control desk, either automatically or by the operator, the switch to distillate operation, unloading, circuit breaker opening, engine stop and post run cooling is fully automatic under the control of the central control desk and unit control panel.

Abnormal Operations

There are four main abnormal modes of operation:

The first occurs when a bus coupler is used in multi–generator applications.

When the main generators are supplying total power demands and station load, the bus coupler is opened by a fault.

The main power station generation then becomes split into two sub generating groups. Under these circumstances and dependant upon the site load being supplied by each sub generation group, load shedding may be necessary. This is automatic and under the control of the central control desk.

The second abnormal mode occurs when the main generators are supplying the total power demand and there is a failure of a power station auxiliary transformer. If there is not a secondary supply, the power station will automatically shut down. Restoration of the power station supplies to the power station and hence the plant would be by following the black start procedure.

The third abnormal mode occurs when the main generators are supplying the total requirements of the outgoing supply and station and a main generating unit is lost. In this circumstance, the spinning reserve, controlled by the central control desk, will enable the outgoing load requirement to be met and continue in operation until an additional main generator is started.

The fourth abnormal mode is when starting up of a large drive is required requiring a large power supply and one of the auxiliary units is not available.
In this event the load cannot be catered for until the auxiliary unit is available.

Plant Start up (Black Start)

Assuming that the correct pre-start up checks have been carried out, the following steps are taken.

1. All circuits on the medium and low voltage switchboard are open. (some moulded circuit breakers may be closed).

2. The black start generator is started and the circuit breaker to energise the low voltage bus bar closed.

3. The generator / main engine services as necessary to bring the main generator services to operating condition (fuel supply, air compressors, cooling systems, batteries, lighting etc) supplies are switched on.

4. The selected main generating set is started and synchronised to the main bus bar. Synchronising is automatic if selected from the central control desk or manual from the unit control panel. The load is then transferred to the main generating set and the black start generator shut down. The central control desk is set to automatic and the main generators are started automatically as required.

Operating Mode after a Main Engine Fault

Assuming that the station load and power demand is in the normal operating mode and a critical (fault) condition arises or an emergency stop button is pressed:

1. The generating set circuit breaker is opened and the engine is shut down. The fuel supply changes over to distillate operation, if not already triggered by a fault alarm. Post run cooling and lubrication is now under unit control panel control.

2. At the same time, the central control desk automatically starts up the stand by main generating set and synchronises and loads the unit to replace the spinning reserve.

3. Purging of the fuel system is carried out manually if required.

Manual Control Facilities

All generating sets can be started in local control from the unit control panel. The sequential starting of the auxiliaries, the engine start and excitation is controlled automatically by the unit control panel. Synchronisation is automatic, but with manual initiation, at the unit control panel.

Load control is manual at the unit control panel.

Electrical Power Supplies

24 Volt DC Supply

The 24 volt DC supply is available at all times when the diesel generating sets are required to be run.
As the engine protection systems are energised to run, failure of this supply results in immediate engine shut down.

This supply is also required to provide protection and tripping supplies to the switchgear.

The batteries have a capacity to supply to all services of one generator for a period of 3 hours. Duplicate batteries / chargers are provided to operate on a duty / standby basis with manual changeover.

415 Volt 3 Phase Supply

This supply is always required whenever the main generating sets are required. The supply is derived from the main medium voltage switchboard via a station step down transformer

220 Volt Single Phase Supply

It is recommended that whenever a single phase supply is available it is switched on to the control and switchgear panels to provide anti-condensation heating and lighting and also the generator anti-condensation heaters.

A single phase supply is also used for fuel system trace heating and battery chargers.

The Local Control Panel

A free standing unit control panel is located adjacent to each generating set.

The panel incorporates all necessary control and monitoring facilities for both the engine and the alternator. Each unit control panel is interfaced to its own motor control centre incorporating the starters, contactors etc for the engine auxiliary equipment.

All relevant process indications are displayed at the unit control panel. The panel will incorporate common selection controls, push buttons, alarms, pressure and temperature indications for the engine and alternator.

The panel includes a relay based (hard wired) shutdown system to shut down the engine via the governor and also trips the generator circuit breaker.

An internal programmable logic controller carries out all automatic sequence controls, alarm and shutdown monitoring, system display generation and exhaust gas temperature monitoring.

All data processed by the programmable logic controller is available at the central control desk and for further remote monitoring at the central control desk via a communication port.

The engine section of the local control panel also houses the electronic governor controls.

Central Control Desk

Overall control of the generating plant is undertaken from the central control desk which interfaces directly with other individual unit control panels.
This gives comprehensive control of the main generators and other circuits via the internal programmable logic controller.

