THERMAX
Boiler & Heater Group

Operation & Maintenance Manual

FOREWORD

Thermax represents that the information contained in this manual has been developed in accordance with Thermax Standard Technical Procedures and Practices from latest information available at the time of this manual was issued.

Please read and follow the instructions contained in the Manuals carefully for safe operation.

This manual provides simple and basic instructions on boiler operation & maintenance to assist the operating personnel.

Owner should review all the operating instructions & be sure that the persons operating & maintaining the equipment are familiar with all the information provided, including manuals from various suppliers of vendor equipments.

WARNING

Boilers & accessories by their vary nature operate at high pressure and temperature can be dangerous when not properly operated and maintained, therefore owner must provide adequate operating maintenance and safety training for its personnel. The company must provide qualified operators for operation.

OPERATION & MAINTENANCE MANUAL

FOR 5 X 115TPH

RAAGESHWARI GAS / ASSOCIATED GAS/ DIESEL OIL FIRED BOILER

SUPPLIED TO

CAIRN ENERGY PRIVATE LIMITED

BASRMAR, RAJASTHAN

THERMAX JOB NO. - PF1051/52/53/54/55

THERMAX LIMITED

BOILER & HEATER GROUP PUNE INDIA

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Contents

Volume 1 — Boiler Description

Chapters Covered in this Part

Section A

Topics Covered in this Chapter

Number and Type of Boiler

5 x 115 TPH, Water tube, Natural Circulation, Natural Gas / Oil Fired Bi-Drum Packaged boiler. Bottom Supported Pressure part arrangement.

1 Design Specifications of Auxiliary Boiler

PARAMETERS	UNIT	VALUE
Boiler Rating [MCR]	TPH	115
Steam Pressure at Main Steam Stop Valve Outlet from minimum Load upto MCR	Kg/cm2 (g)	42.32
Steam Temperature at the Main Steam Stop valve at MCR	Deg C	371±5
Main Steam Temperature Control range at the Main Steam Stop Valve Outlet.	% MCR	40 –100
Hydraulic Test Pressure	Kg/cm2 (g)	81
Design Pressure	Kg/cm2 (g)	54
Fuel Firing		Combination of Associated gas and Raageshwari gas and LDO. The system should be capable of firing 100% MCR max with either fuel. The percentage of firing will be on heat input basis.
Boiler Performance Testing Procedure		ASME PTC 4 Energy Balance

2 Design Code

Boiler & Economiser / Pressure Parts: As per IBR 1950 with latest amendments

3 Material Specifications — Pressure Parts

Description	Details	Size In Mm	Material
Steam Drum	Shell	1500 ID x 70 Thk	SA 516 Gr 70
	Dished end for S.D. (Hemispherical)	1500 ID x 50 Thk	
Water Drum	Shell	960 ID x 50 Thk	SA 516 Gr 70
	Dished end for W.D. (2:1 Semi Ellipsoidal)	960 ID x 50 Thk	
Super Heater	Pass I	50.8 OD x 4.5 Thk	SA 213 T11
	Pass II	50.8 OD x 4.5 Thk	SA 213 T22
	Pass III	50.8 OD x 5.0 Thk	SA 213 T22
	I/L & O/L Header	350 NB x 160 SCH	SA 335 P11
Attemperator Header		300 NB x 80 SCH	SA 335 P11
Boiler Bank Tubes		50.8 OD x 3.25 Thk	SA 210 Gr. A1
Boiler side wall tubes		50.8 OD x 3.66 Thk	SA 210 Gr. A1
Boiler side wall panels		63.5 OD x 4.06 Thk	SA 210 Gr. A1
Bank Rear wall		76.2 OD x 4.06 Thk	SA 210 Gr. A1
Furnace Tubes	Side Wall Tubes	76.2 OD x 4.06 Thk	SA 210 Gr. A1
	Rear Wall Tubes	76.2 OD x 4.06 Thk	SA 210 Gr. A1
Baffle Wall Tubes		76.2 OD x 4.06 Thk	SA 210 Gr. A1

4 Heating Surface Area

Zone	Unit	Value
For Boiler Bank	Sq.Mtr	1596
For Superherater	Sq.Mtr	235
For Economiser	Sq.Mtr	3008
Heating Surface Total	Sq.Mtr	4839

5 Fuel

a) Main Fuels: Raageshwari Gas/Associated Gas/Diesel Oil

6 Fuel Analysis

Gas	Associated Gas	Raageshwari Gas
Composition	(%)	(%)
Methane	68.78	83.04
Ethane	0.52	11.01
Propane	0.66	3.1
Iso Butane	0.28	1.15
Normal Butane	0.36	0.71

Gas	Associated Gas	Raageshwari Gas
Iso Pentane	0.15	0.28
Normal Pentane	0.15	0.2
Hexane	0.01	0.11
Heptane	0.84	0.07
Nitrogen	0.2	0.24
CO_2	19.94	0.01
Water Vapour	7.99	0.08
Total	100	100
Operating Temp °C (Min/Normal/Max)	80 / 85 / 95	15 / 40 / 50
Operating Pressure(kg/cm2)	3.57 / 4.22	3.57 / 4.22
Design Temp (°C)	130	130
Design Pressure(kg/cm2)	10.5	10.5
Total Molecular Weight	23.4	19.7
LHV (kJ/Sm3)	27510	40520
LHV (kcal/kg)	6541	11641
Fuel Fired(kg/hr)	11670	6540

Diesel Oil No.2

Composition	Unit	Value
Carbon	% wt	90.355
Hydrogen	% wt	9.21
Nitrogen	% wt	0.155
Sulfur	% wt	0.05
Moisture	% wt	0.05
Ash	% wt	0.04
Carbon Residue	% wt	0.3
Vanadium	ppm	<25
GCV	Kcal/kg	10,305
LHV	Kcal/kg	9820
Kinematic Viscosity @ 40°C	cst	2 – 5
Density @ 15 °C	Kg/m3	820 – 860
Flash Point(min) (Pensky Martens closed cup)	°C	66
Pour Point(min) (Winter / Summer)	°C	15-Mar
Conditions at Battery Limit		
Pressure		
(Max / Nor)	kg/cm2(g)	18.97 / 12.24
Normal Operating Temp	°C	15 – 40

7 Site Condition

Site Location	CEIPL, Barmer, Rajasthan
Ambient Temperature	
Performance	40 ° C
Maximum	50 ° C
Minimum	— 2° C

8 Continuous Blow Down

Design : 3%

Normal : 1%

9 Safety Valves

DESCRIPTI ON	UNIT	DRUM #1	DRUM #2	SH
APPLICATION				
TYPE	-	SPRING LOADED		
MAKE		TYCO SANMAR		
TAG NO	-	PSV-7018B	PSV-7018C	PSV-7018A
SIZE ORIFICE	-			
		3 x L2 x 6	3 x L2 x 6	2.5 x K2 x 6
SET PRESS.	Bar(A)	53	54	47
OPERATING TEMP.	DEG.C	267	268	376
RELIEVING CAPACITY	Kg/hr	54,808	55823	32377
QUANTITY	-	1nos.	1nos.	1nos.
FLUID	-	Sat. Steam	Sat. Steam	SH Steam

10 Fans

Duty conditions	Unit	FD Fan
Make		Andrew Yule And Co. Ltd
Model		SI.BCB-92
Quantity	02 No.	1 x 60%
Nature of medium		Clean Air
Design Mass Airflow (MCR)	Kg/s	17.24 (Associated Gas)
		17.16 (Raageshwari Gas)
		17.4 (LDO)
Air Temperature at Fan Inlet	Deg C	40
Absorbed Power at operating temp. with speed control	KW	160
Fan Speed	Rpm	1480

Duty conditions	Unit	FD Fan
Inlet Static Pressure	mmWC	-35
Outlet Static Pressure	mmWC	417
Free/Fixed Bearing		22218C (Anti Friction) + Housing SAF-218
Bearing Lubrication		VEEDOL ALITHEX – 20 or eqvt. Grease (500 gms for first fill)
Motor		200 kW /4 Pole, Type-M38M/GM 355LK4; ABB MAKE
Coupling Model / Make		Flexible spacer type (80 SPL-262-140) / MAKE- Metaflex

11 Burners

Burner	Units	Gas
Type		
Burner Make		Thermax Babcock & Wilcox
Operating Draught Type		Forced
Quantity (for MCR)		3 x 36.67%
Type of Air control & Accessories		Lead Lag Arrangement; VIV at Fan Suction Control
Type of Ignitor		Gas fired electric ignited lighter
Supply From		Plant
Differential Pressure at tip inlet at peak	Kg/cm2	11
Air quantity required for burner (Associated / Raageshwari / LDO)	Kg/hr	41370 / 41193 / 41755
Excess air	-	10%
Fuel flow at MCR (Indicative) (Associated / Raageshwari / LDO)	Kg/hr	3890 / 2180 / 2604
No. of Flame Scanner	-	2 No (UV scanner) / burner

12 Dosing System

HP DOSING SYSTEM : METAPOW INDUSTRIES

Sr. No.	DESCRIPTION	HP DOSING	LP DOSING	PH DOSING
1	TANK (SS) SIZE / VOLUME	I.D 940 X 1000 X 3 THK. / 500 Lit	I.D 940 X 1000 X 3 THK. / 500 Lit	I.D 940 X 1000 X 3 THK. / 500 Lit
2	PUMP CAPACITY PRESSURE (MAX)	0-15 L.P.H	0-15 L.P.H	0-15 L.P.H
		51 kg/Cm2 (Nor.)	4 kg/Cm2 (Nor.)	6 kg/Cm2 (Nor.)
		59 kg/cm2 (Design)	5.5 kg/cm2 (Design)	7.5 kg/cm2 (Design)
3	PUMP MAKE	MetaChem	MetaChem	MetaChem
4	TYPE & SPEED	RECIPROCATING PLUNGER	RECIPROCATING PLUNGER	RECIPROCATING PLUNGER
5	NO OF PUMPS	2 Sets	2 Sets	2 Sets

Sr. No.	DESCRIPTION	HP DOSING	LP DOSING	PH DOSING
6	MOTOR	0.5 Hp. X 1500 RPM , 415 Volt, Crompton	0.5 Hp. X 1500 RPM , 415 Volt, Crompton	0.5 Hp. X 1500 RPM , 415 Volt, Crompton
7	MOTORISED AGITATOR / MOTOR	1 HP X 1000 RPM , 415 Volt, Crompton	1 HP X 1000 RPM , 415 Volt, Crompton	1 HP X 1000 RPM , 415 Volt, Crompton
8	PRESSURE RELIEF VALVE SET PRESSURE	59 Kg/Cm2	5.5 KG/Cm2	7.5 KG/Cm2
9	LUBRICATION (For pumps)	SERVOMESH 460	SERVOMESH 460	SERVOMESH 460

Section B

Topics Covered in this Chapter

1 Section Overview

This section gives a brief overview of the project, boiler packages and associated systems. The description of the various systems that form part of the auxiliary boiler package is also included. The aim of this section is to make the reader / user familiar with the auxiliary boiler package components before introducing the operation and maintenance sections.

BRIEF OVERVIEW

The five package boilers supplied by THERMAX BABCOCK & WILCOX, India are of fully modular (FM) type, shop/port assembled, bi-drum construction, water tube, natural circulation type, bottom supported, forced draft designed for firing with Associated Gas / Raageshwari Gas / Diesel Oil.

The main parameters of individual boilers are –

Sr. No.	DESCRIPTION	VALUE
1	Maximum Continuous Rating	115 TPH
2	Steam Pressure	42 Kg/cm2 (g)
3	Superheated Steam Temperature	371 ± 5 °C
4	Fuel Fired	Raageshwari Gas / Associate Gas / Diesel Oil

The construction of the Boiler can be understood from the pressure parts arrangement of the Boiler. P & I D of the water and steam system.

The boiler is divided into a 'furnace' section and a 'second pass' by a division membrane wall. The furnace section is made of tube walls and a refractory wall. The furnace comprises the furnace side-wall, roof, floor & rear walls and the front refractory wall. The furnace side, roof and floor, rear walls are of membrane panel construction. The furnace front wall is of refractory construction. The second pass comprises the Superheater, convection bank tubes. The second pass is enclosed by the rear wall & boiler side-wall. Entire array of tubes in the furnace & second pass is connected to the steam and water drums. The Superheater is designed for convective heat transfer and is fully drainable.

Feedwater from plant is admitted to the economiser through a feedwater control station. The feedwater is then led to the steam drum. Steam is generated in the convection bank tubes. In the riser tubes partial evaporation takes place due to the heating. The resulting water-steam mixture returns to the steam drum where the separation of steam from water takes place. The saturated steam is led to the Superheater and then through the main steam stop valve to the process plant.

Combustion of the fuel takes place in the furnace with the help of the burners mounted on the furnace front refractory wall. Combustion air is sucked from the plant environment by the FD fan. The burners are capable of firing Associated Gas / Raageshwari Gas / Diesel Oil safely and efficiently.

Flue gases generated from combustion pass through the convection bank and is led to economiser through flue gas duct and finally into the atmosphere through a steel stack.

Two burners have been provided on the furnace front wall in two elevations for burning fuel oil . The starting, stopping and safe shutdown of the burner are monitored by a PLC based Burner Management System (BMS). DCS based controllers are provided by contractor for the control loops. The operation of the boiler is envisaged from the DCS operator stations.

Three long-retractable & three rotary soot blowers are provided in the superheaters, boiler bank and Economiser surfaces, when the burners are in service. Soot blowing is done to keep up the heat transfer efficiency at the maximum level.

Safety valves have been provided in the Drum and in the main steam line of the Boiler. Suitable insulation around the drum, the membrane panels, steam lines, feed water lines, hot air and flue ducts have been provided to minimize heat loss and for Operators safety.

Pressure, Temperature, Level transmitters, conductivity, pH, oxygen analyzers etc., for local indication as well as input to the DCS have been provided. Microprocessor based automatic (as well as manual) control of Drum level, combustion, steam temperature etc., has been provided. Operation of the boiler as well as Data Acquisition has been envisaged through the DCS.

Description & details of equipment of the various systems of the boiler package are elaborated in the subsequent sub-sections and chapters of this manual.

2 Water and Steam System

The water and steam system covered in this sub-section describes the components that convert the feedwater water into steam.

The components in the serial order of the flow path of water/steam are –

- Deaerator
- Boiler feedwater control station
- Economizer
- Boiler assembly
- Super Heater
- Attemperator
- Main steam piping
- Operational Control
- Dosing System
- Sample System

2.1 Deaerator

Purpose of Deaeration :-

Deaeration removes the corrosive gases such as dissolved oxygen and free carbon dioxide from the boiler feed water. This ensures protection of the feed water lines, steam lines, boiler tubes and other pressure parts of the boiler against corrosion and pitting, saves costly boiler re-tubing and expensive plant shutdowns. Further as the temperature of feed water is raised from ambient to Deaerator operating temperature of 130 °C [which corresponds to the operating pressure of 169 kPa (g)] and then fed to boilers, the overall boiler thermal efficiency also increases.

Deaeration is done by heating the feed water with steam. Vigorously scrubbing the water with this steam removes the last traces of non-condensable gases and brings down well below the recommended level in feed water.

Construction Feature :-

The Deaerator supplied is of Thermal - Mechanical Deaerator in which DM water/ makeup feed water is heated to its boiling temperature at the operating pressure by steam. At boiling point all the dissolved gases such as Oxygen, Carbon Dioxide, Etc. are liberated as solubility of gases decreases with increase in temperature. The mechanical scrubbing between water and heating steam ensures release of the dissolved gases.

Deaerator is of spray and trays type, consists of a storage tank and a vapour tank. Water is sprayed from the top of the vapour tank by spray nozzles on set of multi level trays below it. Steam is fed from the supply pipe to the distribution headers inside the storage tank below the water level. Partial scrubbing of the steam and water takes place in the storage tank water and the rest is taking place in the vapour tank with the incoming water spray.

Vapour tank is mounted upon the storage tank. Both the tanks are connected with steam connection Nozzle at the middle. This interconnection nozzle of 100 ID & 20 THK is flushed with inner wall of the vapour tank's dished end and embedded inside the water level of storage tank to facilitate the feed water flow from vapour tank to the storage tank. Interconnection accommodates concentrically the steam balancing connection assembly. This steam connection is projected inside the vapour tank and masked from the water flow direction by a hood fitted at the top, thus facilitates the steam flow from storage tank to vapour tank.

DM water enters to the vapour tank through the topside nozzle N2 to the distribution ring header. Five spray nozzles are fixed on the ring header to spray the water into fine particles covering the entire cross section of the tank so that easy and complete scrubbing with steam is possible. Perforated stainless steel trays at six levels are placed inside the vapour tank to provide enough delay time to scrub the feed water with the upcoming steam. Feed water from vapour tank flows into the storage tank through the interconnection pipe.

Condensate enters to the vapour tank through the topside nozzle N2 to the distribution ring header.

Nozzles are fixed on the ring header to spray the water into fine particles covering the entire cross section of the tank so that easy and complete scrubbing with steam is possible.

Heating Steam is supplied through the supply pipe (Nozzle N1) to the steam distribution headers kept inside the storage tank well below the water level. Two steam distribution headers connected to the supply pipe are lied at the bottom and along the length of the storage tank. These headers are perforated pipes to distribute the steam along the entire length of the storage tank water space.

Steam rises from the bottom of Storage Tank, heating the water and rises through the interconnection pipe into the Vapor Tank. Perforated Trays inside the Vapor tank increase the residence time of water and Heating Steam. Oxygen, Carbon dioxide and other dissolved gases are vented out along with Vent Steam through the nozzle N18

The dissolved Oxygen level in the feed water by mechanical deaeration can be brought to 0.02 to 0.03 ppm. If required the residual dissolved Oxygen can be further scavenged by the reaction with chemicals such as sodium sulphite (catalyzed or un-catalyzed) or Hydrazine. By chemical scavenging the dissolved Oxygen level can be brought down to as low as 0.007 ppm. Chemical may be dosed in the storage section of the deaerator through a header. Nozzle N5 20NB is provided for this and can be utilized. The dosing of the particular chemicals is done in predetermined quantity and concentration. A sample cooler provided in the feed water outlet piping is used to collect the sample for analysis of water.

Storage tank is supported by saddle supports. One of the saddles is fixed and the other is sliding one to take care of thermal expansion. PTFE sheets are provided under the sliding saddle for free movement of saddle. Platforms and ladders are provided for tanks and condenser for O & M feasibility.

The Accessories and the Mountings :-

1. Deaerator Level Control :- The desired normal water level (NWL), which is maintained through a level control valves LV 7110 of DM water line & condensate return line combinely. Level in the storage tank is monitored remotely by the level transmitter [LT 7111 A,B,C]. Two nozzles (N11A,B & N14A,B) at this elevation are provided for LT connection at distance of 875 mm above and 2125 mm below (for N11 A/B) and at distance of 900 mm above and 2140 mm (for N14 A/B) the NWL.

   A Feed back control loop with the electronic controller LIC 7110 is provided for automatic level control. Process variable signal for the level controller is transmitted by the LT 7110. Set point of the level controller is to be kept at ’0’ mmWC, which corresponds, to NWL.

   Apart from this remote level indication direct level gauge glass [LG 7110] are provided to cover the height between very low level and upto over flow level. These level gauge are mounted on a water column connected to the Nozzles N14

- Pressure Control :- The deaerator operating pressure of 169 kPa (g) is maintained by the pressure control loop, which contains the pressure control valve [PV 7110] in the steam line, a pressure transmitter [PT 7110] mounted on the storage tank nozzle N10 and an electronic pressure indicating controller [PIC 7110] in the control room. Set point for the pressure controller shall be kept at (169 kPA (g)).

  A local pressure gauge [PG 7112] is also provided (on Nozzle N9) for deaerator pressure indication.

- Pressure Relief Valve (PSV 7111) :- A Nozzle N20 is provided at the top of vapour tank to mount a relief valve. Relief valve would relieve the steam at the design set pressure of 245 kPa (g), when there is excessive pressure build-up inside the vessels (system) incase of sudden reduction of water out flow/ intake to deaerator or malfunctioning of pressure control loop.

- Vacuum Breaker :- A Vacuum Breaker assembly consists of Non Return Valves [VRV 7111] directed towards vapor Tank from atmosphere mounted on the Nozzle N20. This is to prevent Deaerator from operating at vacuum or negative Pressure. Vacuum condition inside the Deaerator would mean that the Deaerator is not being supplied with enough Steam with respect to the water flow leading to condensation of heating Steam. In case the Deaerator happens to go under vacuum, atmospheric air will rush through these Non Return Valves breaking the vacuum.

- Air vent :-Air vent is provided (nozzle N18) on topside of the vapour tank. Air vent is provided with an orifice and a globe Valve in parallel with it. Through the Air vent, Steam and dissolved gases are vent out to the atmosphere. The Valve shall be throttled to minimize the outflow of Steam.

- Other Connections :-
  - Feed water outlet nozzle N3 is provided. Water outlet piping going to the boiler feed water pumps suction header.
  - A drain nozzle (N4) for draining the storage tank.
  - Pegging steam connection (Nozzle N7): A perforated pipe connected to the nozzle is laid along the length of the storage tank below the water level. Admitting steam in a small quantity through pegging line and heating the water to a temperature upto 150 Deg C before admitting the main steam in large quantity will reduce the possible hammering.
  - Nozzle N16 is provided for recirculation line from the boiler feed water pumps.
  - A Manhole are provided two for storage and one for vapour tank.
  - A sample cooler is provided in the water outlet of deaerator for the analysis of the water sample. Sample cooler is a coil & shell heat exchanger, sample water is passing through the coil and cooling water through the shell. Needle valves are provided at the inlet and outlet respectively to regulate the sample flow.

Deaerator Specification:

UNIT	VALUE
Deaeration capacity	126.5 TPH (Max)
Operating pressure	169 kPa (g)
Operating temperature	130 ° C
Design pressure	294 kPa (g)
Design temperature	200 ° C
Design & Construction code	ASME SECT. VIII DIV1 Edition 2007, (WITHOUT STAMPING)

Reference Drawings :

Sr. No.	Descreption	Drawing No	Revision
1	Assembly of Deaerator	W21-1FM-45966	03
2	Assembly & Details of Vapour tank	W21-1FM-45967	03
3	Assembly & Details of Storage tank	W21-1FM-08203	04
4	P & I Diagram for Deaerator,	D12 -1FM- 6712P	02

2.2 Boiler Feedwater Pump

The feed water pump is customer scope of supply

2.2.1 Feed water pump's associated system :

Suction piping:

Common suction header for all the three pumps is connected from the deaerator outlet piping, providing necessary suction to the pump with isolation valve [DA032]at exit of De-areator.

Minimum circulation piping:

The minimum circulation piping is provided with individual pumps. This ensures that during the operation of the pump there will always be a minimum flow across the pump even when there is no discharge into the boiler.

An auto re-circulation valve is provided on individual pump discharge line for the above purpose

Throttle valve – for controlling the flow through the circulation line.

Non-return valve – to prevent the back flow.

Discharge Piping:

Discharge of each pump is connected to the common discharge header, which supplies feed water to the boiler. A pressure gauge [PG 7018] installed on the discharge header for observing the discharge pressure.

Auto re-circulation valve (ARC) installed at the pump discharge maintains the minimum flow required through the pump, when the flow to boiler is low. This minimum circulation flow is taken through a line connected back to the deaerator storage tank with a gate valve (DA 031).

2.3 Boiler Feedwater Control Station

Feed water is supplied continuously to maintain normal water level in the steam drum. The Feedwater Control station installed in the feed water line modulates the water flow to maintain the level in steam drum. Water flows from the flow control station through the economizer before entering into steam drum.

Feedwater from the plant is received at Terminal point. Following instruments are provided to measure the feedwater inlet parameters:

- Flow orifice [FE 7018-A] with a DP transmitter [FT 7018-A] for feed water flow measurement. Flow transmitter transmits the measured signal to the flow indicating controller(FIC 7018-A) in DCS
- A pressure transmitter [PT 7018-A] to provide feed water inlet pressure signal at DCS.

The feed water control station consists of a three pneumatic flow control valve [LV 7018-A], [FV 7018-AA] & [7018 -AB] with capacity of 30%, 110% and 110% MCR respectively. The control valve is provided with isolation valves BW009, B0013 & BW0017 respectively on its upstream and BW 010, BW014 & BW018 on its downstream respectively. These isolation valves are normally kept open. A drain valve is provided at the down stream of the control valves for maintenance. To prevent back flow from the boiler a NRV [BW023] is installed in the feed water line to Economizer. The thermocouple [TE 7018-E] installed with transmitter [TT 7018-E] will provide the feed water temperature at economizer inlet in DCS.

Drum Level Control Loop

Three-element feed water control system is provided to regulate the quantity of feed water flowing into the boiler to maintain the required water level in the steam drum. In three-element control, the drum level is controlled by the three process parameters (variables) - drum level, feed water flow & steam flow.

Drum level is measured by the differential pressure type level-transmitter [LT 7018-A] . The measured process variable (PV) from LT is compared with the fixed set point (SP) in the drum level indicating controller [LIC 7018-A] block and a control signal is generated. The level controller control output is added with steam flow signal from the main steam line in the feed forward block. This is done to achieve a better level control by taking corrective action in anticipation. The output of the feed forward block is used as a variable remote set point to the water flow-indicating controller [FIC 7018-A]. This variable set point is compared to the actual feed water flow signal from [FT 7018-A] and the controller [FIC 7018-A] will position the feed water control valve through a current-pneumatic converter. Action of the control valve is Air/ Signal fail to open and provided with air lock relay.

There are two flow control valves [FV 7018-AA and 7018-AB] provided with capacity of 110% MCR out of which only one control valve shall be kept in AUTO mode at a time. Out of the two any one can be used during three element mode when selected.

Another flow control valve with 30% MCR capacity is provided in parallel with the rest two flow control valves. When the boiler load is less, this valve shall be used in single element mode to have better control on the drum level. Also because of low dP across the valve, erosion possibility because of flow is minimized.

Alarms are generated from the transmitter signal in the DCS for low drum level (LALL) and high drum level (LAHH).

2.4 Economizer

A continuous finned tube economizer is located on the flue gas duct from the boiler to recover economically feasible heat from the flue gas before discharging to the atmosphere. The recovered heat increases the temperature of feedwater entering the steam drum. The direction of feedwater flow (inside the tubes) and flue gas (outside the tubes) are opposed cross flow for optimum heat transfer. Flue gas flows vertically through the Economizer.

The coils are made of SA 210 GrA1 material and of size 50.8 OD * 3.66 thick and arranged between inlet and outlet headers. The headers 20NB x 120 SCH are made of SA 106 Gr B material. The coils are supported on either side, inside the casing. The economizer is fully drainable by the drain valves provided on the inlet header [FD007 & FD008] and on the outlet header [FD004 & FD005]. Manholes are provided on the casing for cleaning and inspection of the economizer surfaces.

During operation, feedwater from control station outlet flows to the economizer inlet header and through the coils absorbing heat from the flue gas. Then it flows into the steam drum from the outlet header.

2.5 Boiler Assembly

The boiler is of bi-drum construction. Upper drum of the boiler is the steam drum and the lower drum is the water drum. Both the drums are provided with manholes on each side for access inside the drum. The drums are closed tight at either end by cover plates bolted against the manhole rim by two holding bars. A gasket is fitted between the cover plate and the mating machined surfaces in the end shield. The cover plates swing inside, for convenience during opening.

All the boiler tubes are connected to these two drums except the rear wall panel tubes, which are connected to the steam drum through riser pipes and through down comers to the water drum. The tubes enter the drums radially and have been expanded mechanically inside. The tubes support the steam drum, whereas water drum rests on the saddle supports.

The boiler is divided into a furnace section & a second pass by a baffle wall made of membrane panel. The flue gases that are generated from combustion in the furnace pass to the second pass through screen tubes at the rear side. Heat transfer takes place in furnace by radiation and in second pass by convection. Furnace is formed with the furnace side, roof & floor wall made out of single membrane panel and at rear it has flat studded wall construction. The furnace front wall is constructed out of refractory bricks, which houses the burners and access door. Furnace floor is covered with refractory bricks to facilitate effective natural circulation in the furnace wall tubes.

In the second pass, the superheater and the convection bank tubes are located. In between the baffle wall and the studded boiler sidewall the superheater and convection bank are accommodated. Combustion products (flue gas) from the furnace pass over the superheater and then to the convection bank tubes. The flue gas exits the boiler at the front of the boiler sidewall.

Baffle wall is fitted with upper and lower rows of refractory plugs. These plugs are provided for inspection and water washing of convection bank. On completion of water washing these plugs are installed back to seal the gaps. View ports are provided at the furnace side and rear walls for observing the flame.

Steam drum receives feedwater from the economizer. A perforated feed pipe inside the steam drum distributes feedwater across the length. Water flows to the water drum through portion of the convection bank tubes, which are not baffled at steam drum from the water level, acting as down comer tubes.

Boiler tubes absorb the heat from combustion and convert water into water-steam mixture and this conversion keep the tubes cool, within their safe permissible operating temperature.

Steam drum receives steam-water mixture from the furnace tubes, rear wall tubes and a portion of the convection bank tubes after evaporation. This mixture is routed to the cyclone separators through the baffles inside the steam drum. The mixture flows tangentially through the cyclone separators. While flowing through the cyclones, water that is heavier gets separated from steam and tickle down to mix with the water in the steam drum. Steam rises upward to flow through the scrubbers provided at the top of the steam drum. Scrubbers provide a tortuous path to the Steam and during this passage, last traces of water are stripped out from steam. Saturated dry steam collects at the saturation chamber above the scrubber and then passes to the superheater through the steam supply pipes to increase the temperature of steam.

For controlling and monitoring of various parameters, Steam drum is fitted with several components & instruments -

1. Level Sensing Instruments :- Level sensing instruments are tapped off from the front & rear sides of the steam drum on the hemispherical dished ends.
    - Level Gauges [LG 7018-A/B]:- Two direct level gauges are provided one each on front and rear side of the steam drum. Level gauges serve for direct and accurate reading of the steam drum level. The level gauges are used to verify the readings of level transmitters.
    - Level Transmitters :- Six level transmitters [LT 7018-A/B/C/D/E/F] is installed on the steam drum. From these six level transmitters three [LT 7018-D/E/F] are taken for drum level very low & high safety interlock as two out of three logic in BMS

to trip the burners. The other three level transmitter [LT 7018 A/B/C] signal is used for drum level control as process variable.

2. PRESSURE INDICATORS :-Two pressure gauges [PG 7018-F/G] are provided for local indication.

3. PRESSURE TRANSMITTERS :- Four pressure transmitters [PT 7018-CA/CB/CC/CD] are installed on steam drum. From these six pressure transmitters three [PT 7018-CA/CB/CC] are taken for drum pressure high high safety interlock as two out of three logic in BMS to trip the burners. The other one pressure transmitter [PT 7018-CD] signal is used for density compensation as process variable.

4. DRUM SAFETY VALVES PSV 7018 B/C] :- To protect the boiler and the personnel against the consequences of abnormal pressure increase caused by sudden load cut, malfunctioning of firing system, closure of steam valves etc., two spring loaded mechanical safety valves have been fitted on the steam drum. On increase of the steam pressure beyond the set value of the Safety Valve's, [5198 kPa (g) & 5295 kPa (g) respectively] the valves open automatically to relieve the steam to atmosphere. The safety valve closes when the drum pressure falls to the reset pressure of the valve. The relieving capacity of all the Safety Valves put together is designed in such a manner that even at maximum firing rate of the Boiler, the valves are capable to relieve the total generation of steam thus safeguarding the boiler.

5. AIR VENT :- An air vent, with isolation valve [DM 039] along with motorized valve [MOV 7018-G] is provided on the steam drum to vent out air during initial boiler filling & cold startup and while de-pressurization/ shutting down the boiler to prevent the drum from going into vacuum pressure due to condensation. While boiler cold start up, the air vent is kept open till the steam drum pressure reaches 2 bar (g) and similarly it is opened when the drum pressure falls to 2 bar (g) during shutdown.

6. N2 CONNECTION :- A connection with an isolation valve [NI 001 & NI 002] along with NRV [NI003] to fill N2 for boiler preservation has been provided on steam drum. Preservation procedure is explained in maintenance section of this manual. N2 line is isolated normally during the operation of the boiler.

7. DOSING AND BLOWDOWN CONNECTIONS :- A Continuous Blow down (CBD) connection and a Chemical Dosing connection are provided on the steam drum for conditioning of the Boiler Water.

   - CONTINUOUS BLOWDOWN :- Due to continuous evaporation of boiler water in the drum, minor impurities present in the feedwater concentrate to high impermissible levels in the boiler water. Rise in hardness of water, phosphates, content of chlorides, silica etc., have to be kept to a minimum to prevent scale formation or deposits in the boiler evaporation tubes, drums, superheater, steam piping and the down stream equipment. Sample of boiler water is collected through a sample cooler. Based on measured value of conductivity, determined amount of water is continuously drained from the boiler drum through the Continuous Blow Down (CBD) line by a CBD valve [MOV 7018-F] along with isolation valves [BD 001/002/003] to reduce the concentration of impurities and to maintain within the permissible levels.

     A 25 NB pipe with its one end open is laid along the water space of steam drum below the normal water level. This pipe is connected to blowdown drum with an isolation valve [BD 001/002/003] & main blow down valve [MOV 7018-F].

   - PHOSPHATE DOSING CONNECTION :- Tri-Sodium phosphate is dosed into the boiler water to maintain a phosphate concentration of maximum 34 ppm and pH of 9.0 to 11.2. The Phosphate has the capacity to convert hardness producing insoluble calcium/ magnesium salts to soluble salts, which are drained through the blow down.

     A typical reaction can be as follows: $3\ CaSO_4 + 2\ Na_3PO_4 \rightarrow Ca_3(PO_4)_2 \downarrow + 3Na_2SO_4$. The dozed phosphate also provides desired alkalinity to the boiler water. An alkaline pH minimizes the possibilities of corrosion.

     Dosing of phosphate to the Boiler water is to be done in a manner that it quickly mixes with the whole of Boiler water. To enable this a perforated pipe has been laid along the length of the steam drum and connected to the HP chemical dosing system through line with an isolation valve [HP 021 & HP 023] and NRV [HP 022].

- IBD CONNECTION :- The water drum is provided with connection to collect the sludge and other impurities, which will be removed through the intermittent blow down (IBD).

  To drain the boiler completely during shut down and to remove the silica/ sludge collected in the boiler during operation a drain line from water drum is provided with a intermittent blow down valves [FD 016, FD 017 & FD 018] along with IBD valve BD013. During normal operation of the Boiler IBD shall be operated by the operator once in a shift for approximately 1 minute duration. IBD can also be operated during emergency to lower the drum level if the drum level increases beyond specified limits (like swelling during cold start up and during load upsets). IBD line is connected to the IBD tank through the drain header.

2.6 Superheater

Saturated steam from the steam drum flows to the superheater assembly to increase the steam temperature. Saturated steam from the steam drum internals flows through the supply pipes to the superheater primary header, from where it is distributed to other Superheater tubes. Superheater tubes are placed in between the Superheater primary (inlet) and outlet headers. The headers are baffled to form multiple passes for effective heat pickup to attain the desired steam temperature. In order to maintain the final steam temperature a spray type attemperator is installed in-between the passes.

