BOILER TEGB
INSTALLED 1997

OPERATION AND MAINTENANCE
INSTRUCTION MANUAL

ISSUE 5

0.INTRODUCTION

This manual describes the Turbine Exhaust Gas Boiler (TEGB) and associated equipment, its operating and maintenance instructions, and procedures for starting, stopping and laying up the boiler for storage. These instructions are limited to the scope of supply of the equipment supplied by HDS Energy under this contract.

Equipment identification numbers used in this manual are those found on the appropriate P&I diagrams, and valve and instruments lists, copies of which are included in this manual.

HDS Energy Ltd and ESBIE/HDS Consortium are not responsible for any damage or injury caused by any omission on the part of the purchaser or operator, or by actions taken that are contrary to the instructions contained in this manual and in the appropriate safety legislation.

1.PLANT DESCRIPTION

1.1Description

The TEGB is a partly shop assembled water tube, natural circulation boiler with integral superheater and economiser, an uncooled, insulated casing, a separate, uncooled, insulated furnace, and a free-standing chimney connected to the flue gas duct from the economiser.

The boiler has been designed in accordance with the requirements of the following codes for steam generating equipment:

- TRD, for the pressure parts
- NFPA 85C, for the burner safety equipment
- BS 4076, for the main and bypass chimneys

The boiler is designed principally to operate as a waste heat recovery boiler in conjunction with an EGT Tornado gas turbine generator set. It is, however also equipped with a dual-fuel, auxiliary burner and draft equipment to permit fired operation with refinery tail gas (RFG) or Distillate Oil (DO).

A small, support burner can operate in the waste heat recovery mode to facilitate rapid change over to auxiliary fired mode, but combined operation, in waste heat mode and with the main burners in operation (supplementary firing) is not possible.

The flue gas duct from the economiser has been designed with a facility for additional heat recovery surface, if required in the future, which will allow an increase to be achieved in the boiler's steam output.

1.2 Construction

1.2.1 Tube Panels

The boiler comprises a series of panels of tubes mounted between headers and arranged in groups by function to intercept the flow of hot gases and take up the heat contained therein. The boiler comprises the following groups of tube panels.

1.2.1.1 Screen

Two panels of bare tubes, arranged in staggered formation, to protect the following parts of the boiler from radiant heat. Functionally, the screen panels are connected within the boiler as part of the evaporator.

1.2.1.2 Superheater

A single panel of finned tubes. The superheater is arranged as a single pass, downflow panel, taking steam in at its top header from the steam drum and discharging from the bottom header to the boiler main stop valve.

1.2.1.3 Evaporator
Twenty-one panels of finned tubes. The top and bottom header of each panel of evaporator tubes and those of the screen tubes is connected to a top and bottom main header respectively.

1.2.1.4 Economiser
Two panels of finned tubes, arranged for four-pass flow, with both inlet and outlet at the bottom headers. The economiser is arranged before the feed water regulator valve so that it always operates at the highest possible pressure, to ensure that steaming does not occur.

1.2.2 Downcomers
The boiler is equipped with two, external downcomers, carrying water from the boiler drum to the bottom main header. Because of their unheated arrangement, the downcomers assure good circulation and maintain an even water level in the boiler drum.

1.2.3 Drum
The boiler is equipped with one steam drum; there is no bottom (mud) drum on this type of boiler. The boiler drum is fitted with two manholes, 320 x 420 mm, for access to the drum internals, and with all necessary internals to assure good steam separation and to maintain water supply and quality.

Feedwater is distributed within the drum by means of a submerged sparge pipe; to ensure proper missing of the incoming feed water with the boiler water.

To assure steam quality, the drum is equipped with simple, efficient internals comprising:

- Battle plates as primary separators, mounted along the side of the drum, between the steam water mixture and the higher – density water;
- A ‘Peerless’, chevron-pack demister as a secondary separator, arranged at the top of the drum, to extract the last traces of water and impurities from the steam leaving the boiler drum.

The boiler drum is equipped with both automatic, continuous blowdown equipment, including a boiler water sampling facility and sample cooler, and a manual drum drain valve.

For wet storage, there is a boiler drum chemical dosing facility, comprising a nozzle on the drum and a sparge pipe to ensure equal distribution of the conservation chemicals throughout the bulk of the drum water.

1.2.4 Accessories
The boiler is equipped with the three safety valves, one each:

- At the economies outlet, before the feedwater regulator valve
- On the boiler drum;
- At the superheater outlet before the boiler main stop valve.

The groups of tube panels comprising the boiler are fitted with detuning bars, to prevent aerodynamically – or harmonically-indeed vibration in the tubes. Detuning bars are fitted to each panel of tubes in the boiler.

The boiler casing is fitted with access doors to permit entrance to:

- The furnace
- The boiler, between the super heater and the evaporator
- The boiler, between the evaporator and the economiser
- The flue gas duct, after the economiser

Peepholes have been fitted to permit inspection of the flame when in auxiliary fired mode. Te peepholes allow a view of the end of the flame, looking across the screen tubes and also both sides of the flame, viewed from the boiler end of the furnace. In addition, the burner is equipped with a peephole to permit viewing of the flame from the upstream side.

The flue duct, both upstream and downstream of the economiser, is fitted with an array of sample points, to permit profile sampling of the flue gas conditions, if desired, for boiler efficiency determination.

Dual oxygen analysers/flue gas temperature monitors are fitted to the flue gas duct, to optimise combustion efficiency when the boiler is operating in auxiliary fired mode. A further gas temperature monitor is fitted to the boiler between the evaporator and the economiser.

1.2.5 Furnace

The furnace is separate from the boiler and comprises a simple, uncooled duct section, having a cross-section that varies from the burner throat to the interface with the boiler. The furnace duct is made of reinforced steel plate, lined on the inside with calcium silicate board and refractory brick. The brick is quite friable and is easily damaged if walked upon.

1.2.6 Burner

The burner is an in-duct type of burner, supplied by Rodenhuuis en Verloop b.v. The burner system has four separate burners:

- A main gas burner, for RFG
- A main oil burner, for DO
- A small support burner, burning RFG
- An igniters, burning propane gas

The main burners can operate independently, or together, to provide a heat source to the boiler when the gas turbine is not available, and for starting up.

The support gas burner is designed to provide a support flame when the boiler is recovering heat from the gas turbine exhaust (TEG Mode), and when the main burner is burning RFG to facilitate rapid change-over to fired mode burning DO in the event of loss of turbine exhaust gas or RFG fuel. The RFG supply to the support burner comes from a different source to that for the main gas burner. Both the RFG supplies

to the main gas burner and to the support burner can be supplemented by the addition of propane or butane gas by IRC in the event of failing RFG pressure. The burner system will automatically compensate for the addition of propane and butane gasses to the main gas burner RFG supply, to prevent over firing the boiler, by means of a signal from the propane and butane evaporators proportional to the flow of those gases. In the case of propane, the signal is proportional to the drive signal to the propane pressure-reducing valve, and in the case of butane, the actual gas flow is measured.

1.2.7 Draft Equipment
Draft equipment on the boiler comprises:

1.2.8.1 Forced draft fan
The forced draft (FD) fan provides the main combustion air to the boiler, when operating in fired mode;

1.2.8.2 Forced draft fan damper
The FD fan damper regulates the air flow into the boiler when in fired mode, and closes off the FD fan to protect it from hot turbine exhaust gases when in TEG mode. The FD fan damper is equipped with double seals. This allows the space between the seals to be pressurised with cold air when the damper is closed to afford 200% air tight sealing against the turbine exhaust gases. For further details of the FD fan, see the Turbo Dynamics manual in volume 2 of this manual.

1.2.8.3 Seal air Fan
The seal air fan provides air to the FD fan damper when it is closed, by injecting air at a pressure higher than that of the turbine exhaust gases into the space between the damper seals.

1.2.8.4 Seal air fan valve
The seal air fan is equipped with an air valve to prevent loss of combustion air through the seal air fan when the FD fan damper is open and the seal air fan is not running, and to prevent the seal air fan from being run backward by the FD air flow;

1.2.8.5 Auxiliary air fan
The auxiliary air fan provides flame stabilising air and atomising air to the burners, and cooling air to various services around the burners. For further details of the auxiliary air fan, see the Turbo Dynamics manual in volume 2 of this manual.

1.2.9 Valves and mountings
The boiler is supplied with all necessary valves and mountings. All flanges on the boiler, and all equipment mounted directly onto the boiler, are equipped with flanges to DIN standards; all other flanged equipment has flanges to ANSIB16.5

1.2.10 Start-up Valve Schedule
A list of all the boiler valves, including their status at start-up, is contained in Appendix 1: Start-up Valve Schedule

1.2.11 Feedwater System

The boiler is supplied with duplicate boiler feedwater pumps. Each pump is of the centrifugal horizontal, multi-stage type with vertically split casings. One pump is drive by an electric motor, and other by a stream turbine. Either pump is capable of supplying the whole of the feedwater requirements of the TEGB at all boiler loads.

Each boiler feed pump is equipped with suction and discharge isolating valves, a discharge check valve, a constant flow leak-off system to ensure there is always the required minimum flow through the pump, and a thrust balancing system to minimise axial thrust on the pump bearings. Both of these systems are fitted with drain lines returning to the existing deaerator.

For detailed information about the pumps or the electric motor, see the Sulzer Pumps O&M manual, contained in the CHP Auxiliary Equipment O&M Manual. For detailed information about the steam turbine, see the Coppus O&M manual, issued separately.

1.2.11.1 Chemical dosing system

1.2.11.1.1 Sulphite dosing

Sulphite dosing is provided by the existing dosing system, injecting into the feedwater system before the boiler feed pump' suction.

1.2.11.1.2 Transport Plus dosing

A dispersant-type of water treatment is recommended to maintain waterside cleanliness and to maintain all impurities either in solution or in suspension. Because the boiler has no bottom ('mud') drum, it is essential that a non-precipitation dosing regime of chemicals is adopted. The precise requirements for feed water dosing will be recommended by water treatment specialists retained by Irish Refinery based on the feed water quality. However, the chemical should be one of the Transport plus mixtures supplied by Nalco ltd or similar.

To provide the Transport Plus injection, two dual-head chemical dosing pumps have been provided. One head of each pump is connected to an injection quill in the boiler feedwater line downstream of the boiler feed pumps; the second head of each pump provides chemical injection to boiler SG4. For further details of the chemical dosing pumps, see the Bran + Luebbe manual in volume 2 of this manual.

1.2.11.1.3 Lay-up dosing

When the boiler is to be take out of service for any length of time it must be protected against corrosion, as described below in section 4.5 – Conservation. To permit the injection of chemicals for wet conservation, a laying-up chemical dosing pump is provided, injecting into a sparge pipe in the boiler drum. This pump may only be used when the boiler pressure has fallen below 5 bar g: it is not intended for operation at normal boiler pressure. The sparge pipe ensures good distribution of the conserving chemicals throughout the boiler water.

As the lay-up dosing pump is not normally required, provision has been made to permit the pump to be easily dismounted for storage, if required.

1.2.12 Valve Tag Schedule
A list of the valves on boiler TEGB for which valve tags are be provided, together with the text to be engraved on the tags and a description of each valve's location, is contained in Appendix 2: Valve Tag Schedule

1.2.13 Control and instrumentation equipment
A detailed description of the Control and instrumentation equipment is contained in Appendix 3: Control and Instrumentation equipment.

1.2.14 Boiler Control System
A detailed description of the boiler/burner control system and its operation is contained in Appendix 4: Control System

2. BOILER OPERATION INSTRUCTIONS

2.1 Pre-start inspection
The boiler and its auxiliary equipment must be properly installed, with all necessary wiring and piping connection correctly before it can be operated. This ensures both satisfactory and safe operation. Before the boiler is installed any shipping damage should be determined and repaired. Shipping damage normally shows as dented outer casing, or damage burner refractory. Damage to the pressure parts is unlikely but not impossible. Any indication of severe rough handling calls for a hydrostatic test to determine if tubes have been loosened in their seats. If a hydrostatic test is required, test at no more than 1 ½ the normal operating pressure and be sure to gag the safety valves before the test.

Thermal expansion will occur when the boiler is started; consequently, room for expansion must be provided. Safety valve vents must be supported so as not to impose strains on the safety valves. (See safety valve instructions). Steam lines must be supported and have sufficient expansion loops to prevent excessive reactive forces on the boiler. Refer to the applicable boiler arrangement drawing for specific information. The same applies to feedwater lines and blow-off lines.

All temporary cribbing, blocking, and bracing, both internal and external, must be removed before the boiler is started up. In some cases, cribbing is used inside the furnace to hold burner refractory in place during shipment. If allowed to remain, it may burn at uncontrolled rate during initial firing and damage units. In other cases, temporary steel bracing may be installed to prevent distortion of large, uncooled furnaces during shipping. If not removed, it will result in distortion of the furnace on firing and hot spots on the casing. External bracing can prevent the normal expansion of the boiler. There are instances where separately shipped items are shipped inside the furnace, therefore, the furnace access door must be removed to make sure all parts, cribbing and bracing are removed from the furnace area.

The gauge glass must be clean, visible, its gaskets tight, and it must show the correct water level in the steam drums. 'Normal' operational water level for this boiler is 100 mm above the drum centre line.

The boiler pressure gauge must be installed in such a manner that is also visible to the operator. It should be calibrated, and its connecting piping should be filled with condensate to protect the gauge from hot steam.

The burner and fuel lines must be clean and adjusted as called for in the burner operating instructions.

FOR THE PROTE CTION OF PERSONNEL ALL STEAM LINES, WATER LINES, FLUES, AND DUCTS THAT MAY BE TOUCHED SHOULD BE INSULATED TO PREVENT INJURY. ALL BLOW OFF AND DRAIN LINES SHOULD DISCHARGE AWAY FROM PERSONNEL.

ALL OIL SUPPLY LNES (WHEN THE OIL IS HEATED), FROM THE OIL HEATER TO THE BURNER, SHOULD BE PROPERLY INSULATED DUE TO THE WAX-LIKE PROPERTIES OF LOW SULPHUR OIL AT WHEN AT REDUCED TEMPERATURES.

A supply of feedwater must be available and at sufficient pressure to feed as required to maintain the correct water level.

The feedwater piping must be flushed with water to remove all debris. A temporary strainer (screen) may be installed upstream of the feedwater regulating valve to prevent debris from entering the valve and causing it to malfunction.

2.2 Refractory drying-out procedure

Where a boiler contains a significant amount of refractory, a drying procedure must be observed to prevent cracking of the refractory.

Visually inspect the furnace lining to ascertain if there is any item not in place, any obvious damage or any debris on the furnace floor, replace the inspection opening insulation and bolt up the inspection door. Operate the burner at MINIMUM firing, preferably using Support Gas only so as to minimise the heat input. Do not exceed 20% of MCR, even in short bursts of heat.

Monitor the furnace of flue gas temperature(s). If the rate of temperature rise is greater than 25^{o}C/hr then stop the burner for 15 minutes and then resume firing.

This situation should be continued for a period equal to 2 hours/inch thickness of the furnace lining, or for at least 10 hours, and until all signs of steam in the flue gas have gone. The temperature should then be raised at a rate of 25^{o}C/hr towards a final furnace temperature of 450^{o}C with pauses at 120^{o}C and 240^{o}C for periods of approximately ten hours.

2.3 Boiling-out procedure

Shop assembled boilers are cleaned internally or all foreign material before they are shipped. Site-finished boilers should be inspected carefully and any debris resulting from the site erection procedures carefully removed. If the manhole cover has not been removed, it will not be necessary to make an internal, water side, inspection. A water soluble lubricant was used with the expanding equipment when the tubes were

expanded into the drum. A boil-out procedure is recommended to remove this lubricant and any grease before the boiler is put into normal operation.

The boiler should be filled with treated or filtered water through the regular feedwater connection to a level of 50mm in the drum gauge glass. The temperature of the water used for filling should be within about +/- 100oC of the steam drum temperature to avoid excessive stresses and possible tube seat leakage.

The chemicals used for the boiling-out process should be completely dissolved in water before being placed in the boiler. They may be injected through the regular chemical feed connection or introduced through the open steam drum manhole after the water level has been brought up to near the manhole.

WARNING!
THESE CHEMICALS WILL BURN THE SKIN AND DAMAGE CLOTHING

A good cleaning job can be obtained with one of the following four combinations and concentrations of chemicals, however solution No.1 is preferred. Solution No.4 should not be used on boilers operating above 600 psi because of the silica at these higher pressures will carry over in a volatile form. Alternatively, recommendations for a cleaning chemical combination can be obtained from water treatment specialists.

