Appendix E
Florida Department of Environmental Protection
Air Quality Permit Application

Attachment I-4

Operation and Maintenance Plan

MISSION™ D-type Boiler

1 Description

The MISSION™ D-type is a vertical two-drum boiler, insulated with boiler mountings for easy operation.
The boiler is top-fired and equipped with a dual fuel burner. Like the burner, the local control panel and all relevant boiler mountings are mounted on top of the boiler. The boiler is easily operated and monitored from the burner platform.

The control system supplied with the MISSION™ D-type boiler unit provides fully automatic operation of the boiler and the dual fuel burner.

1.1 Boiler Gas Firing

The use of gas, as a fuel, requires operating a gas-fired burner in the enclosed space of the SRS's boiler room to be provided with an array of safety features. If gas should leak from pipework or equipment and accumulate, it could be ignited. Prevention of gas leaks is overcome by using:

- specially designed fully welded and double walled or enclosed gas piping;
- continuous, automatic monitoring of the piping for possible leaks;
- creation of air purged containment areas (valve hoods) within the boiler room for the gas valves and instrumentation;
- continuous, automatic monitoring of the valve hoods and the purged air;
- custom designed dual fuel (oil and gas) burners;
- self diagnosing, safety rated PLCs (process logic controllers), to control and supervise the burner management, including automatic safety shut down

All gas pipework uses concentric double walled pipe with the outer jacket sealed and is pressurized with nitrogen at a higher pressure than the maximum working pressure of the fuel gas. Sensors monitor the nitrogen pressure, and if it falls below a pre-determined trip level, the boilers are shutdown and gas is prevented from entering the pipework in the machinery spaces.

The burner management system is interfaced to the operator's boiler control panel, which allows each boiler and its burner to be placed into service from the central control room. Operation is divided into distinct sections, including combustion space purge, pre-fire, burner starting, shutdown, boiler trip and alarming. Dual process controllers control boiler feedwater, fuel gas, and air to deliver the required steam at various loads, maintain steam pressure, and ensure clean efficient combustion.

1.2 Boiler Pressure Part

The principal drawing of the MISSION™ D-type boiler is shown in Figure 1

The steam drum is furnished with branch connections and necessary internal fittings ensuring an even distribution of feed water and circulation water from a possible exhaust boiler. Furthermore, a steam separator is installed to ensure a sufficient dryness of steam.

Manholes are conveniently arranged in both steam and water drums and, inside the drums, enough space is available for inspection and maintenance.

The design of the water drum is similar to that of the steam drum. The drum size gives optimal space for the heating coil and easy access for inspection.

The boiler foundation is provided with four supports, i.e. one fixed foot and three foots which provide the possibility of thermal expansion. Counter plates are provided for welding to deck.

Both the furnace and the generating tube bank are located asymmetrically and are separated by the screen wall. Besides the screen wall, the furnace consists of gas-tight membrane walls. The furnace roof, side and floor panel walls are formed from one all-welded membrane wall forming a "D". The furnace front and rear panel walls are welded into the top and bottom headers, which again are welded to the drums.

The generating tube bank consists of vertical pin tubes arranged in a staggered configuration. The tubes are expanded into the drum shells. To avoid the risk of vibration problems, supports are arranged in the middle of the pin element section.

The flue gas passes through the deflected tubes at the bottom of the screen wall, up through the generating tube bank and out through the smoke outlet box.

An effective water circulation in the boiler is achieved, by means of down comers.

The bottom of the furnace is covered with a minimum of refractory.

Access to the furnace is possible through the access door at the bottom of the furnace. Inspection of the generating tubes is possible through the access door provided on the flue gas outlet box. Further inspection of the generating tubes is possible through the inspection door placed in the middle of the pin element section.

The boiler is provided with buck stay in order to avoid the risk of the membrane walls bulging/bursting during operation.

Inspection of the burner flame is possible through the two inspection holes arranged at two different levels on the furnace panel wall.