Superheater is placed at the flue gas entry of Boiler second pass. Continuous and sufficient flow of the steam through the Superheater ensures the metal temperature of the coils does not exceed the design value. Superheater headers are provided with drains, which are connected to the blowdown tank through the drain header. Superheater has to be drained before starting the boiler and after shutdown to remove the condensate. Superheated steam from superheater final header flows to the main steam line.

2.7 Attemperator

An inter-stage attemperator is provided in the superheater to maintain the final steam temperature. Spraying a controlled quantity of feedwater into the superheated steam lowers its temperature as it looses some heat in evaporating the sprayed water.

The attemperator is a header, which accommodates an inner sleeve shaped like a venturi. A spray nozzle is fixed at the entrance to the restricted venturi section. The sleeve is held in position firmly by the locating pins welded to the header at the steam entry side. The sleeve is free to expand at the steam exit side. Water is sprayed through the spray nozzle. The steam passes through the venturi picks up the spray, which completes the evaporation and thoroughly mixes the steam. The connection of the inlet to the spray nozzle embodies a thermal sleeve construction to protect the steam line from temperature differential between the spray water and the steam. A drain connection is provided at the exit of the attemperator.

The spray water is taped from the feed water piping before the feed water control station. A globe type pneumatically actuated control valve [TV 7018-C] is provided to control spray water flow to the attemperator. The control valve is provided with isolation valves [DSH 017/006/014/007] at upstream and downstream. To prevent back flow of steam a NRV [DSH 013] is provided in the line.

A flow nozzle [FE 7018-B] with a differential pressure transmitter measures the flow of feed water to attemperator. It gives the signal to [FIC 7018-A].

2.7.1Steam Tempearture Control Loop

This loop is used to maintain the temperature of Superheated steam at rated value of 371 0C. Steam Temperature is controlled by attemperation i.e. by spraying feed water into the steam by De super heater nozzle located between the Primary super heater outlet & Secondary Super heater inlet.

The final steam temperature is measured by temperature elements [TE 7018CD] & Transmitter [TT 7018CD], output of which acts as a Process value for [TIC 7018CD].

Final steam temperature is controlled by [TIC 7018CD] which will have Local set point (at 371 + 5 0C) set by operator. Output of [TIC 7018CD] will be Corrected by feed forward signal (i.e. output of TIC 7018B) this corrected output is fed to Temp. Control valve [TV 7018C].

Steam temperature at attemperator outlet measured by [TE 7018B] & [TT 7018B] shall act as a process variable signal to feed forward

Controller [TIC 7018B] which compares process variable with Remote set point generated from high selector block for generating the correction value for [TIC 7018CD] controller output.

2.8 Main Steam Line

Temperature & Pressure Measurements

The main steam line connects the steam outlet from super heater to the plant steam main at the terminal point main steam stop valve.

This line incorporates the following -

Temperature element [TE 7018CA/CB/CC/CD] with transmitter [TT 7018CA/CB/CC/CD] is provided on the main steam line to measure and transmit the steam temperature to DCS. Temperature signal is taken as the process variable for the temperature indicating controller as explained above and for temperature compensation of the steam flow signal. Steam Temperature HIGH HIGH is generated from the signal of temperature transmitters [TT 7018 CA/CB/CC]

Pressure transmitter [PT 7018B] installed on the steam line provides the main steam pressure signal to DCS & it is also taken for the pressure compensation of steam flow.

Steam pressure HIGH HIGH is generated from the signal of pressure transmitters [PT 7018B].

Safety Valve

To take care of the pressure upset caused by sudden load cut, malfunctioning of firing system, closure of steam valves etc., a safety valve [PSV 7018A] is provided on the main steam line at the superheater outlet. On increase of the steam pressure beyond the set value of the safety valve (4609 kPag), the valve opens automatically to relieve the steam to the atmosphere. The valve closes when the pressure falls to the reseat value of the value. The relieving capacity of the valve along with the two safety valves on the drum is designed in such a manner that even at the maximum firing rate of the boiler, the valves are capable of relieving the total steam generation of the boiler, thus safeguarding the boiler.

Flow Element

Flow orifice [FE 7018C] is installed on the main steam line to measure the steam flow from the boiler. Differential pressure transmitter (FT 7018C) transmits the flow signal to DCS. Steam flow signal is compensated for steam pressure and temperature.

Start Up Vent

During boiler start up, till the operating pressure is reached and connected to the main header, it is necessary to establish steam flow through the superheater to prevent overheating of the tubes. While start up, to establish sufficient steam flow through the superheater tubes, a start up vent is provided with a control valve in the main steam piping. Start up vent flow is regulated by this pneumatic flow control valve [PV 7018B] operated manually through the controller [PIC 7018A] in DCS. A motorised gate valve [MOV 7018C] is provided for positive isolation. The exhaust of the start up vent is led through a silencer to attenuate the noise level.

Start Up Vent Pressure Control:

Boiler HP steam pressure signal from PT 7018B is fed to PIC-7018B where the process variable is compared with the local set point for generating the manipulated variable, which controls the PV-7018B.

Opening of control valves is sensed using position transmitter (ZT7018B), position indication (ZI-7018B) is provided. If start up vent valve opening is more than 5 % open position alarm ZAL 7018B is provided for operator attention.

Steam Flow:

Steam flow is measured using a steam flow transmitter FT- 7018C. that is connected across flow nozzle; the steam flow signal is to be square rooted at the DCS end.

Pressure and temperature compensation of steam flow is carried out to take care of errors arising due to density variation of steam, when boiler is operating at conditions different from design conditions.

Compensated Steam flow as explained above shall generate low flow alarm FAL 7018C when ever HP steam flow is less than 30%. At this time operator shall operate the valve in manual mode (i.e. FAL 7018C shall force) to open start up vent valve PV 7018B through PIC 7018B to pass the 30% MCR flow.

Main Steam Stop Valve (MSSV)

Main steam stop valve [MOV 7018D] is provided to isolate the boiler from the plant during shutdown and during startup until the operating parameters are attained. During regular operation of the boiler, this valve is kept fully open supplying steam from the boiler to the plant main. The main steam stop valve is provided with an integral bypass valve [MOV 7018E] for initial warm up of the down stream steam line and to equalize the pressure across the MSSV prior to opening it. A NRV [MS 010] is provided before the stop valve to prevent back flow of the steam from the plant to the boiler.

Sample Connection

To analyse the super heated steam quality, a sample line is taped off from the main steam line with isolation valve [SAM 001 / 002] and connected to the SWAS panel.

2.8.1Operational Control

A brief overview of operational control points is described below. Operation & troubleshooting are separately explained later.

STEAM DRUM :-

- Maintain feedwater, boiler water quality, and chemical concentration as prescribed.
- Maintain water level in the steam drum within permissible low and high levels. The protection system envisages boiler trip at very low levels, which should not be bypassed.
- Maintain drum level gauge glasses in good working condition. Operators may verify the level transmitter reading with the level gauge once a day.
- Thermal stress in steam drum during startup and shutdown - Steam drum is a large cylindrical shell. Before lightup, the inner and outer surfaces of the drum are at the same temperature. When boiler is lighted up, the inner surfaces gets heated up first by the water (and then by steam) and transmits heat to the outer surface of the drum. The heat transfer is by conduction and is a bit slow. For short time after lightup, there can be differences of temperature between water and steam surfaces of the drum. Such a difference can set up thermal stresses, which are not desirable. To minimize the thermal stresses, the operator must restrict the firing rate.
- Swelling - During boiler startup, as the boiler water temperature reaches 90°C, there is a sudden increase of water level caused by the increase in the volume of hot water. Such swelling, if not controlled, can cause a high level in the drum. To avoid this, initial filling is restricted to a level (about – 50mm) and a smart operator anticipates a swell and uses the intermittent blowdown to drain and control the level.
- Do not operate the boiler with safety valves gagged. Passing of safety valves must be attended during the next shutdown.

General :-

- Boiler water can be drained after a shutdown only after depressurizing to atmospheric pressure and cooling down to 80°C.
- Draining of the boiler water to be done through the blowdown where such provision is available.
- If a tube failure is detected, it is advisable to plan for an early shutdown. It may be possible to quickly repair the failed tube and return to service. If the shutdown is inordinately delayed, there are possibilities of larger secondary damages, which may prolong the shutdown required for repairs.
- Keep the isolation valves of all the instruments fully open.
- Manually operated valves must be closed hand tight only. Use of levers on hand wheels is not desired.

2.8.2Chemical Dosing & Sampling System

Chemical dosing system consists of chemical dosing tank with two pumps with motorised agitator interconnecting piping, valves and mountings. The complete assembly is mounted on the skid. Chemical dosing system are required to maintain feed & boiler water quality at desirable levels.

Phosphate Dosing System

During the boiler operation the impurities in the boiler water keep on getting concentrated. If the boiler feed water is hard the concentration of such chemicals may cause formation & deposition of scales on boiler heat transfer surfaces, which is dangerous. The chemicals dosed (Tri Sodium phosphate-TSP), react and form insoluble compounds, which prevent scale formation and aid in removal of existing scales. The quantity of such chemicals should to be calculated and depending on the analysis of boiler water.

2.8.2.1 Description Of Dosing System Skid (Hp)

Total system is mounted on a Base frame. Chemical-mixing tank made of SS of capacity 500-litres for HP dosing is provided, where the chemical is mixed with water for 8/24 hrs dosing. Following are the attachments of the tank - A level gauge, One mixing water connection, one drain, one over flow connection with isolation valves, one motorised agitator for proper mixing of the solution and a perforated screen at the inlet to avoid foreign material entry.

Phosphate Dosing Pumps

Two phosphate dosing pumps (A & B) of have been provided, out of which one is for service at a time, and the other is a standby. The pumps are plunger operated reciprocating, positive displacement type. The stroke of the plunger can be altered to vary the capacity of the pump as per requirement. The pump is driven by a motor through a gearbox. The vendor manual of the pump and gearbox is available with full information on construction and parts detail.

Pump suction line is tapped of from the bottom of the tank. It is connected to the pump through an isolation valve and a strainer. A direct connection of the DM water is given in between strainer and isolation valve for flushing of the discharge piping & strainer. Y strainer traps dirt or other solid particles in its basket. The Y strainer is to be cleaned once a month, after stopping the pump and closing its inlet and outlet isolating valves.

Each pump is connected to a common discharge line with the following valve arrangement:

- In the discharge line a pulsation dampener is given to dampen intermittent discharge from the pump. On the discharge side of the pump, a pressure gauge and two outlet isolating valves are fitted before the common discharge line. A safety relief valve has also been fitted on the discharge line to relieve any over pressures in case of closure of valves on the discharge line. The outlet of the relief valve is returned to the mixing tank. The relief valve must be tested for its operation at the set pressure atleast once a year. The pump must not be operated with the relief valve continuously operating. (Cause of relief valve operation must be found and rectified). The pressure gauge is fitted with a dampening device to minimize pulsations on the gauge when the pump is in service.
- The common discharge line is connected to the HP dosing line of the steam drum through an NRV and an isolation valve. The isolating valve is verified open before boiler light up and normally remains open all the time. Phosphate dosing is through a perforated pipe along the full length of the water space in the drum.
- Availability of a minimum level in the mixing tank is a pre condition for starting or running of the dosing pumps. For this purpose a level switch has been provided for the tank that gives level low signal LSLL 773A0, which is interlocked to dosing pumps to prevent accidental start-up during low tank level. Out of the two pumps, one pump is selected for service and the other is in reserve (DCS macro, Local panel). The pumps are interlocked such that when a working pump trips, the reserve pump starts automatically. (Please refer Vendor manual for relief valve set pressure)
- Discharge of the relief valve is connected back to the tank. Pressure gauge is provided with a Snubber and a Diaphragm, snubber helps to dampen the fluctuating pressure and diaphragm avoids direct contact of chemicals and the gauge internals. One drain provided after the pressure gauge is used to release pressure while adjusting the relief valve setting. Also it can be used to check the flow.
- According to the system, discharge line of the H.P dosing is connected to Steam Drum. Supports at required elevations are given. All the piping in the system is to withstand corrosive chemical solution.

2.8.2.2 Amine Dosing System (PH Dosing System)

Amine dosing is required continuously to keep feed water quantity as per recommended parameters. Feed water pH may reduce due to mixing of condensate at deaerator. In order to boost the pH of feed water, 2.5% concentrated solution of Cyclohexyl Ammine to be prepared for continuous dosing to make up water line to de-aerator vapour tank. Dosing pump stroke are set to get required Ph.

The quantity has to be sufficiently diluted and dosed in 24 hrs.

Description Of Dosing System Skid

Total system is mounted on a Base frame. Chemical-mixing tank made of SS of capacity 500-litres for dosing is provided, where the chemical is mixed with water for 8/24 hrs dosing. Following are the attachments of the tank - A level gauge, One mixing water connection, one drain, one over flow connection with isolation valves, one motorised agitator for proper mixing of the solution and a perforated screen at the inlet to avoid foreign material entry.

Amine Dosing Pumps

Two amine dosing pumps (A & B) of have been provided, out of which one is for service at a time, and the other is a standby. The pumps are plunger operated reciprocating, positive displacement type. The stroke of the plunger can be altered to vary the capacity of the pump as per requirement. The pump is driven by a motor through a gearbox. The vendor manual of the pump and gearbox is available with full information on construction and parts detail.

Pump suction line is tapped of from the bottom of the tank. It is connected to the pump through an isolation valve and a strainer. A direct connection of the DM water is iven in between strainer and isolation valve for flushing of the discharge piping & strainer. Y strainer traps dirt or other solid particles in its basket. The Y strainer is to be cleaned once a month, after stopping the pump and closing its inlet and outlet isolating valves.

Each pump is connected to a common discharge line with the following valve arrangement:

- In the discharge line a pulsation dampener is given to dampen intermittent discharge from the pump. On the discharge side of the pump, a pressure gauge and two outlet isolating valves are fitted before the common discharge line. A safety relief valve has also been fitted on the discharge line to relieve any over pressures in case of closure of valves on the discharge line. The outlet of the relief valve is returned to the mixing tank. The relief valve must be tested for its operation at the set pressure atleast once a year. The pump must not be operated with the relief valve continuously operating. (Cause of relief valve operation must be found and rectified). The pressure gauge is fitted with a dampening device to minimize pulsations on the gauge when the pump is in service.
- The common discharge line is connected to the deareator DM & condensate water line through an NRV and an isolation valve. The isolating valve is verified open before boiler light up and normally remains open all the time.
- Availability of a minimum level in the mixing tank is a pre condition for starting or running of the dosing pumps. For this purpose a level switch has been provided for the tank that also gives level low signal LSLL 774A0, which is interlocked to dosing pumps to prevent accidental start-up during low tank level. Out of the two pumps, one pump is selected for service and the other is in reserve (DCS macro, Local panel). The pumps are interlocked such that when a working pump trips, the reserve pump starts automatically. (Please refer Vendor manual for relief valve set pressure)
- Discharge of the relief valve is connected back to the tank. Pressure gauge is provided with a Snubber and a Diaphragm, snubber helps to dampen the fluctuating pressure and diaphragm avoids direct contact of chemicals and the gauge internals. One drain provided after the pressure gauge is used to release pressure while adjusting the relief valve setting. Also it can be used to check the flow.
- Supports at required elevations are given. All the piping in the system is to withstand corrosive chemical solution.

2.8.2.3 O2 Scavenging System (LP)

Removal of dissolved oxygen/gases from boiler feed water is essential. Presence of dissolve gases can cause corrosion and pitting of feed water lines, steam line or condensate lines, boiler tubes and other pressure parts resulting in pre-matured failure of pressure parts or other expensive plant shut down.

Sodium sulphite (catalysed or un-catalysed) or hydrazine is to be used for oxygen removal from boiler feed water. The major amount of dissolved oxygen is removed in deaerator by mechanical deaeration. The remaining traces of oxygen are removed by reacting with chemical (sodium sulfite or hydrazine).

Description Of Dosing System Skid

Total system is mounted on a Base frame. Chemical-mixing tank made of SS of capacity 500-litres for dosing is provided, where the chemical is mixed with water for 8/24 hrs dosing. Following are the attachments of the tank - A level gauge, One mixing water connection, one drain, one over flow connection with isolation valves, one motorised agitator for proper mixing of the solution and a perforated screen at the inlet to avoid foreign material entry.

O2 Scavenging Pumps

Two phosphate dosing pumps (A & B) of have been provided, out of which one is for service at a time, and the other is a standby. The pumps are plunger operated reciprocating, positive displacement type. The stroke of the plunger can be altered to vary the capacity of the pump as per requirement. The pump is driven by a motor through a gearbox. The vendor manual of the pump and gearbox is available with full information on construction and parts detail.

Pump suction line is tapped of from the bottom of the tank. It is connected to the pump through an isolation valve and a strainer. A direct connection of the DM water is given in between strainer and isolation valve for flushing of the discharge piping

& strainer. Y strainer traps dirt or other solid particles in its basket. The Y strainer is to be cleaned once a month, after stopping the pump and closing its inlet and outlet isolating valves.

Each pump is connected to a common discharge line with the following valve arrangement:

- In the discharge line a pulsation dampener is given to dampen intermittent discharge from the pump. On the discharge side of the pump, a pressure gauge and two outlet isolating valves are fitted before the common discharge line. A safety relief valve has also been fitted on the discharge line to relieve any over pressures in case of closure of valves on the discharge line. The outlet of the relief valve is returned to the mixing tank. The relief valve must be tested for its operation at the set pressure at least once a year. The pump must not be operated with the relief valve continuously operating. (Cause of relief valve operation must be found and rectified). The pressure gauge is fitted with a dampening device to minimize pulsations on the gauge when the pump is in service.
- The common discharge line is connected to the LP dosing line of the De-aerator through an NRV and an isolation valve. The isolating valve is verified open before boiler light up and normally remains open all the time. Dosing is through a perforated pipe along the full length of the water space in the de-aerator.
- Availability of a minimum level in the mixing tank is a pre condition for starting or running of the dosing pumps. For this purpose a level switch has been provided for the tank that also gives level low signal LSLL 775A0, which is interlocked to dosing pumps to prevent accidental start-up during low tank level. Out of the two pumps, one pump is selected for service and the other is in reserve (DCS macro, Local panel). The pumps are interlocked such that when a working pump trips, the reserve pump starts automatically. (Please refer Vendor manual for relief valve set pressure)
- Discharge of the relief valve is connected back to the tank. Pressure gauge is provided with a Snubber and a Diaphragm, snubber helps to dampen the fluctuating pressure and diaphragm avoids direct contact of chemicals and the gauge internals. One drain provided after the pressure gauge is used to release pressure while adjusting the relief valve setting. Also it can be used to check the flow.
- According to the system, discharge line of the scavenging pump is connected to De-aerator. Supports at required elevations are given. All the piping in the system is to withstand corrosive chemical solution.

Flushing Line

In the system, the chemical mixing water line is connected to the pump suction line also, called as flushing line. This is provided to clear the line whenever there is no need for dosing.

Whenever the dosing is stopped, always there is a chemically concentrate water is stagnant inside the piping. If this liquid is not evacuated, it may tend to solidify and settle inside the piping, which will create a problem for free flow of chemical whenever the dosing is re-started.

Whenever the dosing is stopped, first close the mixing tank outlet valve and open the flushing line valve, operate the pump for 2 hrs. In this process, the chemically concentrated water is replaced with the clear water; thus choking of piping can be avoided.

2.8.3Sample System

This sub-section provides an overview of the sample collection and cooling system provided on the boilers.

The sample system includes the sample cooler and the associated analyzers and the cooling water sub-system

Sample Coolers :-

There are four sample coolers provided in the boiler to get Saturation steam, boiler feed water, drum sample and main steam sample

One sample cooler is provided for drum water sample emerging out from the continuous blow down line. Sample cooler two is provided for the superheated steam sample from main steam line. Sample cooler three is provided saturation steam before steam entering in to superheater. Sample cooler four is provided to feed water line sample water before entering in to drum

The sample coolers are simple shell and coil type heat exchangers. In these sample coolers, the sample is passed through the coils while the cooling water is passed around the coils on the shell side.

Individual sample coolers are provided with isolation valves on the cooling water inlet & cooling water return lines. The cooling water is provided from the plant.

3 Valve Positions Chart (Before Light Up)

Valve Tag no.	Service	Open	Close	Remarks
FEEDWATER LINE TO STEAM DRUM				
BW017, BW018	Upstream and downstream isolation valves of flow control valve (FV7018AA)	Y		To be closed when the control valve is under maintenance
BW013, BW014	Upstream and downstream isolation valves of flow control valve (FV7018AB)	Y		To be closed when the control valve is under maintenance
BW009, BW010	Upstream and downstream isolation valves for level control valve LV7018A	Y		To be closed when the control valve is under maintenance
BW011, BW012	Drain after level control valve (LV7018A)		Y	To be closed when control valve is under maintenance
BW015, BW016	Drain after flow control valve (FV7018AB)		Y	To be closed when flow control valve is under maintenance
BW019, BW020	Drain after flow control valve (FV7018AA)		Y	To be opened when flow control valves are under maintenance
ATTEMPERATER LINE				
DSH001	Attemperation line isolation valve	Y		To be closed only for maintenance of line
DSH006, DSH007	Upstream and downstream isolation valves for flow control valve (TV7018C)	Y		To be closed only for the maintenance of flow control valve
DSH008, DSH009	Drain after flow control valve		Y	To be opened only for the maintenance of flow control valve
TV-7018C	Attemperation water flow control valve	Y		Operated from DCS
DSH010	Bypass to flow control valve		Y	To be opened only during the maintenance of flow control valve
SD007, SD008	Attemperater drain Isolation Valves		Y	To be closed when condensate is drained completely at 5 bar (g) pressure.
ECONOMIZER				
ECO001, ECO002	Economizer top header Vent Isolation Valves.		Y	To be open only during initial filling or draining of Economizer/ boiler.
ECO005, ECO006	Economizer bottom header Vent Isolation Valves.		Y	To be open only during initial filling or draining of Economizer/ boiler.

Valve Tag no.	Service	Open	Close	Remarks
FD004, FD005,	Economizer Top header Drain Isolation Valves.		Y	To be open only during initial filling or draining of Economizer/ boiler.
FD007, FD008	Economizer bottom header Drain Isolation Valves.		Y	To be open only during initial filling or draining of Economizer/ boiler.
STEAM DRUM & MAIN STEAM LINE				
DM039, DM040	Drum vent manual isolation valve of	Y		To be closed when drum pressure reaches 2 bar (g) during boiler pressurization.
NI002,NI 004	N2 preservation connection		Y	To be opened only when boiler is to be preserved with N2
DM021, DM022, DM023, DM024	Isolation Valves for manifold on Steam Drum for Level Indicating Instruments.(LT7018A)	Y		To be closed during maintenance of level transmitter
DM001, DM002, DM003, DM004,	Isolation Valves of Steam Drum Level Gauge Glass (LG7018A)	Y		To be closed during maintenance of level gauge
DM007, DM008, DM009, DM010	Isolation Valves of Steam Drum Level Gauge Glass (LG7018B)	Y		To be closed during maintenance of level gauge
DM025, DM026, DM027, DM028,	High level switch (LSHH7018B) isolation valves	Y		To be closed during maintenance of level switch
DM029, DM030, DM031, DM032	Low level switch (LSLL7018C) isolation valves	Y		To be closed during maintenance of level switch
DM038, DM039	Auxiliary connection		Y	
SH001, SH002, SH003, SH004	Saturated steam line vent valves	Y		To be closed when drum pressure reaches 2 bar (g) during boiler pressurization.
sd001, mov7018-a sd004, mov7018-b,	Superheater Inlet & Outlet Header Drain	Y		To be closed when condensate is drained completely at 5 bar (g) pressure.
MS001, MS002	Main steam line vent	Y		To be closed when drum pressure reaches 2 bar (g).

Valve Tag no.	Service	Open	Close	Remarks
MS011, MS012	Main Steam line drain before MSSV	Y		To be closed when condensate is drained completely.
MOV7018-C	Isolation Valve of Startup Vent Valve	Y		To be opened before opening start up vent valve.
MOV7018-E	Motorized Pressure Equalization Valve of Main Steam Stop Valve		Y	To be opened for equalization of pressure.
MOV7018-D	Motorized Main Steam Stop Valve		Y	To be opened after reaching the rated Pressure.
DM043, DM044	Rear wall vent isolation valves		Y	To be open only during initial filling or draining of boiler.
BLOWDOWN SYSTEM				
BD001, BD002, BD003	CBD Isolation Valve	Y		To be closed only for the maintenance of CBD valve
MOV7018-F	CBD control valve		Y	To be opened as per requirement.
FD016, FD017	IBD Isolation Valve of IBD Line	Y		To be closed only for maintenance of IBD valve
BD013	IBD Valve from Water Drum.		Y	To be opened when IBD is required to be given. And during initial filling
DRAIN SYSTEM				
FD019	Drain Header to Blowdown Tank,		Y	To be opened when drain is to be routed to the Blowdown Tank.
FD001, FD002, FD003	Rear wall header drain valve		Y	To be open only during initial filling or draining of boiler.
FD010, FD011	Drain header draining valves		Y	To be open for draining of drain header/ Boiler during shutdown to atmosphere.
BD005, BD006	Isolation valves for level gauge (LG737AO)	Y		To be closed during maintenance of level gauge
BD009	Blowdown tank drain valve			
BD010	Quenching water to Blowdown tank	Y		To be throttled as per quenching water requirement
FUEL GAS SYSTEM				
N-001	Inert gas isolation valve		Y	To be open for purging of the line with N2.

Valve Tag no.	Service	Open	Close	Remarks
FG-001	Natural Gas Main Isolation Valve	Y		To be Closed when boiler is under Shut down for Long period.
FG007, FG008, FG017, FG014	Natural Gas line drain valves		Y	To be kept closed and opened to drain line to remove condensate.
FG013	Vent isolation valve		Y	To be opened for manually venting fuel gas.
XV-7012 B	Fuel gas MFT valve		Y	Will be opened/Closed from BMS command
FV7012A	Fuel Gas Flow Control Valve	Y		
PV7012 C	Fuel Gas pressure control valve	Y		
FG003, FG004,	Fuel gas flow control valve upstream & downstream isolation valve.	Y		To be closed when flow Control Valve is under Maintenance.
FG005, FG006	Fuel gas pressure control valve upstream & downstream isolation valve.	Y		To be closed when pressure Control Valve is under Maintenance.
FG009	Manual isolation valve of header vent shut off valve	Y		To be closed only for maintenance of vent valve(XV-7012G)
XV-7012 G	Gas line vent shutoff Valve		Y	Will be Opened/Closed from BMS Command
FG010	Fuel gas to burner A isolation valves	Y		To be closed when burner is under maintenance.
XV-7014DA, XV-7014DB, XV7014E	Block & Bleed Valves (Burner “A”) for main gas line		Y	Will be Opened and Closed by BMS command
PILOT GAS SYSTEM				
FG051	Pilot Gas Main Isolation Valve	Y		To be Closed during long Shutdowns
PCV 7013	Pilot gas pressure control valve	Y		To be set at required pressure
FG055	Manual isolation valve of header vent		Y	To be opened for venting pilot gas line
FG052	Burner A Pilot gas isolation valves	Y		To be Closed during maintenance
XV-7014H, XV-7014GA, XV-7014GB	Block & Bleed valves (Burner “A”) for pilot gas		Y	Will be Opened and Closed by BMS command
COOLING AIR SYSTEM				
SA-01, SA-02, SA-03, SA04, SA05, SA06	Isolation valves for Cooling Air to Scanners	Y		To be Closed only during Maintenance after ensuring that Furnace temperature is below 80 Deg C

Valve Tag no.	Service	Open	Close	Remarks
ATOMIZING STEAM SYSTEM				
SM037, SM038	Atomizing steam line battery limit isolation valves	Y		To be closed during maintenance
SMO43, SM044	Isolation valve of Pressure control valve (PV7011A)	Y		To be closed during maintenance of PV7011A
SM003, SM005	Strainer upstream and downstream isolation valves	Y		To be closed when the strainer is to be cleaned
SM007, SM008	Isolation valves of differential pressure control valve (PDV7011B)	Y		To be closed during maintenance of PDV7011B
SM012	Bypass of differential pressure control valve (PDV7011B)		Y	To be opened during maintenance of PDV7011B
SM009, SM046	Drain after differential pressure control valve (PDV7011B) and bypass valve (SM012)		Y	To be opened during maintenance and draining of condensate
XV-7014C	Atomizing steam to burner A shutoff valve		Y	Will be Opened/Closed from BMS Command
SM027	Main gun atomizing shutoff valve	Y		To be closed during shutdown
SM028	Auxiliary gun atomizing shutoff valve	Y		To be closed during shutdown
XV-7014B	Clearing steam line shutoff valve		Y	Will be operated by BMS command
SM018	Clearing steam to main oil gun isolation valve	Y		To be closed when the gun is under maintenance
SM019	Clearing steam to auxiliary oil gun isolation valve	Y		To be closed when the gun is under maintenance
SM011, SM002	Isolation valves for steam trap SM035 & SM036 respectively	Y		To be closed for maintenance of steam trap
SM039, SM040, SM040, SM042, SM001, SM010	Drains for condensate		Y	To be opened during charging/shutdown to remove condensate
ATOMIZING AIR SYSTEM				
SM013	Atomizing air battery limit isolation valve	Y		To be closed only for the maintenance of atomizing air line
SM045, SM015	Strainer upstream and downstream isolation valves	Y		To be closed when the strainer is to be cleaned
SM007, SM008	Isolation valves of differential pressure control valve (PDV7011B)	Y		To be closed during maintenance of PDV7011B

Valve Tag no.	Service	Open	Close	Remarks
SM012	By pass of differential pressure control valve (PDV7011B)		Y	To be opened during maintenance of PDV7011B
SM009, SM046	Drain after differential pressure control valve (PDV7011B) and bypass valve (SM012)		Y	To be opened during maintenance
XV-7014C	Atomizing air to burner A shutoff valve		Y	Will be operated by BMS Command
SM027	Main gun atomizing shutoff valve	Y		To be closed during shutdown
SM028	Auxiliary gun atomizing shutoff valve	Y		To be closed during shutdown
XV-7014B	Clearing air line shutoff valve		Y	Will be operated by BMS command
SM018	Clearing air to main oil gun isolation valve	Y		To be closed when the gun is under maintenance
SM019	Clearing air to auxiliary oil gun isolation valve	Y		To be closed when the gun is under maintenance
FUEL OIL SYSTEM				
DF001	Diesel oil battery limit isolation valve	Y		To be closed only for maintenance.
DF002, DF003	Upstream and downstream isolation valves of flow transmitter	Y		To be closed only for maintenance of flow transmitter
DF004	Drain for flow transmitter		Y	To be opened only for maintenance.
DF005	Bypass valve of mass flow transmitter		Y	To be opened during maintenance of flow transmitter
DF006, DF007	Upstream and downstream isolation valves of flow control valve	Y		To be closed only for maintenance of control valve.
DF009, DF010	Upstream and downstream isolation valves of pressure control valve (PV7010B)	Y		To be closed only for maintenance of control valve.
DF008	Drain for flow control valve line		Y	To be opened only for maintenance of flow control valve (FV7010A).
DF011	Drain for Pressure control valve line		Y	To be opened only for maintenance of pressure control valve (PV7010B).
XV7010D	Main flow trip valve		Y	Will be Opened/Closed from BMS Command
DF024	Oil header drain valve		Y	To be opened only for maintenance.
XV7014A	Burner A shutoff valve		Y	Will be Opened/Closed from BMS Command

Valve Tag no.	Service	Open	Close	Remarks
DF012	Auxiliary oil gun isolation valve	Y		Will be closed when main oil gun is to be taken in line
DF013	Main oil gun isolation valve		Y	Will be opened when main oil gun is to be taken in line
DOZING SYSTEM				
HP023, HP021	HP dozing isolation valves	Y		To be closed only for maintenance of dosing line
FWT07, FWT008	DM water to dozing tank isolation valves	Y		To be closed during shutdown.
SAMPLING SYSTEM				
SAM003, SAM004	Feed water sample line isolation valves	Y		To be closed during maintenance of sample line
SAM005, SAM006	CBD sample line isolation valves	Y		To be closed during maintenance of sample line
SAM007, SAM008	Saturated steam sampling line isolation valves	Y		To be closed during maintenance of sample line
SAM001, SAM002	Superheated steam sampling line isolation valves	Y		To be closed during maintenance of sample line

Note

Root valves of all the instruments to be kept open. Ensure vent and drain valves of all instruments are closed.

Note

Above Philosophy is explained for burner A only. Same philosophy is to be followed for other burners

All above description is based on following drawings:

- P&I Dagram for Steam and Water system D12-0FM-3232P
- P&I Diagram for Firing D12-1FM-6516P Sheet 1 & 2

4 Air and Flue Gas System

The air and flue gas system covered in this sub-section describes the supply of combustion air to the boiler and forcing of the flue gas through the boiler to the stack.

The components that form part of the system are -

- FD fan
- Air duct
- Windbox
- Furnace
- Flue ducts
- Service air for Peepholes

4.1 FD Fan

The FD fan supplies combustion air to the burners. (The Vendor manual for FD Fan is included in Volume-III, which may be referred).

FD fan is of centrifugal type, with aerofoil backward curved blades. FD fan is equipped with motor drive, driven by an electrical motor.

The principal parts of the fan are described as below:

Casing - The casing envelops the impeller. The casing is fabricated out of carbon steel plates and stiffened by angles welded outside to strengthen the casing to resist vibration when the fan is in service. The casing is of split design to enable removal of impeller if required, without disturbing the fixing arrangement of the casing to the foundation. An inspection door fitted on the casing enable inspection of the impeller during shut down. The casing has a drain to drain any accumulated water. The inlet cone provides a stream lined smooth passage for the suction air. Base plate is the arrangement for supporting the fan bearing housing and the motor.

Impeller : Impeller is fabricated out of carbon steel plates. The blades of the impeller are of aerofoil backward curved design. The impeller is statically and dynamically balanced at the works to minimize vibrations during operation.

Shaft with bearings : The impeller is mounted on the shaft with a key arrangement in its hub and the shaft. The shaft rests on two simply supported bearings placed on either side of the fan. The bearings are anti – friction, double row spherical roller type and Grease lubricated. A spring grid type resilient coupling couples the fan to the clutch and then to the drive. Sealing plates have been fitted at each end of the casing to minimize air leakage through the shaft opening on the casing.

Technical Data For Fd Fan -

Duty conditions	Unit	FD Fan
Make		Andrew Yule And Co. Ltd
Model		SI.BCB-92
Quantity	02 No.	1 x 60%
Nature of medium		Clean Air
Design Mass Airflow (MCR)	Kg/s	17.24 (Associated Gas)
		17.16 (Raageshwari Gas)
		17.4 (LDO)
Air Temperature at Fan Inlet	Deg C	40
Absorbed Power at operating temp. with speed control	KW	160
Fan Speed	Rpm	1480
Inlet Static Pressure	mmWC	-35
Outlet Static Pressure	mmWC	417
Free/Fixed Bearing		22218C (Anti Friction) + Housing SAF-218
Bearing Lubrication		VEEDOL ALITHEX – 20 or eqvt. Grease (500 gms for first fill)
Motor		200 kW /4 Pole, Type-M38M/GM 355LK4; ABB MAKE
Coupling		Flexible spacer type (80 SPL-262-140)
Model / Make		MAKE- Metaflex

FD Drive Motor

A squirrel cage induction motor of 160 kW capacity drives FD fan, working on 6-phase power supply with DOL starter. The motor is totally enclosed and force cooled by air. The rated operating speed of motor is 1485 rpm. The motor winding is of class F insulation but winding temperature rise is restricted to class B (120 Deg C) and motor protection class is IP 55.