1	Trisodium phosphate (Na_3PO_4 $12H_20$)	50000 ppm
	Caustic soda (NaOH)	500ppm
	Wetting Agent or detergent	250ppm
2	Trisodium phosphate (Na_3PO4 $12H_20$)	2500ppm
	Caustic soda (NaOH)	2500ppm
	Wetting Agent or detergent	250ppm
3	Trisodium phosphate ($Na_3PO_412H_2O$)	1500ppm
	Caustic Soda (NaOH)	2500ppm
	Soda Ash (Na_2C0_3)	1500ppm
	Wetting Agent or detergent	250ppm
4	Trisodium phosphate ($Na_3PO_412H_20$)	2500ppm
	Sodium metasilicate Na_3Si0_3	800ppm
	Caustic soda(NaOH)	125ppm

In calculating the weight of chemicals required, the normal water holding capacity listed in the front of the instruction book should be used.

Sample Calculations

Required Concentration = 500ppm
Water holding capacity = 10,000kg

Weight of chemicals required = $\frac{500kg\ chemicals}{1{,}000{,}000kg\ water}$ x 10,000kg Water = 5kg of chem

WHEN HANDLING ANY OF THESE CAUSTIC SOLUTIONS, GLOVES AND GOOGLES SHOULD BE WORN TO PROTECT THE HANDS AND EYES FROM BURNS

After the chemicals have been added, close the manhole, open the drum vent or vent-isolating valve, and raise the water level to normal.

BEFORE LIGHTIING THE BURNER, BE SURE THAT ALL BLOWDOWN AND DRAIN CONNECTIONS DISCHARGE AWAY FROM ANY CONSTRUCTION OR OPERATING PERSONNEL

Light the burner as described in the burner operating instructions and adjust the firing rate at minimum. Where a manual drum vent is fitted, when the drum pressure reaches 0.3 bar g, or when steam blows from the vent at a steady rate, close the drum. When the drum vent is closed blow down the water column and gauge glass for a few seconds to warm them evenly and to make sure the lines are clear.

Continue firing at minimum firing rate until a pressure of at least 6 bar g is reached, but not exceeding 40 bar g or 75% of normal operating pressure, whichever is lower. Fire as required to maintain this pressure for at least four hours. When the required pressure is reached, open the continuous blow down and leave it cracked slightly open for the remainder of the boiling out operation. This removes any oil or grease as it accumulates on the water surface in the steam drum.

Every hour during the boil-out operation use the lower drum blow-off valves to blow down approximately one-half gauge glass of water. For boilers having no bottom drum, blow down a smaller amount every 20 minutes to avoid disturbing circulation. At the end of the blowdown re-establish the water to normal by adding feedwater.

After boiling for at least three hours, take samples of the boiler water and check them for residual phosphate, sulphite and alkalinity, if necessary adding more of the necessary chemicals to the boiler either through the chemical dosing system by depressurising the boiler and adding them through the drum manhole door. Following confirmation of the chemical balance, increase the pressure to about 75% of normal operating pressure and continue to boil for a total of at least 23 hours form staring, this period need not be continuous. The boiler may be shut down over night, if required.

At the end of the boiling-out, blow down the water column and gauge glass and stop the burners, then, when the boiler pressure has fallen to below 5 bar g, blow down the boiler quickly, until it is completely empty, refill the boiler with good feedwater and drain again. This will rinse out any remaining traces of boiling out chemicals and contamination.

2.4 Setting safety valves

All safety valves should be tested for the popping and closing pressure, but should not be tested until the boiler water has been changed after the boil-out because the high concentration of boil-out chemicals can cause foaming and carry-over of chemicals to the safety valves where valve seats may be damaged, and until the burners have been set up to permit safe operation at MCR.

Separate instructions for the safety valves show how to install, gag, maintain, and adjust the safety valves. However, operation of the boiler is normally not included in the safety valve instructions. The testing procedure should be as follows:

1. It is recommended that the boiler be off the line with the steam line stop valves closed
2. All safety valves not being tested must be gagged.
3. Maintain normal water level during the testing procedure
4. Light the burner as described in the operating instructions for the burner and fire at minimum firing rate until the pressure approaches the popping pressure of the valve being tested.
5. Lift the valve by hand to test the valve actions. USE SUFFICIENT LENGTH OF LINE ON THE LIFTING LEVER TO STAY WELL CLEAR OF THE VALVE THUS PREVENTING POSSIBLE INJURY FROM THE BLOWBACK OF STEAM OR WATER.
6. Let the valve cool for a few minutes, and then raise the boiler pressure to pop the valve. When the valve pops, stop firing and let the pressure decrease to below the closing pressure for that valve and the next valve to be tested.
7. Adjust the safety valves as required according to the instructions for the safety valves.

2.5 Starting-up

WARNING

THE BOILER MUST ALWAYS BE STARTED IN FIRED MODE THE BOILER MUST **NOT** BE PUT INTO WASTE HEAT RECOVERY (TEG) MODE UNTIL OPERATING PRESSURE AND TEMPERATURE HAVE BEEN ACHIEVED AND STEAM EXPORT HAS COMMENCED.

A description of the start up sequences is given in Appendix 5: Event Sequence Lists

2.5.1 Prior to Start-up

An external examination of the boiler should be carried out by the operator. This examination should include, but not be limited to:

(a) Correct installation of the equipment
(b) All equipment powered up
(c) Air, Water, Steam and Fuel systems checked for tightness
(d) Alarms cleared
(e) FD fan, Seal air fan and FD damper system
(f) Auxiliary air fan
(g) Fan inlet openings clear
(h) Burners
(i) Gauge glasses
(j) Gauges
(k) Valves
(l) Lines-de-spaded

The position of all manual valve should be checked in accordance with the attached schedule and start-up check list – see Appendix 1: Start up Valve Schedule.

The pressure of the Fuel Gas and Fuel Oil supplies must be checked.

A lamp teat on the burner control panel is carried out

Any alarms or trip conditions indicated should be attended to as necessary

The operator must be satisfied that all requirements are met and the boiler is in a safe condition prior to start-up.

All start-ups will be preformed using the Auxiliary Burner mode.

2.5.2 Cold Start-up procedure

When the boiler is to be started from cold, certain conditions should exist:

1. Steam drum vent and automatic vent isolating valves opened.
2. Blowdown valves closed
3. Water level established at least 150 mm above the bottom of the gauge glass
4. Boiler steam stop valve closed but not tightly seated.
5. Pressure Control Valve manual control indictor is in the neutral position
6. Boiler feed pump and a supply of feedwater available
7. Drain the superheater of condensate by opening the stream trap bypass valves.
8. Drain the steam outlet line of condensate by operating the steam trap bypass valves.

Follow the directions for the burner, controls, fan and fuel system, in preparation for firing at the minimum-firing rate.

A water level is established in the boiler and verified in the gauge glass. The water level should initially be well below the drum centre line-as much as 150 mm below centre line is acceptable for a cold start.

Select Manual on the Drum Level controller and reduce the output to zero, if not already so.

Select Manual on the Steam Flow controller and reduce the output to zero, if not already so.

The Furnace page is initiated from the control room BMS panel by the operator action of pressing either the START GAS BURNER, or START OIL BURNER button. Assume a gas burner start is requested. The FURNACE PURGE COMPLETE indicator on the panel will flash until the purge is complete.

The FD fan and Auxiliary Air fan will start and the FD damper will commence opening. After a time interval of 300 sec (5 min) from the FD FLOW CORRECT indication lighting the FURNACE PURGE COMPLETE indicator will go steady, assuming the purge has been completed satisfactorily. Note that the auxiliary air

fan is automatically started in low speed when a gas burner is initiated, and in high speed for an oil burner initiation.

If safe boiler conditions still exist following the purge then the sequence will advance immediately to start the igniter burner. The igniter burner will start and five seconds later the igniter burner will be in operation with the relevant displays active.

When the igniter burner is in operation, the gas burner will start automatically but with only the support gas flame active since minimum fuel requirements has been set o the Steam Flow controller. The GAS BURNER IN OPERATION indicator will light 10 seconds after burner start is initiated.

N.B. The flame detectors must register a flame for igniter and then the support gas at the relevant stages. If this does not happen then the burner will trip.

The igniter burner will shut down when a gas flame is established.

The superheater start-up vent must be opened fully to ensure an adequate flow of steam through the superheater at all times when the main stop valve or the pressure control valve is closed.

As the boiler starts to heat up, close the feedwater flow regulator block valve and crack the feedwater flow regulator bypass valve to give a flow of at least 1 t/hr, and open the drum drain valve to maintain the drum water level at a constant level. This operation maintains a minimum water flow through the economiser and prevents it form boiling. If the economiser is allowed to boil by having no flow of water through it, the economiser safety valve will lift and will discharge water to ground.

The boiler is then allowed to heat up gradually, taking a period of 3-4 hours to reach full operating pressure, using the main gas burner as necessary. A firing rate of 20% will be sufficient for initial heating, until a boiler pressure of 3-5bar g is reached, and a firing rate of not more than 35% from 5 bar g up to operating pressure (25-30 bar g). Under no circumstances should the boiler be brought to boiling (say 0.3 bar g) in less than one hour. If the oil burner is used, the burner must be left at the minimum firing rate to prevent heating the boiler too quickly. The oil burner may be run at 20% (approximately minimum firing rate) and 30% respectively as per the gas burner above. The firing rate may need to be increased slightly once the boiler begins to export steam, at about 25-bar g to continue to increase pressure. Monitor the steam temperature, keeping it below about 300^0C (the high steam temperature trip is at 113^OC) during pressure rising. Monitor the drum water level during this time and take any necessary corrective action to maintain the water level.

The manual drum vent should be closed when steam is venting steadily from the vent. (approximately 0.2 bar g)

The automatic drum vent isolating valve must be open at all times, the thermostatic vent valve will discharge any air in the drum and will close when the

boiler begins to boil, it will also allow air to enter the boiler, as the boiler cools when it is shut down, to prevent a vacuum from forming in the boiler.

When the drum pressure reaches 16 bar g the Drum Level controller may be put into Auto mode and the feedwater flow regulator block valve opened and bypass valve closed. The drum blowdown valve can be adjusted to maintain the minimum 1 t/hr feedwater flow.

N.B. The heat input to the boiler is set manually by the operator adjusting the Steam Flow controller output up or down. Values of demand greater than zero will result in the main gas flame also being established when the gas burner is selected.

Drain and warm the steam line by opening the steam trap bypass valves at the initial firing stages and close them when a steady flow of dry steam is observed and the respective trap sets are seen to be operating. Ensure that all steam trap-isolating valves are fully open. Before opening any steam stop valves all condensate should be drained from both sides of the boiler stop and pressure control valves and from both sides of the steam flow meter orifice plate.

The boiler pressure is allowed to rise gradually. At a pressure of approximately 10-bar g open the Main Steam Stop Valve. There will be no steam flow at this time as the non-return valve and steam pressure control valve will be closed. Again ensure that the steam main is fully drained after the boiler main stop valve and after the steam flow transmitter orifice plate. Keep all drains open for as long as required to ensure that all condensate is properly drained from the line. Failure to observe this precaution carefully will result in water hammer when the steam pressure control valve opens and steam starts to flow along the steam main.

When the steam drum pressure reaches a pressure somewhat higher than 25-bar g then export of steam will automatically commence. Once an export steam flow of greater than 2.0 t/hr (minimum) is measured, the superheater start-up vent may be closed.

When the steam it is clear that no condensate is being discharged, the steam main drains may be closed. Check that all steam trap-isolating valves are fully open. Any further condensate will be cleared by the steam traps.

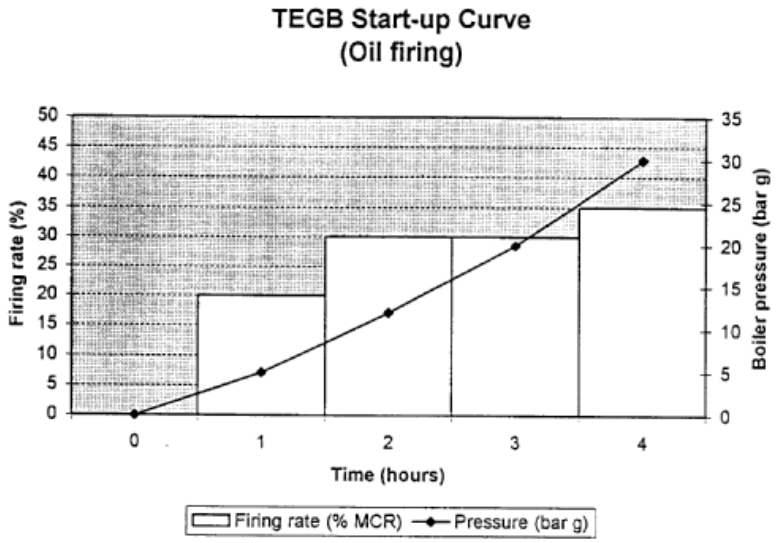
The Drum Level controller should be put into Remote mode at this point, and the boiler drum drain valve should be closed.

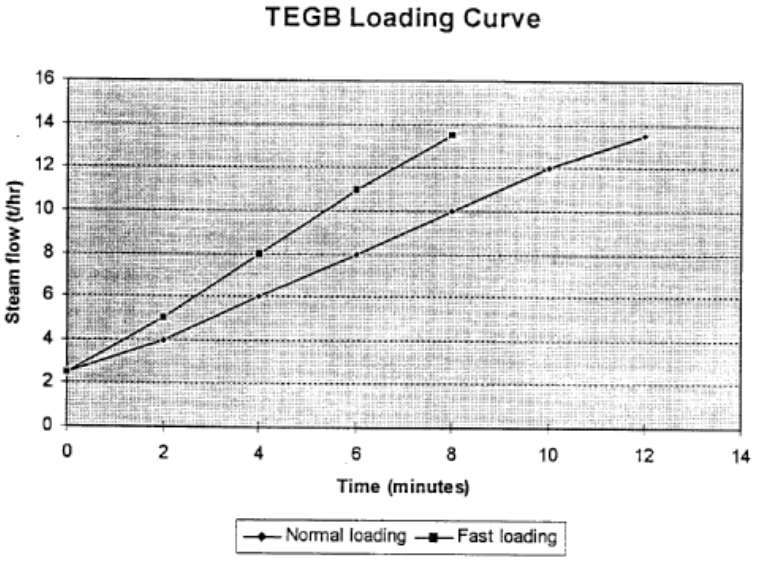
The local demand on the boiler is then slowly increased to allow the boiler to take up its share of the load. The steps of increase in the load demand should not exceed 10% firing rate each, with time allowed between each step increase for the boiler to stabilise at the new load. Once full operating pressure (30 bar g) has been reached, the rate of increase in the steam flow should be about 1.0 t/hr per minute, under no circumstances should the rate of increase of steam output exceed 1.5 t/hr per minute, as this will give rise to control difficulties. When the boiler reaches the required load the Steam Flow Controller is then placed in either Auto or Remote mode, as appropriate.

The Steam Flow Controller then takes control of the burner management system and maintains the boiler steam flow at the appropriate value. The Steam Pressure Control valve will maintain the boiler pressure at the desired set point defined in Controller 2, loop 3.

2.5.3 Start-up and Loading Curves

Start-up and loading curves for the TEGB are given below:





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2.5.4 Immediately after going on line

The Low Water Level Alarms should be checked at this point, the boiler gauge blow down and the drum water level verified as being correct with the gauge glass. See section 11 for the Low Water Level Testing Procedure.

The TDS, i.e. is continuous, blowdown line isolating valve should be opened as soon as possible after going on line.

Ensure that the Drum Level Controller is in Remote mode and that the drum level is being satisfactorily maintained.

If this boiler is to be included in the Master Pressure Controller regime then changes may need to be made to the selector switch at the MPC panel.

2.5.5 During Operation

When the boiler has been placed on line and steady state conditions reached then a water sample from the boiler should be taken and examined for:

(a) TDS
(b) Hardness
(c) PH
(d) Sulphite content
(e) Phosphate/Transport Content

2.5.6 Change-over between Auxiliary Fired and TEG Modes

If the boiler is to be operated in waste heat recovery (TEG) mode then the gas turbine must be in a steady running state with its outlet gas temperature above 420^0C. This condition will be indicated on the burner control panel by the indicator GAS TURBINE RUNNING being illuminated.

Before a change to TEG mode is made, the boiler must be brought to operating temperature and pressure by the operator, and have started to export steam at a rate of about 11 t/hr. This is necessary as the change to TEG mode is equivalent to instantly setting the boiler heat input to about 80% MCR. The boiler control system makes no check that the boiler is operating in a suitable condition permitting the change over to occur.

A description of the change over sequences between fired and a TEG mode is given in Appendix 5: Event Sequence Lists.

2.5.6.1 Change over Auxiliary Fired To TEG mode

Pressing the push button BOILER TO EXHAUST GAS MODE will initiate an automatic change over to the TEG mode, assuming all conditions remain valid for the procedure.

The only conditions in the boiler control system, which can prevent the change over occurring, are a pre-existing boiler fault condition (red warning light on the burner control panel) or absence of the GAS TURBINE RUNNING signal from the gas turbine.

If the change over fails to complete within 30 seconds, as evidenced by the EXHAUST GAS DAMPER OPEN BOILER indicator failing to light, then the damper will be commanded to re-close to allow the gas turbine to continue running.

