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1 PREPARATION FOR STEAMING

- 1.1 If the boiler has been water wedged, close the water supply from the header tank valve SI7 and the header tank supply valve MW27. Open vent valve SI8.
- 1.2 Open the boiler blowdown valve B1 and the diaphragm operated valve B17 and lock open with pin on chain. Open valves B13 and B14 to drain boiler to gulley. When the water level comes down to one third of the gauge glass close all blowdown valves. This operation takes about forty minutes.
- 1.3 If the boiler has not been water wedged and is empty or part full then refill with the boiler feed pump (see section 2) or drain down as necessary.
- 1.4 While the boiler is draining down or filling take the opportunity to check that the engine steam valves S52 and S66 are shut and that the emergency shut down valve is closed. Check that the air valve adjacent to S66 is closed.
- 1.5 Close the blowdown drum drain valve B11. Open the cooling water supply valves MW13 and MW28 and fill the drum until it overflows to drain. Then shut MW28.
- 1.6 Open mains water valve MW10, supply to softener. Check the water main pressure by opening sample valve TW7. If the pressure falls check that the main water supply valve MW9, located on top of the raw water tank in the engine house is open.
- 1.7 Open the treated water pump suction valve TW3 and check that the pump discharge valve TW5 and the treated water tank outlet valve TW2 are open.
- 1.8 Check that the local power supply switches for the softener and treated water pump are on.
- 1.9 Switch the treated water pump to ON on the main panel.
- 1.10 Check that the local power supply switches for the treated water tank and hotwell level controls are on.
- 1.11 Check that the local power supply switches for the chemical dosing pumps are on and set the dosing pumps switch on the main panel to AUTO.
- 1.12 Switch on the boiler panel. Reset the alarm switch and mute the alarm in the engine house.
- 1.13 Check the salt ;and water levels in the water softener brine tank (blue).
- 1.14 Open the rear smoke box drain cocks B15 and B16.

2. STARTING FROM COLD.

- 2.1 Fix the boiler house side door open.
- 2.2 Record the starting conditions on the log sheet.
- 2.3. Check that preparation to raise steam is correct as detailed in Part 1.
- 2.4 Open the flue damper.
- 2.5. Open the main gas valve G6. If gas alarm sounds, press the alarm reset button.
- 2.6. Set the burner modulation switch to HAND and set the firing rate to LOW.
- 2.7. Switch the burner ON for 15 minutes, then OFF for 15 minutes and continue this 15 minute ON/OFF cycle.
- 2.8. As soon as copious amounts of steam issue from the vent on top of the boiler close the bottom vent valve S16 and then the top vent valve SI8.
- 2.9. When the boiler pressure reaches 2 bar (on the pressure gauge) switch the burner control from HAND to AUTO.
- 2.10. Blow down the water level gauge and verify correct operation. Refer to the instructions by the gauges.
- 2.11. Close the rear smoke box dram cocks B15 and B16.
- 2.12 Open boiler feed valves BFW1 at hotwell and BFW4 and the chemical injection valve CD5 at boiler. Set the boiler feed pump switch to AUTO
- 2.13. When the pressure reaches 5 bar an authorised boiler operator should carry out the boiler safety checks as detailed in Section 6.
- 2.14. At 5 bars open the manifold valves S2 and S9. Crack open SI, the boiler stop valve, one quarter turn. Allow the steam main to warm through until the pressure in the engine house levels out with the boiler pressure, then fully open SI slowly to avoid water hammer in the steam main.
- 2.15 Open steam header drain valve S8 (carefully) and flush out dirt pocket.
- 2.16 Open hotwell steam valve S13 at the hotwell. The hotwell temperature should stabilise at 85 to 90 degrees.
- 2.17 Open the bottom blow down valve B1 and then open diaphragm valve B17 for 10 seconds every hour.
- 2.18. Check all readings and enter in the log sheet every hour.
- 2.19. Start warming the engine as specified in the Engine Operating Instructions (Day One).
- 2.20. For overnight shut down at the end of the day use procedure detailed in Section 4.
- 2.21. Record the final conditions in the log. Any defects found must also be recorded in the log. If a defect is serious or likely to affect future operation, inform the person in charge or the chief engineer or both.

3. STARTING FROM WARM AND UNDER PRESSURE

- 3.1 Check that the steam inlet valves S52 and S66 on the engine are closed and that the emergency stop valve on the engine is tripped shut.
- 3.2 Fasten the boiler house side door open.
- 3.3 Record the starting conditions on the log sheet.
- 3.4 Open MW10 and TW3 valves.
- 3.5 On the main panel switch on the treated water pump.
- 3.6 Open the flue damper.
- 3.7 Open the water level gauge water and steam cocks, (handles vertical).
- 3.8 Open the main gas valve G6. If the gas alarm sounds, press the alarm reset button.
- 3.9 Open the boiler feed valves BFW1 and BFW4 and the chemical injection valve CDS.
- 3.10 Switch on the boiler panel.