4.2 Air Duct

FD Fan Suction Duct

The FD fan is provided with a suction duct for sucking the combustion air from the plant environment.

The suction duct is provided with a rain hood and a bird screen.

An absorption type silencer is installed to attenuate the noise.

A control damper (inlet guide vane) has been fitted at the suction of the FD fan. The pneumatic actuators [FV 7150-A] are provided to operate the damper, which is modulated by the signal from airflow indicating controller [FIC 7150]. The actuator is provided with position feed back switches for the 0% & 100% opening, which are used as safety interlocks for fan start permissive and furnace purge cycle respectively.

FAN Discharge Duct

FD fan Discharge Duct connects the FD fan with windbox.

To measure the flow of combustion air to the burner, an aerofoil [FE 7150] is installed in the discharge of the FD fan. Flow transmitters [FT 7150] measure the pressure drop across the aerofoil, which will be converted into flow signal at DCS.

4.3 Windbox

The air duct terminates in the windbox. Burners are accommodated in the windbox. The windbox is fabricated out of carbon steel and mounted on the boiler front wall. The windbox has suitable opening for mounting the burner front plate and for connecting the combustion air duct. Wind box facilitates proper air distribution around the burners.

Combustion Air Flow Control

The control of FD fan output to meet the combustion air requirements of the boiler is being presented. The airflow given is inclusive of the recommended excess air for complete combustion.

The pressure at wind box is for providing the desired velocity and swirl required for complete mixing of air with fuel gas and to force the products of combustion through the boiler, economizer and finally to the stack.

Out of the two requirements of airflow quantity and wind box pressure, the later is determined by the system resistance to flow of the flue gas by burner throat size.

FD fan damper control is the only device for delivering the required quantity of air for combustion of the required quantity of fuel to produce the required steam flow from the boiler. Combustion controller determines the fuel flow required for the steam flow, demanded from the boiler, computes the air required for that fuel flow from the Air/ Fuel ratio memory set on the controller and sends demand signals to the fuel flow and the air flow controllers.

Combustion air flow is measured by the air flow transmitter [FT 7150] using the principle that the pressure drop across an aerofoil is proportional to the volume of air flowing through it. The air flow signal is fed to the air flow indicating controller [FIC 7150], which compares it with the remote set point received from the combustion controller, develops a deviation signal where necessary and positions the inlet damper of the FD fan through the pneumatic actuator [FV 7150-A].

The combustion controller set point provides the programmed air required for combustion. In actual practice, it may happen that this air may either be a little more or a little less than the desired excess air, measured by the oxygen content in the flue gas, for most efficient combustion. To obtain the desired O2 content in the flue gas, the measured O2 signal from the analyzers [AT 717A0] are fed to combustion controller to trim the airflow set point to [FIC 7150].

With certain digital outputs from the BMS, the [FIC 7150] output is forced to pre determined values. They are 0%, 20%, 50%, 75%,& 100%. During FD fan startup, the actuator is forced to a full close position so as to have minimum load on the motor during the fan startup period. During the burner light up, the FD actuator is forced to the 20% position which ensures the minimum required airflow for the burner light up and for purging the furnace, the actuator is forced to the 50% position.

The flow transmitter [FT 7151A/B/C] are in line with the [FE 7150] to generate the air flow LOW [FSL 7151] and LOW LOW [FSLL 7151] signal based on the output generated by comparing two out of three output from transmitters.

Two fans of 60% capacity provided for the boiler. Both the fans have the outlet isolation damper [XV 7151] and [XV 7152].

Oxygen Trimming

% Oxygen in the flue gas is measured using an Oxygen analyser [AT-717A0] & is taken as process variable to Oxygen controller [AIC-717A0]. This is compared with the remote set point, which is in turn varied according to Boiler Load. The remote SP is actually a function of Steam flow. Oxygen Low alarm shall be generated if the O2 value is less that the required value by 10%. This alarm shall be based on the Steam flow.

Execess Air Adjustment

In any burner system it is necessary to have air flow in addition to theoretical air flow to ensure proper combustion of the fuel being fired. The amount of excess air depends on the burner load at lower load quantity of excess air is higher compare to excess air at higher load. The Oxygen content in flue gas outlet is function of excess air.

For combustion control the amount of excess air required shall be computed from Remote set point of oxygen which is function of total burner load.

4.4 Furnace

The construction of the furnace is such that a totally gas sealed enclosure suitable for forced draft operation is available.

The boiler block is provided with inner and outer casing for making suitable for forced draft operation. The inner casing is of carbon steel and covered by mineral wool insulation for personal protection. The outer casing of carbon steel sheets & corrugated aluminum cladding further covers the insulation.

The furnace floor tubes are covered with refractory bricks to maintain natural circulation of water inside the tubes.

The front wall is covered with refractory bricks and high temperature castable refractory is applied at the Burner throat.

Studded rear wall and the boiler sidewall are sealed with castable high temperature refractory. Furnace peephole areas and the furnace corners are sealed with castable refractory.

The furnace and the second pass chambers have been provided with drains that remain normally plugged. They are to be used to drain water wash effluents during a shut down of the boiler or to drain out the accumulated water due to any tube failure.

Instruments on flue path of furnace:

- A tapping has been provided in the roof wall to measure the furnace pressure. [PT 7017-A] is provided for local indication.
- Three numbers pressure transmitters [PT 7017 BA/BB/BC] are provided for remote indication of the furnace pressure and for furnace pressure high alarm generation.

Access Door And Peepholes

Bolted access door is provided on the boiler front wall for the access to the furnace. To prevent the heating of the door during the operation of the boiler, the access opening is filled with refractory bricks and completely sealed before the door is bolted into position. Peepholes are provided on the furnace sidewall and the rear wall to view the burner flame. The peepholes are pressurized and cooled by service air.

Boiler Base Frame

The base frame supports the entire boiler. The base frame anchored to the concrete foundation. The base frame anchors the water drum at front side so that during operation the Boiler is allowed to expand vertically upwards and on rear side and also allows the furnace to expand sidewise.

4.5 Flue Duct

Flue gases generated in the furnace, pass through the convection bank tubes in the second pass to the economizer and then to stack. Flue ducts are provided to connect the boiler to the economizer and the economizer to the stack.

The flue duct is fabricated from 6mm thick plates. The duct is provided with insulation mineral wool (120kgf/m3 density) of 75mm thick and then provided with aluminum cladding.

To isolate the thermal expansions of the flue duct from the boiler, economiser and the stack, expansion joints have been provided. The expansion joints are provided at the exit of the boiler block (1 no.), entry to the economizer (1 no.), exit of economizer (1 no.) and entry to stack (1 no.)

The following instruments are provided on the duct from boiler to economizer –

- Temperature element [TE 733A0] for boiler exit flue gas temperature indication on DCS
- Local Pressure indicator [PT 733A0] for flue gas draft at boiler exit

The following instruments are provided on the duct from economizer to stack

- Temperature element [TE 717A0] for economizer outlet flue gas temperature indication
- Pressure indicator [PG 717A0] for flue gas draft at economizer outlet
- Flue gas oxygen analyzers [AT 717A0] for measuring the oxygen in flue gas.

Stack

The stack exhausts the flue gases from the economizer to the atmosphere. The stack is a cylindrical steel chimney fabricated out of carbon steel plates. The stack is 30 m height and has an internal diameter of 2.3m

The following have been provided on the stack -

- Sampling nozzles (4 nos.), for the analysis of flue gas for environmental pollution monitoring at an elevation of 20.1 m
- A drain connection from the base ring for draining of rain water from the stack
- Access door for inspection and cleaning of the stack during shutdown.
- Platforms at EL+9500, +19000, & +28500 elevation with ladder for accessing them.

4.6 Cooling Air For Peepholes

Cooling air connection is given to the peepholes to protect the peepholes from the radiation of the furnace. Cooling air connection is provided through service air connection from plant Individual peepholes on the boiler rear and furnace sidewall and burner front are provided with isolation valves and flexible hose.

Operational Control

A brief overview of operational control points is described below. Operation & troubleshooting are separately explained later.

FD FAN

- Ensure that the couplings are properly bolted
- Ensure that the bearings are properly lubricated
- Ensure that the inlet damper of the fan is closed before starting the fan
- Ensure that the access doors on the fan casing are closed before proceeding to start the fan

General

Expansion joints (after boiler block, before the economizer and after economiser) may be checked once in six months to ensure they maintain their permissible dimensions. Collapse or stretching of the joints is to be attended during the next boiler maintenance program.

5 Fuel Firing System

This sub-section describes the burners installed in the boiler and also the fuel lines with their valves and instruments for burner light up, monitoring, control and shut down.

5.1 Components Description

The system consists of the following -

- Burner
- Fuel Gas Oil & Pilot Gas Supply Pipe To The Burner
- Burner Front Piping
- Burner Technical Data
- Burner Management System (Bms)
- Local Burner Panel
- Operational Control

5.1.1Burner System

This chapter describes the burner installed in the boiler with fuel lines together with their valves and instruments for their light up, monitoring, control and shut down.

System Description

Two STS oil burners of Thermax Babcock & Wilcox design have been fitted on the front wall panel of the boiler over the wind box. These burners are capable of efficient and safe combustion of fuel with low excess air and low emission levels. The igniters and the oil guns are fitted with flame monitors and remote operated shut off valves for supervision and control by the Burner Management System (BMS) described in Chapter to ensure safety during light up and operation.

The principal components of the circular industrial burner are:

1. Front plate
2. Air Register assembly
3. Sleeve
4. Swirler
5. Gas chamber and spuds
6. Fuel oil atomizer (gun) assembly
7. Igniter
8. Flame scanners
9. Peep hole / view ports

1. Front Plate

The front plate forms the structural attachment basis of the burner components. Front plate is mounted directly to the windbox front face by frames with series of equi-spaced bolts along four sides of the front plate.

2. Air Register Assembly

The air register consists of a series of vanes arranged circumferentially in the air passage from the wind box to the oil gun, axially surrounding the impeller of the gun. All the vanes operate uniformly through linkages on a shaft, end of which is located outside the oil burner housing in the front. The required movement of vanes is obtained by less than a quarter turn of the shaft. The vanes which overlap each other in the closed position, by swinging through 55 0 on turning the operating shaft, reach full open position.

The air register vanes provide a (rotary) swirling motion to the combustion air, which it imparts to the mist of atomized fuel oil being sprayed by the oil gun, enabling the air and the oil mist to mix intimately for quick and complete combustion. In the 'closed' position of the air register vanes, exit of air is more tangential, increasing the swirl of the atomized fuel. In the 'open' position of the vanes, the combustion air exit is more radial, with a reduction in the swirl. Velocity of combustion air to the burners is high when the vanes are in closed position. It decreases as the vanes are opened. Air velocity determines the

starting point of flame with respect to the gun impeller and also the stability of the flame. Air register vanes in the 'close' position offer more resistance to airflow than in the 'open' position and thereby increases the wind box to furnace differential as also the wind box pressure.

Air registers are not to be used for control of air quantity to the burners. (Air quantity adjustments are only by varying the FD fan output). Air register adjustments are for obtaining optimum swirl of the fuel air mixture and suitable velocity of the air stream to produce a well-shaped flame.

A well-shaped flame has the following characteristics

- Starts slightly away from the swirler of the oil gun.
- Does not touch the water walls
- Light orange in color.
- No sparks or smoke around the flame.

The Air registers are produced with clock-wise swirls of the air stream. In this boiler, Burners A B & C all are clock wise swirls.

Air register vanes of the three burners are positioned by power cylinders & by solenoid valves on command from BMS. The percentage opening of the power cylinders are registered back in BMS.

The BMS requires 100% of air register opening as a pre condition for furnace purge. After furnace purge, before boiler light up, the air register opening is set at 20%. Suitable settings of the register '20%' and '100%' openings are determined during initial commissioning of the Boiler.

3. Sleeve

Burner sleeve makes the air distribution and balancing across the cross section of the burner. The design assures equal air distribution and acceleration of air to the required velocity for complete mixing with fuel. Air from windbox enters into the burner through para flow damper is accelerated to a velocity in multiple of the windbox velocity and also diverted axially into the burner. The converging cone of sleeve further accelerates the air and also distributes it equally across the cross section. Re-accelerating the air forces to pass through and around the impeller. Pressure drop is an effective means of assuring even airflow distribution at higher flow rates. Its effect at lower flow rates is reduced, as the pressure drop is proportional to the square of the air velocity. Thus, at higher turn down conditions it is more difficult to maintain the burner performance and flame shape using only the pressure drop principle. To measure the pressure drop across the burner tapings are provided in wind box & furnace. Sleeve assembly accommodates the gas spuds, oil gun, impeller and igniter and also supports them.

4. Swirler

A circular swirler of diameter 406 mm and having vane type blades is mounted on the regulating rod of the burner gun assembly. Air passing through the swirler is referred to as primary air, which gets further accelerated due to the pressure drop across swirler. The primary air is imparted with a swirl, which is a function of the swirler blade angle. This additional acceleration and swirling gives the air the strength to penetrate and mix with the fuel.

The swirl gives the air an outward trajectory from the centerline of the burner. The outward trajectory creates a low-pressure region immediately in front of the swirler. This referred as primary combustion zone volume. The size and shape of this zone is dependent on swirler blade angle, swirler diameter, swirler pressure drop and position of the swirler with respect to the throat. The important feature of this zone that it re-circulates the surrounding gases back into the zone. The size and re-circulating strength of this zone are critical to the flame stability and to the ability to retain the desired flame shape.

The air distributed around the swirler is termed as secondary air. The secondary air provides the oxygen for complete combustion process.

5. Gas Chamber & Spuds

Fuel gas is introduced through eight equally spaced gas spuds located in the secondary air annulus. Gas for the spuds is introduced through the gas chamber mounted on the burner front plate. The gas spuds are drilled with injection orifices, properly sized to provide the correct velocity to the exiting gas. In addition, the spuds are angled such that the gas is directed for improved mixing with air to give proper flame shape and minimum emissions. More small holes are provided in the circumference of the pipe just behind these gas holes called stabilizer holes. For shielding the root flame a cover plate is welded behind the gas holes.

6. Fuel Oil Atomizer- Gun Assembly

The gun uses the energy of expanding steam to atomize the fuel oil, that is to divide the oil into very fine particles for spray as a mist, for complete mixing with air for easy combustion.

The fuel oil gun is composed of two concentric pipes to lead steam and oil up to the atomizer. Atomizer comprises of mixing chamber and sprayer cap. Fuel Oil flows through the inner pipe and reaches to the atomizer at the end. Steam/Air, which flows outside the inner tube, enters the atomizer through tangential slots in the mixing chamber of the atomizer, mixes with oil and atomizes it. The pressure energies of oil and steam get converted into velocity energy of the furnace – steam/air mixture and sprays into the furnace through the holes in the sprayer cap. The screwed sprayer cap of the oil gun keeps the mixing chamber, the oil and steam pipes tight without leakages. The mixing chamber and the sprayer cap are precision machined ground, hardened and lapped for this purpose and require care in cleaning. Soft nylon brushes with a solvent such as diesel oil can be used for cleaning. The impeller is bolted on to the gun serves to guide the combustion air around the atomized oil spray for intimate mixing and shields the tip of the spray from high air velocities, to initiate combustion.

The oil gun is inserted through a outer pipe in the burner assembly called regulating rod. In the annular space between the gun and the outer pipe, air is admitted from the wind box through the holes provided in the peripheral of rod to cool the gun and also to seal from the pressurized furnace.

The burner throat is made of special refractory work to withstand furnace radiation. The axis of the burner assembly is aligned to coincide with the axis of the burner throat. The oil gun axis coincides with the burner axis.

The axial position of the gun in the burner can be varied by sliding the regulating rod in or out by a few millimeters, so that the oil spray from the gun and the flame clear the burner throat to obtain a well defined flame. The ideal position found during commissioning is secured by a set bolt. Oil spray on the refractory surfaces will cause incomplete combustion and dripping of oil to the furnace front wall and floor.

7. Ignitor Assembly

Ignitor is a gas (pilot gas/LPG) fired lighter with an electric sparking device, which produces a pilot flame to light the fuel air mixture of the main fuel. Establishing the pilot flame and sensing it by a scanner is a pre-requisite for admission of main fuel to the burner.

The Ignitor consists of a gas nozzle to admit pilot gas to a combustion chamber where the gas mixes with the combustion air. The gas nozzle is connected to the pilot gas supply line.

A spark device is an electrode with 3-mm gap fitted on an insulator. The electrode is connected to a High - tension transformer in the burner local control box through an H.T. cable.

The sequence of operations for placing in service the ignitor of a burner is controlled by BMS and will be described in upcoming section. A brief outline is now given for understanding the sequences. On an auto start command of burner BMS energizes for 5 seconds the sparking device with HT supply from the ignition transformer in the local panel to produce steady sparks in the combustion chamber. BMS opens the pilot gas valves & to admit gas to the ignitor combustion chamber where it mixes with air and lights up by the spark already present.

Availability of the flame in the ignitor is viewed by Flame scanner and enables BMS to issue a command for admission of main Fuel. On a normal auto start, the sequences of spark, opening of the gas valve, establishing a pilot flame, and establishing the main flame is expected to be completed within 10 seconds. BMS shuts off the ignitor gas valve after 10 seconds.

8. Flame Scanners

Each Burner is provided with two FIREYE make flame scanners (One Ultra Violet (UV) flame scanner & another one is Infrared flame scanner) in the scanner view pipes for continuous monitoring of the flame and provide an input to BMS. Vendor's manual of the scanner may be referred for more details. A brief description of the principle of operation of the scanner is given. The 'detector'/ UV cell of the scanner is a sealed, gas filled, ultra-violet transmitting envelope containing two electrodes, connected to an A.C. voltage. The detector is aligned to view the flame whereas IR flame scanner is based on photon transistor.

When the flame is there the UV rays/radiation striking the electrodes makes the gas between the electrodes conductive and a current flow from one electrode to the other in the form of pulses. Number of pulses emitted per second are characteristic of the flame and differs from other radiation (for example from the hot refractories) striking the scanner. The pulses are amplified and compared with a pre-set value to detect the presence of flame. The scanner tube is swivel mounted to enable adjustments of the detector for a full view of the flame. Out of these two scanners one is positioned in such a way that to detect the pilot flame properly while light up. However, main flame is detected by both the scanners. To cool the scanners from the heat of flame radiation, scanner cooling air is connected to the scanner view / mounting tube. The UV cell also requires cleaning at regular intervals to maximize its performance. The scanner 'flame On' input of burner, to BMS keeps the shut off valve of fuel to open, when the burner is in service and immediately closes it when no flame is sensed.

In general IR flame scanner justify presence of oil flame as it is having more infrared spectrum in it's flame front whereas UV flame scanner justify the gas flame.

9. View Port

The Burners are provided with peepholes with an inner glass shield and a tiltable outer cover on burner front plate to monitor the flame by operator during burner start up / running. As the boiler is pressurized, sealing air is connected to the peepholes. The burner peepholes are used to the view the flame for carrying out adjustments. It is recommended to monitor the flame from boiler side peepholes as to get better judgement of flame.

5.1.2 Fuel Gas, Oil, Pilot Gas & Atomizing Supply Pipe to the Burner

1. **Fuel Piping**
   Fuel Oil Supply (Associated / Raageshwari)

Fuel oil supply to the burner is provided with the following -

- Main isolation valve [1FG001] at the terminal point.
- Differential pressure transmitters [PDT 7012] for indicating gas pressure across strainers [F-1 and F-2] with three way valve [1 FG-020].
- Tapping (with isolation & NRV) from Nitrogen header for line purging & preservation.
- Flow orifice [FE 7012A] with a transmitter [FT 37012A] for fuel gas flow measurement.
- Temperature element [TE 7012A] used for indicating gas temperature as well for compensating the gas flow
- Pressure transmitter [PT 47012A] used for indicating as pressure as well for compensating gas flow
- Main fuel gas trip valve [XV-7012B]. This valve is a solenoid operated safety shut off valve. The valve is provided with position feedback arrangements for the open and close positions.
- Fuel gas flow control station: The fuel gas flow control station consists of a pneumatic operated spring opposed globe type control valve [FV 7012A]. The control valve is provided with isolation valves. A bypass self acting pressure control valve [PV 7012] completes the flow control station. The bypass control valve is for maintaining the minimum pressure required for startup of the burner. The startup pressure control signal is obtained from [PT 7012C] pressure transmitter.
- Transmitters [PT 7012 DA/DB/DC] logic interlocked to the BMS for fuel gas low and high pressure parameter with 2out of 3 logic.
- A normal pressure transmitter [PT 7012E] with pressure HIGH alarm in DCS.
- Local pressure indicator [PG 7012B] for indicating fuel gas pressure.
- Header vent valve [XV 7012G]. The vent valve is interlocked with the BMS and automatically opens in case of high pressure after the control station before startup of the burner.
- Nitrogen purging connection is available. Nitrogen from plant is connected with an

isolation valve and NRV for purging of fuel gas during long shutdown periods.

2. FUEL OIL SUPPLY (Diesel Oil No. 2)
Fuel oil supply to the burner is provided with the following -

   - Main isolation valve [1DF-001] with a spectacle blind flange at the terminal point [Pressure gauge [PG 7010GA for indicating oil pressure]
   - Flow orifice [FE 7010A] with a transmitter [FT 7010A] for fuel oil flow measurement.
   - Fuel oil flow control station: The fuel oil flow control station consists of a pneumatic operated spring opposed globe type control valve [FV 7010A]. The control valve is provided with isolation valves. A bypass self acting pressure control valve [PV 0710B] completes the flow control station. The bypass control valve is for maintaining the minimum pressure required for startup of the burner. The startup pressure control signal is obtained from [PT 7010B] pressure transmitter.
   - Transmitters [PT 7010 CA/CB/CC] logic interlocked to the BMS for fuel oil low and high pressure parameter with 2 out of 3 logic.
   - Local pressure indicator [PG 010B] for indicating fuel gas pressure.
   - Temperature element [TE 7010] for local indication
   - Main fuel gas trip valve [XV-7010D]. This valve is a solenoid operated safety shut off valve. The valve is provided with position feedback arrangements for the open and close positions.

3. Pilot Gas Supply
Pilot gas for the igniter torch is taken from the natural gas supply piping. An isolation valve [1FG 051] and a self-acting pressure regulator [PCV-7013] are provided. A pressure indicator [PG 7013] are provided to indicate the gas pressure. A pressure transmitter [PT 7013] is provided to indicate High and Low pressure in DCS.

   A NRV (1FG-016) along with a manually operated ball and needle valve [1FG-015] isolates the line from the main fuel line. An additional NRV [1FG-056] is also provided in Pilot line in tandem with main fuel line connection tapping in order to isolate the pilot line when main fuel shall be used as pilot fuel instead of LPG.

4. Atomising Steam And Air Supply

   - Atomizing steam is obtained from the steam drum (4750 kPa (g) through an isolating valve[1SM-037 & 1SM-038].
   - A pressure control valve is provided to reduce the pressure up to <1700 kPa (g) which the set pressure for the line pressure relief valve[PSV 7011].
   - A pressure transmitter [PT 7011A] is provided to generate the High and Low alarm through [PIC 7011A] and give the feedback to [PV 7011A] in order to regulate the header steam pressure to desired limit.
   - Another pressure transmitter [PT 7011B] to generate High High and Low Low alarm in DCS with burner interlock.
   - A steam trap [1SM-035] is provided to remove the condensate after [PV 7011A].
   - An NRV [1SM-004] is provided to isolate the steam line from Air atomization when steam is not available followed by an isolation valve [1SM-003].
   - An NRV [1SM-014] is provided to isolate the Air line from Steam atomization when steam is available followed by an isolation valve [1SM-045].
   - Atomising air from plant at 700 kPa (g) is provided with an isolation valve [1SM-013] for initial atomization purpose when steam is not available.
   - Both Steam and Air line then combines together after the globe isolation valves [1SM-005] and [1SM-015] respectively.
   - A pressure gauge [PG 7011A] is provided for local indication.
   - A differentials pressure control valve [PDV 7011B] is provided to maintain the specified pressure difference with Diesel Oil line. This valve receives the signal from differential pressure transmitter [PDT 7011B]. The differential pressure controller [PDIC 7011B] compares the pressure between Diesel Oil header and Atomizing Line in order to generate the required pressure difference across.
   - Pressure transmitters [PT 7011 BA/BB/BC] are provided to generate the High high and Low Low alarm.
   - A pressure gauge [PG 7011B] is provided for local indication.
   - A temperature gauge [TG 7011] is provided for local indication.

5.1.3Burner Front Piping

The burner front piping involves the piping that connects the fuel oil, pilot gas and combustion air to the burner. The major components include the safety shut off valves, damper. They are described below

1. The fuel gas (Associated / Raageshwari Gas) burner front piping is provided with the following - (For Burner "A")-
   - Isolation valve [1FG-010]
   - Block & bleed arrangement for burner safety shut off valves
   - Two-safety block shut off valves [XV 7014DA] & [XV 7014E] are provided with a vent shut off valve [XV 7014DB] in between them. This arrangement of two shutoff valves and an intermediate vent valve is called a block & bleed arrangement. All the shut off valves are connected to the BMS and interlocked for safe operation of the burner.
   - Pressure indicator [PG 7014E] for local indication of the fuel gas pressure.
   - Flexible hose connects the front piping to the burner.
2. The Diesel Oil burner front piping is provided with the following -
   - Isolation valve [1DF-027]
   - One shut off valve cum ramp up valve [XV 7014A] is provided. This valve is connected to the BMS and interlocked for safe operation of the burner. This valve is having the BMS interlock with a function block for ramp up of burner for smooth light up.
   - A manual three way valve [1DF-030] is provided after shut off valve [XV 7014A] from which two lines are connected to main and auxiliary gun of burner. A three way valve is having limit switches to indicate the open position in BMS whether main gun [ZSM 7014JB] or auxiliary gun [ZSA 7014JA] is in line for running burner.
   - The limit switches for main gun [ZSI 7014A] and auxiliary gun [ZSI 7014B] are provided to indicate the inserted position of main gun and auxiliary gun respectively.
   - An interlock for main and aux. gun is provided in such a way that, for light up of burner with recommended main gun, a three way valve limit switch [ZSM 7014JB], main gun inserted limit switch [ZSI 7014A] and atomizing media three way valve limit switch [ZSM 7014KB] feedback should be available.
   - The auxiliary gun can be fired in the event of chocking of main gun by ensuring auxiliary gun at inserted position with availability of atomizing media at auxiliary gun and by placing the three way control valve towards auxiliary gun.
   - Pressure indicator [PG 7014A] for local indication of the fuel gas pressure.
   - Flexible hose connects the front piping to the burner.
3. The Atomizing Steam burner front piping is provided with the following –
   - Isolation Valve [1SM-049]
   - A Shut off valve [XV 7014C] with limit switches and interlock with BMS. A minimum flow orifice [MFO 7014C] as bypass.
   - A NRV [1SM-026] to restrict the back flow.
   - A three way valve [1SM-027] with limit switches to indicate the position (Main gun [ZSM 7014KB] or Aux gun[ZSA 7014KA]) is provided.
   - Pressure gauges for Main gun [PG 7014C] and Auxiliary gun [PG 7014D] are provided.
   - Flexible hose connects the front piping to the burner.
   - A tapping is routed to main gun and auxiliary gun from first isolation valve [1SM 049] for gun clearing purpose with isolation valves.
4. The pilot gas front piping is provided with the following -
   - Isolation valve [1FG 052]
   - Block & bleed arrangement for pilot gas burner safety shut off valves - Two-safety block shut off valves [XV 7014H] & [XV 7014GA] are provided with a bleed shut off valve [XV 7014GB] in between them. This arrangement is similar to that of the main burner. All the shut off valves are connected to the BMS and interlocked for safe operation of the pilot burner.
   - Pressure indicator [PG 7014F] for local indication of the pilot gas pressure
   - Flexible hose connects the front piping to the burner

The burner is provided with a damper on its combustion airside. This is used for isolating the burner airside during non-operation of an individual burner. The damper is provided with a position feedback arrangement on it open and close positions and interlocked to the BMS.

Note

FOR ABOVE DESCRIPTION REFER P&I DIG. D12-1FM-6516P REV-4 (Sheet I & II)

5.1.4BURNER TECHNICAL DATA

Description		
MAKE	THERMAX BABCOCK & WILCOX LTD.	
MODEL	Industrial Circular Oil Cum Gas Burner	
No. of burners per boiler	3	
Capacity of each burner(% MCR)	36.67%	
No. of oil gun provided in each burner	2 (One Main + One Auxiliary Gun)	
Type of air control & accessories	Lead lag arrangement, VIV at FD fan suction.	
Burner Throat Dia, inch	32”	
Type & no. of gas spuds	Variable Mix Type Gas Spuds, 8 Nos.	
No. of holes per spud	4	
Oil Gun Atomiser	I jet	
Swirler/Impeller information	Swirler	
Fuel Fired	Associated Gas / Raageshwari Gas	Diesel Oil No. 2
Turn Down (auto)	4.4:1 / 3.1:1	3:01
Fuel for Igniter	Natural Gas	
Pilot gas pressure	1440 kPa (g)	
Excess air at burner % @ design heat release rate	15% for Oil, 10% for Gas	
Total air required all burner Kg/hr	124110 - Associated Gas	
	123580 - Raageshwari Gas	
	125265 - Diesel Oil No.2	
Air req. per burner Kg/hr & Temperature	41370 - Associated Gas (Ambient)	
	41193 - Raageshwari Gas (Ambient)	
	41755 - Diesel Oil No.2 (Ambient)	
Burner pressure drop mm WG	182 - Associated Gas;	
	180 - Raageshwari Gas	
	185 – Diesel Oil	
Heat Input per Burner Mkcal/hr	30.939 – Associated Gas	
	30.822 – Raageshwari Gas	
	29.513 – Diesel Oil No.2	
Fuel fired (max) per burner Kg/hr	3890 – Associated Gas	
	2180 – Raageshwari Gas	
	2604 – Diesel Oil No.2	

Description	
Q fired (Total on HHV) Mkcal/hr	84.38 – Associated Gas
	84.06 – Raageshwari Gas
	80.49 – Diesel Oil No.2
Oil Pressure at tip inlet at peak (Psi)	120 (anticipated)
Diff Steam Pressure at tip inlet at peak	10.5 kg/cm2
Quantity for Pilot Fuel (Nm3/hr)	12.95 - Raageshwari Gas
	19.51 - Associated Gas

Burner Flame

Maintaining a well-shaped flame, light orange in color, stable without sparks or smoke surrounding the flame is an essential requirement for stable operation and high thermal efficiency. The under mentioned factors contribute towards good combustion.

- Correct fuel oil combustion air ratio and air register settings. These are controlled automatically. The combustion control and air register control must be fine tuned not only during commissioning but also once every six months, by checking the flame and analyzing the flue gas at furnace exit or Economizer II exit for CO, CO2 & O2.
- The local Operator must be encouraged to view the flame in the boiler two or three times in a shift and report any malfunctions. The local Operator must view the flame through the peephole from one side. Before viewing, availability of sealing air to the peephole must be checked and the Operator should use a shielding glass to protect his sight while viewing.

Clean Gun

Atomization will not be proper in a clogged gun. Steam cleaning may be adequate to clear the gun most of the time. Disassembly and manual cleaning of the atomizer, steam and oil paths and spray plate may have to be done at least once a month (or as often the conditions may require). Correct assembly of the gun is needed after manual cleaning. To save time required for cleaning, a spare gun may be installed, when a gun is withdrawn for cleaning. The clogged gun can be cleaned without affecting the boiler loading. Before a cold start of Boiler, ensure that all guns have been manually cleaned.

- Fuel Oil at gun inlet must be at a temperature of about 15-40 0C with the viscosity of oil to 2 to 5 CST for proper atomization.
- Availability of de-superheated atomizing steam without moisture at pressure of 15kg/cm2 and air at 7 kg/cm2 at oil gun Inlet. De-superheated steam is used as superheated steam may promote carbonization of oil in the gun. Moisture in steam cause sparks in the flame.
- Concentric position of the gun in the burner throat (ensured during maintenance and overhauls) and axial position of the gun to avoid spraying on to the refractory. • Good combustion from the gun requires some skill but a new Operator easily
- acquires it by observation and simple training.

As the spark device of the ignitor, gas spuds, flame detectors must be maintained in good condition by following the vendor instructions. Suitable preventive maintenance schedules for servicing and checking their performance at regular intervals may be drawn up.

Burner Capacity

The oil guns have been designed to operate best between fuel oil pressures of 1.5 kg/ cm2 and 6.5 kg/cm2.To meet the boiler steam flow requirements it is desirable to operate minimum number of burners within their design capacity. As the combustion control functions on auto, the Operator should provide margins in the guns capacity for the control to function. When multiple burners are in service the Operator should :

- Remove one burner from service if the fuel oil pressure to the burners approaches minimum value.
- Take one more burner into service if the fuel oil pressure is near the maximum design value.

The fuel oil to the guns must be maintained clean, free from dirt by monitoring the differential pressure across the duplex filters and bringing the reserve basket into service when the d/p increases. If during cleaning, holes are noticed in the basket, the damages must be repaired.

If frequent cleaning is needed, oil filters in the plant pumping and heating station may have to be checked.

As the spark device, gas nozzle, flame detector of the ignitor influences the quick light up of the oil gun and the UV flame scanner of the oil gun keeps the gun in service, these equipment must be maintained in good condition by following the vendor instructions. Suitable preventive maintenance schedules for servicing and checking their performance at regular intervals may be drawn up.

The emergency scanner cooling air must be continued at least for eight hours after a boiler shut down to shield the scanner from the boiler heat.

For the safety of the equipment (and personnel) protections envisaged in BMS must not be by passed. Any mal-operation of protections or nuisance trips must be analyzed and causes corrected.

Possible fire risks in handling pressurized and heated fuel oil must be recognized. To avoid accidents the following are suggested.

- House keeping should be of a high order. Fuel oil lines and valves must be accessible. Oil leakages from valve glands, bonnet joints, flanges, instrument tapings if any noticed must be promptly attended.
- Operators are to be trained for fighting oil fires.
- Portable fire fighting equipments in working condition should be readily available.
- Smoke, automatic fire detection, gas leak detection systems must be periodically tested.

Other Safety

The scanner cooling air must be continued at least for eight hours after a boiler shut down to shield the scanner from the boiler heat.

For the safety of the equipment (and personnel) protections envisaged in BMS must not be by passed. Any mal-operation of protections or nuisance trips must be analyzed and causes corrected.

Possible fire risks in handling pressurized and gaseous fuel oil must be recognized. To avoid accidents the following are suggested.

House keeping should be of a high order. Fuel oil and valves must be accessible. Fuel gas / Oil leakages from valve glands, bonnet joints, flanges, instrument tapings if any noticed must be promptly attended.