Principal drawing of MISSION™ D-type boiler

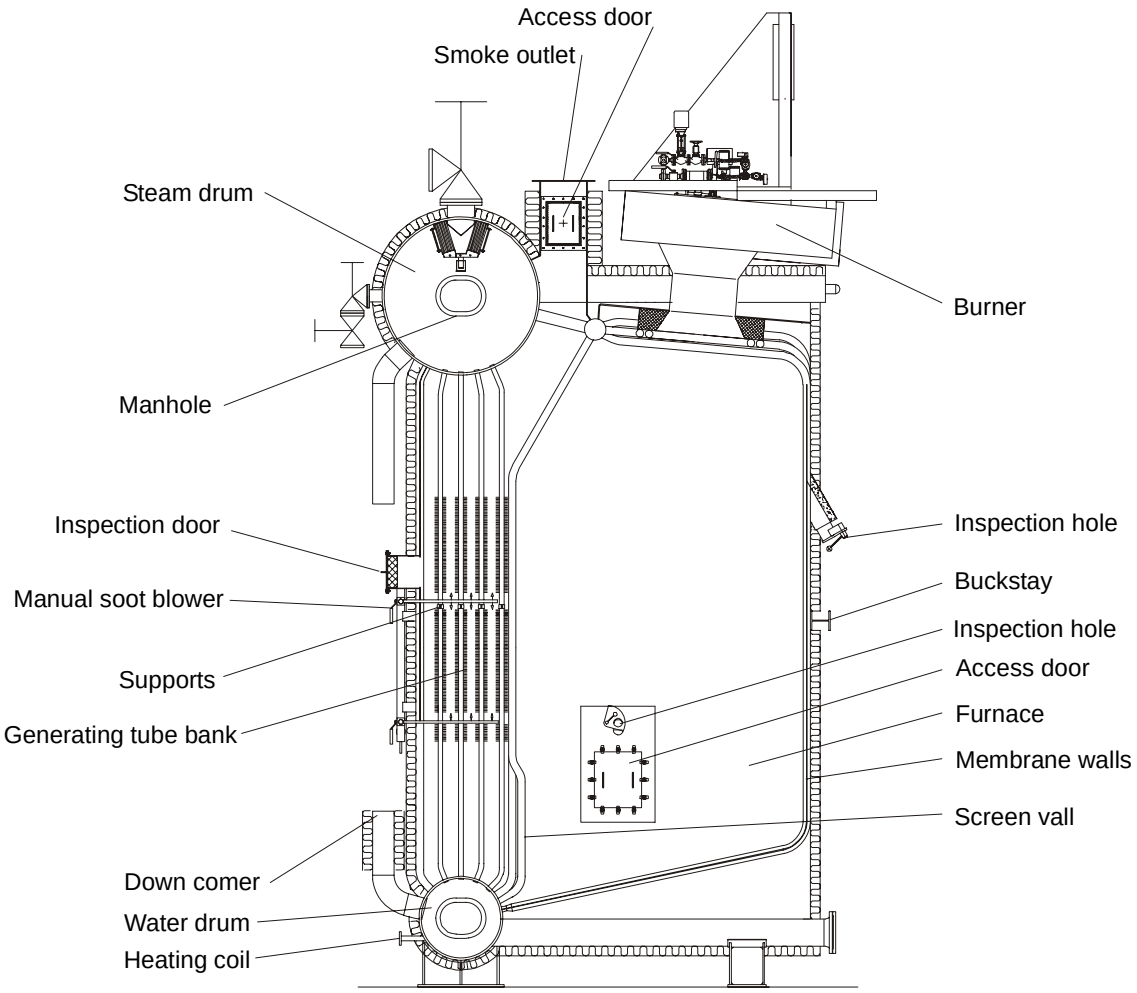

Figure 1

2 Boiler maintenance

The boiler maintenance should always be executed with skill and in accordance with valid rules and regulations from the authorities, and below are given some recommendations for periodical inspections and maintenance.

2.1 Daily operation

During normal operation of the boiler some work and check procedures have to be considered every day.

Check the boiler steam pressure and the water level.

Check that the feed water control system is operational, see separate instructions.

Check the boiler water condition and make necessary countermeasures with regard to the feed and boiler water treatment. If necessary blow-down the boiler.

Check the function of the oil burner at different capacities through the inspection holes on the boiler.

Check the flue gas temperature after and/or the draft loss across the boiler. If either the temperature or the draft loss is too high, the pin-tube section must be cleaned.

2.2 Weekly routine checks

Drain each water level glass for about 10-15 seconds.

In case of contaminated boiler water or insufficient water treatment, the draining of the water level glasses must be done more often.

Check the safety water level device.

Depending on the boiler water tests blown-down the boiler. Open the blow-down valves quickly for a few seconds, and then close and open again for about 5-10 seconds.

Repeat this operation when required according to the boiler water tests.

Perform scum blow out by means of the scum valve when required. The scum blow out must be carried out until the drained water is clean.

2.3 Monthly routine checks

Test all stand-by pumps.

Check all boiler mountings for damage or leaks and repair/replace if necessary.

Check the function of the high steam pressure switch by lowering the set point or by raising the steam pressure, e.g. by closing the main steam valve slowly.

The burner must stop automatically.

3 Inspection of the boiler

3.1 Inspection of furnace

The furnace should be inspected at least twice a year. During this inspection the following issues should be taken into consideration:
Check for cracks at the refractory lining and that the furnace walls are free from excessive soot deposits.
Examine carefully the area opposite the burner. Too much soot deposits indicate that the burner should be adjusted.

Check that the pin-tube elements are intact and that soot deposits are within normal limits.

3.2 Inspection of boiler water side

The boiler water side (interior) must be carefully inspected at least twice a year. This inspection is of great importance and no doubt the most important of all the maintenance measures, since it has a direct influence on the boiler longevity and on the security.

At these inspections, hard deposits, corrosion and circulation disturbances can be found at an early stage, and preventive measures must be taken to avoid unexpected material damage and boiler breakdown.

Presence of hard deposits at the furnace wall and the pin-tubes reduces their heat transfer properties and decrease the capacity of the boiler.

Further, it is possible to make out if the feed water treatment has been satisfactory and if the blow-down has been carried out sufficiently.

Incorrect feed water treatment is commonly causing hard deposits or corrosion

Insufficient blow-down will cause sludge deposits in the tubes and accumulation of sludge in the bottom of the boiler.

If hard deposits are not removed, it may lead to overheating in the boiler plate material which is exposed to the flame in the furnace wall area. This may cause material damages.

Incorrect feed water treatment does not always lead to hard deposits. For example, a too low or too high a pH-value may give an electrolytic reaction, causing corrosion in the boiler.

When the boiler interior is inspected, examine all parts carefully and be attentive to deposits, corrosion and cracks. It is advisable to pay special attention to this inspection. If any unusual signs are found, contact the manufacturer at once for advice.

3.3 Procedure and remarks for inspection

Shut off the boiler and allow it to cool (below 100°C).

Note: The boiler should NOT be depressurised by lifting the safety valves and then filled with cold feed water since the stress induced by too rapid cooling may cause damage.

Empty the boiler and close all valves.

If the boiler is connected to a second boiler, check that the valves between them are closed.

Unscrew and remove the manhole hatch(s) on the boiler and enter the boiler when it is sufficiently cold.

Check the welding in the boiler. A careful examination should be carried out with respect to any possible corrosion or crack formation.

Special care should be taken to the water line area in the pressure vessel where oxygen pitting may occur.

If deposits are found to be forming in the boiler tubes, the boiler should be chemically cleaned.

It is advisable to consult a company of cleaning specialists who will examine the boiler deposits and treat the boiler accordingly.

Note: After chemical treatment the boiler should be blown-down at least twice a day for approximately one week. This will ensure that excessive sludge deposits due to chemical treatment do not collect in the bottom of pressure vessel.