If low water level conditions are indicated by the alarm sounding, mute the alarm and switch the feed pump to hand control. Raise the water level until one third glass is indicated and then stop the feed pump. Reset the low water alarms as the water level rises to safe working conditions.

If water level is satisfactory switch the feed pump to AUTO. Switch the burner to ON. If the pressure is less than 2 Bar cycle the burner for 15 minutes ON/OFF until 2 Bar is reached, then set the modulation switch to AUTO (this overrides the firing rate control).
- 3.11 Blow through the water level gauge glasses and check correct operation.
- 3.12 When the pressure reaches 5 bar crack open SI, the boiler stop valve, one quarter turn. Allow the header and main steam line to warm through until the pressure in the engine house becomes approximately the same as the boiler, then slowly open SI.
- 3.13 Open ball valve SI3, steam to hot well. The hot well temperature should stabilise at 85 to 90 degrees C.
- 3.14. Open the blow down valve B1 and then open the diaphragm blow down valve B17, for 10 seconds every hour.
- 3.15 If it is day 2 of the warm up cycle then follow day 2 instructions in the 'Engine Operating Instructions' for warming through engine.
- 3.16 For overnight or final shut down at the end of the days steaming follow the procedures in section 4,
- 3.17. Record the final conditions on the log sheet. Any defects found must be entered in the log and, if considered serious or likely to affect future operations, reported to the person in charge or the chief engineer or both.

4. BOILER SHUTDOWN

Overnight Shutdown

- 4.1 Switch the boiler feed pump to OFF and switch the burner to OFF. Wait for the post purge cycle to complete, and then switch off the boiler panel.
- 4.2. Close the boiler stop valve SI and steam to the hot well, S13.
- 4.3. Close the flue damper.
- 4.4 Close MW10 and TW3. On the main panel, switch off the treated water pump.
- 4.5 Close BFW1, supply from the hot well to the boiler feed pump and the boiler feed valve BFW4. Close the chemical injection valve CD5.
- 4.6 Close blow down valve, B1.
- 4.7 Close the gas valve G6.
- 4.8 Close the water level gauge water and steam cocks, (handles horizontal). Leave the drain cock closed (handle vertical).

Final shut down at end of steaming

For the final shut down at the end of steaming carry out the following actions in addition to overnight list.

- 4.9 Shut steam manifold valves S2 and S9.

5. WATER WEDGING

- 5.1 If the boiler is to remain shut down for more than one week the boiler must be filled with water (water wedged) to exclude air and prevent corrosion. This is usually done a few days after steaming when there is a partial vacuum in the boiler
- 5.2 Wear full face protection, nose and mouth filter and protective gloves.
- 5.3 Siphon 1/2 gallon (2.25 l.) of sodium metabisulphite solution into the plastic bottle and using the chain provided lift onto the boiler platform. Carefully pour the contents of the plastic bottle into the header tank.
- 5.4 Remove protective clothing after carefully washing the siphon and bottle.
- 5.5 Close vent valve S18, open S16 and then slowly open S17 to allow the sulphite solution in the head tank to be sucked into the boiler. Then open water supply valve MW27 to give a good flush through the head tank into the boiler. Finally close SI7.
- 5.6 Open vent valve SI8.
- 5.7 Switch on the water softener and open MW10 and TW3. On the main panel, switch the treated water pump ON.
- 5.8. Open BFW1, and open BFW4 one turn. Open CD5. Check that the chemical dosing pumps are on AUTO.
- 5.9 Switch on the boiler panel and mute the alarm. Switch the boiler feed pump to HAND. When water flows from the vent connection to drain pipe switch the boiler feed pump to OFF.
- 5.10 Close the vent valve S18 and turn on the water supply to the header tank MW27. Open SI7.
- 5.11 Switch off the boiler panel. Switch off the softeners. Close MW10, TW3, BFW1, BFW4 and CD5. On the main panel switch the treated water pump to OFF.
- 5.12 Shut the blowdown drum cooling water supply valve MW13. Open the blowdown drum drain valve B11 and empty the drum.