2.5.6.2 Change over TEG or Auxiliary Fired Mode
Pressing the push button BOILER TO FD MODE will initiate an automatic changeover to the Auxiliary fired mode using oil. Alternatively the loss of the GAS TURBINE RUNNING signal from the gas turbine will initiate change over the Auxiliary Fired mode using oil.

In either case, if the change over fails to complete within 20 seconds such that the diverter damper is not signalled as closed to the boiler, then the signal from the boiler control panel to the gas turbine permitting the gas turbine to run will fail, thus causing an immediate shut down of the gas turbine. The boiler will also fail to start in Auxiliary Fired mode.

2.6 Shutting-down

2.6.1 Normal Shut-down
The recommended procedure for a normal, complete shutdown is to reduce the boiler load to minimum firing rate over a period of at least 5 minutes to allow the load to be taken up by the other boilers, first switching to fired mode if necessary. Stop firing and purge the unit as described in the instructions for the burner, stop the forced draft and auxiliary air fans if not already stopped, isolate the unit by changing all steam and feedwater stop valves, and then allow the unit to cool naturally to reduce the boiler pressure. Check that the steam drum automatic vent isolating valve is open, alternatively, when the steam pressure has dropped less than about 1 bar g, open the steam drum manual vent valve to prevent the formation of a vacuum in the boiler. If the boiler is to be drained, only drain after the pressure has been reduced to zero. If the boiler is not to be drained it is recommended that the water level be maintained in the gauge glass by adding feedwater as necessary during the pressure-reducing period. More detailed instructions on shutting down the burner are given in the following paragraphs.

In some cases auxiliary equipment may require special attention. If so, separate instructions for the equipment involved includes this information. To reduce corrosion when chelants are used for the boiler water treatment, it will be necessary to either flood the steam drum when the drum vent is opened or to connect a source of nitrogen to the vent. Storage procedures are discussed near the end of these instructions.

2.6.1.1 Shut down the whole boiler
The boiler system must first be returned to the Auxiliary Fired mode, if not already in that mode, by pressing BOILER TO FD MODE push button. The burner will change over to FD mode with oil firing.

When the changeover has been completed the Steam Flow Controller is placed in Manual and the load demand on the boiler is decreased slowly to allow the other boiler(s) to start taking up the load. At this stage the TEGB will still be selected as the Lead boiler.
The other on line boilers are monitored as they 'take –up' the extra load. If the Masters Pressure Control system is operational then change the Lead/Lag selection switch to reflect the new desired arrangement of the boilers.

When the load has been substantially shed the stop Oil Burner button is pressed and , as the steam pressure falls below 18 bar g the steam pressure control valve will close and all steam export will stop. Close the main steam stop valve. If the boiler is to be fired at all after export of steam has ceased, the superheater start up vent must be opened fully, before any firing, to ensure there is always an adequate flow of steam through the superheater. However, this vent may be closed again once the burners have been shut down.

Check that the steam drum automatic vent isolation valve is open to prevent the formation of a vacuum in the boiler alternatively when the steam pressure has dropped to about 1 bar g, open the steam drum manual outlet vent valve.

Once the boiler is depressurised, open the superheater drain valve and also the main block valve drain valve. Open the superheater start – up vent valve, and leave it open in readiness for the next start-up.

2.6.1.2 Shut down a single burner (auxiliary firing, dual fuels)
When it is required to shut down one fuel, when in Auxiliary Firing mode with dual fuels, the fuel to be shut down must first be reduced to zero % contribution before stopping the burner, to prevent a 'bump' on shutdown of that burner.

Adjust the OIL % set point in Loop 3 of Controller 4 to 100% if oil is to be retained, or to the minimum if gas is to be retained, as the single fuel. Allow the fuel system to stabilise at the new fuel radio.

Press the relevant STOP BURNER push button to switch off the unwanted fuel. The remaining fuel will now provide the required heat supply to maintain the desired output steam flow.

2.6.2 EMERGENCY SHUTDOWN
AN EMERGENCY SHUTDOWN PROCEDURE SHOULD BE INTIATED ANY TIME A CONDITION ARISES THAT ENDANGERS PERSONNEL OR EQUIPMENT. THERE ARE EMERGENCY STOP PUSH BUTTONS AT THE BOILER CONTROL PANE AND MOUNTED ON THE BOILER CASING, BESIDE THE BURNER.

Some of the conditions that call for emergency shutdown are loss of ignition, water level, forced –draft fan, auxiliary air fan, electric power or instrument air. Any one of these conditions requires that the fuel be tripped immediately and furnace purged, if possible, to remove any combustible gases.

If the water level falls below the level of either of the low level sensors, the burners will be tripped automatically, if it falls below both sensors, the burner will lock out, and will not restart automatically, even if the water level is restored. If the water level falls below the bottom of the gauge glass and there is no positive proof that the water level is not above the bottom of the steam drum, water must not be added until the boiler has cooled within 50oC of the feedwater temperature.

If a loss of ignition occurs, or the selected fuel incoming pressure falls below a minimum value, or the fuel pressure at the burner tip rises above a maximum value, or the instrument air supply pressure falls below a minimum value, the burner system will be tripped automatically. If the boiler is operating in TEG mode, the diverter damper will attempt to change-over to divert the turbine exhaust gases to the bypass stack; if the diverter damper fails to respond, the gas turbine will be commanded to shut down.

If a tube rupture occurs, even though water level can be maintained and ignition is not loss, it is recommended that the boiler be taken out of service as soon as possible. The impingement of high pressure steam and water from a tube leak can set up a chain reaction and cause the failure of additional tubes. In cases where a high sulphur fuel is used, it should be, recognised that the moisture from a leak will cause gas side corrosion of boiler tubes and casing and that steps should be taken to neutralise the acid condition with a lime flush during the outage for repairs.

2.7 Load/Demand Regulation

During operation, the desired steam output and normal operating pressures are maintained by regulating the firing rate as described in the instructions for the burner and controls. At extremely low loads, on-off firing may be required. Under no condition should the rated output or pressure of the boiler be exceeded.

Maintain the water level at approximately the centreline of the boiler drum; this is approximately two thirds of the way up in the gauge glass. To keep the gauge glass clean and to be sure that the connections to the gauge glass are open, it is recommended that the gauge glass, water column, and low water level trip chambers be blown down daily. Test the low water cutout and alarm daily, a procedure for this is given at the end of Appendix 3: Boiler Instrumentation.

To prevent internal corrosion and the formation of scale, the quality of the feedwater and boiler water should be checked daily and maintained at the recommended quality.

2.8 Water Treatment

Internal corrosion of the boiler and its auxiliary equipment, carry-over of boiler water solids with the steam, and the formation of internal deposits are problems associates with feedwater and boiler water that prevent extended trouble-free operation. These problems can, however, be prevented with the proper treatment with may involve both pre-treatment and internal treatment. Water treatment, then, is a form of preventative maintenance.

However, any water treatment directed at only one of these problems may affect another problem either favourable or unfavourable. All related factors must, therefore, be considered before selecting a water treating method. For this reason, it

is recommended that the services of a competent water treatment consultant be retained prior to the selection of feedwater treating equipment and the operation of any boiler equipment.

Temperature is one the factors affection chemical reactions, solubility of chemicals, and the thermal decomposition of chemicals. Since temperature increases with operating pressure, the recommended limits in the following tables are based on operating pressure.

Table 1 FEEDWATER LIMITS

	Up to 20 bar g	40 bar g	60 bar g	80 bar g
Total hardness: ppm (as $CacO_3$)	10	2 (5 temporary max)	0.5	0
PH	8.5-9.5	8.5-9.5	8.5-9.5	8.5-9.5
Oxygen: mg/l (max)	0.05	0.02	0.01	0.007
Iron+Copper+Nickel:mg/l(max)	-	-	0.02	0.01
Oil	ND	ND	ND	ND
Organic Matter	0	0	0	0

Table 2: BOILER WATER LIMITS,
FOR THE PREVENTION OF CARRY-OVER

Operating Pressure, bar g	Boiler Dissolved Solids, ppm	Boiler Suspended Solids, ppm
Up to 20	3000	200
20-40	2000	50
40-60	1200	0
60-80	700	0
80-100	350	0
100-120	100	0
Above 120	150	0

NOTE: BECAUSE THE TEGB HAS NO LOWER (‘MUD’) DRUM, THE STRICKTER REGIME OF 1200 PPM TOTAL DISSOLVED SOLIDS, NORMALLY APPROPRIATE TO BOILERS OPERATING IN THE PRESSURE RANGE 40-60 BAR G SHALL APPLY.

In most cases, water treatment for boilers is used to eliminate deposit forming materials and to the treatment of those minute quantities which enter the boiler so as to render them harmless. Feedwater treating equipment is used to eliminate, insofar as possible, the deposit forming materials. Internal treatment is used to protect the boiler against upsets in the feedwater treating system. The type of feedwater treating equipment may include clarification, end filtering, cold or hot lime soda softeners, zeolite softening, demineralises, or evaporators.

There are various methods used for the internal treatment of boiler water. The final decision as to the type of treatment to be used in a particular boiler should be based on

the quality of make-up water, the percentage of make-up water, and the nature of the condensate returns to the boiler. In any case, internal treatment should not be substituted for feedwater treatment.

The most common form of corrosion is that caused by the pressure of oxygen in the boiler water. One common approach to this position is the prevention of dissolved oxygen in the water by the use of deaerating feedwater heaters. Sodium sulphite or hydrazine may also be used to remove trace quantities of oxygen entering the boiler.

The carry-over of boiler water solids with the steam may result from mechanical carry-over or vapour carry-over.

Mechanical carry-over is the entrainment of small droplets of boiler water in the steam. Since these small droplets contain boiler water solids in the same concentration as the boiler water, the amount of impurities carried over with the steam varies with the steam varies with the amount of solids carried in the boiler water. This is one reason for limits on boiler water solids.

Among the causes of mechanical carry-over are high water level, high boiler water solids, high alkalinity, oil, or other organic material. Operation at loads in excess of the boiler design rating will provide more carry-over than operation within the design rating. Sudden load changes and water level upsets may cause temporary carry-over.

Vaporous carry-over is the vaporisation of boiler water solids. It is a function of temperature. Since silica is one of the common sources of troublesome vaporous carry-over the recommended boiler water silica limits are reduced at higher pressures.

The amount and frequency of blowing down is determined from a chemical analysis of the boiler water. The use of the steam drum continuous blowdown permits discharge of small quantity of water continuously and allows easy adjustments of the quantity of blowdown as called for by routine chemical analysis of the water.

With the TEGB, a dispersant –type water treatment MUST be adopted. A water treatment chemistry that causes precipitates to form cannot be permitted with this type of boiler. The water treatment chemistry adopted must fulfil the following requirements:

- Keep dissolved solids in solution
- Keep insoluble solids in suspension
- Redisperse any precipitates formed during periods of inadequate dosing and ensure that there is NO sludge in the bottom of the boiler.

The nature and extent of the dosing necessary to achieve these requirements and to meet the recommended boiler water conditions (BS 2489: 1977 recommendations for 40 bar g boiler operation) will depend largely on the quality of the boiler feedwater. The recommendations of a water treatment specialist should be sought and followed.

The recommended water chemistry requirements will make the wetted steel surfaces very clean and so will make carbon steel extremely susceptible to corrosion in the

presence of oxygen. Therefore, good deaeration is a must at all times for this method of treatment. Air must not be permitted to enter the steam drum during cooling and storage periods. During out-of-service periods, the steam drum should be flooded with water and kept flooded by the use of an overhead surge tank or a source of nitrogen must be connected to the stream drum vent and the steam drum pressurised with nitrogen.

For the TEGB it is understood that Nalco have recommended one of their Transport Plus chemicals to provide cleaning and to maintain solids in suspension in the boiler water.

3. INSPECTION AND MAINTENANCE

3.1 Inspection and Maintenance

Normally the boiler will be maintained free, such maintenance on the boiler being limited to renewal of joints at manhole doors etc.

Valves, safety valve, check valves, instrumentation etc, level gauge glasses, 'T' damper unit, should be inspected during the shut-down period in accordance with the manufacturers instructions and insurance and statutory requirements.

The boiler should be taken out of service periodically for routine inspection and, when necessary, cleaning, inspection intervals are usually dictated by insurance requirements. The inspection is to check on the condition of the boiler and furnace and the results of water treatment. The initial inspection should be made after approximately one mouth's operation. Subsequent inspection should be made at intervals based on the condition of the boiler at the last inspection and on the duty imposed on the boiler since the last inspection.

FOR THE PROTECTION OF THE PERSONNEL MAKING THE INSPECTION CERTAIN PRECUATIONS ARE NECESSARY:

Isolate the gas side of the boiler completely by inserting the blanking plate at the burner inlet from the bypass damper, to prevent any possibility of hot or asphyxiating gas from the gas turbine from entering the boiler when personnel might be inside.

Before entering the steam drum, windbox, furnace or any ducts, be sure that there has been completely purged of combustible and dangerous gases, the area is properly ventilated, and the entrance cannot be closed. Station a man at the entrance, notify a responsible person, and run an extension cord through the entrance. Operating and maintenance personnel should know when someone is in the boiler.

Never enter the steam drum or lower drum until all steam and water valves, including drain and blowdown valves, have been closed and locked or blanked. It is possible for steam and hot water to back up through drain and blowdown piping, especially when more than one boiler is connected to the same drain or blowdown tank.

Before removing any manhole cover plates, be sure that the unit is completely drained and all pressure and vacuum is off the unit.

Use low voltage extension cords or cords with properly connected grounds. Bulbs on extension cords and flashlights should be explosion proof.

Never use toxic cleaning fluids such as carbon tetrachloride in confined spaces.

Before inspecting or working on power driven equipment, be sure that the power is turned off and the equipment had come to a complete stop. Always open circuit

breakers and lock open. Any type of equipment that can be set into motion should be locked in place with a clamp or locking device.

The waterside inspection should include the drum, any drum baffles or internals, all connections to the drum, and tubing, where visible and accessible. Look for the signs of corrosion and scale, which may be caused by water conditions. If conditions attributed to water conditions are found, then the water treating process should be reviewed.

The method of removing deposits such as scale and sludge depends on the nature of the deposits. Some deposits may be removed by water washing while others may require turbining or acid cleaning. If acid cleaning is required, an experienced chemical cleaning firm should be retained to perform the cleaning without hazard.

During the inspection, signs of server operating conditions should be looked for. Low water or loads above design may cause overheating and discoloration, tube blowing, swelling, cracking or tube seats leaks.

Drum cracking is a rare occurrence. It is important to differentiate between actual and apparent cracking since most indicated cracks turn out to be slag inclusions, pitting, or tool marks, brought to attention by etching as a result of acid cleaning. If there is doubt, various tests can be made to determine if cracks exist. The ultrasonic or magnaflux test may be used or the indicated crack may be removed by grinding. All abnormal conditions should be investigated, repaired, and their cause corrected. Of course, the method of repair must have the approval of the insurance carrier and local inspectors.

Particular care should be taken to see that all connections are clear of sludge, especially the water column connections and pressure gauge connections.

When entering the furnace, care should be taken not to damage the insulating brick in this area. Wooden sheeting or planking should be put into the furnace before entering, and all persons entering the furnace should stand only on the sheeting.

In inspecting the fireside of the tubes and drums look for signs of overheating, leakage, erosion and corrosion. The tubes in the superheater evaporator and economiser banks can be inspected from the space between these banks; manholes in the boiler casing between the superheater and the evaporator, between the evaporator and economiser, and after the economiser, provide access for inspection.

Any cleaning of the boiler-heating surface may be accomplished by either brushing, scraping, air lancing or water washing. Cleaning of refractories around the burner should be minimised. Cleaning of slag from this refractory surface is normally unnecessary and will eventually tear away refractory and require its replacement.

The fire side inspection should also include the burners. Separate instructions are included for the burners.

Any evidence of hot spots or corrosion of the casing should be investigated and repaired as required.

Field wielding of structural attachments of the tubes or headers (pressure parts) of a boiler is not permitted because of potential metallurgical problems the welding may cause. Where it is necessary to make attachments welds, in particular to drums, the appropriate welding and heat-treating procedure must be in accordance with approved TRD code procedures. An alternate solution to a structural problem does not require pressure part welding is preferable because the three dimensional expansion of the boiler need not be a consideration in the structural design. Additional information can be obtained from the Service Department of HDS Energy Ltd.

Separate maintenance instructions are provided for the burners, fans, gauge glass, valves, and controls. Leaking valves should be lapped or repacked as necessary. Instruments and controls should be inspected, cleaned and recalibrated if required by qualified personnel.

3.2 Conservation

Both the gas and water side of a boiler should be protected against corrosion during out-of-service periods. In cases where the idle boiler may be required for service on the short notice, the wet storage method is recommended. When it is known that the boiler will be idle for six months or more the dry storage is preferred.