3.4 Contamination

If the boiler is contaminated with foreign substances like oil, chemicals, corrosion products etc., it is very important to act immediately to avoid damages to the boiler.
Layers of thin oil films, mud, etc. exposed to the heating surfaces causes a bad heat transfer in the boiler, leading to overheating followed by burned out pressure parts. In order to remove such contamination, a boiling out or acid cleaning have to be performed immediately.

Note: Corrosion products from the pipe system or insufficient boiler water treatment may result in corrosion in the boiler itself. It is therefore important to observe that such circumstances do not occur in the system.

4 Feed and boiler water

4.1 General

There is a number of ways to produce good quality feed water for boiler plants. Methods such as e.g. reverse osmosis plants or ion exchange plants produce good quality distillate. Also evaporators generally produce good distillate. The important thing is that the distillate used should be clean and without foreign salt contamination.

In practice most distillates used contain minor parts of various salt combinations which can and must be chemically treated away. Furthermore, the distillate may contain dissolved gases like for example oxygen (O2) and carbon dioxide (CO2) which may lead to corrosion in the boiler, steam, and condensate system.

Important: Boiler and feed water must be chemically treated in order to avoid corrosion and scaling in the boiler.

4.2 Layout of the treatment system

The condition of the feed and boiler water is an essential part of the boiler operation and operation philosophy. The design and construction of the treatment system should therefore be considered carefully during layout of the plant. Some general requirements and recommendations regarding the conditions of the feed and boiler water are given here. However, there are several ways to obtain this results, or similar, by using different treatment systems. The following should therefore be considered already at the layout stage:

- Choose the treatment system that should be used.
- Present the condensate and feed water system to the supplier of the treatment system and inform about the operation philosophy of the plant.
- Let the supplier indicate where the injection points should be located and also inform if special equipment is required.
- Let the supplier inform about which test facilities is needed.
- Purchase the recommended equipment and install it in the correct way.
- Use the treatment system as soon as the boiler is taken into operation.

4.3 Feed and boiler water characteristics

The following text regarding feed and boiler water treatment is the normal recommendations. These recommendations should be followed strictly in order to have the best working conditions for the boiler plant and to extend the working life of the plant. The requirements/recommendations of the various values for feed and boiler water are listed in Table 1 below.

Requirements for feed and boiler water			
	Unit	**Feed water**	**Boiler water**
Appearance	-	Clear and free of mud	Clear and free of mud
Hardness	ppm $CaCO_3$	Not detectable	-
Chloride content	ppm Cl^-	<15	<100
"P" alkalinity	ppm $CaCO_3$	-	25 - 50
Total (T) alkalinity	ppm $CaCO_3$	-	<2 x "P" - Alkalinity
PH-value at 25°C	-	8.5 - 9.5	10.5 - 11.5
Iron, cupper, and nickle	ppm	<0.03	-
Hydrazine excess	ppm N_2H_4	-	0.1 - 0.2
Phosphate excess	ppm PO_4	-	20 - 40
Specific density at 20°C	kg/m^3	-	<1.003
Conductivity at 25°C	µS/cm	-	<2000
Oil content	-	NIL	NIL

Table 1

If hydrazine (N_2H_4) is not used, sodium sulphate (Na_2SO_4) can be used instead, and the excess should be 30 - 60 ppm.

In cases where other kinds of oxygen binding agents are used, it is recommended that an excess of oxygen binding agents can be measured and indicates that no oxygen has been dissolved in the boiler water.

If it is requested to measure the content of dissolved oxygen directly, it is recommended to keep the value < 0.01 ppm.

In addition to the above values, the various water treatment companies will add further demands, depending on the method used for treatment of feed and boiler water.

However, the most important point is that the above values or their equivalents are observed and that a regular (daily) test of feed and boiler water is carried out.

4.4 Units of measurement

Concentrations are usually expressed in "ppm" i.e. parts solute per million. Concentrations for parts solution by weight are the same as "mg/litre".

4.4.1 Specific gravity

As guidance the following conversion can be used:

- 1 Be° = 10.000 mg/l total dissolved solids (TDS)
- 1 mg/l total dissolved solids = 2 µS/cm
- 1 µS/cm = 1 µmho

5 Feed and boiler water maintenance

The following are recommended water maintenance instructions. More exact details concerning analyses and blow downs should be set up together with the supplier of chemicals for water treatment.

5.1.1 Daily

Step A: Analyses of feed and boiler water.

5.1.2 Weekly

Step A: Skimming (surface blow down) according to analyses, but at least once per week (2 minutes with fully open valve).

Step B: Blow down (bottom blow down) according to analyses, but at least once per week (each blow down valve 1 minute in low load condition).

5.1.3 Monthly

Step A: Check the functions for salinity and oil detection systems.

5.1.4 Every six months

Step A: The boiler water side (interior) must be carefully inspected at least twice a year.

5.1.5 Yearly

Step A: Check of the water side of the boiler and hotwell/deaerator for corrosion and scaling.

Step B: Check the chemical pump unit.

6 Lighting-up curve

Figure 2 shows the lighting-up curve for the MISSION™ D-type boiler. When the burner is started the firing capacity must be adjusted to match the lighting-up curve. Further start/stop instructions are described in the chapter “Start/stop of the boiler”.