6. BOILER SAFETY CHECKS.

- 6.1 When starting the boiler from a cold shutdown, e.g. for a steaming weekends, the following tests of the boiler safety devices shall be carried out and recorded on the boiler log sheet. The boiler safety checks shall only be carried out by an **authorised boiler operator, and the boiler log book signed by the authorised operator to confirm that this has been done.**

The tests should be carried out when the boiler is firing normally, once the pressure has reached about 5 bar, and before the boiler stop valve SI has been opened.

- 6.2 Test the low water level alarms

6.2.1. Switch the boiler feed pump to OFF.

6.2.2. Open the diaphragm blow down valve, B17 and lock open with phi. Allow the water level to fall and note the level at which the burner cuts out. Reset the alarm and continue lowering the water level and note the level at which lockout occurs.

6.2.3. Close the main blow down valve, B17.

6.2.4. Switch the feed pump to AUTO and allow the water level to rise until lockout is cancelled. Press the reset switch. Allow the water level to rise until normal working level is reached when the boiler should restart.

- 6.3 Test the burner flame failure device

6.3.1. Remove the two locking screws securing the burner top domed cover and carefully remove the cover.

6.3.2. Pull the flame photo electric cell out of the socket and lightly cover the active face with your hand but **do not touch the face of the cell**. The burner flame should be extinguished within a few seconds.

6.3.3. Refit the cell in the socket, and refit the cover.

6.3.4. Reset the burner alarm and the burner should start.

- 6.4 Check the flue damper safety switch

6.4.1 Close the flue damper and the burner should stop firing.

6.4.2. Reset the damper in the open position and the burner should restart.

7. WATER TREATMENT

Boiler water treatment is designed to prevent corrosion and scale formation in the boiler and associated pipe work. The water treatment consists of the following.

7.1. Water Softening

Mains water is "hard" and contains calcium and magnesium bicarbonate which would break down due to the heat in the boiler to deposit scale in the form of calcium or magnesium carbonate. Scale in the boiler deposited on the boiler tubes inhibits heat transfer and could lead to overheating of the tube material and possible failure of the tubes.

The mains water, therefore, is softened in a Betz Dearbourn ion exchange softener which converts the calcium and magnesium carbonate into sodium carbonate which is soluble. The softener works by passing the water through a special resin bed which acts as a catalyst to bring about the process and soften the water. Periodically the resin is regenerated by flushing with a solution of common salt which also flushes away the calcium and magnesium.

The softener consists of two vessels, one in operation, the other being regenerated and then on standby. The regeneration is initiated automatically, the only attention required being to replenish the salt solution in the storage drum to the required level.

7.2 Oxygen Removal.

Corrosion can only occur in the presence of oxygen which is dissolved in the water. The softened water is led into an insulated "hot well" tank in which its temperature is raised to 85 to 90°C by the injection of live steam from the boiler. At this temperature the dissolved oxygen is removed from the water.

7.3 Chemical Treatment.

There are three stages of chemical treatment, each chemical solution being injected by automatically controlled dosing pumps, either into the hot well or directly into the boiler. Sodium metabisulphite is injected directly into the boiler to scavenge the remainder of any oxygen and to provide a reserve in the boiler.

Sodium phosphate is injected into the hot well to precipitate any residual hardness in the feed water and to provide for any transient malfunction of the softener.

Filming Amine is injected into the hot well to inhibit corrosion in the steam and condensate lines.

7.4 Blowdown

The result of the boiler water treatment is to produce dissolved and suspended solids in the boiler feed water, which if allowed to accumulate promote foaming and overheating in the boiler. The total dissolved solids (TDS) in the boiler water must not exceed 3,000 ppm. This is prevented by "blowing down" e.g. discharging a quantity of boiler water to a blow down drum, where it is cooled and can then be discharged to drain. There are two methods of blow down:-

7.4.1 Bottom blowdown -

A diaphragm operated valve, B17, at the lowest level hi the boiler discharges boiler water and accumulated sludge to the blow down drum. Current practice, as detailed in the boiler operating procedure, is to open the valve for 10 seconds each hour while the boiler is operating. The automatic control facility for this valve has been disconnected as not necessary.

7.4.2 Continuous blowdown

The boiler is fitted with an Automatic Blowdown Controller, Gestra type LRR1-12, which works in conjunction with a conductivity sensing electrode fitted into the boiler shell. The controller converts the conductivity reading into a TDS value, and can be set to initiate a blowdown sequence when a set value has been reached. This value has been set at a safe level of 2,500 ppm. It has been found, however, that with current operating practice this value is not reached and the continuous blow down valve does not normally operate.