3.2.1 Wet Conservation by means of heating system

Boilers kept in wet storage may be put into service with minimum notice; drain water from the boiler until normal start-up levels are attained and the boiler is ready for start-up.

Where heating steam is available, the boiler can be kept at approximately 105-110^{o}C by holding a steam pressure of 0.2-0.5-bar g. Air, and hence oxygen, is prevented from entering the boiler by the steam pressure, the consequent heat also helps by preventing condensation on the gas side of the boiler. This method of conservation is sometimes referred to as ‘thermal degassing’.

During conservation using steam, the gas turbine bypass damper should be kept open to the bypass stack, i.e. closed to the boiler.

3.2.2 Wet conservation with chemicals.

No unit should be wet stored if there is any possibility of the ambient temperature dropping below the freezing point of water. Deaerated, demineralised water treated with hydrazine to a concentration of 500 ppm, as an oxygen scavenger, and ammonia to a concentration of about 10 ppm, to provide a boiler water pH slightly greater than 10, should be used to fill the boiler. The boiler should be filled through the regular feedwater connection until water appears at the steam drum vent. Where preferred, sodium sulphite (Na_2SO_3, 250 ppm if anhydrous or 500 ppm if hydrated) may be substituted as an oxygen scavenger and caustic soda (NaOH) may be substituted for ammonia as a pH regulator.

When deaerated water is not available, deaeration may be achieved by steaming the boiler after filling.

After the unit is completely filled with treated water close the vents and connect a 0.5 bar g supply of nitrogen to the vents to prevent air from entering the system. In some cases, an expansion tank or surge tank above the drum elevation may be required to accommodate volume changes due to temperature changes. The ammonia and hydrazine are not required for short periods of less than two weeks; however, the nitrogen blanket is recommended along with sodium sulphite to prevent oxygen corrosion. Approximately, 8 ppm sodium sulphite is required to remove one ppm of oxygen.

Boilers can be kept in wet storage for years without corrosion if they remain flooded with the recommended chemical concentrations and the nitrogen blanket. It is recommended, however, that the boiler be drained every six months for an internal inspection and that the sulphite or hydrazine content is checked at least once every three months. Additional quantities of the conserving chemicals should be added if the concentrations fall below or 5 mg/l hydrazine or 50 mg/l of sodium sulphite.

3.2.3 Dry conservation

Boilers kept in dry storage must be completely dry. After the water side has been cleaned of deposits and filled with treated water, the boiler should be fired until the pressure is at least 10 bar g to be sure that all components are hot. Reduce the pressure and drain the boiler as quickly as possible at a pressure of approximately 0.5-1.0-bar g. All drains and vent, including water column and gauge glass drains, must be open during the draining period. Any water remaining will be evaporated by the stored heat in the boiler metal.

The remaining vapour must be removed by purging with nitrogen, or by removing the drum manhole covers and letting air circulate through the boiler. When the unit has cooled, drain and clean out any remaining sludge in the boiler, paying particular attention to the tube panel headers and the top and bottom main headers.

Once the boiler had been cleaned and dried, place trays of non-corrosive desiccant in the steam drum and close all manhole cover plates and vents and drains. The desiccant should be inspected every three months and replaced as necessary. In addition, the air inside the boiler should be displaced with nitrogen and a positive nitrogen pressure maintained on the boiler throughout the storage period.

3.2.3.1 Suitable desiccants

Suitable desiccants include:

Calcium chloride, approx 5 kgs per 100 sq.m heating surface

Silica gel, approx. 5 kgs per 100 sq.m heating surface (this is more expensive than calcium chloride, however, it can be dried at temperature above 1100C again, whereas calcium chloride becomes liquid and consequently cannot be reused)

Quick lime, approx. 10 kgs per 100 sq.m heating surface (this is the cheapest desiccant)

3.2.4 Protection of gas side during storage
Gas side corrosion of an idle boiler can cause considerable damage, especially when high sulphur fuels are used.

The residue from sulphur bearing fuels contains sulphur dioxide. When the sulphur dioxide is absorbed in moisture, a dilute acid is formed which is very corrosive. In preparing the boiler for storage these accumulations must be removed by either blowing with air lances, washing with water, by scraping or brushing. In most cases the deposits cannot be completely removed by mechanical means and must, therefore, be neutralised with alkaline water. The alkaline wash should be continued until the water leaving the boiler is completely neutralised. Litmus paper may be used to determine the acidity of the wash water leaving the boiler; if the wash water leaving the boiler turns litmus paper red, there is still acid present in the boiler.

After the flushing operation has been completed, the boiler should be filled with treated water and fired with low sulphur fuel to completely dry the setting. During the storage period it may be necessary to use auxiliary heaters and blowers to maintain the metal temperature above the dew point. These auxiliary heaters and blowers are also necessary to prevent freezing when the wet storage method is used and the temperature is likely to fall below freezing.

In areas with extremely corrosive atmosphere, all machined surfaces on fuel burning equipment should be protected with a preservative coating.

Throughout the storage period, make sure that no fuel leaks into the boiler setting. It is, therefore, recommended that all oil and gas connections to burners be disconnected.

3.3 Troubleshooting
A basic guide to fault finding is given in Appendix 6: Actions on Alarms. This describes the principal causes of each of the alarm and trip indicators on the boiler control panel, together with the areas of equipment to be examined to rectify the alarm or trip.

APPENDIX 1
START-UP VALVE SCHEDULE

Introduction

This section contains a list of the valves associated with each system on the boiler. It is divided into three sections:

1. A list of each individual valve as it occurs on each system
2. A list of the automated process valves
3. An initial start-up checklist.

Part 1 lists all the valves on the boiler. In normal operation valves to instrumentation etc, will always remain open unless there is a specific reason to close them.

Part 2 deals with the process valves, which are controlled automatically by the control system. It will be part of normal start-up procedure to physically check these valves before putting the boiler on line. These valves are also listed in the complete valve schedule in part 1.

Part 3 gives a summary of all checks required prior to an initial start-up.

Part 1: List of all Valves
Part 1A: On the boiler

CLOSED	OPEN
BF6 Feedwater bypass valve	BF3, BF5 Feed water block valves
MS2 Main steam block valve	MS6 Superheater drain
MS23 Steam pressure control valve	MS14, MS36 Steam drum vents
	MS16 Superheater outlet vent (close once steam export is commenced)
	MS19, MS19A Superheater pressure gauge block valve
	MS37 Main steam block valve drain
	MS38, MS38A Boiler drum pressure gauge block valve.
DL2A Gauge glass drain	DL1, DL2, Gauge glass water and steam
DL16, DL19 Level alarm pots drain valves	DL14, DL15, DL17, DL18 Level alarm pots isolating valves.
BD11 Lay up chemical dosing isolating valve	BD1 Continuous blowdown isol. valve.
	BD4 Continuous blowdown control valve
	BD6 Sample isolating valve.

Part 1 B: On the R+V Control System

Section 1 – FD Fan (Combustion Air) & Seal Air System

There are no valves associated with the electrically driven FD fan on the TEGB

CLOSED	OPEN
	A23 Seal air valve

Section 2 – Auxiliary Air System

CLOSED	OPEN
	X25 Igniter supply
	X27, X29, X31, Pipe bushing supplies
	X33 Sight glass supply
	X35, X37 Flame scanner supplies

Section 3 – Main Gas System

CLOSED	OPEN
M03 Nitrogen valve	M01 Main fuel gas supply valve
M16 Gas vent valve 1	M05 Instrument valve
M16A Gas vent valve 2	M08 Instrument valve
M17 Main gas block valve 1	M10 Instrument valve
M21 Main gas block valve 2	M31 Instrument valve
M26 Main Gas control valve large	M33 Instrument valve
M37 Main Gas control valve, small	M35 Instrument valve
	M25 Burner Gas block valve

Section 4 – Support Gas System

CLOSED	**OPEN**
U03 Nitrogen valve	U01 Support gas supply valve
U09 Gas vent valve 1	U05 Instrument valve
U09A Gas vent valve 2	U08 Instrument valve
U10 Gas Block valve 1	U23 Instrument valve
U14 Gas Block valve 2	U20 Instrument valve

Fixed valves	
U18 Flow Control valve	Support gas flow adjustment by R&V

Section 5 – Igniter Gas System

CLOSED	**OPEN**
G02 Nitrogen Valve	G01 Ingniter gas supply valve
G03 Igniter gas block valve 1	G07 Instrument valve
G04 Igniter gas block valve 2	G08 Igniter gas supply valve

Fixed Valves	
G05 Gas pressure control valve	Igniter gas flow adjustment by R&V

Section 6 – Distillate Oil Supply System

CLOSED	OPEN
L03 Drain valve	L01 Oil Supply valve
L15 Vent valve	L05 Instrument valve
L16 Oil block valve 1	L07 Instrument valve
L20 Oil block valve 2	L25 Instrument valve
	L27 Instrument valve
	L29 Instrument valve
	L30 Oil supply valve

	Minimum setting
	L11 Oil pressure control valve

Section 7 – Oil Gun Purge System

CLOSED	OPEN
P05 Purge air to oil system valve	P01 Purge air supply valve
	P04 Instrument valve

Fixed valves	
P02 Purge air pressure control valve	Purge air pressure adjustment by R&V

Section 8 – Instrument Air System

CLOSED	OPEN
	Y01 Instrument air supply valve
	Y03 Instrument valve
	Y05 Instrument valve
	Y06 – Y10, Y25 Main and support gas valve actuator air supplies
	Y11 – Y13 Oil valve actuator air supplies
	Y14 Purge valve actuator air supply
Y28	Y17, Y27 Diverter damper actuator air supply
Y18	Y19, Y20, Y26 FD damper and seal air valve actuator supplies
Y30, Y31	Y21, Y29 Throat damper actuator air supply

Section 9 – Pressure Switch Rack

CLOSED	OPEN
X20 Condensation sight glass valve	A18 Instrument valve
	A19 Instrument valve
	A21 Instrument valve
	X14 Instrument valve
	X16 Instrument valve
	X17 Instrument valve
	X19 Instrument valve

Part 2: TEGB Process Valves

This is a list of the process valves directly bearing on the control of the TEGB

Part 2A: On the boiler

CLOSED	OPEN
MS23 Steam pressure control valve	

Part 2 B: On the R+V Control System

Most of these items are automatically operated by the burner control system.

Section 1 – FD Fan (combustion Air) & Seal Air system

There are no valves associated with the electrically driven FD fan on the TEGB

CLOSED	OPEN
	A23 Seal air valve

Section 2 – Auxiliary Air System

There are no process valves associated with the electrically driven Auxiliary Air Fan on the TEGB

Section 3 – Main Gas System

CLOSED	OPEN
M17 Gas block valve 1 (automated)	
M21 Gas Block valve 2 (automated)	
M26 Gas control valve, large (automated)	
M37 Gas Control valve, small (automated)	

Section 4 – Support Gas System

CLOSED	**OPEN**
U10 gas block valve 1 (automated)	
U14 Gas block valve 2 (automated)	

Section 5 – Igniter Gas System

CLOSED	**OPEN**
G03 Igniter gas block valve 1 (automated)	
G04 Igniter Gas block valve 2 (automated)	

Section 6 – Distillate Oil Supply System

CLOSED	**OPEN**
L16 Oil block valve 1 (automated)	
L20 Oil block valve 2 (automated)	

Minimum Setting	
L11 Oil pressure control valve	Minimum position fixed by R&V commissioning engineer.

Section 7 – Oil Gun Purge System

CLOSED	**OPEN**
P05 Purge air stop valve to oil system (automated)	

Section 8 – Instrument Air System

There are no process valves associated with the Instrument Air system on the TEGB

Section 9 – Pressure Switch Rack

There are no process valves associated with the Pressure Switch Rack on the TEGB

PART 3: INITIAL START – UP CHECKLIST

At the CHP Control Room side of the boiler:

1. Open the superheater steam trap isolating valve MS4
2. Open the superheater drain valve MS6
3. Open the superheater start-up vent fully MS16
4. Open the superheater pressure gauge isolating cock MS19, MS19A
5. Close the superheater pressure transmitter vent valve (red collar) MS17A
6. Open the superheater pressure transmitter block valve (blue collar) MS17A
7. Open the superheater pressure transmitter isolating cock MS17
8. Close the boiler main stop valve MS2
9. Open the main steam line drain valve downstream of the boiler main stop valve, ensure the line is fully drained, then close again MS37
10. Open the seam flow orifice transmitter isolating cocks MS9, MS10
11. Open the air supply to the boiler pressure control valve MS23A
12. Open the air supply to the feedwater regulating control valve MS23A
13. Check the boiler pressure control valve manual override is in the NEUTRAL position MS23
14. Open the steam trap isolating valve upstream and downstream of the boiler pressure control valve MS4A, MS4B
15. Open the steam trap bypass valve upstream and downstream of the boiler pressure control valve; ensure the line is fully drained, then close again MS6A, MS6B
16. Close the steam main pressure gauge blowdown valve MS35A (downstream of the boiler pressure control valve) and open the pressure gauge isolating cock MS35.

At the open (field) side of the boiler

17. Check that all three economiser drain cocks are closed and plugged BF16A, BF16B, BF16C.
18. Check that the boiler drain valve is closed and blanked BD10
19. Open feedwater flow orifice transmitter isolating cocks BF9, BF10, and close vents BF9A, BF10A
20. Open the economiser inlet isolating valve BF33
21. Close the feedwater flow regulator inlet isolating valve BF5; crack open the feedwater flow regulator bypass BF6 as necessary for start-up filling until the boiler has reached a pressure of 16 bar g; then close the bypass BF6 and reopen the isolating valve BF5 again.

At the top of the economiser

22. Check the both economiser vent cocks are closed and plugged BF13A, BF13B

At the front of the boiler drum (CHP Control Room end):

23. Open the gauge glass and 1st low level pot isolating valves DL1, DL12, DL14, DL15.
24. Close the gauge glass and 1st low level pot blowdown valves DL2A, DL16
25. Open the drum level transmitter and 2nd level pot isolating valves DL4, DL5, DL17, DL18
26. Close the 2nd low level pot blowdown valve DL19
27. Check the drum drain valve is closed MS21
28. Check the drum manhole for alignment and tightness
29. Open the drum vent (air release and anti-vacuum) isolating valve MS14
30. Open the drum pressure gauge isolating valve and needle valve MS38, MS38A
31. Open the drum steam outlet vent MS36

At the back of the boiler drum (field end):

32. Close the TDS sample cooler needle valve BD7
33. Open the TDS blowdown isolating valve and sample isolating valve BD1, BD6
34. Check the 2nd drum manhole for alignment and tightness
35. Check the feedwater inlet valve BF2 is fully open.

APPENDIX 2
VALVE TAG SCHEDULE

Introduction

This document contains a list of the principal valves on boiler TEGB for which valve tags have been provided, together with the text engraved on the tags and a description of each valve's location.

For valves on the burner system manufactured by Rodenhuis en Verloop b.v., refer to R&V P&ID drawing number 26205, pages 1-13.