Lighting-up curve for the MISSION™ D-type boiler

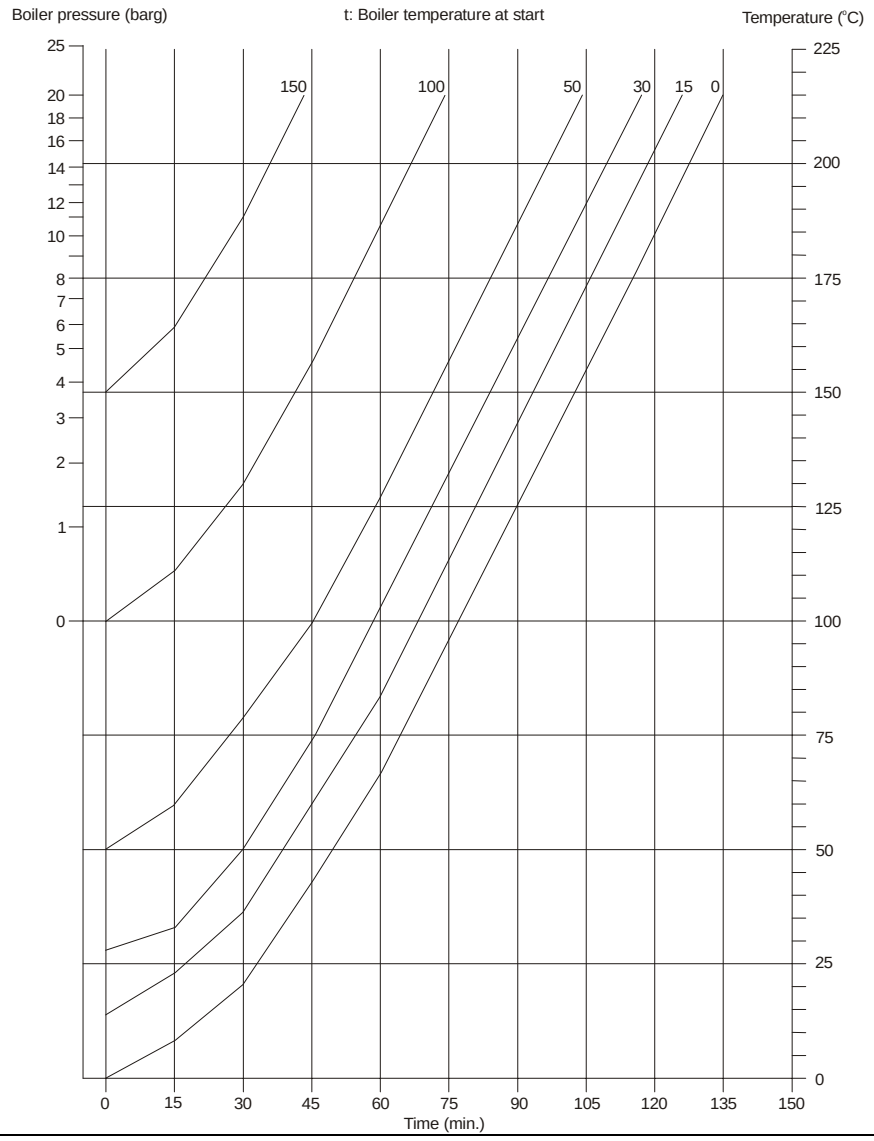

Figure 2 **startcur2.cdr**

7 Start/stop of the boiler

7.1 Start-up

When the boiler is started, the lighten-up rate of the boiler must not be accelerated too much as this might cause an unnecessary overstrain of the boiler material by quick and uneven temperature rises. It might be necessary to perform a number of start/stop sequences to reduce the lighten-up rate.

Attention: At the commissioning start-up of the boiler and after any repair work of the refractory, it is very important to further reduce the lighting-up rate. This is because the new refractory still contains a small amount of water. When heated the water vaporises and expands which might cause fissures and cracks in the refractory. The burner must therefore only be operated at minimum load and in intervals of 1-2 minutes for the first hours. Between each operation interval the burner should remain stopped for approximately 8-10 minutes.

Before start-up of the boiler plant, some general work and check procedures must be considered.

Step A: Check that the main steam valve, by-pass valve and circulation valves if provided scum valve, and blow-down valves are closed.

Step B: Open the feed water valves and the air valve. Fill the boiler with feed water to approximately 50 mm below normal water level. The water level rises due to expansion when the boiler is heated. If the temperature difference between the boiler and feed water exceeds approximately 50ºC, the boiler must be filled very slowly.

Note: When filling a pressure less boiler, the shut-off valve after the feed water pump must be throttled. Otherwise the pump motor will be overloaded.

Step C: Check the water level in the water level gauges. Check frequently during the complete start-up. The water level gauges should be blown down several times to ensure a correct indication.

Step D: Check that the water level control system is connected and operational.

Step E: Check the oil system and start the fuel oil supply pump. Pre-heat the fuel oil if the burner should operate on heavy fuel oil.

Step F: Check the burner and the safety functions according to the separate instruction.

7.2 Start and pressure rise

The following work procedures must be followed during start-up of the boiler.

Step A: Check that the gauge board valve and pressure gauge valves are opened.

Step B: Check that the air valve is open if the boiler pressure is below 1.0 barg.

Step C: Start the burner on manual control and on low load. Check that the water level does not rise too high during the pressure rising period.

Step D: Drain via the blow down valves if the water level is too high.

Step E: If the air valve was opened close it when only steam blows out. A pressure reading should be indicated on the boiler pressure gauge before the air valve is closed.

Step F: Tighten all covers such as manholes, hand holes, inspection doors, etc. during the pressure rising period. If required, check all flange joints on the plant.

Step G: Change to automatic control of the burner when the boiler pressure is 0.5 barg lower than the working pressure of the boiler.

Step H: Open the by-pass valve slowly to heat-up and pressurise the steam system. If the boiler is not provided with a by-pass valve, the main steam valve should be used to heat-up and pressurise the steam system.

Step I: Open the main steam valve and close the by-pass valve.

Step J: Open the valves to the steam consumers carefully in order to avoid water chocks.

Step K: When the boiler is in normal operation, check that the water level control system and the gauge board functions are fully operational.

Note: After 3-4 weeks in operation, mud and deposits in the piping system may have accumulated in the boiler water. This may cause level variations which disturb the steam generation, and it is therefore recommended to blow down the boiler. It should then be inspected, cleaned, and refilled with boiler water.

7.3 Normal boiler shut down

If necessary, the boiler can be shut down at any load without special preparations.

Note: When the boiler is stopped, sudden temperature and pressure drops should be avoided as they might expose mountings, pipe lines, and the boiler plant to inadmissible temperature gradients.

Step A: When minimum load is obtained, stop the burner.