The desk holds a duty and stand by PC and has the capability to:

1. accept and reset all alarms
2. start and stop the generators
3. start and stop station services where appropriate
4. operate switchgear where appropriate
5. provide full monitoring of generating set and station services

Visual displays include:

a. The configuration of the main medium voltage electrical system, showing the status of each circuit breaker together with the active / reactive power / frequency / power factor generated by each generator and the gross power being delivered to the plant by each principal feeder.
b. The configuration of the low voltage electrical system, showing the status of each circuit and values of current and voltage
c. The parameters for each engine transmitted from the unit control panels
d. The alarm states for each system / item of equipment together with group alarms
e. The status and values for the principle station systems in the form of mimic diagrams where appropriate
f. The date and time sequence of alarms

Neutral Earthing Equipment

The neutral earthing equipment consists of a single pole and three pole vacuum contactor / circuit breaker connected to each generator together with one or two resistors.

The contactors function to maintain and earth on a single running or running group of generators depending upon the configuration of the electrical system.

Auxiliary High Speed Generator

The station is supplied with a high speed auxiliary generator to facilitate in the black start operation of the station.

The size of unit is such that essential services are started on the low voltage bus bar to allow the starting of a main generating set.

SECTION TEN

THE POWER STATION BUILDING AND LAYOUT

POWER STATION BUILDING AND LAYOUT

Buildings

The design of buildings, enclosures and plant minimise regular and long term maintenance by the selection of **appropriate materials and finishes to withstand the environment**.

Wall and roof membranes, windows and doors are designed to be **weatherproof** and to give adequate protection from solar gain and glare and to **minimise the entry of dust.**

Where appropriate windows and doors are provided with projecting surrounds and canopies and where necessary, provided with fly screens.

The building frame is of structural steelwork with bolted connections. External wall and roof cladding is generally of metal sandwich construction in combination with brick or block dado perimeter walls. Steelwork protection systems are appropriate for the site environment to give a **period to first maintenance of 10 years**.

All rooms or compounds containing equipment liable to fire or explosion are designed to minimise the effects and **safeguard personnel**. At least one alternative means of escape is provided.

Doors are provided of suitable height and construction to **permit installation and maintenance of equipment and plant.**

Building work includes floor screeding and floor finishes, carpentry and joinery, sanitary and plumbing installation, plastering and rendering, tiling, suspended ceilings, windows and doors, waterproofing and sealing.

Control rooms are provided with split air conditioning units. Fan assisted ventilation is provided to the rest of the plant and equipment areas. The engine hall is provided with a **forced ventilation system** comprising fans, inlet and outlet louvres.

An electric overhead travelling crane is provided for normal maintenance of the diesel engines. The crane is pendant controlled and capable of supporting the heaviest maintenance lift. Hook heights and approaches are compatible with the maintenance requirements of the engines.

Internal lighting is provided to achieve 200 lux at floor level. Emergency lighting is also provided.

Power ringmains are provided throughout the buildings and annexes.

Drainage Systems

All waste from the building and operations **conforms to the environmental requirements** in force.

Foul water arising from toilets, sinks and the like are piped to a suitably sized septic tank. Effluent from the tank is piped to a purpose built soak away or piped to a nearby existing mains system.

Contaminated water or effluent from boiler blow down or water treatment plant and the like is piped to a holding tank for treatment prior to discharge to the site soak away or nearby existing foul system.
Surface water from roads, oily water from transformer compounds, fuel bunds and the like wo piped to a suitably sized oil/water interceptor. Effluent from this would be discharged into the site soakaway or nearby existing mains system.

Surface Finishes

Access roads are constructed in bituminous macadam, of suitable width and radius to permit access for maintenance and operation of the plant.

Fencing

Perimeter anti-intruder fencing is supplied. Fencing is 1.8m high, galvanised chain link with cranked steel posts.

Perimeter and Site Lighting

Perimeter lighting is provided on metal posts to achieve an illumination level of 10 lux. Lighting is provided around external plant to provide adequate lighting levels for inspection and maintenance.

Bunded Areas

Reinforced concrete bunded areas are provided to fuel storage and transformer compounds of sufficient size to contain 110% of the capacity of the largest tank within each bund. Rainwater collected within these bunds is collected at a sump and manually released into the oily water system via gravity flow or a pumped system.

DESIGN OF THE WORKS

Site And Building Arrangements

The layout and dimensions of buildings and roads is such as to permit **safe access** for installation, operation, inspection and maintenance purposes, of all plant and equipment.
Where required, the layouts are such as to permit future extension of the station with sets of a similar size.

Architecture

The design of the buildings and plant enclosures is such as to be visually related to the surroundings and **comply with the requirements of local environmental authorities.**

Design Codes and Standards

All design and detailing complies with British and International Standards and takes into account any particular requirements of local authorities.