Portable fire fighting equipments in working condition should be readily available.

5.1.5Burner Management System

The Burner Management System (BMS) is a programmable logic controller (PLC) that controls the permissive for burner start, stop and trip functions. The PLC acquires the status from the field instruments. The PLC and its hardware are installed in independent PLC panel. The PLC system consists of a CPU, power supply unit, I/O modules & communication modules. The BMS PLC is provided for the burner safety interlocks/ monitoring of related shutoff valves & Alarm generation.

The PLC system is programmed and configured as per the BMS logic drawings and the I/O list.

The burners can be started / stopped either from local burner panel Installed on the operating platform near the burners or from the DCS operating station placed in control room. The local burner panel is provided with necessary lamps and pushbuttons for operation & Indications. PLC is provided with necessary software and hardware for communicating with DCS.

5.1.6Local Burner Panel

The following indicating lamps / push buttons are provided on the local panel –

Tag No	Description
LHS 7012	Emergency stop
LHS 7010	Lamp test
LHS 7011	Furnace purge start
LHSO 7014A	Diesel burner start
LHSO 7014B	Gas burner start
LHSC 7014A	Diesel burner stop
LHSC 7014B	Gas burner stop

Tag No	Description
LHS 7013	Reset
XL 7016	Main interlock satisfied
XL 7017	Pre interlock satisfied
XL 7014A	Diesel ready to start
XL 7014B	Gas ready to start
XL 7014C	Pilot on
XL 7014D	Diesel firing on
XL 7014E	Gas firing on
XL 7013	Furnace purge required
XL 7012	Furnace purge ready to start
XL 7014	Furnace purge running
XL 7015	Furnace purge finished
XL 715AA	FD fan running

5.1.7OPERATIONAL CONTROL

A brief overview of operational control points is described below. Operation & troubleshooting are separately explained later.

BURNER

The under mentioned factors contribute towards good combustion.

Correct fuel gas to combustion air ratio. The combustion control must be fine tuned not only during commissioning but also once every six months, by checking the flame and analyzing the flue gas at economizer exit for O_2, CO & CO_2. The local operator must be encouraged to view the flame in the boiler two or three times in a shift and report for any irregularity.

As the spark device, gas nozzle and UV flame scanners must be maintained in good condition by following the vendor instructions. Suitable preventive maintenance schedules for servicing and checking their performance at regular intervals may be drawn up.

The scanner cooling air must be continued atleast for eight hours after a boiler shut down to shield the scanner from the boiler heat.

For the safety of the equipment (and personnel) protections envisaged in BMS must not be by-passed. Any mal-operation of protections or nuisance trips must be analyzed and corrective actions initiated.

Possible fire risks in handling pressurized and heated fuel gas must be recognized. To avoid accidents the following are suggested -

- House keeping should be of a high order.
- Fuel gas lines and valves must be accessible.
- Gas leakage, if any, noticed must be promptly attended.
- Portable fire fighting equipment in working condition should be readily available at an accessible location

Section — C

Topics Covered in this Chapter

1 Section Overview

This section describes the startup, shut down procedures of the boiler. Boiler operation and safety are also described.

2 Boiler Start Up and Shut Down

This chapter describes the boiler start up and shut down procedures as applicable for the following boiler conditions:

1. Start up of a Cold boiler
2. Start up of a Warm boiler
3. Start up of a Hot boiler
4. Boiler shut down

Note

The procedures explained in this chapter apply for start up of the boiler already commissioned. Commissioning a new boiler call for several additional requirements.

Note

It is assumed that Operators are fully familiar with the design and construction features described in the earlier section.

Note

It is assumed that Operators are trained in operation of similar type of boilers and have been licensed to operate boilers by the State Boiler authority.

Note

The owner is encouraged to evolve standard operating procedures (SOP) based on the framework and recommendations that are explained in the subsections below. The SOPs have to be well understood by operating personnel for safe and reliable operation.

2.1 Startup of a Cold Boiler

Boiler startup can be termed as cold startup when there is no pressure or when pressure is less than 2-bar (g) in the steam drum.

In a cold start up, possibilities of some inspection or maintenance work having been done is presumed. A walk down check is required and the boiler and its auxiliaries are to be prepared meticulously for a start up from the DCS of the control room. Before a walk down check ensure that all work permits have been returned, safety tags are removed and maintenance permission for boiler start up is available.

Walkdown Checks

Using powerful torches or low voltage inspection lamps, inspect the furnace and the second pass of the boiler and ensure the following:

DEAERATOR

- Ensure that the deaerator drain /overflow piping are terminated safely to the trench.
- Safety Relief valves are in proper working condition and their outlet piping is completed to the requirement and supported properly.
- Check level gauges are in working condition.
- Check that all the instruments are ready for service.
- Ensure that make-up water is available for deaerator filling.
- Ensure that the steam is available at the deaerator inlet line for charging Deaerator
- Ensure that Deaerator is filled with Dm water upto normal water level.
- Ensure that the boiler/s running at considerable load or ensure that enough and continuous out flow of water is available.

Boiler

- Furnace and second pass are clear, all maintenance personnel have been removed and no scaffolding or inspection devices have been left inside.

- Furnace floor, water walls and second pass convection tubes are clean and there is no evidence of any water drips, slag or any other deposits.
- Steam and water drums are clear and manholes are closed properly.
- Verify that all access doors, inspection doors of furnace and wind box are tightly closed.
- Verify that all peepholes have been tightly closed and sealing/ cooling air connections have been made and the air valves are open.
- Verify that the air duct, windbox, external economizer and flue gas duct to stack is clear and that all maintenance personnel have been withdrawn. Ensure that the manhole doors closed properly.
- Verify that the safety valves are not gagged.
- Verify that the illuminators of local level gauges are 'ON'. Inlet valves from steam and waterside is open and their drain valves are closed.
- Verify whether the Nitrogen purging valves are open (connected to the steam drum and main steam piping). If they are open, they have to be closed just before boiler light up, when air vents are opened.

Burner

- Verify that the pilot, fuel gas, oil & atomizing steam/air flexible hoses are connected to the burner.
- Verify that the Ignitor has been inserted in the burner housing and that the HT cable has been connected to the igniter.
- Verify that the Flame Scanners have been installed properly, cooling air hoses are connected and valves are open.
- Verify that the air slide dampers fully open and air supply to actuator is available.
- Verify physically and in DCS that the fuel shut off valves is fully closed and bleed valves are open.
- The manually operated fuel isolating valves are to be verified for shut. These valves have to be opened just before boiler start up.

FD Fan

- Check that the fan inspection doors are closed.
- Ensure that the bearing lubrication is done properly.
- Check that the coupling guards are installed.
- Ensure that the damper actuator is properly fixed to the operating lever and air supply is open to actuator and I/P Converter.

General

Ensure that the battery limit valves are open and the inputs are available:

- Instrument air and Service air.
- Feed water upto level control station.
- Power up of feeders for FD fan motor.
- Fuel oil and pilot gas up to terminal point isolation valve.
- Phosphate dosing at terminal point.
- Cooling water supply at terminal point.

2.1.1System Line Up

Preliminary Requirements

- Power supply: Ensure that the power supply is switched 'ON' and available for all the motors and panels.
- Operating station - DCS is ensured for readiness and emergency push buttons are released, if activated.
- As instrument air is necessary for the operation of most of the valves and actuators, charge the instrument air header, the branch lines and instruments supply lines elsewhere. Root valves of all Instruments (Pressure gauges, Pressure transmitters, DP transmitters, Level gauges, etc.,) must be kept open and their drains if any are to be kept closed. They are not separately listed.
- Ensure that all the transmitters are lined up mechanically / electronically.

Deaerator

- It is always recommended that the deaerator has to be taken in line at lower load/ the water outflow is less. It would be easier to control the parameters and there won't be any hurry in stabilizing the system. It is also recommended to take deaerator inline, as the boiler/s are started and steaming out, so that the risk of corrosion and pitting will be minimised.
- Open the vent valve at the top of vapour tank to atmosphere. Line up all the instruments on deaerator system.

Economiser

- Keep the air vent on the inlet & outlet header of the Economizer open. These valves will have to be closed when sufficient air was released from it at the time of filling.

- Ensure that the drain valves of top and bottom headers are kept closed.
- Ensure that the drain valves of common line is kept closed

Steam And Water Drum

- Ensure that the drum vent valves [DM 039/04] is kept open. These valves will have to be closed when the drum pressure attains 2 bar (g).
- Open the CBD line isolation valves BD 001/002 and keep close the CBD valve MOV 7018-F.
- Keep close the IBD line isolation valves FD016/017 and the IBD valve [BD 013].These valves to be operated only at the time of blow down operation under personal supervision & close after completion of blow down operation.
- Keep open the phosphate dosing line isolation valves [HP 021/023].
- Verify that drains and vents of Stand pipes provided for level transmitters, indicator & gauges are closed.

Feedwater Water Line

- Select the drum level and feedwater flow controllers in manual mode. Keep close the bypass manual valve. Fill-up water in boiler by remote opening main control valve till boiler is filled to recommended drum level.
- The control station drain valve to be kept closed.

Superheater

- Ensure that the drain valves SD 004, MOV 7018-B, SD 001 & MOV 7018-A are kept open. This is to ensure that the superheater coils are totally drained before lightup of boiler. Attemperator drain valves SD 007 & 008 can be kept open.
- Verify that the vent valves on saturated steam supply pipes to Superheater are closed.
- Keep open the startup vent isolation valve MOV 7018C. The Pressure control valve [PV 7018B] has to be kept open 100% during boiler cold startup and let the controller (PIC 7018BA) remain in manual mode. This valve can be manually placed/throttled till boiler reaches to its rated pressure and temperature. Put PIC 7018BA in auto mode once boiler is connected to plant mains.
- Ensure that the MSSV (MOV 7018D) and pressure equalization valve (MOV 7018E) is in close position. MSSV to be open for connecting boiler to the plant mains.

Note

Never close the startup vent valve till the boiler is connected to the plant mains.

Feedwater And Spray Water Line

- Select the drum level and feed water flow controllers in manual mode. Keep close the 110% control valves [FV 7018-AA/AB] Fill-up water in boiler by manually opening LV 7018-A (30% MCR capacity) till boiler is filled to recommended drum level.
- The control station drain valves BW 011/012/015/016/019/020 in upstream and downstream to be kept closed.
- Select steam temperature controller TIC 7018-C in manual mode with 0% output.
- Open the manual isolation valves DSH 006/007/014/017
- Keep the drain valves DSH 008/009 closed.

Sample System

- All the sample lines isolation valves have to be closed. Sample coolers can be taken into service once the boiler is pressurized. Ensure a slight bleeding through the sample line as the boiler is pressurized to 2 bar to ensure that no choking of the line occur.

2.1.2Filling Water in Deaerator & Boiler

- During water filling, for assurance of correct deaerator level, post an attendant at the deaerator level to monitor the local gauges and to communicate to the control room when the level of NWL is reached.
- Fill the deaerator slowly through the makeup water inlet connection by opening the deaerator level control valve in manual mode. Watch the water level in the level gauges and ensure that the gauges are indicating the correct water level. Cross check with the level indication available at control room through the level transmitter LT. Mark the normal water level on local level gauge when control room indication reads ”0” mmWC. Stop the water supply to the deaerator.
- Once, water level has attained NWL, then slowly admit the steam into deaerator through the pegging steam line. It will take one or two hours to heat the water with pegging steam. When the water temperature reaches 60 to 70 0C, deaerator is ready for charging the steam through main supply line.

The following procedure is adapted for filling the boiler:

- During water filling, for assurance of correct steam drum water level, post an attendant at the drum level to monitor the local gauges and to communicate to the control room when the level of ’50 mm’ below NWL is reached.
- Operator to ensure that the feed water control valves are closed and the controller is in manual mode.
- Operators to open slowly the feed water control station by opening the 30% flow control valve [LV 7016-A] and allow the water to fill in Economizer and boiler. The valve has to be modulated gradually so that the water does not rush too much.
- Water rises to the steam drum through the economizer. It will take minutes to fill water to the required level.
- As water level in steam drum reaches ’50mm’ below the NWL on local level gauge (confirmation by the attendant) or in level indicator, water filling can be discontinued by closing the valve.

CAUTION

Filling water temperature should not be more than 38 deg C of the boiler metal temperature. During filling of a cold boiler, the ambient temperature should be used as an indicator of the boiler metal temperature. Assuming an ambient temperature of 40 deg C, the maximum temperature of filling water shall be 78 deg C.

2.1.3Charging of Deaerator

The following procedure is adapted for charging the deaerator (place deaerator in service)

- Charge the steam up to the pressure control valve to warm up the line and keep the steam readily available for charging into deaerator. Once, water level has attained NWL, then slowly admit the steam into deaerator through the pegging steam line. It will take one or two hours to heat the water with pegging steam. When the water temperature reaches 60 to 70 °C, deaerator is ready for charging the steam through main supply line.
- Try to maintain a low water level before admitting the steam through the main supply line. Level may be maintained well above the very low level and below the centerline of the tank. Due to direct scrubbing of steam with warm or cold water there may be little hammering or vibration in the storage tank. By keeping the low Water level the quantity of the water in the storage tank will be less and less steam will be required initially to heat it. Thus vibration or hammering can be reduced while pressurizing the deaerator. Keeping low water level will have to be done manually watching the level in the direct level gauge and by maintaining the water intake manually, as the Level Transmitter will be out off its range.
- Start charging the steam gradually by opening the Pressure control valve. The water will be heated up and steam will start coming out of the vent. The deaerator pressure will start rising, say 0.2 to 0.3 bar (g). Local pressure gauge on deaerator storage tank and the pressure transmitter can be referred for the pressure rise. Care should be taken to rise the pressure gradually.
- At this point of time, increase gradually steam flow and water flow simultaneously. Objective is to maintain Normal Water Level and to increase deaerator pressure up to 0.3 kg/cm2 (g) and to maintain it. Once there is considerable rise in temperature, admitting of steam in more quantity will not cause hammering in the deaerator.
- Water and steam intake should be synchronised so that at no point of time deaerator pressure shall go beyond 1.7 bar (g) and to vacuum pressure. More steam flow will lead to increase in deaerator pressure and less steam flow than the requirement for the water flow will lead to condensing of steam and will result into reduction in deaerator pressure, even to vacuum pressure.
- As the deaerator pressure increases the water temperature will start increasing. If the water outflow from deaerator is faster, then the temperature rise will be faster.
- Once the level and pressure are reached to the set values the controllers can be put into auto mode. Temperature will reach automatically to the operating value of 130 °C.
- Condensate return lines can be taken in to the deaerator at this point of time as the level controller is in auto mode.
- The vent valve can be throttled to optimise the venting steam flow, even it can be closed fully and the steam flow can be through the orifice. If

the water temperature has not increased to the operating temperature means air enveloping taking place and need to increase the venting.

- In the event of taking the Deaerator into line, if abnormal hammering or vacuum situation is created, stop admitting the steam and repeat the whole charging process once again.

2.2 Charging of Fuel (Associated Gas / Raageshwari Gas/Diesel Oil), Automizing Steam & Air Line

Fuel gas lines must be checked carefully before charging to ensure that there are no possibilities of leak through flange joints, valve bonnet, pressure gauge tapings etc., During charging if any minor leaks are noticed Maintenance personnel must be called to attend to the leaks. In case of serious leaks, charging must be abandoned; line to be depressurized, purged and leaks to be attended before proceeding further.

Fuel Gas line is charged for light up:

- Close the Inert gas isolation valve. • Verify that the root valves of all the instruments are open.
- Verify that all the fuel gas, diesel oil and Pilot gas trip valves (XV 7012B, XV 7010D and XV 7014 H/GA respectively) are in 'close' position - physically and in DCS.
- Close the isolation valves of each fuel line till the entire system will be lineup.
- Closed the isolation valve of nitrogen purging line.
- Before the gas line charging, lineup the strainer [F-1 & F-2] & select any one strainer by manual isolation three way valve [1FG-020]. Keep close the other strainer. Other strainer shall be taken on line at the time of main line strainer get choked or under maintenance.
- With information to the plant, crack open the terminal point isolation valve [1FG-101]. Observe gas pressure upto Block valve as the pressure transmitter [PG 7012A] read this. Observe for leaks if any.
- Observe that the pressure is settled and the [PT 7012A] controls it. Then slowly increase the opening of the terminal point isolation valve [1FG-101] to full open position.
- Once it is ensured that the fuel gas is available. Normalize the Block valve (MFT) [XV 7012B] & [PV 7012C]. Keep close [FV 7012A].
- Pressure gauge [PG 7012B] installed in the field for measuring burner inlet pressure.
- For fresh burner starter used PCV [PV 7012C] to get smooth/controlled burner light up, subsequently flow control valve [FV 7012A] can be opened for increasing the firing rate.
- At the time of burner startup [FV 7012A] shall be set at closed position while [PV 7012C] shall be set at 15% open position (the position shall be set at the time of commissioning).

Charging Of Pilot Gas For Lightup:

Ensure the availability of LPG cylinder & industrial regulator to deliver rated pressure from cylinder. The discharge pressure is to be throttled by suitably adjusting the self-acting PCV.

- Verify that all the instrument root valves are open.
- Burner shut off valves (XV7014H, XV7014GA) are in closed position and vent valve (XV7015GB) is in open - physically and from the DCS PANEL.
- Ensure vent valve (FG055) is in close position.
- Ensure root valves of all pressure gauges (FG-151, FG-153) and pressure transmitter (FG-152) open.
- Open the line isolation valve & charge the pilot gas up to burner isolation valve.
- Set the PCV7013 to get required pressure.

Note

The above procedure is explained for burner A. Same procedure is to be followed for burner B & C.

Charging Of Diesel Oil Line For Lightup:

Diesel oil is to be charged from battery limit to burner. The charging of fuel oil is done as follows -

- Verify that the root valves of all the instruments are open
- Ensure spectacle blind is de-blinded.
- The main fuel trip (XV7010 D) and burner manual shut off valve (XV7014A) is in closed position - physically and from the DCS PANEL
- Ensure root valves of all pressure gauges (DF101, DF-103, DF-107, DF-108) and pressure transmitters (DF-102, DF104, DF-105, DF-106) are open.
- The isolation valves for the flow transmitter (DF-002 & DF-003) up stream and down stream respectively are to be kept open.

- Flow control valve upstream and downstream isolation valves (DF-006, DF-007) are to be kept open
- Flow meter bypass valve (DF-005) is fully closed.
- Ensure that the flow control valve (FV7010A) in fully closed position - physically and from DCS.
- Pressure control valve upstream and downstream isolation valves (DF-009, DF-010) are to be kept open
- Ensure that the pressure control valve (PV7010B) in minimum opening position - physically and from DCS. Minimum position of PCV will be decided at the time of commissioning.
- Ensure all drain valves (FD-004, DF-008, DF-011, DF-024) are closed.
- Open the isolation valve at the battery limit (DF-001). This will charge oil up to main shutoff valve (XV7010D).
- PT 7017B, PG 7010B, PT7010CA, PT7010CB, PT7010CC & TT7010 will show pressure and temperature of oil after control valves respectively.
- Initially auxiliary oil gun is to be taken in line so its manual isolation valve (DF-012) to be open & kept closed the main gun burner inlet isolation valve (DF013).
- While taking main oil gun inline so its manual isolation valve (DF-013) to be opened.

Note

The above procedure is explained for burner A. Same procedure is to be followed for burner B & C.

Charging Automizing Steam Line:

- Verify that the root valves of all the instruments are open.
- Ensure strainer [SM – 006] is cleaned and properly tightened.
- Isolation valves of strainer upstream and downstream (SM-003, SM-005) are open.
- Ensure root valves of all pressure gauges (SM-001, SM-007, SM-008, SM-105) and pressure transmitters (SM-102 SM-103 SM-104) are open.
- Ensure burner A atomizing line shutoff valve (XV7014C) and clearing line shutoff valve (XV7014B) is in close position physically and in DCS panel.
- Pressure control valve (PV7011A) is used to control pressure of atomizing steam with feedback from pressure transmitter (PT7011A).
- Isolation valves of differential pressure control valve (PDV7011B) upstream and downstream (SM-007, SM-08) are open.
- Bypass of PDV7011B (SM-012) is closed.
- Keep all the drain valves (SM-039, SM-040, SM-041, SM-042, SM-001, SM-002, SM-009, SM-010, SM-046) are crack open till condensate is drained.
- Once the condensate removed from steam line then line up the steam trap and open the root valve of steam trap continuously.
- Open valves SM-037, SM-038, SM-043, SM-044 one by one to charge steam up to burner.
- Isolation valves (SM-018, SM-019) in clearing steam line to be kept open.
- Main and auxiliary gun clearing line shutoff valve (XV 7014B) to be operated through BMS logic.

Note

Clearing line NRV location should be nearest to the oil line as possible.

Note

The above procedure is explained for burner A. Same procedure is to be followed for burner B & C.

Charging Automizing Air Line:

- At the time of initial firing if steam is not available, air can be used as atomizing media.
- Verify that the root valves of all the instruments are open.
- Ensure root valves of all pressure gauges (SM-102, SM-105) and pressure transmitters (SM-102 SM-103) are open.
- Ensure burner A atomizing line shutoff valve (XV7014C) and clearing line shutoff valve (XV7014B) is in close position physically and in DCS panel.
- Ensure strainer (SM 016) is cleaned and properly tightened.
- Isolation valves of strainer upstream and downstream (SM-003, SM-005) are open.
- Open valve (SM-013) to charge atomizing air up to burners.

- Isolation valves (SM-018, SM-019) in clearing line to be kept open.
- When you charge the air all atomizing steam line valve should be closed
- Once the air will be charged up DP control station, valve line up philosophy will be the same as atomizing steam charging.

Note

The above procedure is explained for burner A. Same procedure is to be followed for burner B & C.

Place Fd Fan In Service

- Check that the suction damper is in the closed position.
- Ensure that the power supply is available for the feeder in MCC.
- FD fan can be started either from DCS or from local burner panel. The remote / local selector switch to be positioned according to the startup location decided. Start the FD fan after selecting the airflow controller into manual mode in DCS console and output as 0%.
- Observe that the fan runs up to speed and comes into service.
- Observe that there are no excessive vibrations (by feel) in the bearings and no abnormal noise from the fan and motor.
- Observe the bearing temperature stabilize below 70 - 80 0C.
- Observe that the motor casing temperature is normal.
- Now the fan is ready for furnace purge. Purge start command may be given if required.

2.3 Boiler Startup and Pressurizing

The preparations for a boiler start up so far described can be summarized as below:

- Walk down checks of the boiler, economizer, FD fan, air & flue ducts and pipelines.
- System / valves line up of the boiler & economizer, feed water system, steam line and drain lines.
- Filling the boiler with feed water and normalizing the drum level.
- Charging the fuel gas lines.
- Start up of FD fan.

Now the boiler is ready for light up. Before light up it is necessary to understand BMS logic.

Burner Light Up

BMS - Burner Management System controls the safe start up, running and tripping of the burner. BMS is a combination of safety logic implemented in the PLC and field instruments required for monitoring the parameters for safe operation / safe shutdown of burners. BMS also generates necessary alarms required for safe operation of burner.

Main Interlocks

In the process of burner light up, first step is to satisfy the 'Main interlocks'. Following are the safety interlocks to be made healthy condition to get 'Main Interlocks Satisfied':

- Emergency stop push button not operated from DCS, ESD, CCR & LBP
- Any one FD Fan Running
- Drum level not low-low
- Drum level not High-high
- Final steam temperature not high-high
- Air Flow not Low-Low
- Furnace Pressure not High-high

Following are the conditions required for Fuel gas firing Interlocks:

- Fuel Gas Pressure not Low Low
- Fuel Gas Pressure not High-high
- Main Interlock satisfied
- Leak test completed
- MFT to open after leak test completed

Following are the conditions required for Diesel Oil firing Interlocks:

- Atomizing steam pressure not low low
- Diesel oil pressure not low low
- Diesel oil pressure not high high
- Main Interlock Satisfied

These above conditions have to be satisfied to proceed further. Operating burner(s) will trip on failure of any (or more) of the above conditions. In case of failure, the same has to be reset before restarting.

Furnace Purging

Purging is the process of pushing out / removing unburned combustible gases present in the furnace before every light up of the burner. This is done by forcing air through the furnace as per NFPA guidelines. In this case the purging is done with an airflow of 50% MCR for five minutes.

Upon satisfaction of the main interlocks & other purge conditions, "Purge Ready For Start" indication will be available in Local burner panel and in DCS. Before pressing the purge start PB on panel, the operator has to manually position the air damper(IGV) of FD Fan to increase air flow about 50% air flow and satisfy the interlock. As soon as these purge interlocks are satisfied (Airflow >50%), five minutes purge cycle will be started and 'Purge Running' will be indicated. On elapse of the five-minute purge timer 'Purge Completed' will be indicated.

If there is any interruption during purging, " Purge required " will be indicated and re-purging has to be done.

Following are the conditions which need to be satisfied for having 'Purge ready for start' condition:

- Any burner start up started
- No flame detected in furnace
- All burner block valves closed
- Main interlocks satisfied
- Purge not completed
- Furnace purge not running

On having ' Purge ready for start ', purge start PB is to be operated either from local or DCS, following events occur on operating purge start:

- Open command is given for all burner windbox dampers from BMS logic.
- Open command to FD fan damper for purge position

After all windbox dampers open and FD fan damper open to purge position air flow will increase to purge value

Purge sequence proceeds further on satisfying following conditions

- All burner windbox damper open feedback
- Air flow at purge value (60TPH)

Above conditions ensure that sufficient air is available and purge path is free.

On satisfaction of above conditions, purge running indication is available. Purge continues for 5 minutes (i.e. 300sec) provided above conditions prevail. On completion of 5 minutes of purging, purging is completed & purge completed indication is available on LBP.

After purge finished command will be given to FD fan suction damper to light up position. This will bring down the airflow to start up position.

Purge required condition be generated on following cases:

On having ' Purge ready for start

Purge start Push button is to be pressed either from LBP or SCADA screen, Following events occur on pressing Purge start:

- Purge is not completed
- No burner is running
- No Furnace purge running

On completion of the furnace purge a stand time of 10 minutes will commence during which time a burner must be successfully started. In the event of failing to start burner within this time the system will revert to furnace purge required status. Then Purge should be carried out again.

Following indications concerning purge are provided in Local burner panel:

- Furnace Purge Ready for Start
- Furnace Purge required
- Furnace Purge running
- Furnace Purge Finished

For Fuel Gas (Associated / Raageshwari)

- FD fan damper has to be set to the burner startup position manually by operator (minimum open position / about 20%) this will satisfy "Air Flow at light off valve" condition.
- Fuel gas flow control valve have to be set for close position. PRV [PV 7012C] to be set at 15% open position(Final position to be set at time of commissioning).
- Operator has to open the battery limit manual isolation valve [1FG-101] manually. Fuel gas pressure in the header would be normalized by the Pressure control valve [PV 7012C], a pressure transmitter PT 7012C will generate high & low alarm in the event of pressurisation. Permissive will be available to open the Shut off valves [XV 7012B] & close vent valve [XV 7012G] through BMS after pressing Burner start push button.
- In any condition if gas pressure reaches to 400 kPa (g) shut off valve PV 7012G will allow gas to vent out in atmosphere at safe location.

For Diesel Oil No.2

- FD fan damper has to be set to the burner startup position manually by operator (minimum open position / about 20%) this will satisfy "Air Flow at light off valve" condition.

- Diesel oil flow control valve [FV 7010A] have to be set for close position. PRV [PV 7010B] to be set at 15% open position.
- Operator has to open the battery limit manual isolation valve [1DF-001] manually. Fuel gas pressure in the header would be normalized by the Pressure control valve [PV 7010B], a pressure transmitter PT 7010B will generate high & low alarm in the event of pressurisation. Permissive will be available to open the Shut off valves [XV 7010D] through BMS after pressing Burner start push button.

2.3.1First Burner Lightup Sequence With Fuel Gas

Ignition conditions to be satisfied –

- Gas burner startup interlock satisfied
  - Fuel gas MFT to open command,
  - No flame inside the burner
  - Block valve close start permissive
- Burner A no main flame failure
- Fuel gas burner ignition permissive
  - Any one FD fan motor running
  - Fuel gas FCV at close position.

These ignition settings are valid for first burner startup; these conditions are bypassed by fuel gas any one burner ON.

- Fuel gas burner A ignition not started
- Pilot gas pressure not low
- Pilot gas pressure not high OR
- Diesel oil burner A ON
- Fuel gas MFT open feedback
- Any fuel gas ignition sequence not started

On satisfying the above conditions, burner is ready for fuel gas firing. Fuel gas ready for start indication is available in LBP.

There are two modes of fuel gas firing:

1. Only fuel gas firing
2. Diesel oil to fuel gas changeover (Manual)

1. Following startup sequence shall occur when only gas firing is carried out Burner startup shall be initiated by operating fuel gas burner start P.B. from local burner panel (LBP).

Start	:	Burner Windbox damper energies to open 20% which is burner start up position. (For the first burner start, all burner windbox dampers should be full open following furnace purge, but at the end of the first burner start sequence the non running burners windbox damper should be closed). If windbox 20% open feedback is not received within 5 seconds start command will be removed automatically.
		Fuel gas header vent valve de-energise to open.
Start + Windbox20% open feedback	:	Ignitor energised ON.
		Burner ignition valves energised to open and vent valve energised to close.
Start + 5 sec.	:	Ignitor ON. Burner ignition pilot flame monitored for flame ON. If pilot flame is not ON, start-up sequence will be stopped indicating flame failure signal.
		Fuel gas header pressure monitor for normal pressure during first burner start command. Fuel gas pressure shall be less than 0.6 Kg/cm2g. If pressure is normal fuel gas block valves of burner A energised to open and vent valve energised to close.
		Fuel gas header vent valve energised to close.
Start + 10 Sec.	:	Burner main flame monitored for flame ON. If flame is not sensed ON by any of the two scanners burner will trip.
		Burner ignition block valves de-energised to close and ignition vent valve de-energised to open after 10 sec.
		Burner firing stabilised and burner running condition shall be indicated if main flame is detected.
		Windbox damper on non-running burner will close.
		Windbox damper of the same burner will open to 100% after 60 seconds from start command.

2. Following startup sequence shall occur during diesel oil to gas manual changeover.

Start + 10 Sec.	:	Burner main flame monitored for flame ON. If flame is not sensed ON by any of the two scanners burner will trip.
		Burner ignition block valves de-energised to close and ignition vent valve de-energised to open after 10 sec.
		Burner firing stabilised and burner running condition shall be indicated if main flame is detected.

Following indications concerning burner light up is available on LBP.

- Burner A pilot on
- Burner A ready for start
- Fuel gas Burner A ON

2.3.2 First Burner Lightup Sequence With Diesel Oil

- Diesel oil burner startup interlock satisfied
  - Diesel oil MFT to open command,
  - No flame inside the burner
  - Block valve close start permissive
- Burner A no main flame failure
- Diesel oil burner permissive
- Scavenging permissive
- Diesel oil firing interlock satisfied
- Diesel oil Burner A Ignition not started
- Pilot gas pressure not low
- Pilot gas pressure not high OR
- Fuel gas Burner A ON
- Diesel oil MFT open feedback
- Any Diesel oil ignition sequence not started

On satisfying the above conditions, burner is ready for Diesel oil firing. Diesel oil ready for start indication is available in LBP.

There are two modes of Diesel oil firing:

1. Only Diesel oil firing
2. Fuel gas to diesel oil changeover (Auto)

1. Following startup sequence shall occur when only oil firing is carried out: Burner startup shall be initiated by operating diesel oil burner start P.B. from local burner panel (LBP).

Start	:	Burner Windbox damper energies to open 20% which is burner start up position. (For the first burner start, all burner windbox dampers should be full open following furnace purge, but at the end of the first burner start sequence the non running burners windbox damper should be closed). If windbox 20% open feedback is not received within 5 seconds Start command will be removed automatically.
Start + Windbox20% open feedback	:	Ignitor energised ON.
		Burner ignition valves energised to open and vent valve energised to close.
Start + 5 sec.	:	Ignitor ON. Burner Ignition pilot flame monitored for flameON. If pilot flame is not ON, start-up sequence will be stopped indicating flame failure signal.
		Diesel oil block valves opens after 5 sec through digital output and 4 to 20 mA. This signal is enerated in the PLC using a ramp generator and given to the valve.
Start + 10 Sec.	:	Burner main flame monitored for flame ON. If flame is not sensed ON by any of the two scanners burner will trip.
		Burner ignition block valves de-energised to close and igntion vent valve de-energised to open after 10 sec.
		Burner firing stabilised and burner running condition shall be indicated if main flame is detected.
		Windbox damper on non-running burner will close.
		Windbox damper of the same burner will open to 100% after 60 seconds from start command.

2. Following startup sequence shall occur in auto mode

Auto changeover command + 10 Sec.	:	Burner main flame monitored for flame ON. If flame is not sensed ON by any of the two scanners burner will trip.
		Burner ignition block valves de-energised to close and ignition vent valve de-energised to open after 10 sec.
		Burner firing stabilised and burner running condition shall be indicated if main flame is detected.

Following indications concerning burner light up is available on LBP.

- Burner A pilot on
- Burner A ready for start
- Diesel oil Burner A ON

Upon satisfaction of above interlocks, 'Burner Ready for Start' will be indicated in local burner panel and on DCS.

Burner start command can be given by pressing the start push button either from local burner panel or from DCS.

On issuing the Burner start command following will be the sequence of actions:

- Igniter spark "ON" (For 5 Secs.)
- Burner Ignitor air solenoid valve will open
- Pilot burner upstream & downstream SOV will open, vent valve SOV will close.
- Burner Pilot flame proven through ionization.
- Pilot gas shut off valves will open based on feed back from Pilot detection.
- Flame "ON" indication at DCS and in LBP.

Igniter spark will be "ON" only for 5 seconds, pilot flame to get established and detected by the ionization rod within this period. Failure of the pilot flame detection stops the sequence.

On successful establishment of pilot flame and if the flame is detected by flame scanner then the pilot gas shut off valves will be kept opened for a predetermined time for enabling the main flame to establish. On receiving the feedback signal 'flame detected' within 5 seconds of burner start command, a signal is given to open the Burner main shut off valves. If the main flame is stabilized and remain detected by the flame scanners even after 10 seconds from the opening of block valves, Burner "ON" indication will be available on DCS and LBP. Failure of flame detection after pilot withdrawal will trip the burner and Burner flame failure / Trip will be indicated in DCS / LBP.

2.3.3 Boiler Pressurization and Loading

Once the burner is ON, Boiler will be pressurized according to the pressurizing curve.

After establishing flame in burner, the operator takes care of the following:

- Operator has to inspect the flame in the furnace through peepholes. Clear furnace with proper flame is important.
- Monitor the steam drum water level.
- Monitor the parameters, which can cause a boiler trip as explained in BMS logic.
- Line up the phosphate dosing to steam drum at a slow rate.
- Operator has to be on alert for swelling of drum level when the boiler water temperature builds up to 90 0 C. Open the IBD valve and regulate such that the water level is within limits. IBD Valve is to be closed once the water level is normalized.
- Modulate the firing / fuel flow so that the boiler pressurization is following the pressurization curve (attached later in this section). Firing rate has to be increased manually from DCS console. Positive air fuel ratio has to be maintained during modulation. Start up vent/ pressure control valve may have to be throttled in the process of pressurization to follow cold start up pressurisation curve.
- At 2 bar (g) drum pressure, drum vent valves have to be closed.
- At 2 bar (g) drum pressure, superheater drain valves have to be closed.
- Once the swelling is over and the drum level normalizes, select the drum level controller into single element control and into auto mode with set point of 50%. Monitor that the drum level is being maintained.
- Operator shall have a walk down check of feedwater line, fuel gas line, the boiler and the valves. Any water, steam leakage (through

valve glands, bonnets, flanges) and other minor abnormalities noted can be corrected when the boiler pressure is less than 5 bar (g).