Step B: Keep the water level at normal level until the boiler stops producing steam.

Step C: Stop the feed water pump and close the feed water valves.

Step D: Close the main steam valve.

7.4 Emergency shut down

The boiler must be taken out of service immediately if:

- parts of the heating surface have been glowing or the boiler shows recognisable deformations. The supervising authorities must be informed, and the boiler must not be used until approval from these authorities is available
- a substantial loss of water is noted
- the feed water system is unable to provide the necessary amount of feed water, e.g. due to failure of parts
- the safety valve cannot function
- sudden cracks or damage are noted in the refractory, and if steam or moisture is coming out of the refractory
- oil in the feed water is detected
- too high salinity level is detected

If an emergency shut down must be carried out, the fuel supply should be stopped. The main steam valve should be closed gradually, and the boiler must be cooled. The safety valves must not be operated. Parallel working boilers should be disconnected at once.

7.5 Stop for repair or inspection

The following describes the measures to be taken when the boiler is shut down for repair or inspection.

Step A: Clean the boiler of soot by water washing.

Step B: Operate the burner for at least 15 minutes after the soot removal to dry out the remaining water.

Step C: Stop the boiler as mentioned previously.

Step D: Check the furnace and the pin tubes with regard to cleanliness.

Step E: Empty the boiler from water and clean it. Check if lime stone appears.

Step F: Check and clean the outer fittings. Change gaskets where required.

Step G: Clean the feed water tank and feed water pipes.

Step H: Clean and grease the bearings of motor, pump, and fan.

Step I: Check and align the burner, if necessary.

Step J: If the boiler is shut down for a long period of time, the pin tubes must be thoroughly cleaned.

Step K: Check that the necessary spare parts are available. Order complementary parts in time.

Warning: It is of extreme importance that the boiler is NOT operated without water when the oil burner is in operation, e.g. due to disconnection of the water level safety devices. This will immediately cause complete break down of the boiler.

04. Maintenance Schedule

04.1 General

The actual operating conditions, and above all the quality of the fuel used, will largely determine the maintenance necessary for the engine. Because of the difficulty in anticipating the various operating conditions that may be encountered in the field, the periods stated in the schedule should be used for guidance purposes only, but must not be exceeded during the warranty period. Where any indications are encountered that the performance of a maintenance procedure is required in advance of the recommended time period, prudent industry practice dictates that the suggested maintenance procedure be performed. Additionally, where inspection or observation reveals that a part shows wear or use beyond the prescribed tolerances, that part should be renewed immediately.

See also the instruction books of the turbocharger separate instructions for additional equipment and chapter 03.

1 **Before any steps are taken,** carefully read the corresponding item in this Manual.

2 **Note the Risk Reduction** in chapter 00A.

3 **Note the Environmental Hazards** in chapter 02A.

4 **At all maintenance work,** observe the utmost cleanliness and order.

5 **Before dismantling,** check that all systems concerned are **drained or the pressure released**. After dismantling, immediately cover holes for lubricating oil, gas and air with tape, plugs, clean cloth or the like.

6 **When exchanging a worn-out or damaged part** provided with an identification mark stating cylinder or bearing number, mark the new part with the same number on the same spot. Every exchange should be entered in the engine log and the reason should be clearly stated.

7 **Always renew all gaskets, sealing rings and O-rings** at maintenance work. **Note!** The O-rings in the cooling water system must not be lubricated with oil based lubricants, use soap or similar.

8 **After reassembling,** check that all screws and nuts are tightened and locked, if necessary.

Caution! When overhauling the engine, make absolutely sure that the automatic start and the priming pump are disconnected. Make also sure that the starting air shut-off valve located before main starting valve is closed. Then drain the engine starting air system to avoid engine damage and/or personal injury.

Caution! When overhauling the engine, make absolutely sure that the generator breaker is secured/gear box is not engaged to avoid accidental turning of engine.

Caution! Accidental turning of engine may cause engine damage and/or personal injjury.

04.2	Dayly routine inspections	
Control mechanism	**Inspect for free movement**	22.
Gas system	**Inspect the gas system for leakage** Inspect the gas system for leakage by using a hand held gas detector.	17.
Oil mist detector (if installled)	**Observe normal operation**	
Pneumatic system	**Drain condensated water**	21.5

04.3	Every second day, irrespective of the engine being in operation or not	
Automatic prelubrication	**Check operation**	03.1
Crankshaft	**Marine engine:** In a stopped engine, turn crankshaft into a new position	03.

04.4	Once a week irrespective of the engine being in operation or not	
Start process	**Test start (if the engine on stand-by).**	03.1

04.5	Interval: 50 operating hours	
Air coolers	**Check draining of air coolers** Check that the draining pipes are open, check if any leakage.	15.6 03.6.2
Automation	**Check operating values** Check and record all operating values.	03.6.2
Cooling water system	**Check water level in cooling system** Check the water level in the expansion tank(s) and/or the static pressure in the engine cooling circuits. Inspect that the ventilation (de-aerating) of the expansion tank is working.	19.
Gas, fuel and lub. oil filters	**Check pressure drop indicators** Replace filter cartridges if high pressure drop is indicated.	17.2 18.2
Governor, actuator	**Check oil level in governor** Check oil level, and look for leaks	02.2.5 22.2
Turbocharger	**Water cleaning of compressor** Clean the compressor by injecting water.	15.4
Valve mechanism	**Check valve clearances** Check the valve clearances after 50 hours' running in new and overhauled engines.	12.2.5 06.1

04.6	Interval: 100 operating hours	
Turbocharger (Diesel mode)	**Water cleaning of turbine if the engine is using HFO fuel** Clean the turbine by injecting water; more often if necessary.	15.3

04.7	Interval: 500 operating hours	
Centrifugal filter	**Clean centrifugal filter(s)** Clean more often if necessary. Remember to open the valve before the filter after cleaning.	18.3
Charge air cooler	**Measure the pressure drop over charge air cooler(s)**	15.6
Cooling water	**Check water quality** Check content of additives.	19.1 02.3
Control mechanism	**Maintenance of control mechanism** Check for free movement, clean and lubricate.	22.
Injection and fuel system	**Check clean leak fuel quantity in diesel mode** Check the amount of clean leak fuel from the injection pumps and nozzles running in diesel mode and pilot injection temporary switched off.	03.6.2 17.
Lubricating oil	**Take oil sample** In a new installation or after change to use of a new lubricating oil brand, take samples for analyzing.	02.2.4
Oil mist detector (if installed)	**Inspect function** See manufacturers instruction.	
Turbocharger (Diesel mode)	**Water cleaning of turbine if the engine is using MDO fuel** Clean the turbine by injecting water; more often if necessary.	15.3
Wastegate valve	**Function inspection**	15.M
By-pass valve (if installed)	**Function inspection**	15.