Design Requirements

Loading

All structures, foundations and their component parts are capable of withstanding the worst practical combinations of dead and live loads, surge, braking, wind, seismic and erection forces, impact, temperature and shrinkage effects, without exceeding the prescribed ultimate and serviceability limit states. **Fifty year return period values** are used for environmental loading as appropriate. Seismic loading is in accordance with local codes or equivalent UBC. Loading adopted for design purposes takes account of all requirements relating to the construction , operation and maintenance of the plant, including those for permanent and mobile cranes, laydown or any other imposed loads.

Vibration and Noise

All buildings are designed to ensure that noise and vibration levels are kept within acceptable limits where defined. The design of structures and foundations for vibrating machinery are in accordance with current practice for dynamic analysis and structure/soil interaction. Vibrations transmitted from plant foundations to adjacent surroundings do not have a deleterious effect on the surrounding structures or plant. Noise levels in buildings normally occupied in the course of operation of the plant are reduced to a level appropriate to the activities in that building.

Topographical Survey

Prior to the design of the works, a detailed topographical survey of the site area will be undertaken.

Geotechnical Survey

Prior to the design of the works, a detailed geotechnical investigation will be undertaken, comprising boreholes and trial pits, to establish details of soil strata, the presence of ground water, provide recommendations for foundation solutions and any requirements to protect in ground concrete from injurious salts and chemicals.

Foundations

Foundations for reciprocating plant are designed to ensure that the natural frequency and amplitudes of vibration would be within the limits prescribed by the plant manufacturer. Such foundations are of monolithic construction.

Foundations are designed such that total and differential settlement would not affect the operation of supported buildings, machinery or plant.

The minimum factor of safety against rotation and sliding would not be less than 2 at service loads (unfactored).
Foundations will be in reinforced concrete and be of either piled, raft or pad design, in accordance with the recommendations of the geotechnical investigation.

SECTION ELEVEN

THE ENVIRONMENT AND WASTE MANAGEMENT

THE ENVIRONMENT AND WASTE MANAGEMENT GENERAL

Arun International (Power) Ltd is an active participant in the betterment of the environment The Company works hard in implementing its policy, the key reference points being:

1. The policy covers all the Company activities, products and services. It recognises that all environmental changes must be controlled.
2. Continual environmental improvement. Meeting all relevant legal and corporate needs, setting objectives and targets and reacting to genuine enquiries.
3. Training of key personnel and a pledge to all employees to promote and encourage environmental issues. Asking our suppliers and contractors to follow our environmental goals and to provide suitable help and encouragement to them.
4. Manage all our utilities and resources effectively and to control and reduce all forms of waste. To encourage all types of recycling and reuse and to engage in some community projects.
5. Have effective means of dealing with leaks and spillages. To put in place suitable environmental emergency and disaster plans.
6. To make the policy available to those who want copies of it.

In looking at the design, build and operation of power stations we actively pursue and promote the **POWER** principle namely:

P = Prevent spills and leaks. Use bunded pallets and safe storage areas. Clean up immediately.

O = Order products that do not harm the environment or cause damage. Ask for containers that can be refilled.

W = Wastes must not be mixed. Keep separate and make sure that waste always goes into the correct bins.

E = Energy use must be reduced. Switch off machines, lights etc when not in use. Don't waste power.

R = Recycle and reuse where at all possible

Environmental Waste Control

There are a number of Agencies worldwide that define the acceptable levels of exhaust contaminants and these need to be researched for any given geographic area.

Some of the major controllers are

World Bank
TA- Luft
Environmental Protection Agency

Prior to commencing on any works it is essential that one checks the legislative requirements for any given project.

a. Exhaust Emissions

It is now becoming common practice to install chimneys to assist in expelling exhaust gases into the atmosphere at allowable heights.

It is important to ensure that the SOx levels are also kept within acceptable limits. This is normally achieved by the use of low sulphur fuels. However, should the sulphur levels in the fuel oil be high enough to create a problem, then a De-SOx plant is used.

The capital cost of a De-SOx plant is high and chemicals used in the process need to be handled with care. On going chemical supply, operation and maintenance of the plant adds significantly to the through life cost of the station.

There are two main processes for exhaust gas desuplhurization which operate as follows:

1. $CaCO_3$ Scrubber

The basis of this process is the absorption of pollutants from the flue gas in a free space scrubber using an acidic scrubbing solution as the absorbent.

During the absorption of sulphur dioxide, insoluble elements are generated which are suspended in the scrubbing solution. This suspension is separated from the system and drained. The suspension is drained either by a vacuum belt filter, filter press or centrifuge, depending on the quantity and requirement.

The quantity of the end product is determined by the absorbed pollutants which pass through the scrubber. This quantity depends on the stiochiometric relations and pollutant levels being in the additive.