- When the boiler is in service, the Operator has to be alert to the alarms appearing on DCS. When an alarm registers, the Operator has to check the cause for the alarm. Corrective steps have to be taken wherever necessary to restore normal values. Quick action by the Operator prevents further deterioration of values to the boiler trip level.
- Steam temperature controller TIC 7018-C shall be put into auto mode in DCS console with the set point of 371 °C.
- At around 35 bar (g) of super heater outlet pressure MSSV bypass valve can be opened to warm-up the main steam line to plant or to equalize the pressure across. The trap units in the main steam piping to be lined up.
- When the main steam line pressure reaches about 4150 kPa (g), MSSV (MOV 7018D) can be opened to connect the boiler with plant main. MSSV bypass pressure equalization valve (MOV 7018E) shall be closed.
- Once the steam flow indication is available and it is reached above 40% of MCR, drum level control shall be changed over to 3-Element control mode.
- Now, Combustion control shall be taken into auto mode (Boiler master pressure control). Combustion control will take care of the load demand, by modulating the fuel flow and airflow.
- Regulate the phosphate doing rate to steam drum.
- Operator to adjust flow through SH steam, saturated steam and boiler water sample coolers so that a small stream of cold samples are obtained from them. Call for a laboratory analysis of the SH steam, boiler water and boiler feed water sample. Necessary water & steam parameters to be maintained by adjusting the phosphate chemical dosing rate and continuous blow down rate.
- Once the boiler is connected to the plant header and the combustion controller is put into auto mode, boiler will be responding to the load demands automatically. The control loops shall be tuned up to take care even upto ramp rate of 20% MCR per minute.
- Put Deaerator in service and start dosing LP & pH Dosing.

COLD STARTUP PRESSURE RAISING CURVE

Boiler startup can be termed as cold startup when there is no pressure or when pressure is less than 2-bar (g) in the steam drum.

In a cold start up, possibilities of some inspection or maintenance work having been done is presumed. A walk down check is required and the boiler and its auxiliaries are to be prepared meticulously for a start up from the DCS of the control room. Before a walk down check ensure that all work permits have been returned, safety tags are removed and maintenance permission for boiler start up is available.

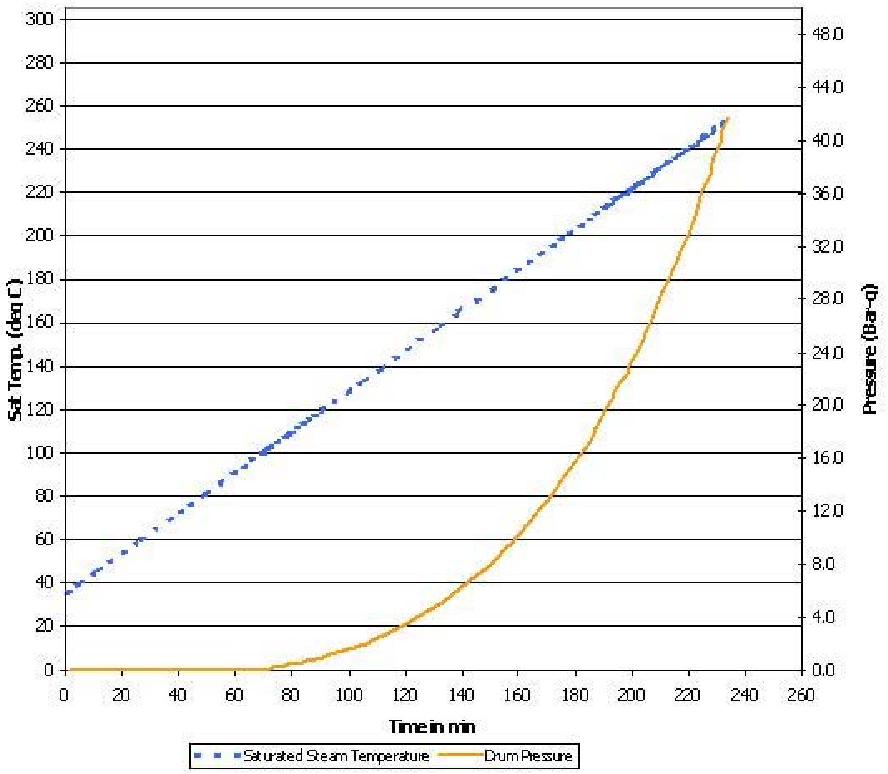


Figure 1

3 Boiler Hot Startup Pressure Raising Curve

Restarting a boiler immediately after a trip when the boiler is still hot and with steam pressure not less than around 32 kg/cm2 (g) is termed as Hot Start-up. As the boiler was in service till the trip out, the required valve line up (as stated for the cold start up) will be available and can be quickly checked by visual inspection. Hot restart requires operations to be done fast, within the maximum permissible firing rates so as to obtain quickly the required main steam pressure and temperature conditions. Boiler can be pressurized to the rated pressure and temperature by using start up vent valve, and can be connected to plant mains after achieving the rated parameters.

Following are the steps involved in the hot start-up:

- Normalise the steam drum level by modulating the feed water flow control valve.
- Start the burner after achieving the necessary BMS interlocks as explained earlier.
- As soon as the burner is started open the Start up vent valve.
- Once the flame is stabilised, increase the firing rate according to the rate of pressurisation specified in the pressurisation curve.
- Maintain the drum level.
- Once rated pressure and temperature is reached connect the boiler to the main header and close the start up vent.

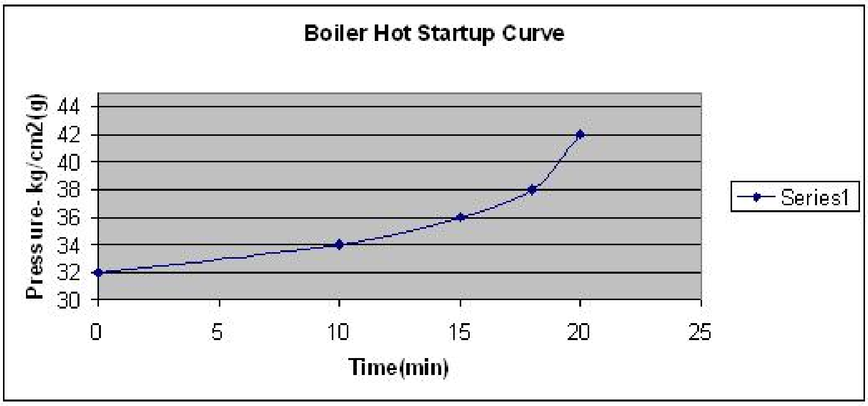


Figure 2

4 Boiler Warm Startup Pressure Raising Curve

Re-start of the boiler with steam pressure not less than 2-kg/cm2 (g) is termed as a warm start-up.

The preparations and valve line up required is as for HOT restart. However as the BOILER has been idle for several hours, the valve line up requires to be verified.

- Super heater drain operations

Opening of Main steam line drains, Superheater drains & Attemperator drains are required in warm start up. These drain valve need to be closed when condense is drained completely at 5 Kg/cm2(g).

The time taken for a warm start may be more than that hot start but less than that of a cold start. Boiler can be pressurized to the rated pressure and temperature by using start up vent valve, and can be connected to plant mains after achieving the rated parameters.

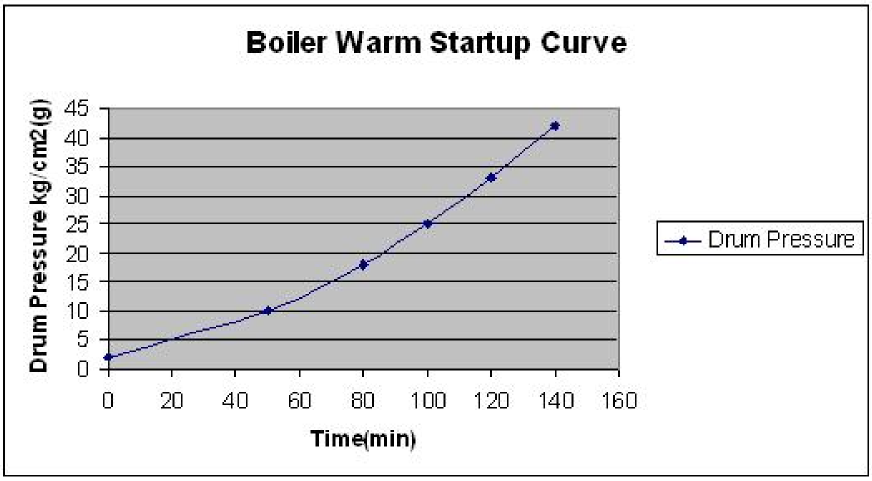


Figure 3

5 Boiler Shutdown

A Boiler shut down can be of two types:

- Planned shut down where the Operator gets advance notice and adequate time to shut down the boiler in an orderly manner, for inspection, maintenance or for cold reserve.
- Boiler Trip on interlock protection or emergency shutdown by the Operator.

5.1 Planned Shut Down

On a planned shut down operator to carryout the following activities in the sequence:

- Reduce the boiler load gradually. At steam flow below 12-15 TPH, stop the top burner from DCS/ LBP.
- Close the MSSV. Take the combustion control loop into manual mode.
- Then stop the burner manually from DCS/ LBP.
- Close the startup vent isolation valve. Ensure that the pressure control valve is closed and select the controller into manual mode.
- Carry out the furnace purge.
- Stop the FD fan and close the suction damper.
- Continue to feed water to the boiler to maintain normal water level. Drum level controller shall be changed to single element mode and maintain the level. Once the level is normalized, take the feed water / drum level controller in to manual mode and close the valve (output as 0 %).
- Stop phosphate dosing. Close the CBD valve.
- Verify the IBD valve is closed.
- Allow the boiler to cool naturally.
- Scanner cooling air supply is continued till the furnace temperature falls below 100 0 C or for at least 8 hours.
- If the proposed shut down of the boiler is for more than 8 hours, fuel gas supply has to be isolated.

- When the steam drum pressure drops to 2 bar (g), open the steam drum vent and the startup vent.

6 Boiler Emergency Trip

Sometime boiler trips either by a protection or due to a power failure or by an emergency trip command by the operator causing the fuel block valve to close and abruptly stopping the firing.

Under such emergency trip conditions the operator action is -

- For protecting the boiler
- For investigating the cause of trip and if possible to eliminate the cause
- If the cause is eliminated, to restart the boiler
- If the cause cannot be immediately eliminated to continue the shutdown till it is done

BOILER PROTECTION AFTER A TRIP

- Close main steam stop valve immediately
- Continue to feed the water if level requires to be maintained
- Check that fuel Oil block valves are closed
- Check that there is no flame in the furnace
- Carry out post trip purge of the furnace

6.1 Boiler Shutdown During Sudden Tube Failure

In case of a sudden tube failure followed by a severe loss of drum water level, it is advised immediately to stop the burners, purge the furnace and also isolate the steam & feedwater system. This is to avoid undue thermal stresses on pressure parts. The drum vent & start up vent have to be opened as the pressure falls to 2 Bar (g). The extent of the damage is to be ascertained after cooling the boiler completely.

In case of a tube rupture, if the water level could be maintained and flame is not lost, it is recommended that the boiler be taken out of service as soon as possible. The impingement of steam & water from a leaking tube on adjacent tubes can cause additional failure of tubes. In such cases, the normal planned shutdown procedure is immediately implemented.

7 Boiler Operation

Walk Down Check List During Operation

Boiler

- Check for unusual noises. This may be from steam or water leakages
- Check for steam or water leaks from valves, connections and fittings
- Check for unusual traces of water on floor
- Check for air / flue leakage from windbox, boiler casing and ducting
- Walk around the furnace exterior and observe for any hot spots or gas leaks.
- Check position of fan suction damper and check for obstruction
- Check for passing from safety valves at normal operating pressure. Check that the drain lines and drip pans are not plugged
- Check for clear & bright flame and clear stack
- Check to see that proper water level is being shown by the direct water level gauge. Check for water or steam leak from ports or drain connections, which will cause a false water level in the gauge glass. Inspect the glass for discoloration or fouling
- Check for any obstruction for thermal expansion

Rotary Equipments

- Listen for any unusual noises
- Feel and inspect for vibration regularly
- Inspect bearing temperature
- Inspect for lubrication level
- Check for any abnormality in couplings
- Check current and voltage of motors

7.1 Do's and Don'ts for Boiler Operation

DO'S

- Maintain all instruments in good working condition
- All equipment interlocks should always be in line
- Maintain normal water level in steam drum
- Maintain water quality as per the recommended limits. A table showing the DM water & drum water quality is included at the end of this section
- FD damper must be in smooth operating condition
- Pressure raising from cold start must be done as per the cold start up curve

- All the duct joints must be leak proof
- Use proper lubricant and maintain the schedule as recommended by the manufacturers
- Operate the boiler within the recommended operation limits
- Boiler, piping, ducts must be properly insulated
- Servicing of equipments should be done as per the manufacturer's schedule
- Maintain proper operation log sheets regularly
- Maintain the instrument air free from moisture and oily matters and the pressure as recommended
- Carry out regular cleaning of direct water level gauge glasses of Boiler drum
- Use proper valve gland packing to avoid leakage
- Use proper gaskets for flange joints
- Operate the blowdown valves as per recommendation
- In case of power failure close the steam stop valve
- If the water level goes up above the limits operate the intermittent blowdown valve immediately and maintain the water level to normal
- Maintain the feed water temperature at Economiser inlet and flue gas temperature at Economiser outlet as recommended
- Use genuine spares
- Boiler surroundings and equipments must be properly illuminated

DON'TS

- Don't bypass any instruments and safety interlocks
- Don't use raw water as boiler feed water
- Don't operate the boiler beyond the operation limits
- Don't leave the furnace door open while the boiler is in operation
- Don't mix up different lubricants
- Don't alter the equipment maintenance schedule
- Don't leave the instrument control panel unattended
- Don't allow unauthorised persons to operate the boiler and associated equipments.
- Do not dose chemicals into the boiler in batch wise, they should be done on a continuous basis
- If boiler is running under combustion control manual mode, then while increasing load air should be increased first followed by oil. Ensure always-proper air to fuel ratio corresponding to load.

7.2 Boiler Log Sheet

It is suggested to record the boiler parameters during start-up and normal operation. Observed abnormalities (if any) recorded can be used for analysis, troubleshooting and maintenance purposes.

Log sheet to be filled once in every hour by the operating staff.

Feed water, boiler water quality are also to be noted once in four hours.

Total Fuel consumption and steam production of a day to be noted.

Logbook should furnish the details about

- Boiler trips with reasons and time.
- Boiler running hours.
- Boiler shut down details (forced or planned, outage hours, jobs carried out, etc.,)

Sample log sheet is enclosed.

7.2.1Log Sheet for the Boiler

Date:

Shift:

SL.No.	PARAMETER	TAG NO.	UNIT	TIME		
1	Drum Level	LT 7018 A/B/C/D/E/F	MMWC			
2	Main Steam Pressure	PT 7018–B	Kg/cm2 G			
3	Steam Flow	FT 7018–C	TPH			

SL.No.	PARAMETER	TAG NO.	UNIT	TIME		
4	Steam Flow Totalizer		Tons			
5	Gas Flow	FT 7012–A	Kg/Hr			
	Oil Flow	FT 7010–A	Kg/hr			
	Air Flow	FT 7015	Kg/hr			
	Feed Water Pressure at Control Station Inlet	PT 7018–A	Kg/cm2 G			
	Feed Water Temp. at ECO. Inlet	TI 7018–E	DEG C			
	Feed Water Temp. at ECO. Outlet	TI 7018–D	DEG C			
	Flue Gas Temp. at Furnace Exhaust	TI 733A0	DEG C			
	Flue Gas Temp. at ECO. Outlet	TI 717A0	DEG C			
	FD Outlet Pressure	PT 7150	MMWC			
	Windbox Pressure	PT 7151	MMWC			
	Furnace Pressure	PT 7017BA/B/C	MMWC			
	Flue Gas Draught at ECO. Inlet	PT 733A0	MMWC			
	Flue Gas Draught at ECO. Outlet	PT 717A0	MMWC			
	Flue Gas Oxygen	AT 717A0	%			
	Feed Water Analysis pH Conductivity TDS Silica Hardness Oxygen					
	Drum Water Analysis: pH TDS Alkalinity as CaCo3 Silica Phosphate as Po4 Sulphite as SO3					
	Sat. & Sh Steam Analysis: pH Conductivity					

SL.No.	PARAMETER	TAG NO.	UNIT	TIME		
	TDS Silica					

8 Boiler Safety

8.1 Emergency Procedures

Low Water Level

Causes

1. Feedwater control system failure.
2. BFP failure
3. Tube leak

Action

Compare control room indication with gauge glass level. If the water level falls out of sight due to momentary failure of water supply system, due to negligence of the operator, due to momentary fluctuations that might occur with extraordinary changes in load, appropriate action should be taken at once to trip the fuel. Any decision to continue to operate, even if only for a short time at a reduced rating would have to be made by someone in authority who is thoroughly familiar with the circumstances that led to the emergency and positively certain that the water level can be restored immediately without damaging the boiler.

In the absence of such a decision

1. Stop the fuel feeders and Fans immediately. Shut off the main steam stop valve .

Simultaneously, if feedwater has become available and the operator is assured that no pressure part has been damaged

1. Take the feedwater control system into manual mode
2. Allow the water flow to boiler gradually to normal water level. (Do not hurry up which may lead to sudden quenching and tube leak) if pressure part damage is suspected
3. Reduce the steam pressure gradually
4. Open the drum air vent when the pressure drops below 2 kg/cm²
5. Cool the boiler so as to examine the extent of damage
6. Drain the boiler after cooling
7. If any tube rupture and bulging is observed rectify the same
8. If any tube leakage were observed rectify / repair the leaking tubes and after the repairs conduct hydrotest
9. Determine the cause of low water

High Water Level

Causes

1. Feedwater control malfunction
2. Operator error
3. Instrument air supply failure
4. Foaming

Action

1. Take the drum level control loop into manual mode
2. Reduce the water level immediately by operating the intermittent blow down to maintain the drum level
3. Reduce the steam discharge rate, if necessary
4. Start the stand by compressor if required

Furnace Puffing & Back Firing

Causes

1. Uncontrolled feeding of fuel into the furnace
2. Sudden increase in FD fan air
3. Tube rupture
4. Foaming

Action

1. Take airflow control system into manual mode and maintain the furnace pressure
2. Never increase fuel / air flow suddenly. Always increase air first then fuel / oil / gas while taking boiler on load
3. In case of tube failure take the boiler out of service immediately
4. Keep the water wall tubes clean by monitoring the combustion conditions.

Boiler Explosion

Causes

1. Accumulation of fuel in the furnace due to incomplete combustion

2. Loss of ignition
3. Fuel oil valve leakages
4. Frequent unsuccessful startups
5. In-sufficient purging of furnace

With the mixture of unburned fuel with air in explosive proportions and the application of heat sufficient enough to raise the temperature of the mixture to ignition point.

Action

1. Trip the FD Fan immediately
2. Analyse the reasons for explosion and rectify the system
3. Evacuate or clean the furnace to the possible extend

Conditions for Boiler Restart after Furnace Explosion

After a case of furnace/ boiler explosion, the restart of the boiler has to be carried out only after a thorough and detailed investigation & understanding of the cause of explosion. Following necessary actions have to be completed to prevent the repeat incidence of explosion and before restart of the boiler.

Find out the root cause for the explosion and rectify the same.

1. Inspect the furnace for any signs of bulging or damage to the tubes.
2. Inspect the furnace refractory for damages
3. Inspect the air and flue ducts for any signs of damage
4. Inspect the expansion bellows in the air and flue ducts for damages
5. Inspect the economizer casing for damages
6. Assess the damage if any and rectify the same.
7. Carry out the hydro test of the boiler. In the event of a failure of the hydro test, identify the tubes that have failed and proceed to rectify the same as explained in the maintenance section.

8.2 Operational Precautions for Safety

Introduction

The handling and burning of any fuel is potentially hazardous. Some fuels ignite more readily than others. Safe handling and operation demands knowledge of the characteristics of the fuel and careful observance of necessary precautions.

1. Operating the boiler with low feed water temperature along with high excess air will result in exceeding metal temperature. There should be no hesitation to bring down the load on the boiler if this temperature cannot be brought under control by other means.
2. In the case of tube failure which can be identified by hearing the noise in the boiler gallery and cross checked by difference in steam and water flow, gas and steam temperature, the boiler should be shut-down at the earliest by regular procedure for maintenance work. Otherwise large number of tubes may fail due to steam erosion and impingement.
3. Entry of wet steam into superheater and first row or after desuperheaters will result in removal of oxide film due to thermal shock. Boiler salt in the steam will accelerate corrosion. Austenitic steel is the worst affected due to stress corrosion in this case. Hence temperature after the desuperheater should be maintained well above the saturation point in the case of direct spray type.
4. Boiler washing (when the unit is shut down) can be done effectively by using hot water. Immediately after washing, the surfaces should be dried.
5. Always use deaerated, de-mineralised water for boiler feeding with the recommended feed water quality.
6. Feedwater temperature must also be maintained at the highest level possible either with the help of feedwater heaters or heating the water in the feed tank. Low feedwater temperature obtained during low load operation will result in external corrosion of economiser.
7. The economiser circulation system if provided should be kept in service when there is fire in the boiler with no feed flow.
8. Steaming in economiser is harmful to economiser unless otherwise it is designed as steaming type and hence steaming should be prevented by keeping a watch on economiser outlet water temperature.
9. Carryover of salts in steam occur either due to mechanical or vapour carry over from steam drum. Efficient drum internals can only reduce mechanical carry over. Silica is always carried

over in vaporous form. Continuous monitoring of sodium and silica in steam is desirable.

10. Before operating a boiler, ensure complete knowledge of water chemistry.

11. Whenever boiler is started after a shutdown of more than 3 days, check all safety interlocks before boiler start up for proper functioning.

12. Superheater drain valve should be operated as per recommendations.

13. The steam drum should normally be filled upto the point when water is showing in the bottom part of the gauge glass. This is to allow for the swell on heating and to reduce any blowing down resulting from this cause to a minimum.

14. Firing should be maintained having regard to the instructions for protection of superheater, which will limit the maximum gas temperature in the superheater zone.

15. Once the boiler is boxed up, the water level in the steam drum must be raised to the very top of the drum. Filling the drum like this will prevent excessive temperature differentials along the drum wall. The water is then shut-off and the boiler is allowed to cool.

16. When staring from cold, the drains on both the inlet and outlet superheater boxes should be wide open (if applicable)

17. While raising pressure on boilers, a technique of continuous firing should be developed if possible, since intermittent firing may result in recondensation in the tube loops.

18. Where spray type attemperator are fitted, it is very important that control of steam or superheater tube metal temperature is not attempted by the use of the spray during pressure raising. This can lead to the entry of spray water into the secondary superheater tube loops.

19. Ensure the availability of fuel / bed material / recycle ash in the bunkers.

20. Never allow oil or gas to accumulate anywhere, other than in a tank or lines which form a part of a fuel supply system.

21. Purge the furnace completely before introducing any light or spark. On a multiple burner unit, burners may be ignited without a purge if one or more in service already.

22. Have a lighted torch or spark producing device in operation before introducing any fuel into furnace.

23. Maintain a positive airflow through the burners into the furnace and up the stack.

24. Maintain adequate oil pressure and temperature for atomisation & also adequate steam or air pressure in case of steam or air atomisers.

25. Ensure operation staff alerts to all abnormal conditions. To observe the above rules, automatic control instruction may include :-

    a. Purge interlocks e.g. requiring a specified minimum airflow for a specific time period sufficient to purge the setting before the fuel trip valve can be opened.

    b. Flame Detector: Each burner should have its own flame detector connected to an alarm and interlocked to shut-off the fuel to the burner, it serves upon flame failure.

    c. Closed position switches for burner shut-off valves, requiring that all shut-off valves be closed to permit opening the fuel trip valve.

    d. Shut-off of fuel on failure of draft fan (s).

    e. Shut-off of fuel in the event of low fuel pressure and low atomising steam or air pressure, and low instrument air pressure.

    f. Shut-off of fuel in gas fired units in event of excessive fuel gas pressure.

    g. Shut off of fuel in the event of electric power failure.

26. The raising and lowering of steam parameters should be restricted to the value given in the starting diagram. Exceeding these values will result in reduced fatigue life of pressure parts.

27. Entry of wet steam into superheater and first row or after de-superheaters will result in removal of oxide film due to thermal shock. Boiler salt in the steam will accelerate corrosion. Austenitic steel is the worst affected due to stress corrosion in this case. Hence temperature after the de-superheater should be maintained well above the saturation point in the case of direct spray type.

28. Carryover of salts in steam occur either due to mechanical or vapour carryover from steam drum. Efficient drum internals can only reduce mechanical carry over. Silica is always carried over in vaporous form. Continuous monitoring of sodium and silica in steam is desirable.

29. Before operating a boiler, ensure complete knowledge of water chemistry.

30. The threaded portion of the burner tip should be covered with a non-hardening

high temperature lubricating compound. This facilitates easier subsequent removal. (Please refer burner manual)

31. Lapped burner tips must be kept in a plastic container to prevent damage for atomising steam with internally mixing type steam atomisers.

32. Whenever boiler is started after a shutdown of more than 3 days, check all safety interlocks before boiler start up for proper functioning.

Proper Handling of Access Door

1. Never open an access door while the unit is operating.
2. Any access door can have large amount of material built up behind it even after the bed has been drained. This material will fall out when the door is opened. Bed material can stay hot for many days even after boiler shutdown.
3. Open the door slowly and always stand to the side of the opening.
4. Look at the cavities through the door before entering into the boiler. have sufficiently bright light available at all times when personnel are in the furnace and or in convection pass.

Proper Handling of Thermocouples

1. Repair or changing of thermocouple / thermowells during boiler operation is absolutely prohibited, particularly in the positive pressure zone of the boiler. However if the need arises, always recall that the furnace is pressurised and that the thermowell may be an open path to the pressurised furnace. slowly and carefully disconnect the thermocouple from the well
2. If you encounter resistance in removing the thermocouple, it is an indication that the thermowell has eroded and is packed with ash and bed material. abort the attempt to replace the thermocouple and refasten it until the boiler is off the line and cooled.
3. If no resistance is encountered then carefully remove the faulty thermocouple and replace it.
4. Never look into the thermowell opening.

Handling of Secondary Air Ports

1. The hand-operated dampers in the secondary air nozzles will be very hot.
2. While handling the dampers / ports protective gloves should be worn and enough attention to be given.

Handling of Solid Piles

1. Always be cautious of piles of bed material.
2. The surface of piled material may be cool in the surface while just below the surface still may be very hot.
3. Bed material in a pile can stay hot for several days.

Handling of Furnace Ports and Observation Doors

1. Ports and observation doors are open to the positive pressure in the furnace.
2. Never stand directly in front of the ports.
3. Do not leave the poking rod in the furnace for long. It will heat up quickly making the rod hot to handle and hazardous when it is removed from port.
4. Never look directly into the port or stand directly in front of the open port. If there is a pressure pulse in the furnace, hot bed material can suddenly and unexpectedly spurt out.
5. Never use anything that may burn or melt, such as plastic or rubber, to temporarily blow the port.
6. Properly dispose of all combustible material from the port area. If any hot material blows out from the boiler it presents a potential fire hazard.
7. Be sure aspirating air is on before you open the port door. If the air is not on, a stream of hot furnace gas, ash and bed media will blow out of the boiler. • Open the port cap slowly.
8. When inserting a probe in the port, stand as far back as you can. Due to pressure some bed material can blow out.
9. When extracting the probe, again stand well back.
10. Never leave the port unattended ever for short time while working.

Safety Precautions

1. Do not attempt to open the boiler doors or observation ports without observing the proper safety procedure.
2. Always use a full-face mask with tinted glass.

3. Do not stand directly in front of open ports or doors especially when they are opened.
4. Use sealing air when opening the doors / observation ports.
5. Use ear protection devices, whenever it is necessary.
6. Wear protective gloves when working around the boiler.
7. Do not use open-ended pipes for rotting observation doors or ports.
8. Never enter drums, ducts etc. until all the steam and water valves including the drain and blow down values have been closed to check and tagged.
9. Do not enter a confined space until it has been cooled below 30 °C and property ventilated.
10. Completely drain the solids from the bed, hoppers etc. while entering.
11. Always use low voltage extension cords and light bulbs with properly connected ground.
12. Never open or enter the rotating equipment until it has come to a complete stop and circuit broken i.e. open
13. When entries the furnace ducts etc. be prepared for falling.
14. Never step into fly ash or bed material. It can be cold on the surface yet remain hot and smoulder underneath for extended period of time. Always secure the drive mechanism of dampers, gates and doors before passing through them.
15. Watch for hot water in drum and headers when removing manhole and manhole covers.
16. Never use toxic fluids like CTC in confined spaces without adequate ventilation.
17. Never direct an air or water stream into an accumulation of fly ash in a confined area. If the fly ash is smouldering the asatation could result in an explosion.

Safety Tips

1. All scaffolding materials are removed and cleaned.
2. Check any observation for expansion and dampers operations.
3. Ensure that all inspection doors, access doors and openings are closed and pad locked as required.
4. Disconnect and isolate the nitrogen purge if it was used during the outage.
5. Open the steam drum vents and the vents.

9 Tube Failures

Operating the boiler with a known tube leak is not recommended. Steam or water escaping from a small leak at pressure can cut other tubes by impingement and set up a chain reaction of tube failures. Large leaks can be dangerous. The boiler water may be lost, the ignition may be lost and boiler casing can get damaged.

Small leaks can sometime be detected by the loss of water in the cycle or system. A loss of boiler water chemicals or by the noise made by the leak. If a leak is suspected the boiler should be shut down as soon as possible by following the normal shutdown procedure.

After the exact location of the leak or leaks is located, the leaks may be repaired by replacing the failed tube or by splicing in a new section of tube, conforming to relevant ASME code.

An investigation of the tube failure is very important so that the condition causing the tube failure can be eliminated and future failures can be prevented. This investigation should include a careful visual inspection of the failed tube and in some cases a lab analysis. It is recommended that every effort be made to find the cause of tube failures before operation is resumed.

10 Trouble Shooting Chart

The following chart is to be used for solving problems arising during operation.

Indication	Probable Source	Probable Cause	Repair method & Preventive Measures
Unable to maintain boiler water concentration	Tube Leak Hideout	Slight leakage from pitting or cracking of tube or tube seat leak.	Remove boiler from service at first convenient time. Hydrostatic test to be done to locate leak. Repair by welding or splicing as indicated and as approved by insurance or State Inspection. Determine cause of failure and correct it. Operation at normal loads should put chemical back in solution.
Sound of steam blowing in furnace or seeing visible steam from the stack.	Tube leak	Substantial leak from tube/tubes. Over-heating as from scale or tube seat leakage.	The same as above plus tubes re-rolling.
Steam explosion in furnace followed by inability to maintain water level.	Tube rupture	Failure of tube from low water, tube blockage or erosion of exterior metal surface.	Remove boiler from the line immediately. Inspect or determine whether tube splicing or wholesale tube replacement is necessary.
High conductivity	Solids carry over in the steam or high CO2 or NH3 in boiler water	High boiler water concentrations, excessive water level fluctuation drum baffle leakage or deposits on scrubbers	Check for baffle leaks in steam drum when out of service, or boiler water contamination. Check of degasified steam sample will indicate if CO2 or NH3 is high
High gas temperature	High excess air	Improper control /adjustment of airflow.	Check excess air at furnace boiler outlet, and correct airflow if required
Excessive water level fluctuation	Water load or control conditions	High boiler concentrations, extreme load swings, varying supply pressure or control loop adjustment	Correct condition leading to the problem

Indication	Probable Source	Probable Cause	Repair method & Preventive Measures
Bowed water wall generating tubes	Overheating	Internal deposit or low water. Usually internal deposits result in tubes bowing away from the furnace & low water /starve results bowing toward the furnace.	Severity of bowing will determine extent of tube replacement. Internal scale will call for internal cleaning. If low water is indicated a thorough inspection for drum damage and tube seat leakage must be made. Take steps to prevent recurrence or low water condition
Tube blisters	Localised overheating	Internal deposit	Repair by re-tubing or welding in tube section or by heating and driving back blister depending upon insurance carrier or State Inspector's approval. Clean internally by turbining or acid cleaning.
Internal pitting sharp edged and covered with barnacles in drum or tubes.	Corrosion	Oxygen in Boiler water	Depth and extent of pitting determines need and extent of tube replacement. Extensive drum pitting can be welded but is subject to approval by either the manufacturer & insurance carrier or State. Source of oxygen must be located and eliminated
Internal loss of metal not sharply defined and accompanied by black iron oxide (Fe_3O_4)	Corrosion	Overheating resulting in breakdown of water into H & O2 Cause is usually from sludge letdown or pluggage.	Individual inspection will determine extent or replacement, internal cleaning and correction of water conditions are required
External pitting	Corrosion	From corrosive ash deposit and moisture either from dew point or external source such as leaking soot blowing tube.	Extent of repair must be determined by individual inspection. In emergency tubes out of high heat zone can be plugged, being sure they are cut to vent and to prevent differential expansion with adjacent tubes. Proper external cleaning can prevent out of service corrosion.

Indication	Probable Source	Probable Cause	Repair method & Preventive Measures
			Locate and eliminate source of moisture. If dew point is from in -service corrosion, take steps to raise metal temperature
Tube cracking	Mechanical stress or a combination of stress corrosion or tube variation.	Interference with expansion or differential expansion with adjacent parts to give mechanical stress or this stress plus corrosion attack. Vibration set up by turbulent gas flow characteristics over tubes.	When accessible and with insurance or State approval, the cracks can be ground out and welded, otherwise splice in section or replace tube. Locate & eliminate source of expansion difficulty by inspection or hot to cold expansion measurements. Using tube spacers can stop vibration.
External metal loss. Highly polished area	Erosion	Mechanical abrasion from soot blower action.	Where accessible and with insurance or State approval pad weld or splice in a tube section. Eliminate channeling of steam from soot blowers or use tube shields
External metal loss. Oxidized fire scale area.	Overheating	Prolonged or repeated overheating.	Extent of metal loss will determine extent of tube or tube section replacement. Inspection or a thermocouple installation will determine cause of overheating

11 Water Quality Recommendations

Feedwater

Parameter	Unit
pH at 25 Deg C	8.0 to 9.5
Total Iron as Fe	< 0.05 ppm
Total Copper as Cu	< 0.03 ppm
Dissolved Oxygen	0.007 ppm
Carbon Di Oxide	-
Residual Hydrazine	0.02 ppm
Residual Phosphate / Permanganate	-
Chlorides / Sulphates / Total Organic Carbon	Nil
Oil & organics	Nil

Parameter	Unit
Total suspended solids	Nil
Total Dissolved solids	0.1 ppm
Total Hardness	Commercial Zero
Conductivity at 25 deg C after cationic column	0.2 msiemens/cm
Total Silica	0.06 ppm

Drum Water

Parameter	Unit
pH at 25 deg C	10.8 min - 11.2 max
Total Dissolved solids	< 200 ppm
Silica as SiO2	5.5 ppm
Total Alkalinity as CaCO3	40 ppm
Residual Phosphate as PO4	20 – 40 ppm
Sodium Sulphite as SO3	18 – 30 ppm
Oil & Grease / Cu / Fe	Nil
Free Chlorine / suspended Solids	Nil

Steam

Parameter	Unit
TDS	<0.1 ppm
Silica	< 0.02 ppm max

Note

The drum water quality should be continuously monitored and suitable adjustment in blowdown to be made to maintain the drum water as per above recommendations.