04.8	Interval: 1000 operating hours	
Air filter (on-built)	**Clean turbocharger air filter(s)** Remove the filter(s) and clean according to instructions of the manufacturer (more often, if necessary).	15.
Electrical fuel feed pump	**Regrease el. fuel feed pump** Regrease the pump under running condition.	17.
El. lubricating oil pump	**Regrease prelubricating pump** Regrease the pump under running condition.	18.
Engine fastening bolts	**Inspect tightening** Inspection to be done on new installations.	
Fuel filter	**Clean and inspect fuel oil filter** Clean the wire gauze and filter housing. The filter is to be cleaned earlier if the pressure difference indicator shows too high pressure drop.	17.6
Fuel system	**Replace pilot fuel oil filter cartridges** Clean the wire gauze and filter housing. Replace the filter cartridges. (The cartridges are to be replaced earlier if the pressure difference indicator shows too high pressure drop).	17.9
Gas filter Engine mounted	**Clean gas filter cartridges** The engine mounted filter cartridge can be cleaned by pressurized air from inside, replace cartridge if necessary. Clean the filter housing outside and inside. The cartridge is to be replaced earlier if the pressure difference indicator shows too high pressure drop. Following intervals for the filter 4000 hours.	17.1 17.2
Gas filter On gas regulating unit	**Replace gas filter cartridges** Gas regulating unit, replace the filter cartridge. Clean the filter housing outside and inside. Following intervals for the filter 4000 hours or when the pressure difference indicator shows pressure drop ≥0,5 bar.	17.1 17.2

04.9	Interval: 2000 operating hours	
Air cooler(s)	**Check water side of charge air cooler(s)** The first time check and possible cleaning of the **waterside.** If in good condition and deposits insignificant: future intervals 4000 running hours.	15.6
Automation	**Functional check of safety system** Check function of the sensors for the alarm system and automatic stop devices.	23.7 01.2
Control mechanism	**Check control mechanism** Check for wear in all connecting links between the governor and all injection pumps. Inspect that the fuel rack moves easily and the fuel pumps follow.	22.
El.-pneu. overspeed trip device	**Check el.-pneumatic overspeed trip device** Note that the electrical overspeed trip takes place first. Check function and tripping speed.	22. 06.1
Gas system	**Maintenance of gas system** Make the leak test.	 17.2
Governor	**Change oil in governor** Change lubricating oil.	02.2.5 22.2
Lubricating oil filter	**Clean and inspect lubricating oil filter** Drain the filter housings. Clean the wire gauze and filter housing. The filter is to be cleaned earlier if the pressure difference indicator shows too high pressure drop.	18.
Oil mist detector (if installed)	**Replace fresh air filter** See manufacturers instruction.	
Valves	**Check yoke and valve clearances.** Check yoke and valve clearances.	12.4 06.1
Valve rotators	**Visual inspection of valve rotators** Check valve rotators.	12.4 06.1

04.10	Interval: 3000 operating hours	
Injection valves	**Inspect fuel injectors** Test fuel injectors if engine operated in diesel mode.	16.6

04.11	Interval: 4000 operating hours	
Air cooler(s)	**Clean the charge air cooler(s)** Clean and pressure test. Look carefully for corrosion. Cleaning interval is based on the cooling performance of the cooler. Measure the pressure difference over the charge air cooler before and after cleaning. Use U-gauge.	15.6
Automation	**Check connectors and cables** Check mounting and connections. Apply contact lubricant to contact surfaces. Check tightness of connections. Check condition of cables, wires and cable glands. Replace damaged connectors and cables.	23.10
Camshaft	**Inspect contact faces of camshaft** Check the contact faces of the cams and tappet rollers. Check that the rollers rotate. Rotate the engine with the turning gear.	14.1.3 03.1
Crankshaft	**Check crankshaft alignment** Check alignment, use form No. 4611V005. Alignment check is performed on a warm engine. If mounted on rubber not necessary to perform.	11.1.3
Flexible coupling Vulkan-Rato-S/R	**Inspect flexible coupling** Make a visual inspection of the flexible coupling. See manufacturers instructions.	
Flexible coupling	**Check alignment of flexible coupling** Check alignment of flexible coupling. use form WV98V041.	
Flexible mounting (if used)	**Check the alignment** Check compression of the thrust rubber elements. Inspection according to maintenance instructions for resilient installation. See technical documents.	
Gas filter	**Replace gas filter cartridges** Replace the filter cartridge. (The cartridge is to be replaced earlier if the pressure difference indicator shows too high pressure drop.) Clean the filter housing outside and inside.	17.1 17.2
Gas filter On gas regulating unit	**Replace gas filter cartridges** Gas regulating unit, replace the filter cartridge. (The cartridge is to be replaced earlier if the pressure difference indicator shows too high pressure drop ≥0,5 bar.) Clean the filter housing outside and inside.	17.1 17.2
Wastegate	**Check the wastegate valve and actuator** Change the positioner pilot valve.	15.M.