Principal valves on the burner system:

VALVE DESCRIPTION	VALVE NUMBER	TAG REFERENCE
FD air dP switch isolating valve	A18	BH- TEGB- A18
FD air dP switch isolating valve	A19	BH- TEGB – A19
FD air dP transmitter valve block	A21	BH-TEGB-A21
	A23	BH-TEGB-A23
Aux air dP switch isolating valve	X14	BE-TEGB-X14
Aux air dP switch isolating valve	X16	BH-TEGB-X16
Aux air dP switch isolating valve	X17	BH-TEGB-X17
Aux air dP transmitter isolating valve	X19	BH-TEGB-X19
Condensate sight glass isolating valve	X20	BH-TEGB-X20
Igniter air isolating valve	X25	BH-TEGB-X25
Pipe bushing air seal isolating valve	X27	BH-TEGB-X27
Pipe bushing air seal isolating valve	X29	BH-TEGB-X29

Principal valves on the boiler (continued):

VALVE DESCIRPTION	VALVE NUMBER	TAG REFERENCE
Pipe bushing air seal isolating valve	X31	BH-TEGB-X31
Sight glass cooling air isolating valve	X33	BH-TEGB-X33
Flame scanner cooling air isolating valve	X35	BH-TEGB-X35
Flame scanner cooling air isolating valve	X37	BH-TEGB-X37
Main gas manual isolating valve	M01	BH-TEGB-M01 MAIN FUEL GAS SUPPLY
Nitrogen purge valve	M03	BH-TEGB-M03
Press indicator isolating valve	M05	BH-TEGB-M05
Press indicator isolating valve	M08	BH-TEGB-M08
Main gas vent isolating valve 1	M16	BH-TEGB-M16
Main gas vent isolating valve 2	M16A	BH-TEGB-M16A
Main gas block valve 1	M17	BH-TEGB-M17
Main gas block valve 2	M21	BH-TEGB-M21
Main gas manual block valve	M25	BH-TEGB-M25
Main gas control valve, large	M26	BH-TEGB-M26
Press indicator isolating valve	M31	BH-TEGB-M31
Press switch valve block	M33	BH-TEGB-M33
Press transmitter valve block	M35	BH-TEGB- M35
Main gas control valve, small	M37	BH-TEGB-M37

Principal valves on the boiler (continued):

VALVE DESCRIPTION	VALVE NUMBER	TAG REFERENCE
Support manual gas isolating valve	U01	BH-TEGB-U01 Support gas supply
Nitrogen purge valve	U03	BH-TEGB-U03
Press indicator isolating valve	U05	BH-TEGB-U05
Press indicator isolating valve	U08	BH-TEGB-U08
Support gas vent isolating valve1	U09	BH-TEGB-U09
Support gas vent isolating valve 2	U09A	BH-TEGB-U09A
Support gas block valve 1	U10	BH-TEGB-U10
Support gas block valve 2	U14	BH-TEGB-U14
Support gas pressure control needle valve	U18	BH-TEGB-U18
Press indicator isolating valve	U20	BH-TEGB-U20
Press switch valve block	U23	BH-TEGB-U23
Igniter gas manual isolating valve	G01	BH-TEGB-G01 IGNITER (PROPANE) GAS SUPPLY
Nitrogen purge valve	G02	BH-TEGB-G02
Igniter gas block valve1	G03	BH-TEGB-G03
Igniter gas block valve 2	G04	BH-TEGB-G04
Igniter gas pressure control needle valve	G05	BH-TEGB-G05
Press indicator isolating valve	G07	BH-TEGB-G07
Igniter gas manual block valve	G08	BH-TEGB-G08

Principal valves on the boiler (continued):

VALVE DESCRIPTION	VALVE NUMBER	TAG REFERENCE
Distillate oil manual isolating valve	L01	BH-TEGB-L01 DISTILLATE OIL SUPPLY
Distillate oil control valve	L11	BH-TEGB-L11
Distillate oil drain valve	L03	BH-TEGB – L03
Press indicator isolating valve	L05	BH-TEGB-L05
Press switch valve block	L07	BH-TEGB-L07
Air release vent valve	L15	BH-TEGB-L15
Press indicator isolating valve	L25	BH-TEGB-L25
Press switch valve block	L27	BH-TEGB-L27
Press transmitter valve block	L29	BH-TEGB-L29
Distillate oil block valve 1	L16	BH-TEGB-L16
Distillate oil block valve 2	L20	BH-TEGB-L20
Distillate oil manual block valve	L30	BH-TEGB-L30
Purge air manual isolating valve	P01	BH-TEGB-P01 PURGE AIR SUPPLY
Purge air pressure control valve	P02	BH-TEGB-P02
Press indicator isolating valve	P04	BH-TEGB-P04
Purge air stop valve to oil system	P05	BH-TEGB-P05
Compressed air manual isolating valve	Y01	BH-TEGB-Y01 COMPRESSED AIR SUPPLY
Press indicator isolating valve	Y03	BH-TEGB-Y03
Press switch valve block	Y05	BH-TEGB-Y05

Principal valves on the boiler (continued)

VALVE DESCRIPTION	VALVE NUMBER	TAG REFERENCE
Instrument air isolating valve	Y06	BH-TEGB-Y06
Instrument air isolating valve	Y07	BH- TEGB-Y07
Instrument air isolating valve	Y08	BH-TEGB-Y08
Instrument air isolating valve	Y09	BH-TEGB-Y09
Instrument air isolating valve	Y10	BH-TEGB-Y10
Instrument air isolating valve	Y11	BH-TEGB-Y11
Instrument air isolating valve	Y12	BH-TEGB-Y12
Instrument air isolating valve	Y13	BH-TEGB-Y13
Instrument air isolating valve	Y14	BH-TEGB-Y14
Instrument air isolating valve	Y18	BH-TEGB-Y18
Instrument air isolating valve	Y19	BH-TEGB-Y19
Instrument air isolating valve	Y20	BH-TEGB-Y20
Instrument air isolating valve	Y21	BH-TEGB-Y21
Instrument air isolating valve	Y25	BH-TEGB-Y25
Instrument air isolating valve	Y26	BH-TEGB-Y26
Instrument air isolating valve	Y27	BH-TEGB-Y27
Instrument air isolating valve	Y28	BH-TEGB-Y28
Instrument air isolating valve	Y29	BH-TEGB-Y29
Instrument air isolating valve	Y30	BH-TEGB-Y30
Instrument air isolating valve	Y31	BH-TEGB-Y31

Principal valves on the boiler (continued):

VALVE DESCRIPTION	VALVE NUMBER	TAG REFERNCE
Boiler feed water stop valve	BF2	BH-TEGB-BF2
Boiler feed water isol valve	BF3	BH-TEGB-BF3
Feed water regulator	BF4	BH-TEGB-BF4
Feed water regulator air supply isolating valve	BF4A	BH-TEGB-BF4A
Boiler feed water isol valve	BF5	BH-TEGB-BF5
Feed water regulator bypass	BF6	BH-TEGB-BF6
Feed water flow transmitter isolating valve	BF9	BH-TEGB-BF9
Feed water flow transmitter blow down valve	BF10	BH-TEGB-BF10
Feed water flow transmitter isolating valve	BF10A	BH-TEGB-BF10A
Feed water line drain valve	BF16	BH-TEGB-BF16
Economiser drain valve	BF16A	BH-TEGB-BF16A
Economiser drain valve	BF16B	BH-TEGB-BF16B
Economiser drain valve	BF16C	BH-TEGB-BF16C
BFP1 inlet isolating valve	BF18	BH-TEGB-BF18
BFP1 outlet isolating valve	BF21	BH-TEGB-BF21
BFP1 leak-off isolating valve	BF22	BH-TEGB-BF22
BFP1 balance isolating valve	BF35	BH-TEGB-BF35
BFP2 inlet isolating valve	BF23	BH-TEGB-BF23
BFP2 outlet isolating valve	BF25	BH-TEGB-BF25

Principal valves on the boiler (continued):

VALVE DESCRIPTION	VALVE NUMBER	TAG REFERENCE
BFP2 leak-off isolating valve	BF27	BH-TEGB-BF27
BFP2 balance isolating valve	BF36	BH-TEGB-BF36
Economiser feed water stop valve	BF33	BH-TEGB-BF33 FEED WATER STOP VALVE
Main steam stop valve	MS2	BH-TEGB-MS2 MAIN STEAM STOP VALVE
Steam trap isolating valve	MS4	BH-TEGB-MS4
Steam trap isolating valve	MS4A	BH-TEGB-MS4A
Steam trap isolating valve	MS4B	BH-TEGB-MS4B
Superheater drain	MS6	BH-TEGB-MS6
Steam main drain valve	MS6A	BH-TEGB-MS6A
Steam main drain valve	MS6B	BH-TEGB-MS6B
Steam flow transmitter	MS9	BH-TEGB-MS9
Steam flow transmitter blow down valve	MS9A	BH-TEGB-MS9A
Steam flow transmitter blow isolating valve	MS10	BH-TEGB-MS10
Steam flow transmitter blow down valve	MS10A	BH-TEGB-MS10A
Boiler drum vent	MS14	BH-TEGB-MS14
Start-up steam vent valve	MS16	BH-TEGB-MS16
Start-up steam vent drain valve	MS16A	BH-TEGB-MS16A

Principal valves on the boiler (continued):

VALVE DESCRIPTION	VALVE NUMBER	TAG REFERENCE
Steam pressure transmitter isolating valve	MS17	BH-TEGB-MS17
Steam pressure transmitter valve block	MS17A	BH-TEGB-MS17A
Pressure gauge isolating valve	MS19	BH-TEGB-MS19
Pressure gauge valve block	MS19A	BH-TEGB-MS19A
Drum intermittent blowdown	MS21	BH-TEGB-MS21
Steam pressure control valve	MS23	BH-TEGB-MS23
Steam pressure control valve air supply isolating valve	MS23A	BH-TEGB-MS23A
LP steam main pressure relief valve	MS27	BH-TEGB-MS27
BFP2 steam inlet stop valve	MS28	BH-TEGB-MS28 STEAM PRESS CONTROL VALVE
BFP2 steam control valve	MS29	BH-TEGB-MS29
BFP2 steam outlet stop valve	MS31	BH-TEGB-MS31
HP steam outlet stop valve	MS34	BH-TEGB-MS34
LP steam main pressure indicator blowdown valve	MS35	BH-TEGB-MS35
LP steam main pressure indicator blow down valve	MS35A	BH-TEGB-MS35A
Steam main drain valve	MS37	BH-TEGB-MS37
Drum press gauge isol valve	MS38	BH-TEGB-MS38
Drum press gauge needle valve	MS38A	BH-TEGB-MS38A

Principal valves on the boiler (continued):

VAVLE DESCRIPTION	VALVE NUMBER	TAG REFERENCE
Gauge glass isolating valve	DL1	BH-TEGB-DL1
Gauge glass isolating valve	DL2	BH-TEGB-DL2
Gauge glass isolating valve	DL2A	BH-TEGB-DL2A
Drum level transmitter isolating valve	DL4	BH-TEGB-DL4
Drum level transmitter isolating valve	DL5	BH-TEGB-DL5
Drum level transmitter isolating valve	DL10	BH-TEGB-DL10
Drum level transmitter isolating valve	DL11	BH-TEGB-DL11
Drum level alarm chamber 1 isolating valve	DL14	BH-TEGB-DL14
Drum level alarm chamber 1 isolating valve	DL15	BH-TEGB-DL15
Drum level alarm chamber 1 isolating valve	DL16	BH-TEGB-DL16
Drum level alarm chamber 2 isolating valve	DL 17	BH-TEGB-DL17
Drum level alarm chamber 2 isolating valve	DL18	BH-TEGB-DL18
Drum level alarm chamber 2 isolating valve	DL19	BH-TEGB-DL19

Principal valves on the boiler (Continued):

VALVE DESCRIPTION	VALVE NUMBER	TAG REFERENCE
Continuous blowdown isolating valve	BD1	BH-TEGB-BD1
Continuous blowdown control valve	BD4	BH-TEGB-BD4
Continuous blowdown sample isolating valve	BD6	BH-TEGB-BD6
Continuous blowdown sampling valve	BD7	BH-TEGB-BD7
Boiler drain valve	BD10	BH-TEGB-BD10

APPENDIX 3
BOILER INSTRUMENTATION

Introduction

To allow for the use of electronic controllers in the R&V system, and to meet modern safety standards for low water level protection, the following items have been fitted to the boiler.

LOW WATER LEVEL PROBES

This system consists of two vertical, tubular, stainless steel stilling chambers or ‘pots’, mounted alongside the gauge glasses and connected to them via isolating valves so that the drum level is also established in the chambers.

In each chamber, mounted vertically down form the top flange, there is a stainless steel probe cut to the requisite length so that its lower tip is at a specified distance below the drum centre line: 275 mm for the LH and 325 for the RH system.

If the water level is above the bottom of the probe then the electronics unit connected to the probe is satisfied and gives a VALID signal to the burner system.

If the water level falls below the end of the probe, or the self-checking electronic system detects a fault, thus a FALSE signal is sent to the burner system.

If only one of the probes becomes exposed then the burner is stooped, but allowed to restart automatically when the water level is again satisfactory.

If both probes become exposed then the burner is put into a LOCKOUT state and requires operator action to restart following restoration of adequate water level.

Probe Type:	NRG 17-11
Cut length of probes:	LH=855mm, RH=945 mm, to the assembled unit head shoulder. Note that the level of the flanges on the two tubes is not the same and the actual probe lengths take account of the difference.
Electronic Unit Type:	NRS1-7B
Manufacturer:	GESTRA (UK) LTD.

Drum Water Level Sensor/Transmitter

The Drum Water Level measuring system consists of a differential pressure sensor/transmitter connected via stainless steel impulses lines to the same tappings on the boiler steam drum as the gauge glasses and water level probes, with an equalising 'pot' in the drum steam connection to ensure a constant head of water in this line. Thus, changes in the drum water level will cause equivalent changes of pressure in the other impulse line, which are then converted by the sensor/transmitter to an output signal in the range 4020 mA.

The drum steam pressure is effectively applied to both impulse lines and so has no effect on the sensor differential pressure, and hence no effect on the final output signal.

The 4-20mA signal is fed into Controller 1 on the boiler panel to allow control of the water level by adjustment of the feedwater control valve, to give an indication on the controller of the actual water level, and to allow for High-High, High and Low water level alarms to be generated.

NOTE: **Care must be taken during blowdown of these impulse lines to ensure that live steam cannot reach the sensor itself. Excessive blowdown may result in false water level values being measured until the impulse lines are refilled with condensate**.

Differential Pressure Unit Type: IDP10-B

Range: 100-750mm WG=4-20mA

Manufacturer: FOXBORO

Boiler Steam Pressure Sensor/Transmitter

The final boiler superheater outlet steam pressure is measured by a conventional pressure sensor/transmitter, which gives a 4-20mA signal representing steam pressure over the range 0-40bar g.

The sensor is connected to the boiler steam superheater pressure outlet via a stainless steel impulse line so designed to fill up with relatively cool condensate and thus prevent 'live', and therefore hot, steam actually coming into contact with the sensor itself.

Pressure Unit Type: IGP10-E

Range: 0-40bar g = 4-20 mA

Manufacturer: FOXBORO

Note: **Care must be taken during blowdown of the impulse line to ensure that live steam cannot reach the sensor itself.**

Feedwater Flow Sensor/Transmitter

The feedwater flow is measured using a Differential Pressure Sensor/Transmitter of similar type to that used for the drum water level measurement.

The differential pressure is developed across an orifice plate in the feedwater line. The pressure on each side of the orifice plate is connected to the sensor/transmitter by stainless steel impulse lines, which fill up with relatively, cool feedwater.

The static feedwater pressure is applied to both sides of the sensor and so does not affect the resultant output caused by the differential pressure.

Note: Care must be taken during blowdown of these impulse lines to ensure that the hot feedwater cannot reach the sensor itself.

Differential Pressure Unit Type:	IDIP10-B
Range	0-1000 inches WG=0-15t/hr = 4-2-mA
Manufacturer	FOXBORO

Steam Flow Sensor/Transmitter

The steam flow is measured using a differential pressure sensor/transmitter of similar type to that used for the drum water level measurement.

The differential pressure is developed across an orifice plate in the steamline, the pressure on each side of the orifice plate is connected to the sensor/transmitter by stainless steel impulse lines, which fill up with condensate for protection of the sensor.

The static steam pressure is applied to both sides of the sensor and so does not affect the resultant output caused by the differential pressure.

Note: Care must be taken during blowdown of these impulse lines to ensure that live steam cannot reach the sensor itself.

Differential Pressure Unit Type:	IDP10-B
Range:	0-1000 inches WG=0-15t/hr = 4-20mA
Manufacturer:	FOXBORO

Temperature Sensor/Transmitters

The various temperatures are measured using a platinum resistance sensor.

Temperature Sensor Unit Type:	PT100
Range:	$0\text{-}300^0$C=4-20mA all except steam temp. $0\text{-}400^0$C=4-20mA steam temperature only
Manufacturer:	Bush, Beach, a division of Hartmann & Braun(UK)Ltd

Boiler Water TD System

The boiler water TDS is measured by a suitable transducer mounted in a pipe connected to the boiler drum. A small flow of water continuously passes the probe to ensure that it sees a representative sample of the boiler water. The probe is connected to a display/control unit mounted on the R&V burner panel.

For checking and calibration purposes a sample of the boiler water can be taken, via sample cooler, from the same tapping point on the boiler drum as the conductivity p robe.

The controller shows the time of day, an indication of the measured TDS value and whether the blowdown valve is being driven in the open or closed direction. Alarm indications are also provided if the measured value exceeds a HI or LO operator adjustable value.

TDS Probe Type:	ERL 16
Controller Type:	LRR1-10
Controller Display Range:	0-9999ppm
Manufacturer:	GESTRA (UK) ltd

For full details of the above sensor/transmitter and associated items refer to the relevant data sheets as part of the full documentation for the boiler.

Procedure for blowing down the Impulse Lines

The following procedure should be adopted when blowing down the impulse lines from any of the following sensors:

- Drum level
- Steam Flow
- Feedwater Flow

Controller 1, the water level controller, be put into **M**anual Mode.

The **feedwater valve** will then remain a the same position, irrespective of the signals generated by any of the three above items. However, there could still be alarms generated by the controller for Low, High and High-High water levels, but these will not have any direct effect on the boiler operation.

AND

Controller 2, the steam load Controller, be also put into **M**anual mode.

The **fuel request,** and hence the **firing rate** of the burners, will then remain fixed at that value irrespective of any changes in the steam flow signal.

Following blowdown of the impulse lines, and time allowed for them to regain normal operational status, both the controllers should be returned to **A**uto mode.

During the time the controllers are on **M**anual then the operator should carefully monitor the steam flow and pressure values and also the condition of the boiler water level using the conventional gauge glasses, and take any corrective action deemed necessary to maintain the boiler in a safe condition.