Note

2. Steam Quality is based on Feed water quality.

Section — D

Topics Covered in this Chapter

1 Section Overview

This section describes the various maintenance practices, overhauling, and preservation techniques. Also discussed are failures and repair techniques

2 Recommended Maintenance Practices

Systematic maintenance is essential to keep the boiler and its auxiliaries in good condition and to obtain reliable operation of the boiler with high availability and plant load factor. Effective maintenance aims at timely inspection of parts to repair or replace defective components and to prevent their failure when the boiler is in service.

Maintenance can be classified as -

- **Preventive maintenance** – mostly condition based
- **Annual Boiler overhauls** to clean and inspect pressure parts. The shutdown period of the overhaul is also utilized to attend to systems and parts which cannot be attended during short shutdowns or when the boiler is in operation

The vendor manuals of the fans, motors, control valves with their positioners and actuators, instruments and controls, power cylinders etc., prescribe certain minimum maintenance requirements which are to be carried out in one of the above two maintenance categories.

2.1 Preventive Maintenance

The objective of the preventive maintenance program is to obtain trouble free service from the component till the next maintenance.

Vendor manuals for various equipments suggest inspection periods, checks to be done and recommended spares. The true objective of the maintenance program can only be realized, if a master plan of maintenance of all the components is prepared as per vendor instructions.

Full benefits of maintenance can be obtained only if proper parts are used. Mandatory spare part list covers most of the spares required. It may be found that in the first two years of operation due to variations of site conditions, some additional spares not included are also required. Action has to be initiated to procure such spares.

Some equipment have 100% reserve standby units. (Feedwater pumps etc.). Maintenance of such equipments can be organized even when the boiler is in service, although some minimum risk is involved. Equipment such as igniters, scanners have replacement spares which can be utilized when the working equipment are to be maintained without affecting the boiler operation. The prepared master plan for maintenance should be periodically reviewed during the first three years of the boiler operation.

It may be found that due to varying site conditions, the frequencies and quantum of work scheduled as per vendor manuals are either too much or too less. Based on site experience, the frequencies and work schedules can be modified. A scientific method of preparation of the preventive maintenance schedules is to make them condition based. In condition based maintenance, the equipment and components of the plant are inspected daily, weekly monthly etc., as per a suggested schedule by the local operators and deteriorating conditions if any observed are reported. Suggested inspection program is given in this section. Based on operator reports of such inspection, maintenance works are planned for the next available planned shut down. Mandatory inspections prescribed by the vendors are also taken care of, irrespective of the equipment condition.

2.2 Schedule of Inspections for Condition Based Maintenance

The schedule of daily, weekly and monthly inspections given in the following pages do not require a boiler shutdown and in fact can only be done when the boiler is in service. Three and six monthly inspections are done utilizing an available planned shutdown approximately in the the specified time period.

Objective of these inspections is to ensure that

- The components are in trouble free condition
- To carry out any minor repairs or adjustments which can be done with the boiler in service
- To plan for repair of such items, which cannot be attended when the boiler is in service, during the next available shutdown
- To collect a database to determine optimum service life of the systems and components before maintenance is required

The schedule can be expanded, curtailed or modified based on experience in the first two years of operation.

Daily Checks

To be done once a day by the local operator during his walkdown checks. Such walkdown checks are to be encouraged to be done in each shift by the operators. Only those operational checks that require maintenance work for correction have been included.

EQUIPMENT	CHECK	WORK TO BE DONE
1. Local level gauge on steam drum	• Check illumination is proper. • Leaking valve glands. • Leaking ports. • Blurred level.	• Replace fused bulbs • Isolate level gauges and tighten leaking glands • Replace leaking ports • Steam wash mica as suggested by vendor (Not to be done too frequently)
2. Comparison of levels indicated by local level gauge with that of remote level indicators in the control room	Compare the levels after verifying there are no leaks from valves, glands etc., of the level gauge and indicators. Report discrepancies.	If there are serious discrepancies, calibration of the remote level indicators has to be planned immediately.
3. Traces of water on boiler cladding etc.	Such spots are indicative of valve leaks, Instrument tapping leaks, boiler tube leaks etc., Trace the source of leak.	Maintenance to be planned to eliminate the source either immediately or during next planned shut down (depending on the source and quantity of leak and accessibility for maintenance)
4. Fans & drive motors.	• Check bearing temperatures • Check for vibration levels.	If higher than normal bearing temperatures are noticed check for cause-proper oil level / oil circulation, correct grade and quality of oil, abnormal sound or vibration. If bearing temperatures are very high, start the reserve equipment (if avl.) and plan for a maintenance check.

EQUIPMENT	CHECK	WORK TO BE DONE
5. Drum safety valves.	Check for passing of safety valves (noise or wisp of steam through silencer)	• Hand pop the affected safety valve one or two times to clear any dirt sticking to the valve seats. • Lightly tap on the stem of the safety valves. • If these measures do not succeed, request for check of the safety valve during next planned shutdown.
6. Purity of Instrument air	• Check by visual observation that the instrument air is oil and moisture free • If there is a feel by visual inspection, Oil and moisture content can also be checked by laboratory examination as per standards	• Oil and moisture in the instrument air is likely to clog the positioners of pneumatic controllers / solenoids and make their operation sluggish or unreliable. • Open drain valves of air-receivers for short time to drain condensate if any. • If these measures are not successful, inform the Maintenance Group
7. Scanner cooling fan suction-damper linkages and power cylinders.	Check for their proper operation	Sluggish operation of fan suction damper may be due to stuck linkage, stuck damper, faulty power cylinder, and faulty positioners. Check for possible cause. Maintenance works have to be planned.
8. Steam or water leakages from valves and from flange joints	• Loose valve gland • Loosened bolts of flange joint and / or failed gasket	• Tighten the gland nuts. If the leakage not getting arrested, plan for maintenance during shut down. • Tighten the bolts. If the gasket failed then plan for the maintenance during shut down.
9. Boiler cladding, air duct or flue gas duct	Check for hot spots	Hot spots may be due to leakage of flue gas or hot air. Source of leakage has to be located after selective removal of insulation (to be planned for the next planned shut down)

Monthly Checks

EQUIPMENT	CHECK	WORK TO BE DONE
1. Fans and blowers.	With a vibration analyzer record vibration and measure bearing temperature. Also note the operating condition of the equipment at the time of the above observations and record them.	By monthly recording of data, establish a database for deciding the overhaul time of the equipment. An overhaul once in two or three years may be adequate. Such a database will help in deciding the time frame. Sharp increase in vibration levels bearing temperatures or sound levels may call for early scheduling of overhauls

Checks Every Six Months

During a planned shut down of the boiler, the following checks can be done.

EQUIPMENT	CHECK	WORK TO BE DONE
1. Boiler Pre-interlock, purge interlocks, start permissive, boiler trip protection.	Coinciding with a planned shut down of boiler, carry out the checks to identify malfunctioning or sluggish pressure, temperature switches, solenoid operated valves, positioners, proximity switches, actuators etc.,	Plan for maintenance or re-calibration of defective items if any noticed, during the shut down period.
2. Burner refractory work.	Visual check that there are no loose bricks, spalling or cracks	If any abnormalities are seen repair works to be planned during next available shut down
3. UV Scanner components	Clean UV Scanner cell and check its output as per vendor manual. Check its amplifier and flame relay	Replace scanner cells if output is suspect. Adjust amplifier flame relay if required.

Checks Every Year

(Refer also work listed under Boiler overhaul)

EQUIPMENT	CHECK	WORK TO BE DONE
1. Pressure temperature, Flow level, differential pressure controllers	Utilizing the boiler annual shut down for overhaul, recalibrate all pressure, temperature, flow, level and d/p controllers as per vendor manuals	Carry out any maintenance replacement or adjustment needed to secure initial calibration values as per commissioning records
2. Pressure gauges, temperature gauges, Pressure/temperature Switches	Recalibrate, Verify functioning of pressure/temperature switches as per design	Repairs or adjustments as necessary
3. Positioners, actuators	Verify functioning of positioners and actuators by feeding current inputs to positioners and measuring the air pressure output of the positioners and opening closing of actuators	Repairs or adjustments as necessary as per vendor manuals to obtain performance as per commissioning records. Verify functioning of proximity switches where provided. Clean filters of air regulators. Check functioning of air regulators. Verify tightness of air connections

2.3 Boiler Annual Maintenance and Overhaul

In addition to the check and inspections listed under preventive maintenance, the boiler requires an annual shut down of about 10 to 15 days for cleaning, inspection ad overhaul of boiler pressure parts. The shut down period is restricted to a minimum by deploying adequate resources. If required, Field Engineering department of TBW can assist the customer in carrying out the boiler overhaul.

The annual shutdown is utilized for cleaning and inspection of the pressure parts and to collect data on the wear pattern of boiler, superheater and economizer pressure parts. The shutdown opportunity is also utilized for overhaul of safety valves, regulating and isolating valves and components, which can not be attended when the boiler is in service. (The valve overhauls need not be done every year).

Annual Overhaul

Planning Before Overhaul

- Prepare a list of jobs to be done during the overhaul based on earlier inspection reports and the jobs listed below.
- Ensure availability of spares required for the proposed jobs.
- Ensure tools, tackles, scaffolding materials required for the job.
- Ensure availability of manpower required for the job (Own sources, contract labor etc.) Services of TBW are also available for carrying out annual overhauls and inspections.

Shutdown and Cooling the Boiler

Shutdown the boiler in a planned manner. Cool the boiler. Open all access and inspection doors. Refer to the Section B of this volume for the shutdown procedures.

Inspection after Cooling

Carry out a preliminary inspection after cooling to check cleanliness and any sign of deposition on water wall panels and the need for water wash.

Drums Inspection

- Open the access doors at either end of the drums
- Allow the drum to ventilate for about 8 hours. If necessary two fan coolers can be fitted over temporary stands to force air through the drum
- From the time the drum manholes are opened till they are closed after inspection, the area around the drum must be cordoned to restrict entry only to specifically authorized personnel
- The names of persons who are entering the drum for inspection, along with tools they carry must be entered in a register. Persons coming out of the drum after inspection should be asked to account for the material they carried into the drum. This precaution is to prevent accidental dropping of foreign material through the water wall tubes, which may block water circulation through them and can cause tube failures
- Carry out a preliminary inspection of the drum to check for any deposits on the waterside of the drum
- Using nylon brushes, the deposits (which are normally soft) are cleaned, collected on trays and disposed off outside the drum. Washing down the deposits to the boiler tubes is not recommended
- In case of excessive deposits, the chemist is asked to analyze the nature of the deposits. A review of phosphate concentrations and boiler water quality control, (high conductivity) may be made to reduce the deposits in the next year of operation.
- After cleaning the following examinations are made
  - Examine the boiler drum metal for scale, pitting, corrosion and metal wastage. (Drum thickness is measured at a few selected spots using ultrasonic instruments and compared to design thickness)
  - Inspect fastenings of the baffles and demisters to see that they are intact, without corrosion pitting or holes. Eroded or corroded drum internals to be attended. No welding however is permitted on the drum metal. The demisters can be examined in position. They need not to be dismantled. Reasonable water tightness of the baffles is to be ensured
  - Examine that feedwater pipe is intact with flange connections tight and discharge exit correctly oriented
  - Examine that the continuous blowdown and dosing pipes are not plugged or corroded, their supports are normal, and their holes have been correctly oriented

After the inspection, clean the manhole seats and provide new gaskets. After the inspection and verifying that all men and material have been removed from the drum, close the manholes and bolt them tight.

Inspections in the Furnace

Check the water wall tube panels in the furnace for

- Evidence of pitting / erosion / corrosion on tube outer surfaces (exposed to the flue gas path)
- Evidence of overheating (bulging of tubes, blue color of tubes, blisters, disturbed vertical alignment of panels)
- On suspicion of any abnormalities consult TBW or a metallurgist for advice.
- Check the duct burner & accessories as per vendor manual & its setting.
- Any loose material inside the furnace needs to be cleared.
- The scaffolding inside the furnace should be removed after such inspection (if any) and manhole door to be closed tightly after ensuring that the refractory blocks is placed in the manhole.

Safety Valves, Start UP Vent Valves and Other Isolating Valves

These valves require regular overhauls, normally once in three years even if condition reports do not indicate any abnormality. Earlier overhauls can be scheduled if condition reports warrant. Overhauls of the valves can be staggered after the first two years of operation in a manner that certain number of valves are overhauled every year. Overhauls of the valves are as per their vendor manuals enclosed.

Expansion Joints

Examine the expansion joints. Eroded / corroded parts can be patched by welding. When severe erosion is noticed (after several years of service) the expansion joints are to be replaced. Collapse or stretching of the expansion joints is usually due to forces exerted by the connecting ducts. Readjustment of duct supports will solve the problem and will assist the expansion joints to regain their original dimensions.

Insulation and Cladding

Verify insulation as per drawings and correct wherever necessary. Inspect cladding for damages due pitting, hotspots, dislocation etc. Repaired as necessary.

Other Equipment

Overhaul of seal air fans, control valves, actuators etc., is scheduled as per vendor instructions and condition monitoring described under preventive maintenance

Light UP of the Boiler After Maintenance and Overhaul

The pressure-raising rate during the first light up after the overhaul should be slower than usual giving time for check of equipment and components. Valve flange joints and glands must be checked for absence of leaks and can be re-tightened where necessary when the boiler pressure is less than 5 Kg/cm2. Burner performance has to be verified and its axial position corrected if required. If overhauled, performance of the safety valves must be verified by floating them. The boiler expansions must be verified during pressure raising. A boiler overhaul is considered successful if it enables another twelve months of trouble free boiler operation.

2.4 Tube Thickness Survey

To make a quantitative assessment of wastage of tubes (both internal and external) a tube thickness survey using ultrasonic tube thickness gauges is recommended. For a useful tube thickness survey program measurement location on water wall, super heaters and economizers' tubes must be specified and indicated on a drawing. Vulnerable locations are usually chosen. On request, the Field Engineering Department of TBW can establish such a program. The following are the suggested areas for a tube thickness survey -

- Boiler bank, economizer coils, deaerator panel tubes & MUWH..

Tube thickness measurements at the selected locations are made and recorded after water washing and drying, during the first annual overhaul. The base value is the design thickness of the tubes. Subsequent measurements are made at the same locations, every alternate year. The tube thickness survey provides useful data on corrosion / erosion rates and can alert the owner when serious loss of thickness is noticed.

3 Welding Procedure Specifications (WPS)

The pressure part of the boiler is made of several types of steel of varying thickness. Welding is the basic technique used in the fabrication of the boiler. The joints produced by welding should have strength not less than that of the parent metal. In the weld joint, the parent metals should fuse together, without cracks, blowholes, slag inclusions or defects of any kind. The weld joint apart from proving its mechanical strength in tension must also be able to resist bending without cracking. Such requirements can only be met if the welding process used is strictly controlled.

ASME (and other organizations) classify materials into categories (P1 P2, P3, ... P9) as per carbon content and alloying metals (chromium, Nickel, Molybdenum etc.) and specify the procedure to be used for welding materials of the same category or one category with another category. A specification of the materials and shapes adopted by TBW can be obtained on request. The welding procedure distinguishes between welding of thin and thick material. The welding process specification defines the following for each category of welding.

- Edge preparation (angle, shape)
- Joint preparation (cleaning, gap) and tagging
- Joint pre-inspection before welding
- Pre-heat of the weld joint, if any required (method of pre-heating, temperature method of checking temperature)
- Root weld (gas welding, TIG or Arc, size of electrode, type of electrode)
- Radiographic inspection of root weld if required
- Subsequent runs of welding (TIG, Arc or other methods, size of electrode, type of electrode, number of runs)
- Post weld heat treatment if any required (temperature, rate of increase of temperature, method of increasing temperature, holding time, rate of cooling)
- Radio graphic examination of the weld joint, indicating defects if any to be corrected
- Correction of weld defects
- Final acceptance of the weld joint

The WPS indicates compatible categories of materials that can be welded. The WPS also lays down the type of electrode to be used for each category of welding. As the electrode deposits materials, the composition of the electrode must be compatible with the material welded and add strength. The coating of the electrode also must meet specific requirements.

The WPS must be used not only during fabrication of the boiler, but also when any repair or maintenance works are to be done. TBW has WPS to cover every welding job connected with fabrication of the boiler in the factory and erection of the boiler at site, conforming to IBR requirements. The Field Engineering Department of TBW will be glad to provide a WPS for any site repair weld jobs required for maintenance.

4 Boiler Preservation Procedure

Introduction

Both the gas and waterside of a boiler should be protected against corrosion during out of service periods. It is known that many of the corrosion problems of boiler and auxiliary equipment have their inception during storage. Rusting of tube surfaces, as indicated by the formation of the red hematite (Fe_2O_3), not only cause a roughened tube surface but also results in attack of parent metal.

The advantages of efficient feedwater and boiler water treatment during operation may be lost if the same diligence is not applied to protect heat. Transfer surfaces during idle periods. Protection from corrosion during storage becomes vitally important considering the number of times during the life of a boiler when it and its auxiliary equipment are idle.

To minimize the possibility of corrosion, boiler to be placed into storage must be carefully prepared for the idle period and closely watched during the outage. There are two methods available for storing the unit dry storage and wet storage. Although the wet storage procedures is preferred such factors as availability of good quality water, ambient weather conditions, length of storage period, auxiliary supply of heat, etc may dictate that the dry storage procedure is more practical.

4.1 Definitions of Water Quality

Some cleaning procedures, hydrostatic testing and storage require water of higher quality than others. For the purpose of economy and convenience the lowest water quality consistent with requirements is specified in these various procedures. The terms that identify the different water qualities along with their definitions are list below: Station service water - Water normally used for drinking, fire protection, etc.

Softened water - Filtered, sodium zeolite softened water with total hardness less than 1 ppm.

Two- bed demineralised water - Water then has been passed through cation and anion ion exchanges in series.

Mixed bed demineralised water - Water that has been passed through a mixed bed demineraliser. Water from an evaporator is considered to be of equal quality.

Treated demineralised water - Mixed bed demineralised water that has 200 ppm of hydrazine and enough ammonia added to give final concentration of 10 ppm (or a pH of 10.0). In this procedure, condensate is considered to be treated demineralised water.

4.2 Dry Storage Preservation

When it is known that a boiler is to be idle for a considerable length of time and that a brief period will be allowed for preparation to return it to service, the dry storage method is recommended. In this method the unit is emptied, thoroughly cleaned internally and externally dried, and then closed up tight to exclude both moisture and air. Trays of lime, silica gel, or other moisture absorbent may be placed in the drums to draw off the moisture in the air trapped by the closing up of the boiler.

The following general procedure is recommended when placing a unit into dry storage:

1. Fire the boiler according to the normal start-up procedure and establish upto 3.5-kg/cm2G-drum pressure. Stop firing. Secure the boiler and when the pressure decays to 1.3 kg/cm2G, immediately drain the boiler and headers under air. As soon as possible, open the drums to allow air to circulate for drying of all internal surfaces. This step is included for a unit that has been in service and is to be placed into storage. For a unit that has never been in service, start with Step 2.

2. If the unit is full of water and cold, drain the unit under air. All non-drainable boiler tubes should be blown with compressed air. If an external source of heat is available such as a steam coil air heater, portable heaters, etc., operate these heaters to assist in drying the internal boiler surfaces.

   Install trays (of non-porous construction and capable of passing through the drum manhole) containing the moisture absorbent (silica gel is preferred) into the drums. Insert the trays into the drum being certain that none of the absorbent comes into contact with the metal surface of the drum. To insure against an overflow of corrosive liquid after the moisture has been absorbed, the trays should not be more than ½ full of dry absorbent. The amount of absorbent can vary but the recommended minimum is one Kg of absorbent per 1000 Kg per hour steam flow capacity of the unit.

3. Open the isolation valve for nitrogen connection, on the steam drum, close all other vents and drains and pressurize the boiler to 0.3 to 0.6 kg/cm2G with nitrogen. The amount of nitrogen required will vary according to the volume of the unit.

4. With the boiler pressurized, alternately open all boiler drains to purge air from the unit until pressure decays to zero. It may be necessary to repeat this process several times to reduce the amount of oxygen left in the unit to a minimum.

   The unit should now be stored under 0.3 to 0.6-kg/cm2G nitrogen pressure maintained at the steam drum. To maintain the nitrogen pressure, all connections and valves should be blanked or tightly closed. Check gas pressure daily to ensure protection. We would recommend that periodic inspection of the unit be performed every 3 months to assure that no corrosive action is taking place and to replenish the absorbent as required. Since air will enter the unit during this inspection, it will be necessary to repeat Steps 3 & 4 to expel the air.

CAUTION

The unit should be properly tagged and the appropriate warning signs attached noting that the boiler is stored under nitrogen pressure and that complete exhaustion of the nitrogen must occur before anyone enters the drum. Before entering drums test to prove that the oxygen concentration is at least 19.5 %. The above procedure is intended to include the economizer.

4.3 Wet Storage

The advantage of employing the wet storage procedure is that the unit is stored completely wet with the recommended levels of chemicals to eliminate a wet-dry interface where possible corrosion can occur. It is suggested that volatile chemicals be used to avoid increasing the level of dissolved solids in the water to be used for storage.

In preparing a unit for wet storage, the following procedure is recommended.

The unit should be filled with deaerated, Demineralised water treated with 200 ppm hydrazine ($N2H4$) for oxygen removal and sufficient ammonia ($NH3$) in order to attain a pH of 10 (for demineralised water, this will require approximately 10 ppm ammonia).

We strongly recommend pre-mixing of the chemicals with the water to insure a uniform mixture entering the boiler. This can be accomplished by the blend-fill method. The blend-fill method consists of blending the chemicals with the demineralised water at a continuous rate such that a uniform mixture is entering the boiler. Simply introducing the chemicals through the drum after establishing water level will not insure adequate dispersion of chemicals to all internal surfaces, unless sufficient heat is delivered to the furnace (i.e. firing the boiler) to induce natural circulation throughout the boiler.

Fill the unit with the treated demineralised water to the normal centerline of the steam drum. Stop filling further.

Back-fill the with treated Demineralised water until a rise in steam drum level is noted. Continue filling until water exits from the steam drum vents. After filling, all connections should be blanked or tightly closed.

A source of low-pressure nitrogen should be connected at the steam drum to maintain 0.3 to 0.6 Bar G to prevent air from entering the unit during the storage period.

CAUTION

The unit should be properly tagged and the appropriate warning signs attached noting that the boiler is stored under nitrogen pressure and that complete exhaustion of the nitrogen must occur before anyone enters the drum.
Before entering drums test to prove that the oxygen concentration is at least 19.5%.

If storage continues into winter, ambient temperatures below the freezing point of water create a real hazard to the boiler pressure parts and it will be necessary to provide a means of keeping the unit warm to avoid damage.

At some later date when the unit is to be placed into service, the boiler can be drained to normal start-up water level and placed into operation.

In some cases, an expansion tank or surge tank (such as a 55-gallon drum) above the steam drum elevation may be required to accommodate volume changes due to temperature changes. This tank is equipped with a tight cover and sight glass and contains properly treated water. The tank should be connected to an available opening, such as a vent line at the top of the steam drum in order to create a hydrostatic head. This tank will provide a ready, visual check of water level or in leakage during lay up.

A source of low-pressure nitrogen should be connected to the surge tank to maintain 0.3 to 0.6 Bar G to prevent air from entering the unit during the storage period.

The treated demineralised water should be analyzed weekly, and when necessary, sufficient chemicals should be added through the chemical feed line, to establish the proper levels recommended. Samples of the treated water can be taken at the continuous blowdown line or any suitable drain connection.

No unit should be stored wet when there is any possibility of a temperature drop to the freezing point unless sufficient heat can be provided to the unit to eliminate the danger of water freezing and subsequent damage to pressure parts.

4.4 Nitrogen Blanket

Nitrogen can be introduced at the following locations

1. Through the steam drum
2. Through the main steam line

The nitrogen required to seal the drainable components may be supplied from a permanent nitrogen system or portable tanks located near the vent elevations. Due to differences in plant layout, the owner should choose his own method of piping the nitrogen, either from their permanent system or from portable tanks, to the vent (or drain) locations listed.

CAUTION

The unit should be properly tagged and the appropriate warning signs attached noting that the boiler is stored under nitrogen pressure and that complete exhaustion of the nitrogen must occur before anyone enters the drum.
Before entering drums test to prove that the oxygen concentration is at least 19.5 %

4.5 Boiler Lay UP Procedures

TYPE OF SHUTDOWN	PROCEDURE
SHORT OUTAGES 4 DAYS OR LESS. UNIT NOT DRAINED	Maintain the same hydrazine and ammonia concentration as present during normal operation. Establish 0.3 to 0.6 kg/cm2G nitrogen cap on the steam drum
SHORT OUTAGES 4 DAYS OR LESS. UNIT IS DRAINED	Drain and open only those sections require repair. Isolate remainder of the unit under 0.3 to 0.6 BarG nitrogen pressure where possible. Maintain the same nitrogen and ammonia concentration for water remaining in the cycle
LONG OUTAGES LONGER THAN 4 DAYS UPTO 15 DAYS. UNIT IS DRAINED	Fill the boiler with Polish water having 200 ppm of hydrazine and 10 ppm of ammonia to maintain pH 10. Establish nitrogen cap of 0.3 to 0.6 kg/cm2G over the steam drum.
LONG OUTAGES MORE THAN 15 DAYS - UNIT IS DRAINED.	Dry storage of boiler with nitrogen alone is preferred procedure. Nitrogen cap of 0.3 to 0.6 kg/cm2G to be maintained on the steam drum. Installed silica gel tray in the steam drum to soak moisture if any present in the drum atmosphere.

4.6 Preservation of Rotating Equipments

1. Put the rotating equipment in service once in every 48 hours or atleast once in a week
2. If the equipment is going to be under long shutdown
   a. Fill bearing block full of oil to preserve the bearing and rotate the Fan/Pump Shaft by 90o once in every 48 hours
   b. Cover the bearing block & uncovered portion of shaft with plastic sheets to prevent dust/water ingress
   c. Ensure no dust/water accumulates on the rotating equipment

4.7 Preservation of Instruments

1. Cover all field instruments with plastic sheets
2. Power up the panel instruments and check the operation
3. Keep the control room dust and moisture free
4. Operate control valves, power cylinders once a week and check operation.
5. Operate quick shutoff valves frequently (Twice a week)
6. Ensure that O2 analyzer is powered up and reference air supply is given when flue gas is present.
7. Check operation of Ignition Transformer once in 2 weeks
8. Check operation of Flame Scanners & Flame Amplifiers once in 2 weeks

5 Tube Failures

Operating a boiler with a known tube leak is not recommended. Steam or water escaping from a small leak can cut other tubes by impingement and set up a chain reaction of tube failures. Large leaks can be dangerous. The boiler water may be lost, the ignition may be lost, and the boiler casing may be damaged.

Small leaks can some times be detected by the loss of water in the cycle or system, a loss in boiler water chemicals or by the noise made by the leak. If a leak is suspected the boiler should be shut down as soon as possible by following normal shut down procedures (If situation permits).

After the exact locations of the leak or leaks are identified, the leaks may be repaired by replacing the failed tube or by splicing in a new section of tube as per relevant codes.

CAUTION

An investigation of tube failure is very important so that the condition causing the tube failure can be eliminated and future failures can be prevented. This investigation should include a careful visual inspection of the failed tube and in some cases a laboratory analysis.

1. It is recommended that every effort be made to find the cause of tube failures before operation is resumed.
2. It should be ensured that, whenever a spool piece is inserted in the failed zone, the weld joint needs to be of proper weld quality.
3. Free from excess weld penetration to avoid any obstruction in the water / steam mixture flow inside the tube. Excess weld penetration can cause internal tube erosion and results in tube failures.
4. It is suggested to have all the joints are x-rayed and interpreted by qualified / experienced radiographer.

5.1 Tube Failure Investigation / Analysis Method

Investigation / analysis methodology is listed as follows, which needs to be followed to find the actual root cause of the problems.

PLEASE FILLUP THE ENCLOSED (end of this sub-section) OBSERVATION FORM AND THE SAME MAY BE SENT TO TBW ALONG WITH TUBE SAMPLE FOR ANALYSIS.

Objectives of Failure Investigation

Boiler tube failures are the largest cause of forced outages experienced by a utility. To avoid or minimize outages and the associated economic penalties, it is important to identify the mechanism and root cause of tube failures. Informed visual inspection is often adequate for this purpose, however failure analysis involving detailed metallurgical investigation is necessary. Tube failures may be due to overheating, corrosion, erosion, fatigue, hydrogen damage etc. A failure investigation and subsequent analysis should determine the primary cause of a failure, and based on determination, corrective action should be initiated that will prevent similar failures.

Stages of Failure Analysis

Although the sequence is subject to variation, depending upon the nature of a specific failure, the principal stages that comprise the investigation & analysis of a failure are:

- Collection of background & selection of samples
- Preliminary examination of the failed part (visual examination & record keeping)
- Non destructive testing
- Mechanical testing (including hardness & toughness testing)
- Selection, identification, preservation, and/or cleaning of all specimens
- Macroscopic examination and analysis (fracture surfaces, secondary cracks, & other surface phenomena)
- Microscopic examination and analysis
- Selection & preparation of metallographic sections
- Examination and analysis of metallographic sections

Collection of Background Operating DATA:

Boiler operating data just before & at the time of a tube failure is very important, as it will give information of the service conditions faced by the tube at the time of failure. This operating data should also be co-related with the past operation data & abnormalities if any should be taken care off. Water chemistry analysis, fuel analysis should also form an important part of this data. This data

& the metallurgical analysis will help us in true sense to arrive at the exact cause of a tube failure.

Investigation of Tube Failure in a Boiler

Study the boiler log sheet & water chemistry record prior to tube failure and after tube failure. Preserve the copies of these log sheets. Record, if any abnormality noticed, such as mal operation, malfunction, very high or low temperature/loads, fluctuating loads, sudden increase in load or temperature, poor water chemistry, start up vent crack open / close etc. etc. (if possible collect and send the water samples, internal scale from drum & tubes, external scale samples).

After entering in boiler and before proceeding to tube failure location inspect & record the condition of boiler and pressure parts without disturbing the evidence i.e. distortion of pressure parts/coils, bulging of pressure parts, scaling / lump formation on pressure parts, blockage of flue gas path, other / secondary failures etc. etc. In such case taking photographs will help in great extent in analyzing of the tube failure, boiler problem. The failed pressure part tube should not be hammered, any mechanical impact should be avoided.

Inspect the failed tube and record all findings on the same as well as its adjacent tubes. Carry out dimensional measurement of failed tube and affected adjacent tubes.

Number mark the failed tube for its location, flue gas flow, steam flow with oil paint. After completion of inspection, recording and photography, cut the failed tube and affected adjacent tube, if any, with the help of HACKSAW only. Gas cutting of the tubes should be avoided as much as possible. The failed tube, keeping the failed portion in middle should be cut for total length of minimum 350 mm. Immediately after cutting the tube sample both the ends should be covered with plastic caps. While doing this, internal or external scale of tube should not fall down.

The failed tube samples should be carefully packed in plastic bag / wooden case accompanying duly filled format with water chemistry of boiler log sheets should be sent to TBW, Pune.

Removal of Failed Tube Sample

- The tube sample should be cut with a hacksaw blade. Gas cutting should be avoided
- The sample should be cut approx. 8-10 inches above & below the affected area
- The exact location & elevation should be marked on the tube sample
- The direction of the fluid flow should be marked on the tube sample
- Immediately after cutting the tube sample both the ends should be covered with plastic caps. Internal or external scale of tube should not fall down

The failed tube sample nicely packed in plastic bag / wooden case accompanying duly filled format as given below with water chemistry of boiler log sheets should be sent to TBW H.O for metallurgical investigations.

Tube Failure Analysis Observation Sheet

SR.NO: DATE:

NAME OF THE CUSTOMER	
BOILER SPECIFICATIONS	
CAPACITY	
STEAM PRESSURE	
STEAM TEMPERATURE	
FUEL FIRED	
LOCATION OF TUBE SAMPLE	
DURATION OF SERVICE OF BOILER	
DURATION OF SERVICE OF TUBE SAMPLE	
DATE OF FAILURE	
SAMPLE RECEIVED ON	
NO. OF SAMPLES HANDED OVER TO LAB ON (With identification Mark/No) Nos. / Date	
VISUAL INSPECTION REPORT	

NAME OF THE CUSTOMER	
WITH SKETCH / NATURE OF FAILURE	
TUBE MATERIAL (Specified)	
TUBE OD x THK (Specified)	
ORIENTATION OF TUBE	
FLUID FLOW DIRECTION	
(With marking)	
BOILER OPERATING CONDITION	
AT THE TIME OF FAILURE (Water	
Chemistry & boiler operation log sheets)	

ANY OTHER RELEVANT INFORMATION ABOUT THE

5.2 Window Patch Welding

Purpose

The purpose of the window patching method is to allow the welding of tubes that could not otherwise be welded because of limited access to part of the tube diameter. This procedure is restricted to that use.