04.12	Interval: 6000 operating hours	
Flexible pipe connections	**Inspect flexible pipe connections** Renew if necessary.	
Exhaust manifold	**Inspect expansion bellows** Replace parts if necessary. Inspect supports of the exhaust system.	20.
Injection valves	**Inspect injection valves** Replace the nozzle with new ones. Renew the O-rings. Adjust the main needle opening pressure in a test pump. Renew the complete injection valve if necessary.	16.6
Mechanical overspeed trip device	**Check function of the mechanical overspeed trip device** Note that the electrical overspeed trip takes place first. Check function and tripping speed.	22. 06.

04.13	Interval: 8000 operating hours	
Fuel system	**Check and adjustment of fuel system** Check the adjustment of the pressure control valve.	17.7

04.14	Interval: 12000 operating hours	
Air filter (in pneumatic systems)	**Clean the filter** Clean the cartridge, replace if necessary. Clean the filter housing outside and inside.	21.
Injection pumps	**Overhaul of injection pumps** Clean and inspect injection pumps, replace worn parts. Replace the erosion plugs.	16.3
Flexible pipe connections	**Renew flexible pipe connections** Depending on the condition of the connection and the target of usage these can be used even longer.	
Oil mist detector (if installed)	**Replace oil mist detector supply air filter** See manufacturers instructions.	
Turbocharger(s)	**Dismount and clean** Inspect and assess the shaft and the bearing parts. Clean turbine and compressor casings and check for any cracks and erosion/corrosion. Clean nozzle ring and check for any cracks and erosion. Measure and note the axial clearance. If the clearance is out of tolerance, contact the engine manufacturer. See manufacturers instructions.	15.2
Turbocharger(s) ABB TPL-chargers	**Inspect turbocharger bearings** Inspect and replace the bearings if necessary. **Replace the bearings by new ones on 36000h at the latest.** See manufacturers instructions.	15.2
Turning device	**Grease the secondary shaft of the turning device**	03.1.2
Wastegate	**General overhaul of wastegate valve and actuator** Change the positioner pilot valve.	15.M.

04.15	Interval: 16000 operating hours	
Fuel feed pump	**General overhaul of fuel feed pump** Inspect pump and replace gaskets. Replace worn parts.	17.8

04.16	Interval: 18000 operating hours	
Air coolers	**Clean the charge air cooler(s)** More often if necessary. Cleaning interval is based on the cooling performance of the cooler.	15.6
Camshaft driving gear	**Inspect intermediate gears** Inspect teeth surfaces and running pattern. Replace parts if necessary.	13.2 06.2
Connecting rods	**Inspect big end bearing, one/bank** Dismantle the big end bearing. Inspect mating surfaces. If defect found, open all big end bearings. Renew bearing shells, if necessary. Measurement records 4611V008 and 4611V003.	11.2 06.2
Connecting rods	**Check small end bearing and piston pin, one/bank** If defects found, open all and renew if needed. Measurement record 4611V004.	11.2 06.2
Crankshaft	**Inspect main bearings** Inspect one main bearing. If in bad condition, check/change all main bearings. Note the type of bearing in use and do the inspection accordingly.	10.2 06.2
Crankshaft	**Check thrust bearing clearance** Check axial clearance.	11.1.4 06.2
Cylinder heads	**Overhaul of cylinder head** Dismantle and clean the under side, inlet and exhaust valves and ports. Inspect cooling spaces and clean, if the deposits are thicker than 1 mm. If cylinder head cooling waters paces are dirty, check also the cooling water spaces in liners and engine block and clean them all, if the deposits are thicker than 1mm. Improve the cooling water treatment. Grind all seats. Grind the valves. Inspect the valve rotators. Check rocker arms. Replace the O-rings in the valve guides. Replace the O-rings at bottom of cylinder head screws at every overhaul. Replace the knocking sensors by new ones. Check the starting valves. Renew parts if necessary.	12.2 12.5 14.1.3
Cylinder liners	**Inspect the cylinder liners** Measure the bore using form No. 5010V001, replace liner if wear limits are exceeded. **Hone the liners**. Check the deposits from cooling bores. If the deposits are thicker than 1mm, clean. **Renew the anti-polishing ring.**	10.5.1 06.2
Engine fastening bolts	**Check tightening of engine fastening bolts**	07.
Gas admission valves Woodward	**Replace the main gas admission valves** In installations where connectors used, replace also the female connector. Gas admission valves can be sent to the engine manufacturer to be reconditioned.	17.4
Gas system	**Maintenance of gas system** Replace sealing's in pipe connections, check sealing faces for wear and corrosion. Make the leak test.	17.2

Continue

Hydraulic jack	**Check function** Replace O-rings in the hydraulic jack if they are leaking when lifting the main bearing cap.	10.2
Injection valves	**Renew complete fuel injection valves** Nozzle holders can be sent to the engine manufacturer for reconditioning.	16.6
Pistons	**Check the cooling gallery deposit, one piston/bank** If the deposition exceeds 0.3 mm, open all piston tops. Inspect the piston skirt, clean lubricating oil nozzles.	11.2
Pistons, piston rings	**Inspect pistons and replace piston rings** Pull, inspect and clean. Check the height of the piston ring grooves, use forms No. 4611V009 and 4611V002. Check the retainer rings of the gudgeon pins. Replace complete set of piston rings. Note the running-in programme.	11.2 06.2 03.8
Turning device	**Change lubricating oil in the turning device**	02.2.7
Vibration damper Viscous type	**Take oil sample from vibration damper** Take oil sample for analyzing.	14.2.6