Low Water Level Alarm – Override Description and Testing Procedure

A Low Water Level Alarm Override system has been installed on boiler TEGB.

The system is designed to allow proving of the Low Water Level Probes, and blowdown of the gauge glass, without a trip of the burner system. An independent override system is provided for each of the two Low Water Level Probes.

The system is designed so that only ONE of the override mechanisms can be activated any time, thus retaining security of low water protection via the other probe during the testing of a probe.

A period of 5 minutes has been set for each override timer, this period gives adequate time for the required operations to be performed.

A separate Watchdog timer checks that any override is released within 10 minutes. If either override is still active beyond 10 minutes then an alarm is generated and both the override actions are disabled by contacts of the watchdog system.

OPERATIONAL TEST PROCEDURE

1. Press the button on the left hand enclosure, labelled TEST STATION A
2. The red indicator should flash to confirm that the level alarm is overridden.
3. Close the lower, or Steam Drum Waterside, valve to the level pot, see diagram on next page.
4. Open the Stilling Chamber Blowdown valve on the level pot. Verify that water/steam issues from the pipe near ground level.
5. Wait for confirmation that the water level in the pot has fallen and that the probe has detected the low water level – signified by the red indicator changing from flashing to steady illumination. The change should occur within 10 seconds or so.
6. Close the stilling Chamber blowdown valve and re-open the Steam Drum Waterside valve on the level pot. As the water level is re-established in the pot then the red indicator should resume flashing, again within a reasonable period, 10 seconds or so.
7. Close the Upper, or Steam Drum Steamside, valve to the level pot and then open the Stiling Chamber Blowdown valve. Allow a short period for the pipes to blowdown, there may not be any effect on the red indicator. Verify that water/steam issues from the pipe near ground level.
8. Close the stilling Chamber Blowdown valve and re-open the Upper, or Steam Drum Steamside, valve. Wait until the red indicator resumes flashing if not already in that state.

CAUTION

If the procedure up to this point has taken a substantial portion of the 5 minutes allowed time, then wait until the red indicator goes out and press the Start button again before proceeding to the next step.

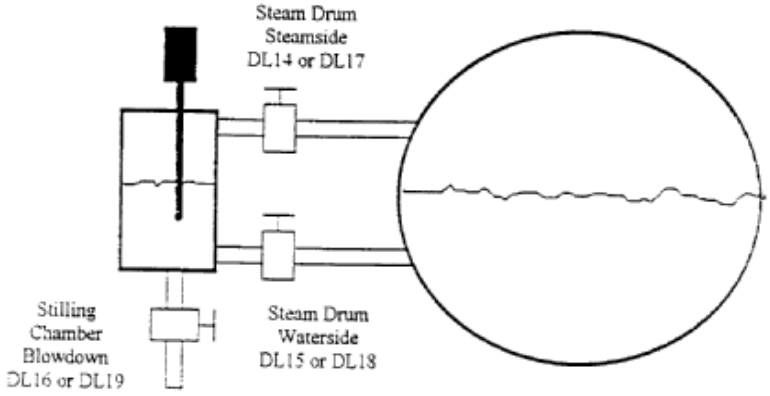
9. Blow down the gauge glass as per normal procedure and then return the valves to normal. There may be an effect on the adjacent water level pot during the gauge glass blowdown such that the red indicator goes steadily this is not a problem. Verify that the red indicator resumes flashing within a reasonable period after the gauge glass valves are returned to normal.

10. Verify that the red indicator goes out after about 5 minutes from the time at which the override timer was last started

11. The above procedure, using items 1-8 only, should now be performed on the right hand level pot using the enclosure labelled TEST STATION B.

12. Record that the above tests have been completed successfully in the boiler logbook.

The diagram below identifies the three level pot valves referenced in the above text.



APPENDIX 4
CONTROL SYSTEM

Control System

This section contains a summary of the control system on the new boiler, TEGB.

The notes are broken up into six parts.

Parts 1-4 each describe one of the four T640 controllers in the boiler control panel. A brief outline of each controller and its function is given, as well as a schematic giving an overall view of the controller system and the major inputs and outputs. The schematic should be used in conjunction with the controller descriptions.

Part 5 describes the interaction and control of the Diverter Damper, FD fan and Seal Air Fan systems

Part 6 describes the interlock signals between the turbine control system and the boiler/burner control system.

For more technical details and descriptions the Rodenhuis en Verloop manual should be consulted, however it should be noted that some details may vary during the commissioning process.

Any queries should be addressed to the Process coordinator.

Part 1 – Controller No. 1

Drum Level Controller

The drum level controller receives two analogue input signals from the boiler, one analogues input signal from Controller 2 and three logic signals. The signals are:

1. Feedwater flow
2. Water level indication
3. Compensated steam flow
4. Inhibit F/W Valve
5. A burner in operation
6. Diverter Damper Open Status

Loop 1 of the controller controls the feedwater flow to TEGB.

The controller may be operated in either:

1. ***R****emove mode* – this means that the required feedwater control valve position is calculated by the PID algorithm in the controller using the drum water level, actual feedwater flow and compensated steam flow. The compensated steam flow is determined in controller no.2 and retransmitted to this controller. The indicated setpoint value will vary somewhat as the steam load varies but will always be 435mm (100 mm above the drum centreline) if there is no burner active and the Diverter Damper is in the bypass position.
2. ***A****uto Mode* – this means that the feedwater flow to the boiler is calculated by the PID algorithm using only the drum water level and the operator defined setpoint. If auto mode is selected from remote mode then the water level setpoint will have the same initial value as was active in remote mode.
3. ***M****anual mode* – This means that the PID algorithm is disabled and the output to the feedwater control valve is determined by the operator via the manual control on the controller. If manual mode is selected from either remote or auto mode then the controller output will have the same initial value as was active in the previous mode. If the signal from the drum water level sensor fails then the controller will be forced into this mode.

Water Level

The normal operating level is 100 mm above the centreline of the drum, i.e. 435 mm on the 0-670 mm range on the controller.

Feedwater Pump Inhibit

If the water level rises above a value of 500 mm on the controller indication the feedwater pump is stopped and only re-enabled when the level has fallen below 450 mm.

Feedwater Valve Inhibit

During normal operation of the TEGB boiler the Steam Outlet valve is controlled so as to maintain the boiler steam pressure at a desired setpoint.

To minimise disturbance on the Steam Header when there is a problem with the heat input to the TEGB, e.g. a turbine trip when in TEG mode or a burner trip in auxiliary mode, the steam outlet valve is controlled so as to provide a steadily reducing steam flow into the steam header.

To maximise the available steam during this period the feedwater valve is closed by forcing the setpoint to 250 mm so as to prevent relatively cold water entering the boiler and reducing the available heat for steam generation.

This action is initiated by the INHIBIT F/W VALVE signal from Controller 2, but which is only allowed to keep the setpoint at 250 mm if the water level is at least 20 mm above the Low alarm level of 200 mm, i.e. 95 mm below the drum centreline. Below this level the valve is returned to normal operation until the level rises by more than 50 mm when the inhibit may be again applied if the INHIBIT F/W VALVE request from Controller 2 is still active.

Alarms

There are three panel alarms:

1. High-High – set at 265 mm above the drum centreline, i.e. 600 mm on the controller.
2. High - set at 215 mm above the drum centreline, i.e. 550 mm on the controller
3. Low -set at 115 mm below the drum centreline, i.e. 200 mm on the controller.

There are 4 controller alarms in Loop 1:

1. Failure of the water level sensing signal. The controller is forced into the Manual mode with the output staying at the previously good value. The text hardware is displayed on the controller fascia.
2. A deviation alarm when the difference between the setpoint and the actual water level is excessive. The text DevAlm is displayed on the controller fascia.
3. A low alarm when the water level signal falls below 0 mm. The text LoAlm is displayed on the controller fascia.
4. A high alarm when the water level rises above 650 mm. The text HiAlm is displayed on the controller fascia.

Monitors

Loop 4 provides a Feedwater Flow monitor in t/hr.

Recording

The feedwater Flow signal is restransmitted to channel 2 of the TEGB recorder as a 4-20 mA signal indicating a value in the range 0-15 t/hr.

Part 2 – Controller no. 2

Steam Flow Controller

The steam flow controller receives four input signals from the boiler and three logic signals.

The signals are:

1. Master Pressure Control Steam Demand requirements
2. Steam Flow
3. Steam Temperature
4. Drum Pressure
5. Main Gas burners in operation
6. Oil burner in operation
7. Diverter Damper Open

Loop 1 of the controller contains a PID control loop with a compensated steam flow correction calculation.

Loop 2 contains the Excess Pressure program

Loop 3 contains the program for the control of the Steam Outlet Valve.

Steam Flow Control

The Steam Flow loop of the controller for Auxiliary Firing Mode may normally be selected to operate in either

1. ***R****emote mode* – In normal operation, when in Auxiliary Firing Mode and in remote mode, the controller receives an input from the Master Pressure Controller (MPC) and this sets the % firing rate for the system. This load demand set point is transferred to controller no. 4, which calculate the fuel requirements for the Fuel Gas controller (no.3) and the Fuel Oil controller (no.4). However, if the MPC signal fails, the controller is forced out of the remote mode and into Auto mode when the previous steam flow becomes the setpoint.

2. ***A****uto mode* – In auto mode the operator is able to change the steam flow set point via the controller. The changeover from Remote to Auto mode is 'bumpless', the last MPC signal being the new auto set point. The controller will adjust the load demand signal to controller 4 so as to maintain the required steam flow.

3. ***M****anual mode*- in manual mode the operator is able to set the fuel demand to five a fixed % firing rate. If manual mode is selected from either remote or

auto mode then the previous controller output becomes the initial manual output.

In the remote and auto modes for auxiliary firing there is also an EXCESS PRESSURE control system, which acts to reduce the demanded steam output, and hence the effective firing rate, if the boiler drum pressure exceeds an operator defined value. This excess pressure set point is available in Loop 2 of the controller with adjustment allowed between the limit of 20.00 and 30.00 bar g. The steam flow demand is reduced by 1.5 t/hr for each 0.2 bar in excess of the pressure set point.

The corrected steam flow value is calculated using Drum Pressure, Steam Temperature, and Boiler Steam Flow. If any of these signals fails then the controller is forced into the manual mode.

The steam Temperature is monitored for a high trip at 315^0C, this trip is intended for protection of the superheater tubes, which may be damaged by excessive temperature.

In TEG mode the heat input, and thus the steam output is steady state conditions, is controlled solely by the heat output of the gas turbine. The output of the Load Demand Calculation is held at a value, which matches the actual steam generation so as to minimise disturbances following a turbine trip.

Turbine Failure.

If the heat supply from the Gas Turbine fails then the auxiliary burner will be automatically fired used diesel as the fuel, assuming that the auxiliary burner is available and the boiler is in a suitable condition, e.g. no water level alarms.

Steam Outlet Valve Control

The TEG boiler will normally be operating at a pressure of about 30 bar g and supplying the steam header, which is at a pressure of about 10 bar g.

The pressure difference is allowed for by the use of a pressure control valve, which is adjusted by the program in loop 3 of the controller. The operator is allowed to set the required boiler operating pressure in this loop within the limits of 20.00-30.00 bar g.

Below boiler pressures of 15 bar g the valve will be fully closed.

As the boiler pressure exceeds 15 bar g the valve is progressively opened, but only when the required position is above 10% open. This mechanism is designed to prevent the type of damage to the valve seat known as ‘wire drawing’, which occurs when a valve is only open a small amount for an extended period.

As the boiler pressure rises the valve is driven further open such that the boiler pressure stabilises at the desired setpoint pressure.

The steam flow at this point will be the amount that the heat input to the boiler can sustain, and, if in TEG mode, will be a substantially steady value since the turbine is intended to run a constant 100% of its output.

Also if the boiler is operating in auxiliary firing mode then the Controller 2 will normally be in **R**emote mode under the control of the Master Pressure Controller signal, which will again be a substantially constant value.

If the Controller is an **A**uto or **M**anual mode then again the steam generation rate will be notionally constant.

However, if the heat input to the boiler does vary, the steam outlet valve will be adjusted so as to maintain the boiler pressure at the desired setpoint, when the actual steam generation rate and hence the supply of the steam header, will vary accordingly.

If there is a problem in the heat source, e.g. a turbine trip, then the valve is controlled to progressively reduce the steam flow to the header to allow the remaining boilers on the system to smoothly take up the load under the direction of the Master Pressure Controller system.

If the problem was a turbine trip then the auxiliary burner will normally be automatically commanded to fire and, as the boiler pressure again rises, the valve will revert to the pressure control regime. Since the support gas burner is normally also active in TEG mode there is no need for a furnace purge and so the auxiliary firing will occur within 30 seconds of the turbine failure.

However, if the auxiliary burner also fails, then the boiler pressure will continue to fall as the reducing steam supply is supplied to the header.

The valve will be commanded to close fully if the pressure falls below 15-bar g, again quickly as the controlled position becomes less than 8% so as to prevent the wire drawing damage potential. The 2% hysteresis between the minimum-value-on-opening and the minimum-value-on-closing is designed to prevent valve 'chatter'.

During this phase of operation, whilst there is no heat input to the boiler, this loop also outputs a digital signal of the Water Level Controller to request closure of the feedwater valve so as to make use of the stored heat in the boiler and so maximise the available steam supply to the header.

The feedwater valve inhibit request has a maximum period of 300 seconds but is removed if heat becomes available again and the boiler pressure starts to rise.

During the period of manual initiated changeover from auxiliary firing to TEG mode, on the reverse, the same procedure will apply to the steam pressure control valve.

Alarms

The controller has two panel alarms:

1. Steam Drum High pressure alarm set, at 31 bar g
2. Steam Temperature high alarm, set at 315^0C

There are 5 controller alarms in Loop 1:

1. Failure of the Drum Pressure, Steam Temperature or Steam Flow signal. The controller is forced into the Manual mode with the output staying at the previously good valve. The text Hardware is displayed on the controller fascia.
2. A deviation alarm when the difference between the setpoint and the actual steam flow is excessive. The text DevAlm is displayed on the controller fascia.
3. A low alarm when the steam flow signal falls below 0 t/hr. The text LoAlm is displayed on the controller fascia.
4. A high alarm when the basic steam flow signal rises about 15 t/hr. The text HiAlm is displayed on the controller fascia.
5. Failure of the Master Pressure Control signal which, if the controller was in Remote mode, will cause a change to Forced Auto with the indicator A flashing in the mode display are of loop 1. The set point for the Auto mode will that value which existed just prior to the failure of the Master Pressure Controller signal.

Monitors

Loop 1 provides a display of the boiler steam flow.

Loop 2 and 3 provide displays on the boiler steam pressure since it is used both for Excess Pressure (loop 2) and Boiler Pressure Control (loop3).

Loop 4 provides a monitor for:

1. The Master Pressure Control Signal, t/hr.
2. Steam Temperature, ^{0}C

Recording

The compensated Steam Flow is transmitted to channel 5 of the TEGB recorder as a 0-10 V signal indicating a value in the range 0-15 t/hr.

The Steam Temperature is retransmitted to channel 8 of the TEGB recorder as a 0-10 V signal indicating a value in the range 0-400^{o}C

Part 3 – Controller no. 3

Fuel Gas Flow Controller

This controller consists of four sections:

1. The Steam Temperature Correction controller
2. The Fuel Gas Flow controller
3. Propane/Butane Injection Compensation
4. The Pre Economiser Flue Gas Temperature monitor.

The Steam Temperature Correction Controller

The Steam Temperature Correction Controller is opened in loop 1 of this controller and consists of a Setpoint block and a PID block. The operator is allowed to set the desired Steam Temperature in the range 270oC to 29oC.

The Steam Temperature Correction controller operates only in the Auto mode. The PID algorithm will calculate the correction factor required for the burner process from the measurement of Steam Temperature, as also displayed in Controller 2.

The Steam Temperature Correction control is only able to reduce the combustion air flow from the normal value establishing during commissioning when in auxiliary fired mode, it has no effect in TEG mode.

If a Low Oxygen or a High Oxygen Deviation alarm occurs whilst in Auxiliary Firing mode then the Steam Temperature Correction is switched off to allow the normal FD air flow to be used for the actual firing rate at that time.

The output of the Steam Temperature Correction loop is passed to controller no. 4 for use in the FD fan control system.

Oxygen Alarms

To limit the gas temperature on auxiliary firing to about the same value as the turbine exhaust gases so that there is no damage to the superheater or screen tubes the amount of combustion air supplied is much greater than for a normal burner. Thus the amounts of oxygen measured in the flue gas will be correspondingly higher.

Each of the two oxygen measurements is monitored by a low alarm. The panel alarm is activated when the oxygen percentage is below 10%. A deviation alarm is activated when the deviation formula shows a value outside a predetermined range; the allowable deviation is larger at higher oxygen levels. Any alarm will disable the Steam Temperature correction and allow the pre-set, higher, combustion airflow.