The subsequent metering of the calcium ions used during the absorption takes place in the form of calcium oxide, carbonate or hydroxide as suspension or in dry form by pH control.

The efficiency of the flue gas desulphurization increases with a constant scrubbing solution and a reduction of the flue gas quantity.

This absorption process has the following features

- high efficiency for SO_2, HCI, HF and dust
- virtually 100% utilisation of the chemicals
- low pressure drop
- small circulating quantities
- no absorption of carbon dioxide
- easy handling

2. NaOH Scrubber

The basis of this process is the removal of SOx emissions from the flue gas stream through wet absorption using a flue gas purification system with water and NaOH as the absorbent.

The absorbent column (scrubber) is designed as a packed scrubber. The flue gas enters the scrubber below the packing material and subsequently flows through the backed bed which is charged with scrubbing solution acting in a counter flow manner.

In the specially designed injection area of the scrubber, the hot flue gas is quenched to the cooling limit temperature.

The absorption of SOx takes place by a caustic soda solution. In the packing stage, this solution absorbs the SOx from the flue gas.

The required caustic soda solution is added via the pH meter installed in the storage tank for scrubbing solution.

In order to prevent an increasing salt concentration of the wash water, a partial quantity of the wash water is drained from the pump pressure pipe to the waste water treatment system.

The system is topped up via a level probe installed in the storage tank.

In order to separate the entrained liquid drops contained in the flue gas stream, a demister is installed in the upper part of the tower.

If the flue gas temperature exceeds the permissible limit temperature at the inlet of the free space scrubber, the emergency spraying in the water inlet socket turns on. At the same time the system has to be changed to the by pass operation, or the fan has to be turned off so that the scrubber is protected against excess temperature.

b. Drains

Care and attention is given to the capacity within the station to capture drainage and spillage from all sources.

The modular construction of the equipment ensures that collection trays are a standard feature throughout the station and that there is provision for draining the trays to a central collecting tank within the station.

Collecting tanks are sized to be able to cater for the largest foreseen spillage and ample reserve margin for pumping the waste away from the station is accounted for.

Fuel and lubricating oil tanks are bunded to contain fuels / oils from spillage or rupture.

Water from the various services must be disposed of through the appropriate external drains systems in line with local authority requirements.

c. Fuel and lubricating oils

Waste fuel and lubricating oil, a result of the power station operation process is the most difficult area of disposal.

In general this waste is incinerated or disposed of through waste collection agencies.

The process in preparing fuels for use involves centrifuging to remove solids and water. The centrifuges are cleaned regularly by flushing with water, amounting in large quantities of sludge and oily water. Oily water is also collected from the draining of settling and service tanks.

This large volume of waste can be reduced significantly by the use of sludge treatment plants.

Heavy fuel oils can contain up to 2% sludge.

Approximately 28% of this is recoverable fuel oil. By sludge treatment, useable fuel can be recovered and returned to the bulk storage tanks for use. Solids can be heated and dried for transport by waste disposal experts.
The water centrifuged off can be further centrifuged to bring the contamination to levels well within the International Maritime Organisation limits and is suitable for discharge to storm water drain.

These sludge treatment systems are available as options within the standard power station build.

d. Noise.

The control of noise is important not only for the protection of operating personnel but also to the station surrounds.

In large power stations, the silencing of equipment within the station is impracticable
And therefore hearing protection is normally worn when around the equipment, with acoustic treated rooms for the protection of operating personnel ie central control room.

External to the building, exhaust gas silencers and air intake silencers are used to control the prime mover noise levels. Noise levels at the premises boundary are normally set by local authorities and this needs careful consideration to ensure that these levels can be met as the silencing of radiators etc. can be expensive.

Arun International

For Reliable Power

SECTION TWELVE

ENQUIRY QUESTIONNAIRE

Arun International

For Reliable Power

ENQUIRY QUESTIONNAIRE

To assist in being able to provide you with a power solution to satisfy your needs kindly fill in this questionnaire and return to your local agent or to us at

Arun International (Power)Ltd
Gerrard House
Worthing Road
East Preston
West Sussex
BN16 1AW
England.

Company Name

Address ....
....
....
....
....

Telephone No. ....

Fax No. ....

E-mail ....

Contact Name and Position ....

Project Name ....

Location ....

Maximum ambient temperature ....
Altitude ....
Humidity ....

Exportable power required ....

Duty ie feeding grid, base load for plant, combination etc. ....

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Output voltage required ....

Are there any large motors ie ball mills? ....

Type of fuel. Give fuel analysis if available ....

What is envisaged storage requirement of fuel one wk / one month? ....

Is heat recovery for process required? ....

Is water for cooling readily available? ....

Is there an existing building or green field? ....

Is finance available? ....

When is station required to be in operation? ....

<u>General Comments</u>

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