Preparation

1. The area to be patched shall be cleaned to bare metal
2. The patch shall be made from tube material of same type, diameter and thickness, as the tube being welded
3. The area of the tube to be removed shall be carefully marked out as close as possible to contour of the patch. The tube section may then be removed using an oxyacetylene gas cutting torch or by mechanical means
4. The weld preparation shall be made as per the Figure #1. The fit up of the patch weld gap shall be 2.4 0.8 mm

Welding

1. A welder qualified to the requirements of ASME shall make the tube and patch welds in accordance with an approved weld procedure.
2. The root pass shall be done with GTAW process. The weld may then be completed with either SMAW or GTAW process. Some acceptable weld procedure specifications are listed in Table below

Testing

1. All the tube and patch welding shall be subject to close visual inspection and 100% radiography in accordance with the requirements of ASME section V. The standard for accepting /rejecting is specified in ASME section I
2. Completed welds are subject to hydrostatic test

Base Material		Filler Metal	
P1 TO P1	CARBON STEEL TO CARBON STEEL	ER 70S.2	E7018
P3 TO P3	CARBON ½ MOLY TO CARBON ½ MOLY	ER80S.B2	E7018A1
P3 TO P3	½ Cr ½ MOLY TO ½ Cr ½ MOLY	ER80S.B2	E8018B2L
P4 TO P4	1-1/4 Cr TO 1-1/4 Cr	ER80S.B2	E8018B2L
P5 TO P5	2-1/4 Cr 1 MOLY TO 2-1/4 Cr 1 MOLY	ER90S.B3	E9018B3L
P8 TO P8	STAINLESS TO STAINLESS	ER308	ER308-16

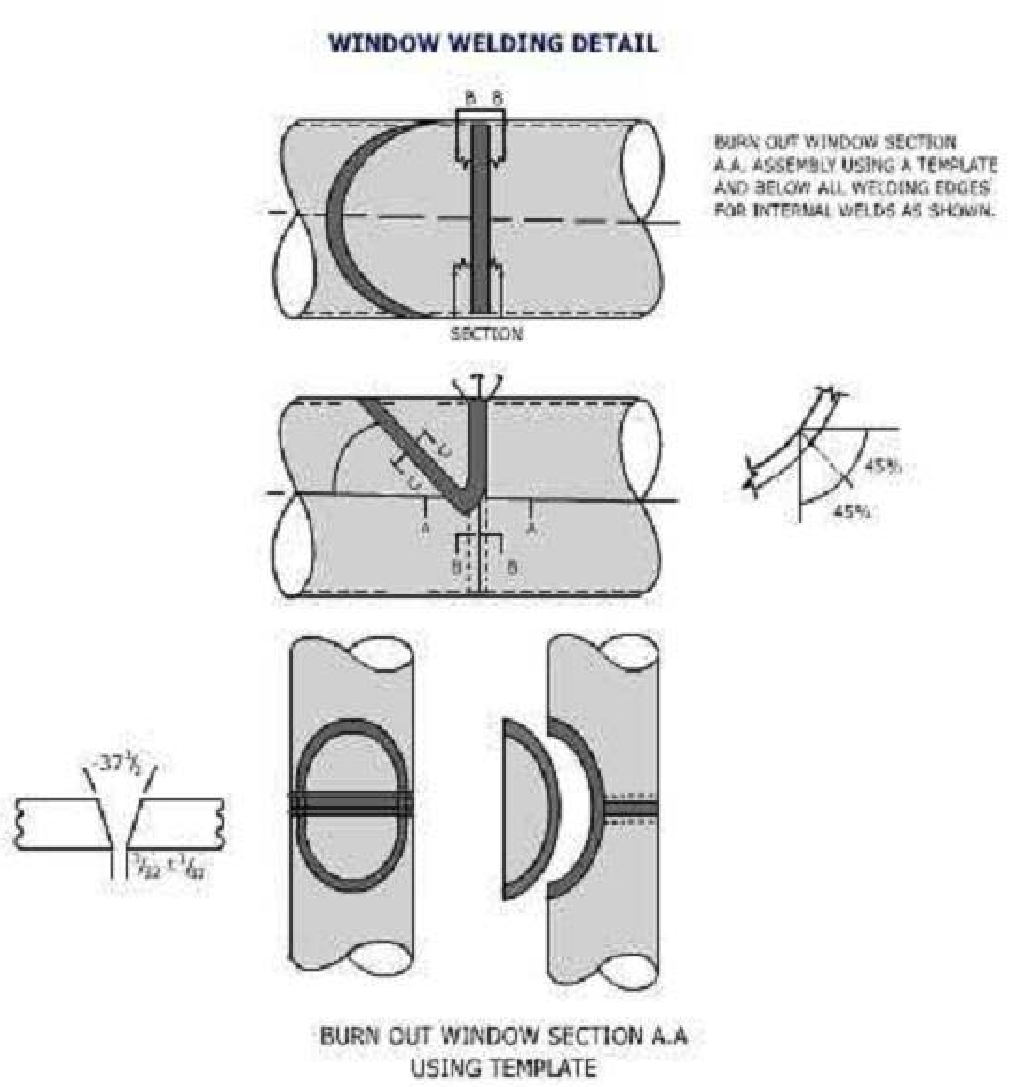

WINDOW WELDING DETAIL
B B
BURN OUT WINDOW SECTION
A.A. ASSEMBLY USING A TEMPLATE
AND BELOW ALL WELDING EDGES
FOR INTERNAL WELDS AS SHOWN.
SECTION
A A
B B
45%
45%
BURN OUT WINDOW SECTION A.A
USING TEMPLATE

Figure 4

6 General Principal of Weld Repairs

Furnace and Boiler Tubes

- The minimum replacement tube length should be not less than 150 mm. A damaged tube should be cut at least 75 mm each side of the defective area.
- Backing rings must not to be used in welding heat absorbing tubes carrying water or mixture of steam and water.
- If a backing ring is not used, the first pass of the weld must be made with inert gas-arc or oxy acetylene. The weld passes may be completed by either process, or by a manual metal arc.
- Pre heat or post heat is not required for welding carbon steel furnace or boiler tubes.
- Prior to welding, clean the tube ends to bright metal inside and outside for at least 40 mm from the weld area. Remove all deposits of oxide, boiler water salts and slag to avoid gas or slag inclusions in the weld.
- Fit-up of the weld joints is important. It is difficult to obtain accurate cuts on furnace tubes especially those in welded furnace walls. However, it is worth to spend extra time to get the existing tube ends squared and correctly chamfered and to cut the replacement tube to the correct length. Poor fit-up increase the possibility of an unsuccessful weld.
- Allow for shrink in the welding, remember, the weld metal and parent metal are melted in the welding process and the molten metal shrinks as it solidifies. A butt weld in the tube will shorten the total tube length about 1.6 mm.
- Use a clamp or guide lug to hold one end of the replacement tube alignment while the first weld is made. Do not tack weld both end of the replacement tubes particularly if the existing tubes are rigidly supported
- As a general rule, first complete the welds at the lower end of the replacement tube. Do not start welding the upper end of the replacement tube until both the replacement and the existing tubes have cooled to ambient temperature.

Weld Repair of Small Cracks in Tube

In the interest of saving time and cost, it is better to weld small cracks rather than replace a length of the tube. The crack must be ground out to form an acceptable welding groove. The groove should continue well beyond the ends of the crack. Inert gas arc or oxy acetylene process must make the first pass of the weld.

Note

This type of the repairs entails some risk. Internal deposits. Particularly copper, may exist under the crack which will result in damaging the parent and/or weld metal causing failure in a short period of time.

Over-heating the tube may have caused the longitudinal crack. In this case, the tube has swollen and the weld thickness reduced. In the modern welded wall construction, it is difficult to accurately measure the tube diameter or circumference to detect the minor swelling. If visual indicates swelling and reduction of wall thickness at the crack, a complete replacement of the damaged tube length is the best solution.

A circumferential crack indicates a failure due to excessive stress applied by expansion restriction, bending or fatigue; welding can repair such cracks. However, unless the cause of failure is diagnosed and corrected, another similar failure could occur at or near the original crack.

Also the tube cannot be cleaned from inside and there is always a possibility internal deposits will contaminate the weld.

Plugging Tubes in Drums & Headers

Often after a tube failure, it is desirable to plug the failed tube in the drum or header shell so the boiler may be returned to service with the least possible delay. It is recommended that the failed tube be replaced whenever possible in lieu of plugging. If the leak is remote from the tube seats and accessible, the faulty section of the tube should be cut out and replaced rather than plugging.

Water wall tubes (space tube) should be replaced if possible and plugged only as a last resort. The plugged tube must be free to expand and distort with respect to the adjacent tubes. Membrane tubes must be repaired and not plugged.

When tubes are plugged, the old tube should be removed from the boiler setting since it probably will burn off due to lack of cooling and could become displaced and obstruct gas lanes, foul up soot blowers, be dangerous to personnel after shutdown, and etc. If the tube is not removed from the setting, a definite hole must be punched or drilled in the tube to prevent a possible dangerous buildup of pressure between the tube plugs.

A expanded tube leaking at the seat should be removed from its seat and

1. a new tube rolled in,
2. a new short stub rolled in and plugged,
3. the tube end seal welded to the shell or, if the drum shell is internally counter bored, a cylindrical plug must be installed and seal welded to the drum shell.

Note

No. (1) is the preferred fix with No. (3) the least preferred.

Seal welding of tube ends, tapered plugs, or cylindrical plugs to the shell should be done in such a manner as to minimize the heating of adjacent tube seats, which may become loose. It is essential that the welding process should be as per standard procedure for carbon steel shells and tubes to be followed very closely to ensure success. Deviations from these parameters will normally result in unsatisfactory connections. The major welding parameters for shells or tubes other than carbon steel may be obtained from qualified welding procedures.

Ensure that welders are qualified in accordance with ASME Section IX and local provincial requirements. They must also ensure that the welding is done to the applicable qualified weld procedure.

It also to be ensured that the proposed repair has been approved by the Boiler Inspection Branch of the local jurisdiction.

Machined tube stubs and plugs are used where the old tube can be removed from its seat without seat damage and for new construction that is drilled for future addition of tubes. The rolled-in tube stub extends into the shell and a solid plug is installed and seal welded to the stub. These stubs and plugs are standardized to have only one tube stub and one plug for each standard tube hole.

Before rolling stubs in, they should be cleaned inside and outside with a wire brush, abrasive paper, or a liquid cleaner until the metal is free of all foreign substances. In general, stubs do not require cleaning beyond the removal of dirt, rust, scale or foreign material.

The stub seat (tube hole) should be similarly cleaned. If a liquid solvent is used to clean either the stub and/or tube hole, care must be taken to dry the metal completely. Liquid trapped between the stub and its seat prevents contact of the two metal surfaces.

Before the expanding tool is inserted, the inside of the stub should be lubricated with a suitable compound. The compound selected should be water soluble to facilitate cleanup. The rolling process should not be rushed since heat generated during rolling is detrimental to the strength of the rolled joint. The tube stub is properly expanded when the wall thickness in the seat is reduced by 6 to 10 percent for generating tubes and 10 to 14 percent for other boiler tubes. The tube stub wall reduction for thin shells should be less than that for thicker shells. This is to prevent over rolling which could cause adjacent tube seats to leak. Since the stub wall itself cannot be measured after it is rolled in its seat, the only alternative is to calculate the increase in the stub ID that is necessary to prove that the wall has in fact been reduced by the required percentage. This depends upon the tube seat ID (hole diameter), tube stub OD, the clearance between these two and also the stub wall. An example of this conversion for a 2 ½" OD by 0.150-inch wall tube stub for a 10% wall reduction is as follows

Measure Hold Dia	=	2.531
Measure Stub OD	=	2.500 / 0.031 Clearance
Measure Stub ID	=	2.200
Clearance	=	0.031 / 2,231 Stub ID @ Contact
Stub ID @ Contact	=	2.231
10% of 0.150 x 2	=	0.030 / 2.261 Stub ID after expanding

Plug all internal counter bored holes in the field with the cylindrical plug when the tube is still in the seat. Some counter bores may be shallow enough that the tube ends are exposed sufficiently to permit seal welding to a tapered plug. See Figure 2. If the tube seat is leaking, then the tube must either be seal welded to the drum shell or the counter bore can be plugged with the cylindrical plug and seal welded per Figures 3 and 4. It may be necessary to machine the tube ends back in order to provide a seat for the cylindrical plug installation. See Figures 3 and 4.

Figure 5 shows the details of this cylindrical plug and gives instruction for the specific plug size desired.

Tapered plugs are used to plug existing tubes where it is not practical to remove the tube from its seat and there is no internal counter bore. These plugs must be tailor made for each tube diameter and tube wall thickness. Figure 6 shows the details of this tapered plug and give instructions for a plug to fit tube diameters from 1-3/4" through 4 ½" OD and any wall thickness. Figure 7 shows the arrangement of the tapered plug seal welded to the tube.

The plugs and seal welds described above are designed for the boiler pressure to be on the head (seal weld side) of the plug only. The ¾ inch diameter by 1/8-inch thick button weld on the plug is to eliminate leakage through the “piping” which can occur at the center of some bar stock.

Figure 8 shows a tube seal welded to the shell. This arrangement may be used when the tube seat is leaking and it is not practical to replace or remove the tube and use a rolled stub and plug.

Economizer headers and superheater headers may be plugged as shown in Figure 9 & 10 where external access is available and the conditions shown on the figures are met. If those conditions cannot be satisfied, tube replacement is recommended. In these two figures, the pressure is on the internal end of the plug and the external strength weld restrains the plug.

Plugged tubes that are below the horizontal centerline of the shell will not drain. Therefore, after chemical cleaning it is necessary that the plug to be removed and the stub swabbed out to remove the chemicals in these stubs. The plug can then be welded back in or in some cases it will have been destroyed in the removal process and anew one will have to be installed. Care must be taken in the plug removal process to not damage or thin the tube stubs wall.

Replacement of Sections of Tubes

Experienced personnel must do the replacement of a section of failed tube. The length of the replaced section should be a minimum of 12 inches. Usual practice is to cut out the defective section with an oxyacetylene torch, but it is preferable to use a saw or wafer disc. Care must be taken to prevent slag from entering the tube. The ends are prepared for welding by grinding or with special tools.

The root pass of the joint should be deposited with the gas tungsten arc process. A 3/32-inch diameter shielded metal arc-welding electrode is recommended for the remainder of the joint. The welding parameters for tubes may be obtained from qualified Welding Procedures.

Removing Tubes from Drums, Headers & Tube Plates

The removal of tubes from their tube seats must be done very carefully to prevent damage to the tube seats. If the tube seat is damaged, it may be impossible to ever roll another tube in and make a tight seal. Gouging of the tube seat could also affect the ligaments between tube holes and integrity of the shell. Tubes can be removed from their seats without seat damage if the following procedures are carefully followed.

With light- gage tubes, it is often possible to cold crimp the tube end to loosen it in its seat, then drive or "jack" the tube out. When the tubes are too heavy for cold crimping, the two-stage heating method may be used. Heat is applied to the inside of the tube end with a torch. Heat is first applied for a short period - not long enough for it to be transferred to the tube sheet.

When the tube end cools, the joint will have loosened enough so that the second heat will not be transferred readily to the tube sheet. The tube end can then be heated sufficiently for crimping and the tube can be pushed out of its seat. If neither of these methods is applicable, the following methods may be employed.

To remove light tube tubs, it is advisable to cut grooves about 3/4 inch apart with a round nose chisel. When the tongue (the metal between the two grooves) is knocked free, the tube can be collapsed and removed.

To remove heavy gage tubes, the type of grooving tool shown in figure 12 is used to prepare the tongues without damage to the tube seat. It is used with a pneumatic hammer, but it is necessary that the tool be suited to the tube thickness so that it will cut the grooves as deep as possible and yet leave a minimum thickness of metal over the tube seat. In very heavy gage tubes, a third groove is often cut, as nearly opposite the tongue as possible, so that less heavy pounding will be required to collapse the stub. These latter two methods require that the flare on the end of the tube be crimped straight before starting, to cut the grooves for collapsing the tube. Of course, the seal weld around the end of any tube must be ground or machined off before attempting to cut the grooves for collapsing the tube. This must be done carefully to prevent damage to the drum shell.

Attached Figures 2 to 10

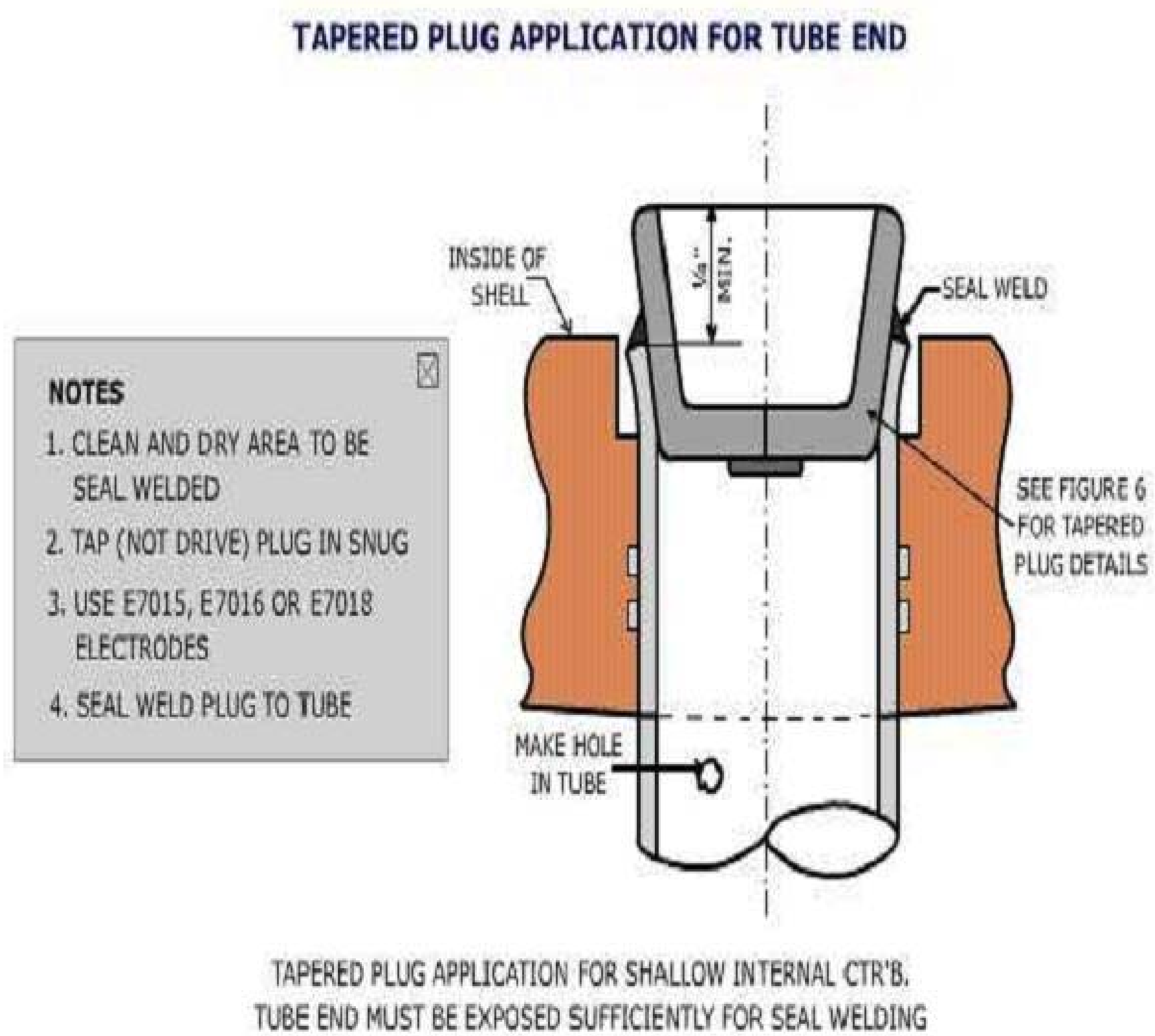


Figure 5

CYLINDRICAL PLUG FOR TUBE END (1¾" to 2½" OD).

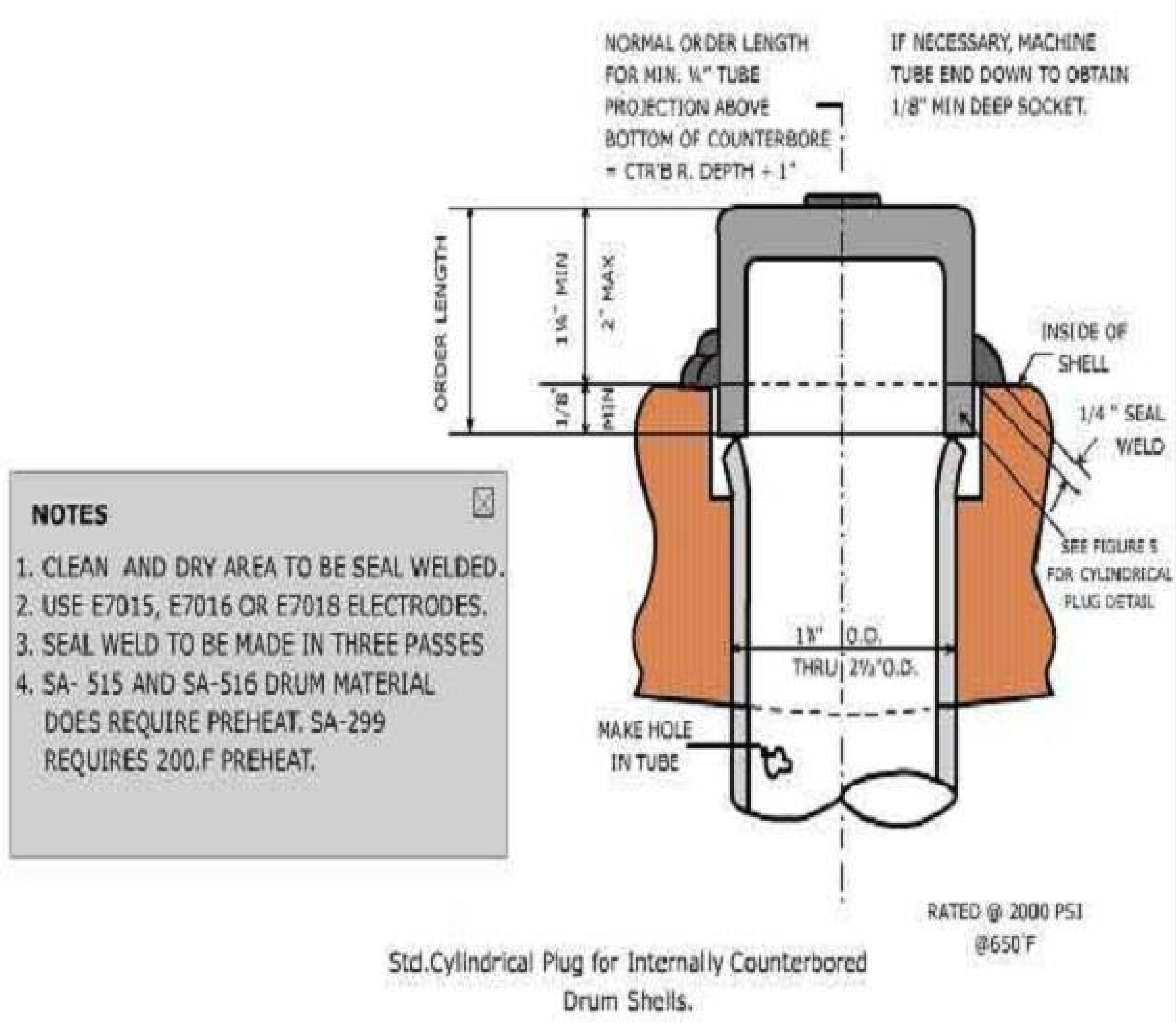


Figure 6

CYLINDRICAL PLUG FOR TUBE END (2¾" OD to 4½")

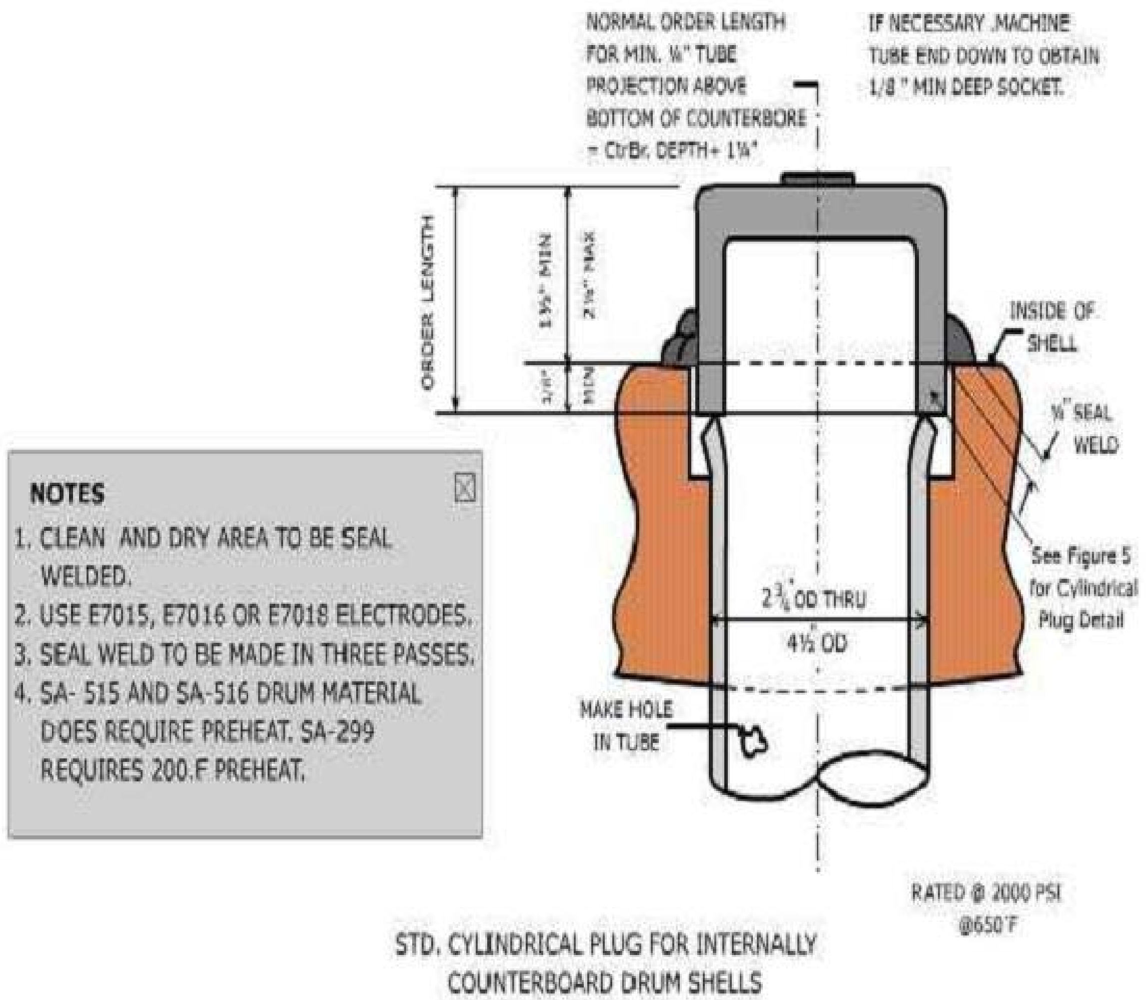


Figure 7

STD. CYLINDRICAL PLUG

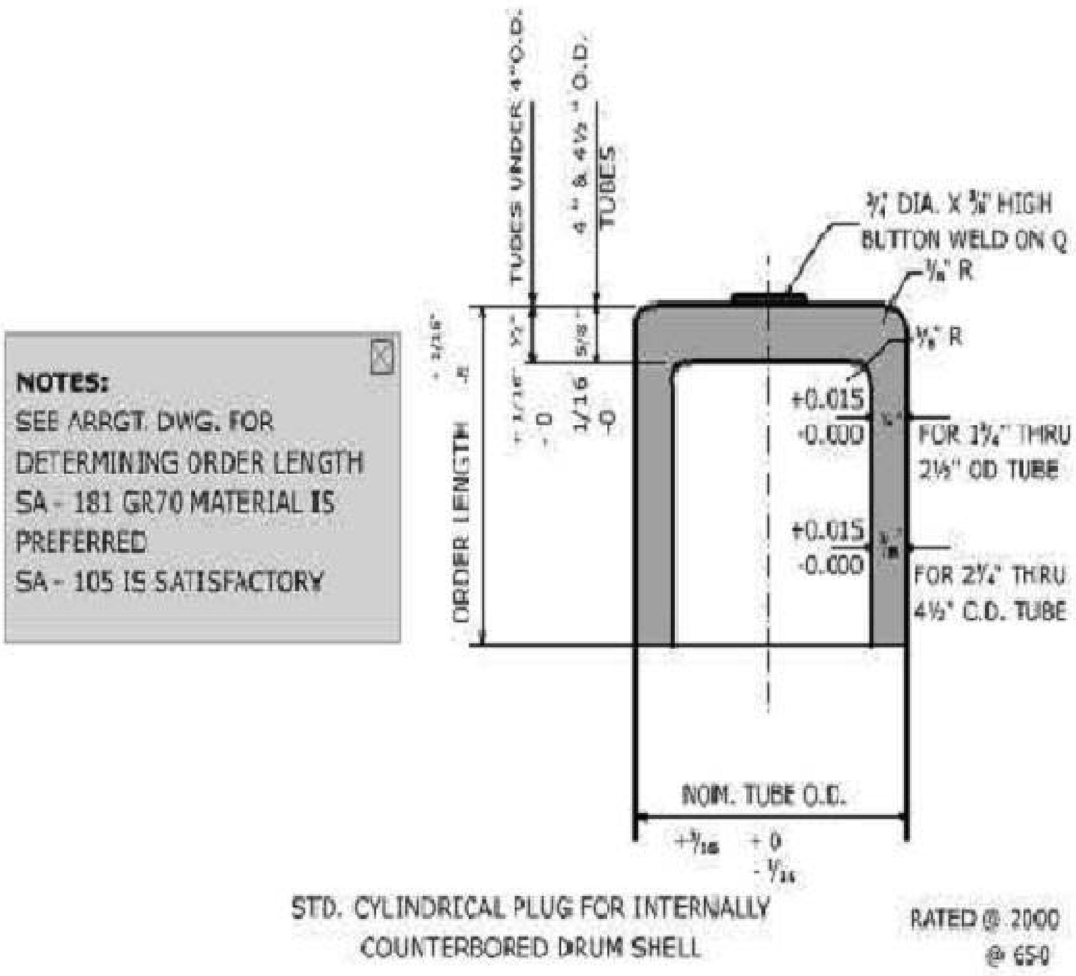


Figure 8

STD TAPER PLUG

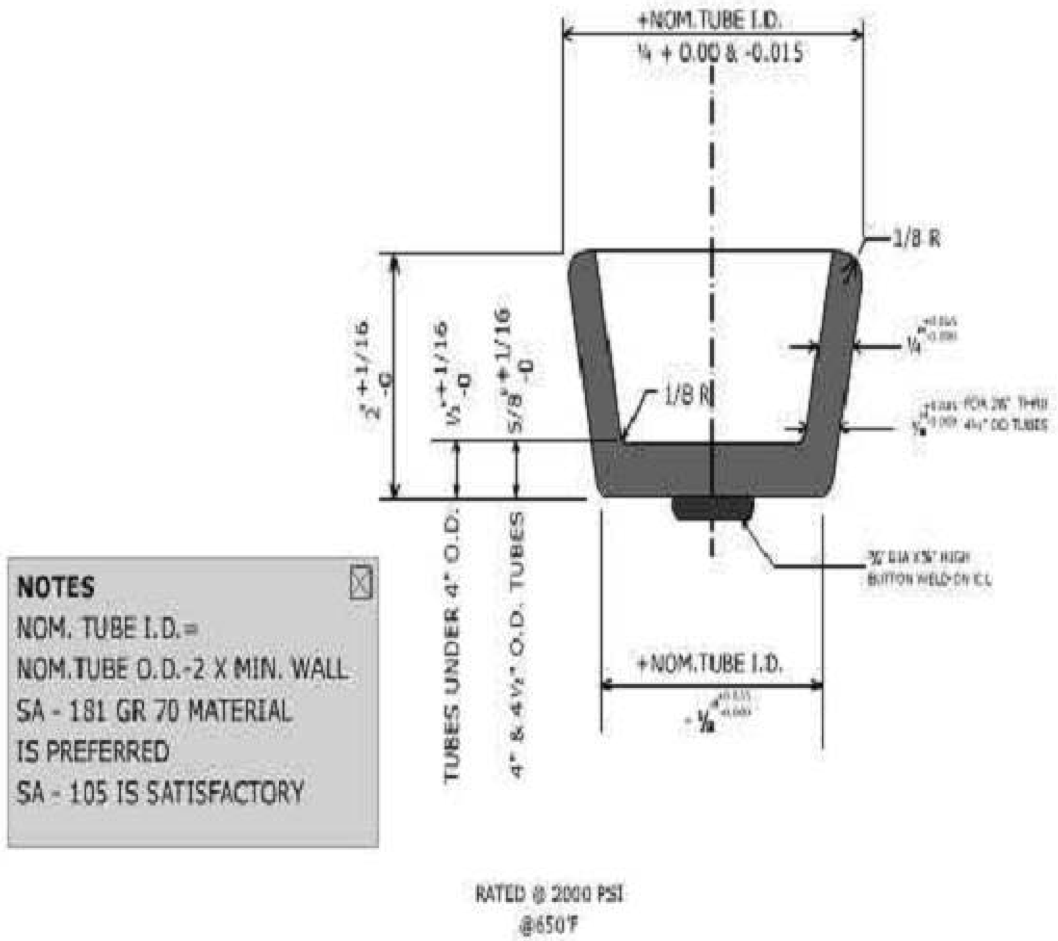
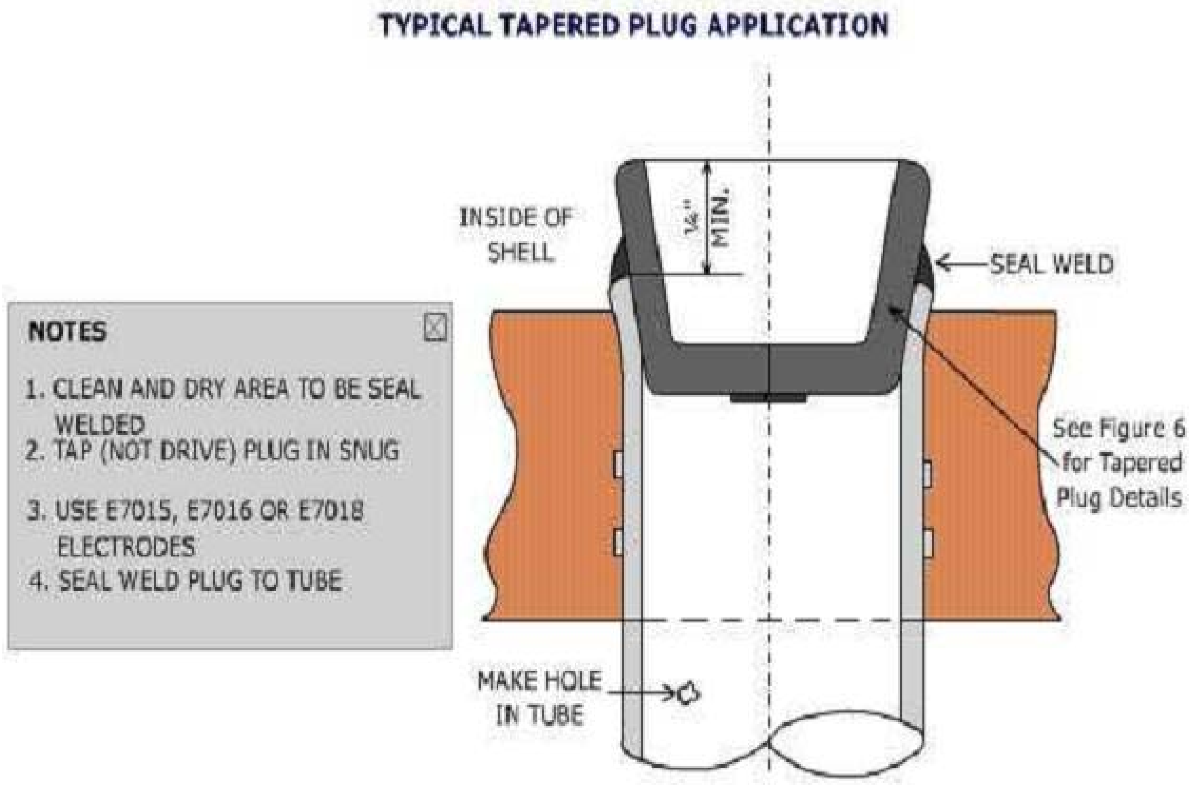