04.17	**Interval: 24000 operating hours**	
Booster servomotor for governor	**General overhaul of the booster servomotor** Replace worn parts. See manufacturers instructions.	22.2
Exhaust manifold	**Renew expansion bellows** Renew the expansion bellows between exhaust pipe sections, after the cylinder head and before the turbocharger.	20.
Flexible coupling (Oil supply from engine)	**Check the flexible coupling** Dismantle and check flexible coupling acc. to manufacturers recommendations.	
Fuel injection pump	**Overhaul of injection pumps** Clean and inspect injection pumps, replace worn parts. Renew fuel injection pump elements. Replace the erosion plugs.	16.3
Governor driving gear	**Inspect governor driving gears** Replace parts if necessary.	22.2.2 06.2
Governor	**General overhaul of the governor** Can be sent to engine manufacturer for overhaul.	
HT-water pump	**Inspect HT-water pump** Dismantle and check. Renew bearings and shaft sealing.	19.2
HT-water pump driving gear	**Inspect HT-water pump driving gear** Replace parts if necessary.	19.2 06.2
HT-water thermostatic valve	**Clean and inspect HT-water thermostatic valve** Clean and check the thermostatic element, valve cone-casing and sealing's.	19.
LT-water pump	**Inspect LT-water pump** Dismantle and check. Renew bearings and shaft sealing.	19.2

Continue

LT-water pump driving gear	**Inspect LT-water pump driving gear** Replace parts if necessary.	19.2 06.2
LT-water thermostatic valve	**Clean and inspect LT-water thermostatic valve** Clean and check the thermostatic element, valve cone-casing, indicator pin and sealing's.	19.
Lube oil pump	**Inspect lubricating oil pump** Renew bearings and shaft sealing.	18.5
Lube oil pump driving gear	**Inspect lubricating oil pump driving gear** Replace parts if necessary.	18.5 06.2
Lube oil thermostatic valve	**Clean and inspect lubricating oil thermostatic valve** Clean and check the thermostatic element, valve cone-casing and sealing's.	18.
Main starting valve	**General overhaul of main starting valve** Renew worn parts.	21.2
Pilot fuel pump	**Replace the pilot fuel pump** Replace the pilot fuel pump.	16.5
Turbocharger(s) ABB TPL-chargers	**Inspect turbocharger parts** Inspect and replace the nozzle ring, turbine diffuser/cover ring if necessary. See manufacturers instructions.	15.2

04.18	Interval: 32000 operating hours	
Turbocharger Napier	**Check rotor balance** Check rotor balance every 32 000 hours or every 4 years. See manufacturers instructions.	15.2

04.19	Interval: 36000 operating hours	
Air cooler	**Renew charge air cooler(s)**	15.6
Camshaft	**Inspect camshaft bearing bush, one/bank** If defects are found, inspect all including driving end and thrust bearing. Renew if necessary. Measurement record 4610V003	10.4.1 06.2
Connecting rods	**Replace big end bearing** Replace big end bearing shells. Inspect mating surfaces. Measure the big end bore, use form No. 4611V008 and 4611V003.	11.2 06.2
Connecting rods	**Replace the small end bearings** Replace the small end bearing shells.	11.2 06.2
Crankshaft	**Renew main bearing shells** Renew main bearing shells, flywheel bearings and thrust bearing halves.	10. 06.2
Crankshaft	**Renew the crankshaft seal** Inspect the crankshaft for wear and renew the chrankshaft seal.	11.1

Continue

Cylinder liners	**Clean cylinder liner cooling water spaces** Clean cylinder liner cooling water spaces and replace the liner O-rings by new ones at every overhaul.	10.5
Cylinder head	**Renew inlet- and exhaust valve seats**	12.3
Cylinder head	**Renew inlet- and exhaust valves**	12.3
Cylinder head	**Renew valve rotators and valve guides**	12.3
Elastic coupling in camshaft driving end	**General overhaul of the elastic coupling** The elastic coupling must only be opened by authorized personnel. Contact the engine manufacturer.	07.
Exhaust manifold	**Renew exhaust pipe support plates**	20.
Fuel injection pump	**Renew fuel injection pump parts** Renew fuel injection pump tappet roller pins, control sleeve and control rack.	16.3
Intermediate gear	**Renew the intermediate gear thrust bearing/bushes** Renew thrust bearing and bearing bushes of intermediate gear.	13.2
Piston	**Inspect the piston cooling gallery, all cylinders** Clean if needed	11.2
Starting air distributor	**General overhaul of starting air distributor** Renew worn parts.	21.3
Valve mechanism	**Check bearing clearances in the tappets and rocker arms, one/cylinder** Dismantle one rocker arm assembly for inspection, proceed with other rocker arm bearings if defects are found. **Renew valve tappet roller bearing bushes.**	12. 14.1 06.
Vibration damper in **camshaft** free end (spring type, optional))	**Dismantle the damper, check condition** The damper must only be opened by authorized personnel. Contact the engine manufacturer.	07. 14.2.6.1
Vibration damper in **crankshaft** free end (spring type, optional)	**Dismantle the damper, check condition** The damper must only be opened by authorized personnel. Contact the engine manufacturer.	07. 11.1.2

04.20	Interval: 48000 operating hours	
Charge air bellow	**Renew expansion bellow(s)** Renew expansion bellow(s) betweenthe turbocharger and air inlet box.	20.
Control mechanism	**Renew parts** Renew: -bearing bushes and thrust washers for control shaft -ball joints between the control shaft and control racks -ball joint for the spring loaded rod	22.
Governor drive	**Renew bearing bushes** Renew bearing bushes for: -governor drive vertical shaft -governor driving gear horizontal shaft	22.
Turbocharger	**Replace rotor and rotating parts** Lifetime dependent of operating conditions. See manufacturers instructions.	15.2
Turbocharger(s) ABB TPL-chargers	**Inspect turbocharger gas-inlet/outlet casings** Inspect and replace the gas-inlet/oulet casings if necessary. See manufacturers instructions.	15.2

04.21	Interval: 72000 operating hours	
Camshaft bearings	**Renew camshaft bearings** Renew camshaft driving end bearing bush and camshaft thrust bearings.	10.4 13.
Cylinder heads	**Renew cylinder heads**	12.2
Fuel system	**Renew fuel system pipes** Renew main injection pipes and pilot injection pipes (optional).	17.
Flexible mounting (if used)	**Renew rubber elements** See technical documents.	
Valve mechanism	**Renew rocker arm bearing bushes**	12. 14.
Piston	**Renew pistons and gudgeon pins**	11.2