An oxygen value below 10% for both of the measurements will cause a shutdown of the burners.

The Fuel Gas Controller

The fuel gas control is only enabled when the gas burner is in operation and there is no 'Gas Burner Pressure High' alarm. The fuel gas burner set point is determined by the Oil % calculator in controller no. 4. The fuel gas controller operates in loop 2 of this controller

The controller operates only in the ***R****emote* mode with the PID algorithm controlling the gas burner pressure, and hence the gas flow, via two valves operating over a split range. The range of valve 1 remaining fully open.

The PV input to this controller is scaled to match the load demand in MW.

The actual gas flow is retransmitted to controller no. 4 for use in the total fuel calculation.

If the fuel gas burner pressure input signal to the controller fails then the controller output is forced to zero and the operator is not able to adjust the value.

The gas burner pressure measurement is compensated for Propane/Butane supplementation, see below for details.

Fuel Gas Alarms.

There are no panel alarms from this controller for fuel gas conditions.

There are 4 controller alarms in Loop 2:

1. Failure of the gas pressure-sensing signal. The controller is forced into the ***M****anual* mode with the output at zero. The text **Hardware** is displayed on the controller fascia.
2. A deviation alarm when the difference between the setpoint and actual gas flow is excessive. The text **DevAlm** is displayed on the controller fascia.
3. A low alarm when the gas pressure signal falls below O kPa. The text **LoAlm** is displayed on the controller fascia.
4. A high alarm when the gas pressure rises above 325kPA. The text **HiAlm** is displayed on the controller fascia.

Propane/Butane Injection Compensation

The air pressure driving the propane injection valve is monitored and used to generate a 4-20 mA signal which is combined with a 4-20 mA signal representing butane flow in the Master Pressure Control panel to give a final 4-20 mA signal which is used via a characteriser in this controller to compensate for the increased calorific value of the main gas supply to the burner.

The **increasing** signal from the propane/butane measurements is used to **decrease** the effective gas flow so as to effectively maintain the same total heat input to the burner.

Direct and delayed signals are used to ensure that the compensation is active before the propane/butane gas reaches the burner and also stays active for a period of time after the injection has ceased to allow the propane/butane gas to be swept from the piping.

The effective % of HI CV injection is available for display in loop 3 of the controller.

If the propane/butane signal fails then it is assured to be 100% so as to give safe combustion conditions. The controller will generate a controller display panel alarm.

Monitors

Loop 3 provides a monitor for the Propane/Butane injection as % HI CV value.

Loop 4 provides a monitor for:

1. Oxygen from oxygen monitor 1, %
2. Gas burner pressure, kPa
3. Fuel gas flow, Nm^3/s
4. Pre Economiser Temperatures, ^oC

Recording

The Fuel Gas Flow is transmitted to channel 6 of the recorder as a 0-10 V signal representing a value in the range 0-1.0 Nm^3/s.

Part 4 – Controller no. 4

Oil Fuel Controller

This controller consists of four sections:

1. FD air Flow controller
2. Oil pressure control
3. Fuel oil/gas ratio setting and calculation
4. Oxygen measurement 2.

The FD Air Flow Controller

The FD fan is electrically driven at constant speed. The FD air flow is controlled by a modulating damper on the fan outlet.

The FD fan damper control loop, no. 1, has two characteristic function blocks, one for gas and one for oil. The gas block is selected when no oil burner is in operation otherwise the oil function block is selected. The program converts the measured FD air pressure into the equivalent airflow value.

The controller operates normally only in ***R****emote* mode. If the FD fan input signal fails the controller is forced into ***M****anual* mode. The output may not be adjusted by the operator, and the output from the controller goes to maximum to give maximum airflow to ensure safe combustion conditions.

When a furnace purge is required, or any burner is operating the FD fan damper output is forced to a minimum of 50% output. A 'greater than' switch selects between the larger of the fixed 50% minimum and the output of the PID blocks the FD fan Damper controller.

The set point for the FD Fan Damper controller is determined by a 'greater than' selector switch which selects between the Load Demand from Controller 3 and the effective sum of gas and oil fuel flows.

If the steam temperature correction is active, i.e. the temperature is lower than the setpoint, and then the correction signal effectively **increases** the measured FD air flow signal thus causing an actual **reduction** in the true air flow, which gives an increase in the furnace gas temperature.

Oil Fuel Controller

The set point for the oil fuel burner is calculated by the oil/gas load calculator as described below. The PID algorithm in loop 2 than determines the position of the oil burner valve to give the desired oil flow, as measured from the oil pressure at the burner. This loop operates only in the Remote mode.

If the oil burner pressure signal fails then the controller is forced into Manual mode with the output forced to zero. The operator is unable to adjust this value. The range of the final controller output to the diesel oil valve position depends on the oil burner status.

For the start-up of the oil burner the controller output is forced to a minimum of 40% by a 'greater than' selector switch which selects the greater of this minimum value and the PID value. The minimum value is designed to allow adequate filling of the oil burner gas during the time allowed for ignition.

Oil/Gas Ratio

This ratio can be set by the operator, using loop 3 of the controller, as a desired OIL % in the range 20-100%. The actual oil % displayed by the controller and will depend on the burners in operation and the requested Load Demand, taking into account the minimum oil firing, if oil is in use. The oil fuel PID controller is give a load requirement set point calculated from the total Load Demand from Controller 2 and the % set point for the oil. If only oil is in use then the oil load setpoint is the same as the total Load Demand, if only gas is firing then the oil load set point is made zero. The gas load set point is then calculated as the total Load Demand – the actual oil load.

The oil ratio loop only operates in Auto mode.

In general the lesser of the Load Demand and the available FD air is used to define the actual total load demand to the burners.

Second Oxygen Measurement/Low Alarm.

For the oxygen alarm system a second oxygen measurement value is monitored in this controller and retransmitted to controller no. 3. There is low alarm set point of 10% for the second oxygen measurement.

Alarms

The controller has one panel alarm on Low Oxygen

There are 4 controller alarms in loop 1:

1. Failure of the FD pressure sensing signal. The controller is forced into the Manual mode with the output at 100%. The text **Hardware** is displayed on the controller fascia.
2. A deviation alarm when the difference between the set point and the actual FD air flow is excessive. The text **DevAlm** is displayed on the controller fascia.
3. A low alarm when the FD air pressure signal falls below 0kPa. The text **LoAlm** is displayed on the controller fascia.
4. A high alarm when the FD air pressure rises above 1000 kPa. The text **HiAlm** is displayed on the controller fascia.

There are 4 controller alarms in loop 2:

1. Failure of the FD pressure sensing signal. The controller is forced into the Manual mode with the output at 100%. The text **Hardware** is displayed on the controller fascia.
2. A deviation alarm when the difference between the set point and the actual FD air flow is excessive. The text **DevAlm** is displayed on the controller fascia.
3. A low alarm when the oil pressure signal falls below 0kPa. The text **LoAlm** is displayed on the controller fascia.
4. A high alarm when the oil pressure rises above 800kPa. The text **HiAlm** is displayed on the controller fascia.

Monitors

Loop 4 provides a monitor for

1. FD air Flow, kg/s
2. Fuel Oil Flow, kg/s
3. Fuel Oil Pressure kPa
4. Oxygen percentage from oxygen monitor 2, %

Recording

The oil flow is transmitted to channel 7 of the recorder as a 0-10 V signal representing a value in the range 0-0.35 kg/s.

Part 5a – Diverter Damper System

The Diverter Damper controls the destination of the hot gases from the gas turbine.

The damper is andopen/closed' type and is not designed for modulation purposes, this it is normally only in one of the two 'end-of-travel' positions. The typical time for travel from one position to another position is 15 seconds. The actual driving force is generated by compressed air and controlled from the TEGB burner panel via solenoid valves according to the requirements of the boiler control logic, the status of the turbine and operator requests.

With the damper in the 'EXHAUST GAS DAMPER OPEN TO BYPASS' position i.e. vertical in the ductwork, the turbine exhaust gases are diverted vertically up the diverter chimney to the atmosphere and the inlet to the TEGB furnace duct is blocked.

With the damper in the 'EXHAUST GAS DAMPER OPEN TO BOILER' position, i.e. horizontal in the ductwork, the turbine exhaust gases are allowed to pass directly into the TEGB furnace duct and the outlet to the diverted chimney is blocked.

At each extremity of the damper travel there are dual limit switches to verify the actual position of the damper. If the damper does not reach the desired end position within the time allowed, 20 seconds, then an alarm is generated and, it the damper is stuck somewhere between the two extremes of travel, them both the turbine and TEGB will be shut down.

When the turbine/boiler system is operating the TEG mode the damper will be in the 'EXHAUST GAS DAMPER OPEN TO BOILER' position. The damper will be commanded to change the 'EXHAUST GAS DAMPER OPEN TO BYPASS' position for any of the following reason:

1. The GAS TURBINE RUNNING (i.e. heat available) signal from the turbine goes to the off status.
2. A problem develops in the TEGB, e.g. a low water level, which requires that the heat input be removed.
3. An operator request to go to the FD (i.e. Auxiliary Fired) mode.

If the reason for the change is not item 1 then the turbine may continue to operate since the damper will change position to allow the turbine exhaust gases to go up the diverter stack.

To allow for safe working inside the boiler furnace area with the turbine running, a separate metal blanking plate is available to be fitted after the diverter damper so as to completely sell off the burner furnace duct form the diverter damper duct.

Part 5b – FD Fan, Modulating Damper and Seal Air System

When the boiler is operating in the Auxiliary Fired mode the Diverter Damper is in the 'EXHAUST GAS DAMPER OPEN BY BYPASS' position and any hot gases coming from the turbine are diverted up the diverter stack to atmosphere.

The FD fan will be running to provide cold ambient air form combustion of the auxiliary fuel in the R&V burner, which is mounted in the furnace ducting. The amount of air required depends on the firing rate and is adjusted as required by use of a modulating damper mounted at the outlet of FD fan casing.

Any small leakage of FD air past the diverter damper towards the turbine will have no effect on the operation of the turbine and will just pass out to atmosphere with the turbine gases.

The seal air fan is stopped a this time and a butterfly valve between it and the FD fan modulating damper ducting is closed to minimise loss of FD air past the seal air fan.

However, when the Diverter Damper is in the 'EXHAUST GAS DAMPER OPEN TO BOILER' position, i.e. TEG mode, the FD fan system must be protected against potential damage from the hot turbine exhaust gases.

The FD fan modulating damper will be in full closed position but, to ensure that no hot gases get pass the damper and damage the fan, the damper has a double sealing system with cold air from the seal air fan being fed between the two seals.

This seal air fan is designed to generate an air pressure between the two seals greater than the pressure from the turbine exhaust gases. Thus any small leakage past the seal's means that cold ambient air is passed into the furnace ducting, rather than hot turbine exhaust gases passing out towards the FD fan. Any air leakage will have a negligible effect on the gases passing to the boiler.

For TEG mode the FD damper must be proven to be in the fully closed position, as verified by the use of limit switches, and the seal air fan and valve must be proved by operating correctly.

If any of these conditions in not met then the diverter damper will be commanded to close to put the turbine into bypass mode.

The auxiliary burner will then be commanded to fire unless the boiler conditions dictate otherwise, or the FD fan/modulating damper/seal air fan also has a fault.

Part 6 – Interlock Signals

There are two interlock signals between the turbine control system and the boiler/burner control system, one signal in each direction.

The signal from the turbine system to the boiler/burner system is valid, i.e. a closed contract when the turbine is in a stable operating state and the exhaust gas temperature is above 420oC. This signal is defined as Heat Available and is displayed on the TEGB panel as 'GAS TURBINE RUNNING'. If this signal becomes false whilst the boiler is in TEG mode then an automatic changeover to Auxiliary Firing initiated as described earlier. If the signal is false whilst in Auxiliary Firing mode then a transfer to TEG mode is not allowed.

The signal from the boiler/burner system to the turbine system is valid, i.e. a closed contact, when the boiler is in a suitable state to accept turbine heat, or the diverter damper is confirmed as being in the 'EXHAUST GAS DAMPER OPNE TO BYPASS' position. The signal is defined as 'TURBINE ALLOWED TO RUN' and is a combination of signals from the burner system and the diverter damper limit proving switches.

During 'normal' operation any problem which requires the turbine exhaust gases to be removed from the boiler will cause an orderly changeover and the turbine will be allowed to continue running with the diverter damper in the 'EXHAUST GAS DAMPER OPEN TO BYPASS' position.

However, if during TEG mode, the burner throat dampers are not proven to be fully OPEN then the 'TURBINE ALLOWED TO RUN' signal is immediately removed and will cause a turbine shutdown.

APPENDIX 5

EVENT SEQUENCE LISTS

Introduction

This is a step by step guide through the sequence of events which occurs during the start-up and firing mode changeovers of the TEGB burners.

Action	Result	Indicator	Other
Place FD FAN to AUTO	None	None	
Press **START GAS BURNER**	Boiler purge started	The **STAR GAS BURNER** indicator lights The **FD RUNNING** indicator will illuminate The **FURNACE PURGE COMPLETE** indicator flashes. The **FD OUTLET DAMPER CLOSED** indicator will go out. The **FD OULTET DAMPER OPEN** indicator will flash then go steady. The **FD FLOW CORRECT** indicator will be illuminated when the airflow has reached, or exceeds this value.	The auxiliary air fan is started in low speed, the FD fan Damper opened to the MIN position. If the auxiliary air low speed pressure switch is not satisfied, then the burner will not start. If FD air flow remains low then the burner will not start.
	After a time interval of 5 minutes the purge is completed.	The **FURNACE PURGE COMPLETE** indicator will be illuminated steadily.	This will remain so as long as valid purge conditions exist, i.e. until a flame is detected in the furnace.

Start Gas Burner – Continued.

Action	Result	Indicator	Other
		The IGNITER FLAME ON indicator will be illuminated The IGNITION BURNER IN OPERATION indicator will be illuminated.	If pressure of the igniter's gas is insufficient then the ignition burner will not start and the burner will shut down.
	With the igniter burner in service the support gas burner is started automatically (the time taken from initiation to the gas burner operations is approx 5 seconds)	The SUPPORT GAS VALVES CLOSED indicator will cancel. The GAS VALVES CLOSED indicator will cancel.	The GAS CONTROL VALVES CLOSED indicator remains illuminated. If the support gas pressure is low then the burner will shut down.
	The flame detectors should register the presence of a support gas flame in the furnace	The MAIN FLAME ON indicators will be illuminated.	If the flame detectors do not detect a flame then the burner will shut down.
	Provided the load demand in controller no. 2 is greater than zero, the support gas burner ignites the main gas burner (takes approx. 5 seconds) The gas burner will stay at its minimum firing position until it is adjusted either manually or automatically. The warm-through and bringing online are as per the normal start up procedure.	The GAS BURNER IN OPERATION indicator will be illuminated The GAS CONTROL VALVES CLOSED indicator cancels	Should either of the gas main valves not function the burner will shut down.

	The increase of firing is now controlled by the steam flow controller, controller no.2		

TEGB Start-up Oil Burners

This sequence assumes that the FD and auxiliary air fans are not running and no burners are firing before the start up described herein, nor has the power been removed from the panel since the last burner shutdown.

Action	Result	Indicator	Other
Place FD FAN to AUTO	None	None	
Press START OIL BURNER button.	Boiler purge started	The START OILBURNER indicator lights. The FD RUNNING indicator will illuminate The FD OUTLET DAMPER CLOSED indicator will go out. The FD OUTLET DAMPER OPEN indicator will flash then go steady. The FD FLOW CORRECT indicator will be illuminate when the airflow has reached, exceeds, this value.	The auxiliary air fan is started in high speed, the FD fan is started and FD damper opened to the MIN position. If the auxiliary air high-speed pressure switch is not satisfied, then the burner will not start. If FD airflow remains low then the burner will not start.
	After a time interval of 5 minutes the purge is completed.	The FURNACE PURGE COMPLETE indicator will be illuminated steadily.	This will remain so as long as valid purge conditions exist, i.e. Until a flame is detected in the furnace

Start Oil Burner – Continued

Action	Result	Indicator	Other
		The IGNITER FLAME ON indicator will be illuminated The IGNITER BURNER IN OPERATION indicator will be illuminated.	If pressure of the igniter gas is insufficient then the ignition burner will not start and the burner will shut down.
	With the igniter burner in service the oil burner is started automatically (the time taken from initiation to oil burner operation is approx. 10 seconds)	The OIL VALVES CLOSED indicator cancels.	The OIL CONTROL VALVE IN MIN POS indicator remains lit. Should either of the oil valves not function the burner will shut down.
	The flame detectors should register the presence of a support gas flame in the furnace	The MAIN FLAME ON indicators will be illuminated.	If the flame detectors do not detect a flame then the burner will shut down.
		The OIL BURNER IN OPERATION indicator will be illuminated.	