Figure 9



TYPICAL TAPERED PLUG APPLICATION

Figure 10

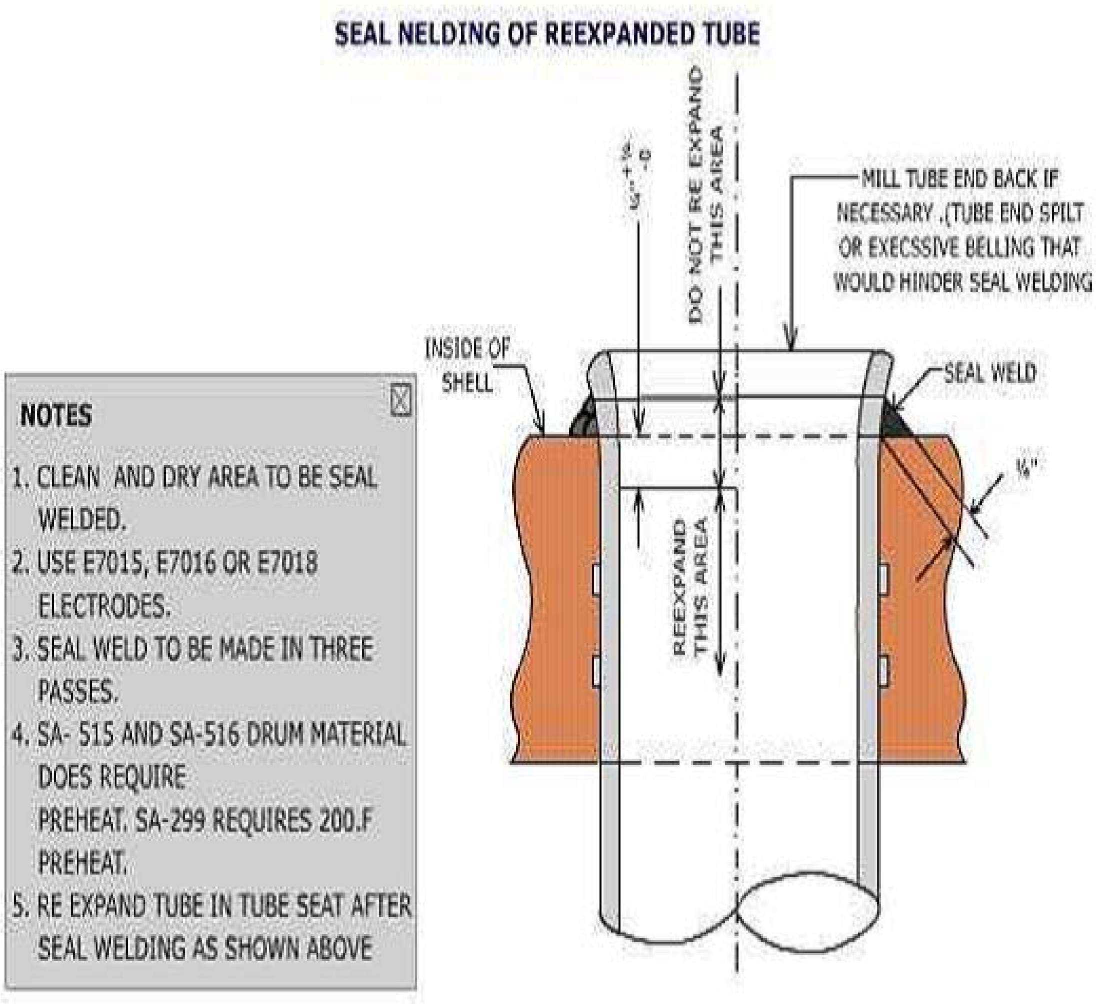

SEAL NELDING OF REEXPANDED TUBE
NOTES
1. CLEAN AND DRY AREA TO BE SEAL WELDED.
2. USE E7015, E7016 OR E7018 ELECTRODES.
3. SEAL WELD TO BE MADE IN THREE PASSES.
4. SA- 515 AND SA-516 DRUM MATERIAL DOES REQUIRE PREHEAT. SA-299 REQUIRES 200.F PREHEAT.
5. RE EXPAND TUBE IN TUBE SEAT AFTER SEAL WELDING AS SHOWN ABOVE
INSIDE OF SHELL
DO NOT RE EXPAND THIS AREA
MILL TUBE END BACK IF NECESSARY .(TUBE END SPILT OR EXECSSIVE BELLING THAT WOULD HINDER SEAL WELDING
SEAL WELD
REEXPAND THIS AREA

Figure 11

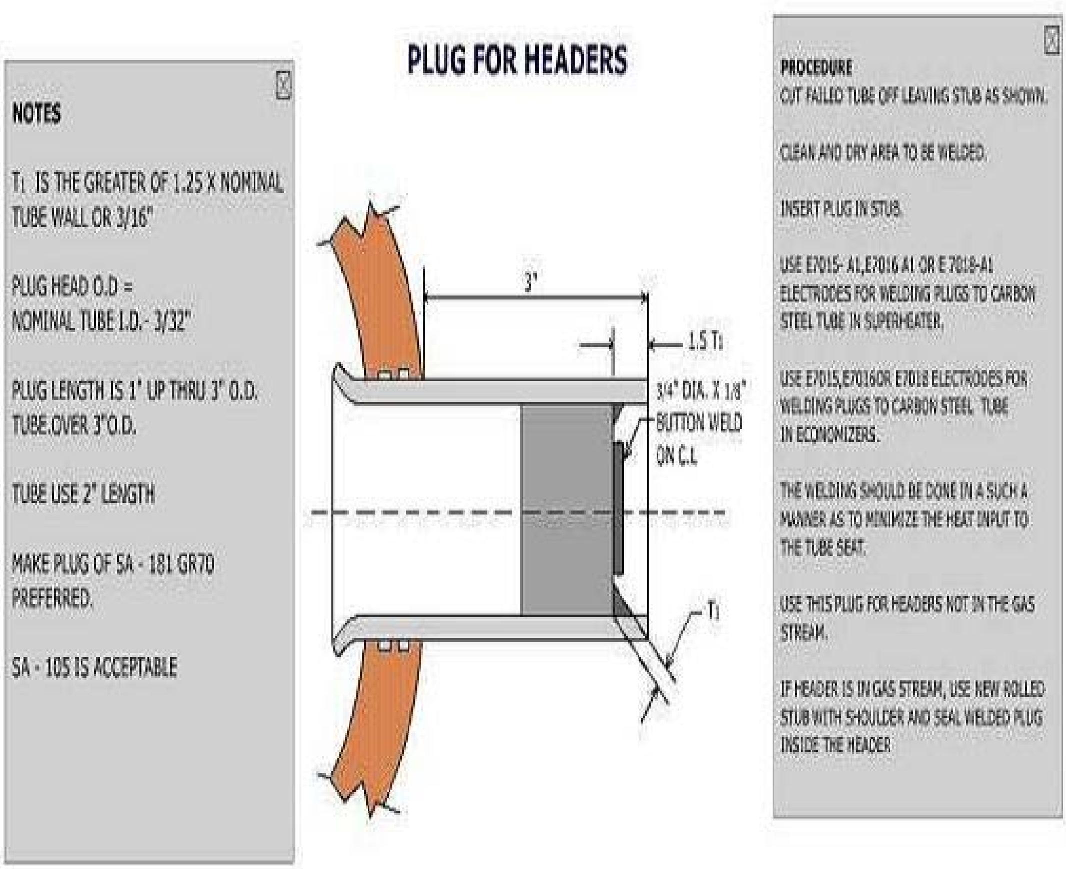

PLUG FOR HEADERS
NOTES
T1 IS THE GREATER OF 1.25 X NOMINAL TUBE WALL OR 3/16"
PLUG HEAD O.D = NOMINAL TUBE I.D.- 3/32"
PLUG LENGTH IS 1" UP THRU 3" O.D. TUBE.OVER 3"O.D.
TUBE USE 2" LENGTH
MAKE PLUG OF SA - 181 GR70 PREFERRED.
SA - 105 IS ACCEPTABLE
3"
1.5 T1
3/4" DIA. X 1/8" BUTTON WELD ON C.L
T1
PROCEDURE
CUT FAILED TUBE OFF LEAVING STUB AS SHOWN.
CLEAN AND DRY AREA TO BE WELDED.
INSERT PLUG IN STUB.
USE E7015- A1,E7016 A1 OR E 7018-A1 ELECTRODES FOR WELDING PLUGS TO CARBON STEEL TUBE IN SUPERHEATER.
USE E7015,E7016OR E7018 ELECTRODES FOR WELDING PLUGS TO CARBON STEEL TUBE IN ECONOMIZERS.
THE WELDING SHOULD BE DONE IN A SUCH A MANNER AS TO MINIMIZE THE HEAT INPUT TO THE TUBE SEAT.
USE THIS PLUG FOR HEADERS NOT IN THE GAS STREAM.
IF HEADER IS IN GAS STREAM, USE NEW ROLLED STUB WITH SHOULDER AND SEAL WELDED PLUG INSIDE THE HEADER

Figure 12

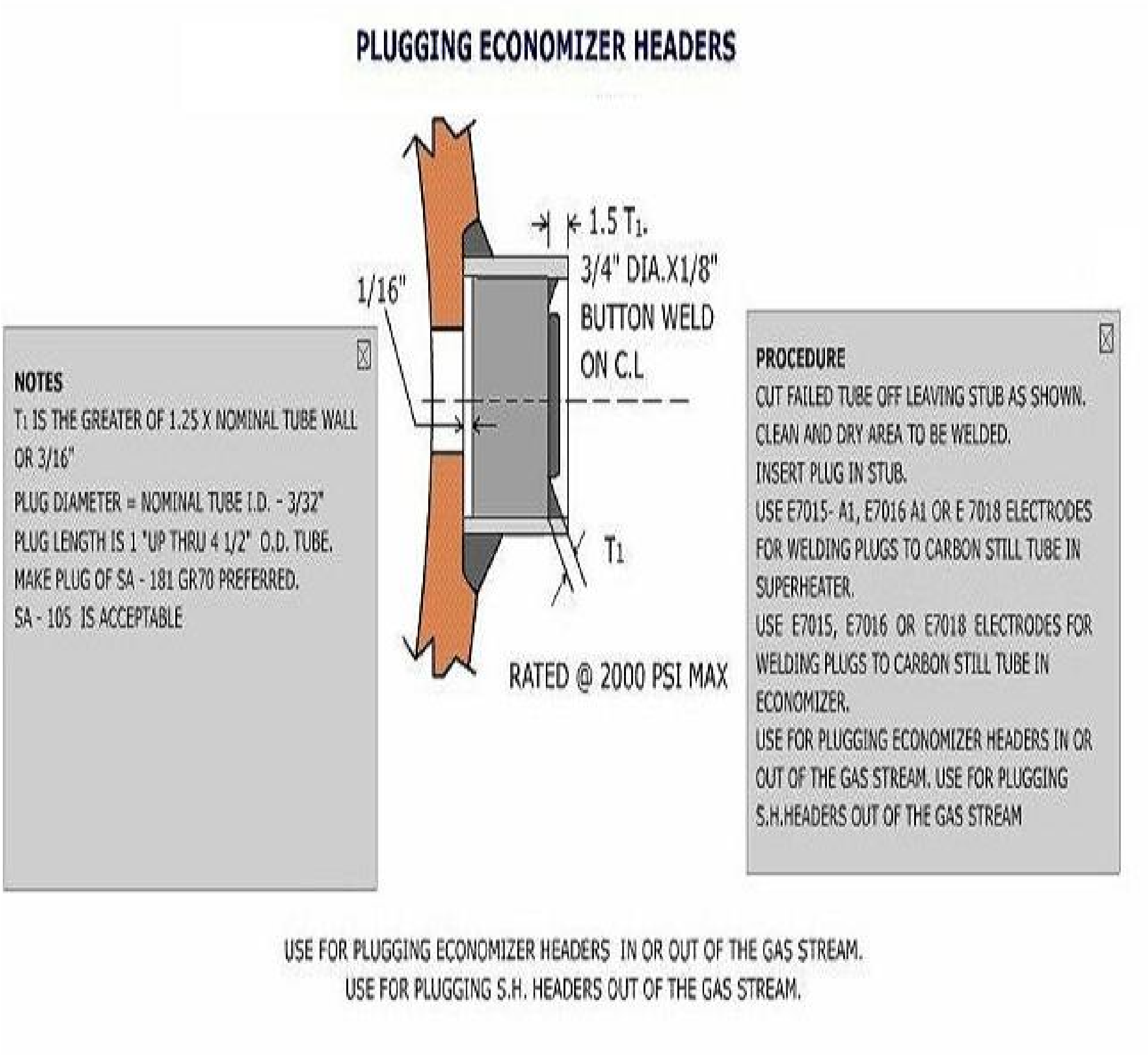

PLUGGING ECONOMIZER HEADERS
1.5 T1.
3/4" DIA.X1/8"
BUTTON WELD
ON C.L
1/16"
T1
RATED @ 2000 PSI MAX
NOTES
T1 IS THE GREATER OF 1.25 X NOMINAL TUBE WALL OR 3/16"
PLUG DIAMETER = NOMINAL TUBE I.D. - 3/32"
PLUG LENGTH IS 1 "UP THRU 4 1/2" O.D. TUBE.
MAKE PLUG OF SA - 181 GR70 PREFERRED.
SA - 105 IS ACCEPTABLE
PROCEDURE
CUT FAILED TUBE OFF LEAVING STUB AS SHOWN.
CLEAN AND DRY AREA TO BE WELDED.
INSERT PLUG IN STUB.
USE E7015- A1, E7016 A1 OR E 7018 ELECTRODES FOR WELDING PLUGS TO CARBON STILL TUBE IN SUPERHEATER.
USE E7015, E7016 OR E7018 ELECTRODES FOR WELDING PLUGS TO CARBON STILL TUBE IN ECONOMIZER.
USE FOR PLUGGING ECONOMIZER HEADERS IN OR OUT OF THE GAS STREAM. USE FOR PLUGGING S.H.HEADERS OUT OF THE GAS STREAM
USE FOR PLUGGING ECONOMIZER HEADERS IN OR OUT OF THE GAS STREAM.
USE FOR PLUGGING S.H. HEADERS OUT OF THE GAS STREAM.

Figure 13

7 Failure Reporting Format

Enclosed is a format for reporting of failure of equipment etc.

The enclosed formats are exclusively for the use by O & M engineers of the client for reporting any malfunctioning or failure of the boiler pressure parts and its auxiliaries. Most of the boilers at site need to be investigated with the help of pas experience and guidance from the O & M. The O & M, in turn, required precise and systematic information on which the failure analysis will have to be based.

TBW request the boiler users to report to TBW any problems that they may come across during routine O & M of the plant, immediately on occurrence.

It is suggested that enclosed formats be used for this purpose and help provide better and quicker services for trouble shooting.

There may be cases when problems arising during the O & M are resolved on temporary or permanent basis by the O & M engineers and there may not be any immediate need for service of TBW or OEM. Even in such cases it is the request of TBW with the enclosed reporting formats be filled in and faxed over to TBW, Pune.

This will go a long way to generate a data bank on the auxiliary equipments and come out with improvement rather for the final users.

Customer Feed Back form

Customer Details:

COMPANY NAME	
COMMUNICATION ADDRESS	
TELEPHONE NUMBER	
FAX NUMBER	
E-MAIL ADDRESS	
CONTACT PERSON	
OTHER DETAILS (IF ANY)	

Boiler Details:

BOILER NUMBER :	
DATE OF COMMISSIONING	
BOILER CAPACITY – MCR	
STEAM PRESSURE	
STEAM TEMPERATURE	
FUEL FIRED	

Feed Back Details:

Equipment Details:

SL.NO	PROBLEM DETAILS	OBSERVATIONS	CORRECTIVE ACTIONS TAKEN	COMMENTS / RECOMMENDATIONS

OTHER INFORMATIONS :

EXPECTATIONS FROM TBW :

REPLY AWAITED / SERVICE ENGINEER VISIT :

SIGNATURE & DATE:

8 Water Chemistry

Introduction

The natural water contains solid, liquid and gaseous impurities and therefore, this cannot be used for the generation of steam in the boilers. The impurities present in the water should be removed before its use for steam generation. The necessity for reducing the corrosive nature and quantity of dissolved and suspended solids in feed water has become increasingly important with the advent of high pressure, critical and supercritical boilers.

The impurities present in the feed water are classified as given below

1. Un dissolved and suspended solid materials.
2. Dissolved salts and minerals.
3. Dissolved gases.
4. Other materials (a soil, acid) either in mixed and unmixed forms.

8.1 Undissolved and Suspended Solid Materials

A) Turbidity and Sediment:

Turbidity in the water is suspended insoluble matter including coarse particles (mud, sediment sand etc,) that settle rapidly. Amounts ranges from almost zero in most ground waters and 60,000 ppm. in muddy and turbulent river water. The turbidity of feed water should not exceed 5 ppm. These materials can be removed by settling coagulation and filtration. Their presence is undesirable because heating or evaporation produces hard stony scale deposits on the heating surface and clog fluid system. Both are objectionable as they cause damage to the boiler system. A standard of measurement of hardness is taken as being the amount of calcium carbonate ($CaCO_3$) in the water and is referred to in part per million (ppm) or grains per gallon (grain/gallon) X 17.1 = ppm.

B) Sodium and Potassium Salts:

These are extremely soluble in water and do not deposit unless highly concentrated. Their presence is troublesome as they are alkaline in nature and accelerate the corrosion.

C) Chlorides:

Majority of the chloride causes increased corrosive action of water.

D) Iron:

Most common soluble iron in water is ferrous bicarbonate. The water containing ferrous bicarbonate deposits becomes yellowish and reddish sediment of ferric hydroxide if exposed to air. Majority of ground surface water contains less than 5 ppm but 0.3 ppm, can create trouble in the feed water system by soft scale formation and accelerating the corrosion.

E) Manganese:

It also occurs in similar form as iron and it is also equally troublesome.

F) Silica:

Most natural water contains silica ranging from 1 to 100 ppm. Its presence is highly objectionable as it forms very hard scale in boilers and forms insoluble deposits on turbine blades. In modern high-pressure boilers its presence is reduced as low as 10-50 ppm.

G) Microbiological Growths:

Various growths occur in surface water (lake and river). The microorganisms include diatons, molds, bacterial slimes, algae; manganese and sulfate reducing bacteria and many others. These can cause coating on heat exchanger and clog the flow passages and reduce the heat transfer rates.

H) Color:

Surface waters from swampy areas become highly colored due to decaying vegetation. Color of feed water is objectionable as it causes foaming in boilers and may interfere by chlorinating of absorption by activated carbon.

8.2 Dissolved Salts and Minerals

A) Calcium And Magnesium Salts:

The calcium and magnesium salts present in the water in the form of carbonates, bicarbonates, sulfates and chlorides. The presence of these salts is recognized by the hardness of the water (hardness of water is tested by soap test). The hardness of water is classified as temporary and permanent hardness. The temporary hardness is caused by the bicarbonates of calcium and magnesium and can be removed by boiling. The boiling converts the soluble bicarbonates into less soluble carbonates, which can be removed by simple blow-down method. The presence of chlorides, sulfates and nitrates of calcium cause the permanent hardness of the water and magnesium and they cannot be removed just by boiling because they form a hard scale on heating surfaces.

8.3 Dissolved Gases

A) Oxygen:

It presents in surface water in dissolved form with variable percentage depending upon the water temperature and other solid contents in water. Its presence is highly objectionable, as it is corrosive to iron, zinc, brass and other metals. It causes corrosion and pitting of water lines, boilers and heat exchangers. Its effect is further accelerated at high temperature.

B) Carbon Dioxide:

The river water contains 50 ppm & well water contains 2-50 ppm of CO_2. It also helps to accelerate the corrosive action of oxygen.

The other gases are H_2S, CH_4, N_2 and many others but their percentage are negligible Therefore their effects are not discussed here.

8.4 Other Materials

A) Free Mineral Acid:

Usually present as sulfuric or hydrochloric acid and causes corrosion. The presence is required by neutralization with alkalis.

B) OIL:

Generally the lubricating oil is carried with steam into the condenser & thorough the feed system to the boiler. It causes sludge, scale & foaming in boilers. Strainers and baffle separators generally remove it.

The effects of all the impurities present in the water are the scale formation on the different parts of the boiler system and corrosion. The scale formation reduces the heat transfer rates and clogs the flow passage and endangers the life of the equipment by increasing the temp above the safe limit. The corrosion phenomenon reduces the life of the plant rapidly. Therefore it is absolutely necessary to reduce the impurities below a safe limit for the proper working of the power plant.

8.5 pH Value of the Water and its Importance

The pH value of the feed water plays very important controlling the corrosion. pH is a number denoting the degree of acidity or alkalinity of a substance. It does not indicate the quantity of acid or alkali in a solution as found by filtration method. It is derived by measuring the amount of hydrogen ion (H+) in grams per liter of solution. The greater the amount of hydrogen ions present in solution its acid reaction becomes stronger. Therefore, pure water is being neutral solution, any solution producing more hydrogen ion than pure water will be acidic and degree is governed by difference and other solution producing less hydrogen ions than pure water will be alkaline and the degree is also governed by the difference.

The Role OF pH IN Corrosion:

The role of pH in corrosion of metals is extremely important. The corrosion rate of iron in the absence of oxygen is proportional to pH up to a value of 9.6. At this point, hydrogen gas formation and dissolving of iron practically stops. This is the came pH produced by a saturated solution of ferrous hydroxide $Fe\ (OH)_2$.

The Oxygen in the water unites with ferrous hydroxide to form ferric hydroxide. This reaction lowers pH of the solution and levels to stimulate corrosion.

Alkalinity adjustment and film formation are closely related. The pH value of feed water should be maintained greater than 9.6 to reduce the corrosion effects caused by the reason mentioned above. The required alkalinity of feed water is adjusted by adding soda ash caustic soda or trisodium phosphate. The calcium hardness, alkalinity and pH are inter-related variables in scale control. Calcium carbonate is one of the most troublesome deposits responsible for scale formation.

8.6 Effects of Impurities

The major troubles caused by the feeding of water of undesirable quality are scale formation, corrosion, foaming, caustic embrittlement, carry-over and priming. The details described below: -

1. Scale Formation

Feed water containing a group of impurities in dissolved and suspended form flows into the Boiler for continuos generation of Steam. With conversion of water into steam in Boiler, solids are left behind to concentrate the remaining water. The scale formation tendency increases with the increase in temperature of feed water. Because, the solubility of some salts (as calcium sulphite) decreases with the increase in feed water temperature. Calcium sulphite has solubility of 3200 ppm. at 15 Deg. C and it reduces to 55 ppm. at 230 Deg. C and 27 ppm. At 320 Deg. C.

Scale formation takes place mainly due to salts of calcium and magnesium. Sometimes, it is cemented into a hard mass by Silica. Among all, calcium is the principal offender and particularly, Calcium sulphate, magnesium sulphate and other Chlorides are sufficiently soluble in water and are not much troublesome. Sodium salts are highly soluble in water and are non-scale forming.

The scale formation takes place mainly in feed water piping and Boiler Tubes. Its first effect on the piping system is to choke the flow of water by reducing the flow area and increases the pressure required to maintain the water delivery. Another effect of scale formation is to reduce the transfer of heat form the hot gases to water. Real dangers of the scale formation exist in radiant heat zone where boiler tubes are directly exposed to the combustion. The scale formation retards the flow of heat and metal temperature increases. Even a thin layer of scale in high heat zone can over-heat the metal enough to rupture the tubes. The metal tubes weakened due to over-heating yield to pressure providing a protrusion known as bag. Such bag provides a pocket for the accumulation of sludge and scale, which eventually causes failure. The over-heating of metal causes layer of metal to separate and form a blister.

2. Corrosion

The corrosion is eating away process of boiler metal. It causes deterioration & failure of the equipment, eventually this cause for major repairs or expensive shut -downs or replacements.

The corrosion of boilers, economizers, feed water heaters & piping is caused by an acid or low PH in addition to the presence of dissolved oxygen & carbon dioxide in the boiler feed water. The presence of oxygen is mostly responsible for corrosion among all other factors. The permissible limit of oxygen content varies with the acidity of water. Generally it should not should exceed 0.5 cc per liter .O2 generally enters into closed system through make up condenser leakage and condensate pump packing.

CO2 is next to O2, which is responsible for corrosion. The CO2 comes out of bicarbonates on heating and combines with water to form weak acids known as carbonic acid. This acid slowly reacts with iron and other metals to form their bicarbonates. The newly formed bicarbonates of metals decompose by heat once more and CO2 is again liberated. This gas again unites with water to form carbonic acid and the cycle is repeated. Adding alkali solution to neutralize acids in water and raise the PH value can minimize the corrosion. The effect of CO2 is minimized by the addition of ammonia or neutralizing the amines in water. This is necessary because CO2 lowers the PH of the boiler feed water and dissolved solids to leave the boiler.

The priming is a violent discharge of water with steam from the boiler. It can be compared to the pumping of water that frequently accompanies rapid heating in a open vessel. In priming the water level in the boiler undergoes rapid and great changes and there are violent discharges of bursting bubbles. Therefore ‘sludge’ of boiler water is thrown over with the steam.

The priming is caused due to improper boiler design, improper method of firing, overloading, sudden load changing or a combination of these factors. The priming effect is reduced by installing steam purifier, lowering water level in the boiler and maintains constant load on boilers.

The foaming is the formation of small and stable bubbles throughout the boiler water. The high percentage of dissolved solids, excessive alkalinity and presence of oil in water are responsible for foaming.

Boiler water solids are also carried over in the moisture mixed with steam even when there is no indication of either priming or foaming. This is known as ‘carry-over’. The carry-over of boiler water solids is partly a mechanical and partly a chemical problem. The amount of suspended solids and alkalinity in the boiler water is also important in addition to other reasons like boiler design, high water level, and overloading and fluctuating loads on boiler.

3. Caustic Embrittlement

The caustic embrittlement is the weakening of boiler Steel as a result of inner crystalline cracks. This is caused by long exposure of boiler steel to combination of stress and highly alkaline water.

The course of embrittlement takes place under following condition:

a) When boiler water contains free hydroxide, alkalinity and some silica. It has been always found that the feed water was high in sodium bicarbonate, which broke down into sodium carbonate in the boiler and partially hydralized as shown by the following reaction in case of embrittlement.

$Na_2CO_3 + HOH = CO_2 + 2\ NaOH$

b) Slow leakage of boiler water through a joint or seam.

c) Boiler metal is highly stressed at the point of leakage. This may be caused by faulty design and expansion etc.

The prevention of caustic embrittlement consists of reducing the causticity or adding inhibiting agents to the feed water. The most practical method of preventing caustic embrittlement is to regulate the chemical composition of the boiler water. The obvious solution to embrittlement is to eliminate all free NaOH from feed water by addition of Phosphates.

9 Feed & Boiler Water Conditioning

1. Introduction

The successful use of boiler is dependent on proper water conditioning and treatment. The quality of water must have accurate for trouble free operation of boiler.

The water as available to industry is not suitable for boiler use. A complete pre-treatment and internal chemical treatment is necessary to make raw water suitable for boiler feed.

The objective of the water treatment is:

- Eliminate scaling - deposition in boiler which cause tube over heating leading to accidents.
- Control corrosion of boiler system, which cause failure of boiler tubes, leading to unscheduled shutdowns.
- Reduce carry over of water with steam, which is the cause of deposition on super heater/turbine blades, leading to the expensive failures.
- To maintain peak boiler efficiency by keeping complete boiler water system clean.

In order to meet above objectives, it is necessary to maintain certain chemical conditions in boiler, condense and feed water systems. A brief review of important factors is given in this section to assist those taking charges of new boiler equipment. It is not possible to cover the subject fully, there fore, it is recommended that the care and control of water quality be entrusted to water treatment specialist.

2. Need for Water Treatment

A. Corrossive Control

Water is corrosive to boiler metal. Typically corrosion due to water will reduce thickness of tube @ 1 mm/year. Thus the life and safety of boiler entirely depends on the rate of corrosion of boiler metal. In order to protect boiler from corrosion, pre-treatment is done to remove excessive corrosion ions like chloride, sulphate etc. However, further chemical conditioning is required to protect boiler and auxiliary systems from corrosion.

Tri sodium phosphate, caustic, ammonia and amines are used as corrosion inhibitors. These chemicals form a protective film over metal surface and reduce corrosion. It is necessary to maintain prescribed concentration of these chemicals in boiler water systems continuously.

B. Oxygen Corrosion Inhibitor:

Oxygen is present in dissolved form in water. At high temperature, oxygen reacts with metal to cause pitting corrosion. Thus prevention of oxygen lead to pin holes in economizer, steam drums and steam tubes.

Most of the oxygen is removed externally by deaerator and preheating of feed water. However, traces of residual oxygen must be removed by chemical conditioning.

Sodium sulfite, hydrazine and amines are recommended for oxygen removal. These chemicals react with residual oxygen making it inactive and protect metal against pitting corrosion. Catalyzed oxygen scavengers are used for quick reaction.

C. Scale / Deposit Control:

Raw water contains dissolved solids, hardness salts and suspended matters.

External treatment is used to remove such impurities.

- Clarification - To remove suspended matters.
- Filtration - To remove residual turbidity
- Softening - To remove hardness salts

Dealkaliser - To remove hardness salts and excessive alkalinity

- Demineralization - To remove residual salts and silica
- Mixed bed - To remove residual salts and silica from DM water.

A combination of above equipments are used to remove undesirable impurities in raw water.

Scale Control

Hardness salts in feed water cause formation in boiler. Under temperature and pressure inside the boiler and due to concentration, hardness salts precipitate in tubes as calcium carbonate, calcium sulphate and Ca/Mg silicate scales.

External treatment like softening, demineralization or de-alkalisation removes most of the hardness salts from boiler feed water. However, malfunctioning of this equipment, occasional bypassing of the softener/DM plant or contamination of condensate or feed water with raw water often led to ingress of hardness in the boiler.

All hardness salt precipitate inside boiler leading to hard scale formation on tubes. Such scale has lower conductivity causing increase in metal temperature, leading to bursting of tubes in extreme conditions.

Therefore, inspire of elaborate external treatment, internal chemical conditioning is always recommended as additional safety. Following chemical methods are used for internal treatment.

Phosphate Conditioning

Trisodium phosphate is commonly used. Hardness salts react with trisodium phosphate to form calcium phosphate precipitate. This precipitate above pH of 9.5 colloidal in nature and therefore do not allow for form hard scale of carbonate and silicates. The precipitated hardness salts are then removed through blow down as sludge and boiler tubes are kept scale free.

Trisodium phosphate, apart from acting as hardness conditioning agent, also is a good corrosion inhibitor. The recommended concentration in boiler water is given in Table -1

Note 1 : TSP will act as hardness conditioner, only when boiler pH is above 9.5 . Below 9.5 pH TSP may cause hard scale formation of Ca3 (PO)2. Therefore, coordinated or congruent phosphate treatment is recommended. The water treatment experts can advise you right treatment after studying your water quality and operation conditions.

Thermax Chemicals can provide services for arriving at right chemical treatment for your boiler.

Chelant- Polymer treatment:

Hardness scales do not precipitate in presence of chelant like NTA/EDTA The chelant treatment is recommended when hardness ingress in boiler is experienced regularly.

⚠ CAUTION

Excessive chelant dosing cause corrosion of boiler
Hence balanced chelant program as recommended by experts should be used.

Organic polymer conditioners are used to prevent hardness scales. Such organic polymer disperse scale forming compounds like CaCO3 & Ca(PO4)2 in colloidal form facilitating their removal through blow down. Polymer and copolymer of acrylic, methacrylic, styrene maleic acrylics are commonly used. Most of the polymers are proprietary in nature and therefore dosage is best recommended by manufacturer.

D. Fouling Control

Suspended matter, oil/grease /oxygen & iron salts commonly cause fouling inside the boiler. Most of the suspended matter and iron salts are removed by external treatment. However due to mfg. of these equipment, contamination through condensate and concentration in boiler cause fouling of boiler tubes.

Similar to hardness scales, such foulants are poor conductor of heat. Thus fouling causes overheating of tubes.

Fouling can best be avoided by maintaining quality of feed water as per norms. In case of upsets or occasional contamination, polymeric disersent help to prevent fouling due to turbidity and organic matter. Iron is picked up mostly in condensate system due to corrosion of condensate line. In such case, condensate corrosion inhibitor like ammonia cyclohexylamine and filming amine is recommended.

E. Turbine / Superheater Deposition Control:

The solids in boiler feed water get concentrated in boiler. The concentration of solids in boiler is decided blowdown and feed water quality. The carryover of boiler water with steam depends on;

Mechanical Factors:

- Boiler load - Higher the load, lower is the steam purity
- Water level in boiler - Higher the water level in drum, lower is steam purity.
- Load Variation - Sudden increase in load reduce steam purity for short time.

- Separation efficiency - Higher efficiency, better is steam purity.

Chemical Factors:

- TDS - Higher TDS in boiler, lower is steam purity.
- Total Alkalinity - Higher alkalinity as % of TDS lower is steam purity
- Organics - Higher the organic contamination, lower is steam purity.
- Foaming - Higher the foaming character of water, Lower is steam purity.

The water carried over with steam due to above reasons is exactly similar in quality to blow-down or boiler water. In superheater or in turbines, water evaporates, leaving dissolved and suspended matter as scales or deposits.

Thus severity of scaling and fouling of superheater and turbine depends on boiler water quality and steam purity.

Maintaining boiler water quality as per norms and maximum steam purity is the only way to prevent deposition due to carryover of water with steam. Antifoam agents help to some extend to improve steam purity in case of excessive in boiler.

F. Silica Deposit Control:

Silica is volatile under high temperature and pressure inside boiler. In turbines, the evaporated silica precipitates during pressure and temperature reduction and form hard scales.

Maximum allowable concentration of silica depends on water analysis. Expert's best decide the maximum permissible concentration after striding the operating parameters.

G. Condensate Corrosion Control:

The carbon dioxide is present in boiler feed water in dissolved and combined from as carbonate. Under boiler pressure and temperature it is liberated and carried over with steam as CO2 gas. This gas re dissolves in steam condensate to form carbonic acid.

$CO_2 + H_2O = H_2CO_3$

H. Maintenance of Peak Efficiency:

Corrosion, scaling, fouling carryover and condensate corrosion can cause unscheduled shutdown, accidents and deterioration of system efficiency.Therefore for trouble free operation and maintenance peak operation efficiency, a combination of various internal chemical treatments is essential along with a good control over boiler water quality.

Maintaining boiler water quality by using commodity chemicals likes TSP, Hydrazine, and Sodium sulfite. However, it is recommended that the care and control of water chemistry be entrusted to specialist.

Section E

This section holds the Lubrication Schedule and Spare Part List for the HCFM Boiler.

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