7.5 Water Quality Testing

7.5.1 Hardness

Take a sample of treated water from the sample valve TW7. Rinse the test tube and fill two thirds full. Add one "Yes/No" test tablet, insert the stopper and shake the test tube. The sample will turn green if the softness is correct. If the water sample turns red the water is too hard and a regeneration cycle of the softener must be activated to correct this as described in the softener instruction manual. The test need only be done once a day unless it is necessary to check corrective action.

7.5.2 pH

Turn on the mains water supply to the sample cooler on the boiler. Open the boiler water sample valve attached to the continuous blow down valve B6 and run the water through the cooler until the water temperature is just hand hot. Take a pH test strip and hold in the water flow for a few seconds. Shake the excess water from the test strip and read the pH value by comparison with the colour scale on the test strip package.

The pH value should lie between 10.5 and 12.0 when the boiler is operating. When starting the boiler the pH value might be below 10.5 but the action of the softener and the chemical injection treatment should correct this.

7.5.3. Sodium Sulphite

Turn on the mains water supply to the sample cooler on the boiler. Open the boiler water sample valve and run the water through the cooler until the water temperature is just hand hot. Fill the sample container to overflowing. Using the syringe provided immerse the tip as deeply as possible into the container and slowly draw up 20 ml of the sample.

Rest the syringe on the top of the test jar and slowly transfer the contents of the syringe into the jar. Add two heaped blades of reagent SI to the jar and swirl to mix.

Holding the S2 dropper bottle exactly vertical add the reagent drop by drop, allowing the drops to form naturally. Do not squeeze the sides of the bottle. In very cold conditions slight pressure may be applied to the sides of the bottle to aid drop formation.

After a few drops agitate the test jar. Repeat until the sample turns blue. Count the number of drops required.

Sulphite (ppm) = no. of drops used x 5 The result should be in the range 30 to 70 ppm.

Note The pH value is the simplest test to check the correctness of the chemical treatment. The sulphite test need only be carried out occasionally to verify the result.

7.5.4. Filming Amine

The test range for filming amine is 0-20 ppm. This is not critically important. If required a test "QAC, Catatonics/Polyamine drop test" may be carried out as described in the test kit instruction booklet.

8. PRESSURE SYSTEMS ANNUAL INSPECTION

8.1. Preparation

- 8.1.1. Drain down the boiler. Remove the manhole and mud hole doors from the boiler. Remove old joints and clean the joint faces.
- 8.1.2 Remove the gas pipe to the burner. Open the front and rear furnace doors and brush out the furnace and brush through the boiler fire tubes.
- 8.1.3 Hose out the boiler, removing as much sludge as possible through the mud holes,
- 8.1.4. Remove the stop valve, the safety valve and the feed check valve. Remove the internals, clean and examine them and lay out for the boiler surveyor's inspection. Remove the end cap on the bottom blow down valve, but do not remove the internals.
- 8.1.5. Scrap all removed gaskets and renew. Ensure that new "TOPOG-E" gaskets are available for the manhole and mudhole doors.
- 8.1.6. Ensure that the sight glasses are working satisfactorily.

8.2. Visual Inspection

The boiler Surveyor will carry out the following inspection as necessary:-

- 8.2.1. Examine the boiler internally by entering the boiler through the manhole and by sighting through the mud holes.
- 8.2.2. Examine the boiler externally, the boiler furnace and fire tubes, and the boiler valve internals.
- 8.2.3. Check the accuracy of the boiler pressure gauge.

On completion of the inspection the boiler is re-assembled ready for steaming.

8.3 . Performance Test

Fill the boiler with water and bring it up to working pressure as detailed in Sections 1 and 2.

The boiler surveyor will observe the following tests being carried out:-

8.3.1 Level alarms.

Proceed as per section 6.2 .

8.3.2 Boiler safety valve.

Temporarily disable boiler pressure control and with boiler on full fire note pressure at which safety valve lifts. This must not exceed 10% above normal working pressure. With burner shut off, safety valve to reseal at no more than 3% below normal working pressure. On completion of tests, return boiler pressure control to normal operation.

8.3.3 Burner photo cell.

Remove photo cell and check that burner locks out.

8.4 NDT (Non-destructive testing)

Every five years a specialist contractor is to be appointed to carry out an NDT examination of the longitudinal seam of the boiler and selected portions of the

circumferential shell to end plate seams. Also the tube to end plate welds are subjected to NDT examination. The procedures used are magnetic particle or ultrasonic examination as appropriate. The NDT contractor will be appointed by the boiler Surveyor.

- 8.4.1 In order to carry out the examination removable panels have been made in the boiler cladding. These panels and the lagging must be removed and then replaced when the examination is completed.
- 8.4.2 The NDT contractor will provide a report of the examination to the boiler Surveyor for approval.