Start Oil Burner – Continued

Action	Result	Indicator	Other
	The oil burner will stay at its minimum firing position until it is adjusted either manually or automatically. The warm-through and bringing online are as per the normal start-up procedure. The increase of firing in now controlled by the steam flow controller, controller no. 2	The OIL CONTROL VALVE IN MIN POS extinguishes once the steam demand exceeds about 20% the minimum-firing rate for oil.	

Note:

If either of the fuels is already in operation then the pressing of the START button for the other fuel will simply allow that fuel to be fed into the furnace where it will ignite from the existing flame.

Whenever oil is firing the Support Gas flame is extinguished since the oil flame has a fixed minimum, thus guaranteeing a flame in the furnace, whereas, the Main Gas Burner flame may modulate down to zero.

If a STOP BURNER button is pressed then that fuel is cut off with the commensurate

Valve Position indication changes. If oil was firing then an OILGUM PURGE cycle is initiated, the igniter is started below the purge cycle commences to ensure combustion of any residual oil ass it exists the gun. If the panel power has been switched off then an oil gun purge is automatically required during the next firing cycle.

TEGB Changeover to TEG Mode

This sequence assumes that the boiler and gas turbine are already in operation before the start of the sequence described herein.

Action	Result	Indicator	Other
Press **BOILER TO EXHAUST GAS MODE** button	The gas and/or oil control valves for whichever fuel was in operations are closed. On the water level T640 Controller the **SETPOINT** will fall to 250 mm.	If the oil burner was in operation, the **OIL CONTROL VALVE IN MIN POS and the OIL VALVES CLOSED** indicators will be illuminated. If the gas burner was in operation, the **GAS CONTROL VALVE CLOSED** indicator will be illuminated	If the gas burner was in operation, the auxiliary air fan and the support gas burner are left operating, and the **SUPPORT GAS VALVES CLOSED** indicator will remain extinguished. The **GAS BURNER IN OPERATION** indicator will remain lit
	The **FD** fan damper will be driven closed	The **FD OUTLET DAMPER OPEN** indicator will be extinguished. The **FD OUTLET DAMPER CLOSED** indicator will be illuminated	The **FD FLOW CORRECT** indicator will be extinguished.
	The burner throat dampers will open.	The **THROAT DAMPER CLOSED** indicator will be extinguished. The **THROAT DAMPER OPEN** indicator will be illuminated	

Change over to TEG Mode – Continued

Action	Result	Indicator	Other
	The GT exhaust	The EXHAUST	If the exhaust gas

	gas diverter damper will open to the boiler	GAS DAMPER OPEN TO BY-PASS indicator will be extinguished. The EXHAUST GAS DAMPER OPEN TO BOILER indicator will be illuminated.	damper fails to complete its changeover within 20 seconds then it will be commanded to return to the vertical position
	The FD fan will stop. The seal air fan will start and the seal air valve will open.		If seal air valve fail to open, the SEALING AIR VALVE NOT OPEN alarm indicator will be illuminated.
If the gas burner was not in operation before the change over press the START GAS BURNER button.		The IGNITION BURNER IN OPERATION indicator will be illuminated.	
	With igniter burner in service the support gas burner is started automatically (the time taken from initiation to gas burner operation is approx. 5 seconds).	The IGNITER FLAME ON indicator will be illuminated. The SUPPORT GAS VALVES CLOSED indicator will cancel. The GAS VALVES CLOSED indicator will cancel.	If pressure of the igniter gas is insufficient then the ignition burner will not start.
	The flame detectors should register the presence of a flame in the furnace	The MAIN FLAME ON indicators will be illuminated.	If the flame detectors do not detect a flame then the burner will shut down and the GAS VALVE CLOSED indicator will be illuminated.
Put the Steam Controller, No. 2, into Remote Mode	Allows the master Pressure Controllers to		

	‘track’ the Steam Flow generated by the TEG mode in preparation for transfer to FD mode		

TEGB Change over to Auxiliary Fired Mode

This sequence assumes that the boiler and gas turbine are already in operation in TEG mode before the start of the sequence described herein.

Action	Result	Indicator	Other
Press **BOILER TO F.D MODE** button, or GT is stopped or trips	The GT exhaust gas diverter damper will open to the bypass chimney	The **EXHAUST GAS DAMPER OPEN TO BOILER** indicator will be extinguished The **EXHAUST GAS DAMPER OPNEN TO BYPASS** indicator will be illuminated	If the exhaust gas damper fails to complete its changeover within 20 seconds, the gas turbine and the burner will be tripped immediately.
	The **FD** fan will start. The seal air fan valve will close and the seal air fan will stop.	The **FD FAN RUNNING** indicator will be illuminated.	The auxiliary air fan is started in high speed. If the auxiliary air high-speed pressure switch is not satisfied, then the burner will not start.
	The burner throat dampers will close	The **THROAT DAMPER OPEN** indicator will extinguished. The **THROAT DAMPER CLOSED** indicator will be illuminated.	

Change over to Fired Mode – continued

	The FD fan damper will open	The FD OUTLET DAMPER CLOSED	

		indicator will be extinguished. The FD OUTLET DAMPER OPEN indicator will be illuminated. The FD FLOW CORRECT indicator will be illuminated.	If FD airflow remains low then the burner will not start.
	If the support gas burner is in operation, the igniter will light, the support gas burner will be stopped If the support gas burner is not in operation, then a furnace purge will begin automatically prior to igniter start.	The IGNITION BURNER IN OPERATION indicator will be illuminated. The IGNITER BURNER IN OPERATION indicator will be illuminated.	If the igniter gas pressure is insufficient the ignition burner will not start.
		The OIL VALVES CLOSED indicator will be extinguished. The OIL BURNER IN OPERATION indicator will be illuminated.	
	The increase of firing is now controlled by the steam flow controller, controller no.2.	The OIL CONTROL VALVE IN MIN POS indicator will be extinguished as the control system increases the steam demand automatically to restore the steam output from the TEGB	

Note:

The TEGB will always re-start burning oil in fired mode after a GT trip or change over from TEG mode.

The operator may switch to gas fuel, if he is satisfied that this fuel is available by pressing the **START GAS BURNER BUTTON,** and then pressing the **STOP OIL BURNER BUTTON**. However, this will cause a relatively severe 'bump' in the TEGB's steam production, a much smother change-over can be achieved by adopting the procedure below. **TEGB Fuel Change over.**

TEGB fuel Changeover

This sequence assumes that the boiler is already in operation in fired mode, burning either oil or gas fuel, before the start of the sequence described herein.

Action	Result	Indicator	Other
In loop 3 of controller 4, set the fuel ratio controller setpoint to 100% of the fuel being burned. I.e. if oil fuel is being used, set if to 100% oil, if gas fuel is being used, set it to the minimum of 20% oil.			This setting has no action while only one fuel is in use.
Press the **START BURNER** button for the fuel NOT already in use.	The block valves for the fuel not already in use will open. The control valve for the fuel not already in use will remain at its minimum position	The fuel **VALVES CLOSED** indicator for the fuel being started will be extinguished. If the gas burner is the one that was being started, **GAS CONTROL VALVES CLOSED** indicator will be extinguished. If the oil burner is the one that was being started, **OIL CONTROL VALVE IN MIN** POS indicator will remain illuminated	If the gas burner is the one being started its flame will not light immediately setting is 0% If the oil burner is the one being started the auxiliary air fan will step to high speed, once it has reached high speed (proven by a pressure switch), the oil burner flame will light immediately at its minimum setting of about 20%, and the gas burner flame will reduce automatically to keep the total heat output constant.

In loop 3 of controller 4, gradually adjust the setpoint for the	The total amount of each fuel will be adjusted to maintain a constant	As the oil control valve moves off, or onto, its minimum position, the **OIL**	As the gas control valve moves off or onto its closed position, the gas

desired fuel ratio over a period of, say 2 minutes to allow the fuel systems to adequately respond	total output.	**CONTROL VALVE IN MIN POS** indicator will be illuminated or extinguished.	flame will start or stop.
If its desired to shut down one fuel as in a fuel change-over, set that fuel to minimum in loop 3 of controller 4. i.e. if gas is to be shut down adjust the setpoint to 100% oil, if oil is to be shut down adjust to the minimum of 20% oil.	The appropriate fuel control valves will move to their minimum position (fully closed, in the case of the gags control valves)		
Press the **STOP BURNER button** for the fuel to shut down.	The appropriate fuel block valves will close.	The appropriate fuel **VALVE CLOSED** indicator will be illuminated.	

APPENDIX 6
CONTROL SYSTEM FAULT FINDING

Introduction

This section contains a list of the recommended actions to be taken following an alarm or trip indication on the boiler control panel. It describes the principal causes of

each of the alarm and trip on the boiler control panel, together with the areas of equipment to be examined to rectify the alarm or trip.

The first part covers the alarm indications, i.e. those conditions that cause an amber light on the control panel to light. The second part covers the boiler a burner condition (trip) indications, i.e. those conditions which trip the boiler and cause a red lamp on the control panel to light.

Part 1: Boiler and Burner Alarms

ALARM INDICATION	RECOMMENDED OPERATOR ACTION
Steam Pressure High	Check boiler drum pressure. The pressure should not be more than 31.0g. The alarm may be caused by a sudden reduction of the total steam load, if one of the valves in the boiler outlet system is not fully open or if the boiler pressure control valve closes suddenly.
Drum Level High-High	Ensure that Controller 1 is in either Auto or Remote mode and that the feedwater regulator bypass valves are fully closed. Check that the water level in the gauge glasses and verify that the level agrees substantially with the indicated value on Controller 1. Check the drive output (%) from Controller 1 by pressing the illuminated mode button. Verify that the feedwater valve spindle is in a corresponding position. If the valve position does not agree with the expected value then isolate the feed water regulator and use the bypass valves to control the drum water level until repairs can be made. Check that the Boiler Steam Pressure is reasonable for the boiler conditions. A sudden fall in the boiler pressure could result in sufficient water swell to give rise to this alarm.
Drum Level High	This alarm can happen during periods of large steam load changes. If the alarm is maintained for a long period then proceed as for Drum Level High-High.
Drum Level Low	This alarm can happen during periods of large steam load changes. If the alarm is maintained for the long period then proceed as for Drum Level High – High.
Feedwater Pressure Low	Not applicable to this system.
Controller Watchdog Failure	Report the failure to the maintenance department. Identify the failed unit and replace with a spare, if available.
Drum Level Low-low	This indicates that at least one of the Drum low level probes is uncovered. This generally indicates a failure of the unit, if not also accompanied by a Drum Level Low-Low in the Burner Conditions display. Check the levels in the gauge glasses and proceed as the Drum Level High-High above.
Water Level Alarm Override Reset	Report failure to the Water Level Alarm

failure	Override system to the maintenance department. Identify the timer or relay unit, which has failed, and replace.
Oxygen Percentage 1 Low	Verify that the indicated value on the oxygen monitor unit is substantially the same as the indicated value on Controller 3. Check for any alarm message on the oxygen unit. If the burner system is still operational, i.e. no trip, then recalibrate the sensor at the earliest opportunity. If the sensor cannot be satisfactorily recalibrated then refer the problem to the oxygen monitor unit manufacturer. If the two sensors substantially agree and the alarm is automatically reset as the load decreases then there may be restriction of the FD fan air supply. Check the conditions of the FD fan system, especially the cleanliness of the fan impeller, instrument air supply availability and pressure, and the proper operation of the FD fan damper.
Oxygen Deviation High	Verify that the indicated values on the oxygen monitor unit are substantially the same as the indicated values on the relevant Controller. Check for any alarm message on the oxygen analyser units. If the burner system is still operational, i.e. no trip, then recalibrate the sensors at the earliest opportunity. If the sensors cannot be satisfactorily recalibrated then refer the problem to the oxygen monitor unit manufacturer.
Oxygen Percentage 2 low	Verify that the indicated value on the oxygen monitor unit is substantially the same as the indicated value on Controller 4. See Oxygen Percentage 1 Low, above, for further checks.
Sealing Air Valve Not Open	Check that the instrument air supply to the valve is available at the correct pressure, and check the free operation of the valve.
Burner Failure	Check the panel display for the 'first failure' indication before accepting or resetting any alarms. This should give help in identifying the problem. Refer to the R&V manual for further details.
Flame failure	This failure will often be caused by dirty glass in the flame detector system. Ensure

	that any glass discs, lenses etc are clean. Note that loss of detection of either flame on the main burner or a failure to detect the igniter flame will indicate a flame failure alarm. Refer to the R&V manual for further details.
Gas Pressure Low	The main fuel gas pressure is below the minimum pressure required for safe operation of the gas burner. Check that the incoming gas pressure is correct (3.1 bar g). Check that the gas isolating valves are open, that there are no spades in the gas supply line, and that the gas filter is not blocked

Part 2: Boiler and Burner Trip Conditions

CONDITION INDICATON	RECOMMENDED OPERATOR ACTION

High Steam Temperature	This trip, which occurs at steam temperatures above 315oC, is generally caused by insufficient steam flow (<2 t/hr), or too rapid an increase in the rate of firing. Steam temperature control, in fired mode, is by means of excess air control. If the steam flow is great than about 3-4 t/hr, or the superheater start-up vent is open, and there has been no excessively fast increase in the firing rate, check the FD air system as described for Oxygen Percentage 1 Low alarm part 1 above.
Furnace pressure High	Check the boiler, including the tube fins, and the down stream ductworks are not choked.
Drum Level Low-Low	This indicates that both drum level probes detected a low water level. Check as for the Drum level low and drum level Low-Low alarms part 1 above.
Auxiliary Air Pressure Low-Low	Check that the auxiliary air fan is running at low speed, the fan intake is not blocked, and that the flexible coupling to the burner is not torn or detached.
Emergency Stop	Determine why one or more of the Emergency stop buttons has been pressed, and rectify any fault as necessary. Release the Emergency Stop and press Reset before starting again.
Combustion Failure	This lamp indicates one or more of the following conditions: In fired mode it indicates that the FD fan not running, the diverter damper not closed to boiler, the burner throat dampers are closed, the FD fan damper is not open, or the minimum FD airflow is not proven. After a change over attempt from TEG mode it indicates igniter burner failure, a main gas block valve not closed, or an oil block valve not closed.
Instrument Air Pressure low	Check that all instrument air-isolating valves are open and that there is an adequate supply of instruments air available. Check that there are no blockages or leaks in the instrument air system.
Oxygen Percentage Low	Indicates that both oxygen sensors are reading a low oxygen contains (<10% oxygen) in the flue gases. Check as the

	Oxygen Percentage 1 and 2 alarms in part 1 above.
Igniter Flame failure	Check the igniter gas supply is adequate and at the correct pressure (3.1 bar g). Check that the filter is not blocked, that the isolating valves are open, and that there are no spades in the line. Remove the igniter carefully and check the spark electrodes and the ionisation flame detector rod.
Main Flame Failure	Indicates failure on both flame detectors to detect a flame. Treat as for Flame Failure alarm in part 1 above
Throat Damper Not Open	Check the instruments air supply to the actuator is adequate, check the flexible hoses are connected. Check the solenoid valve is operating at the appropriate point in the change over sequence. Check the mechanical linkages are intact. Check the wiring to the limit switches and solenoid valve is not damaged.
Ignition Time Expired	This trip is caused by a failure to detect a main oil flame within the allowed time (60 sec) on change over from TEG mode. Reset the alarms and trips and start the burner, following the normal start up procedure described in section 2.5 of this manual.
Gas Pressure High	Indicates a high gas pressure after the main gas control valves. Check the main gas supply pressure. Check operation of the gas control valves. Do not increase the steam load quickly.
Support Gas Pressure Low	The support gas pressure is below the minimum pressure required for safe operation of the support gas burner. Check that incoming gas pressure is correct (3.1 bar g). Check that the gas isolating valves are open, that there are no spades in the gas supply line, and that the gas filter is not blocked.
Gas Control Valves Closed Failure	Check that the gas control valves have both closed fully
Gas Valves Closed Failure	Check that both of the main fuel gas automatic block valves have closed.
Oil Gun Purge Valve Closed Failure	Check that the oil gun purge valve has closed.
Oil pressure high	Indicates a high oil pressure after the oil control valve. Check the oil supply pressure. Check operation of the oil control valve. Do not increase the steam load too

	quickly.
Oil Pressure Low	Check the manual isolating valves are open and that any spades have been removed from the line. Check that the oil filter is not blocked. Check that one of the TEGB oil pumps is running.
Auxiliary Air pressure Low	Check that the auxiliary air fan is running at high speed, the fan intake is not blocked, and that the flexible coupling to the burner is not torn or detached.
Oil Gun Not Coupled	Check the oil gun is firmly pushed into place and that the retaining hand screws are tightened properly. Check that the pressure plate is depressing the limit switch. Check the limit switch cable is not damaged.
Oil Valves Closed Failure	Check that both of the distillate oil automatic block valves have closed.
FD Fan Failure	The FD Fan did not start within the time allowed (4 sec). Report the failure to the maintenance department.