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For Information

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C	7 Apr. 2023	Revised as per design progress.	K.Hirayama	R.Mimura D. Mimura	K.Yamada
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OWNER

VAN PHONG POWER COMPANY LIMITED

PROJECT

Van Phong 1 BOT Thermal Power Plant Project

OWNER'S ENGINEER

AFRY Switzerland Ltd.

Status
- ☐Approved
- ☐Approved with Comment
- ☐Not Approved
- ☐Reviewed
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EPC CONTRACTORS

IHI-TESSC-CTCI-DHI CONSORTIUM

IHI TOSHIBA CTCI 中鼎工程股份有限公司 CTCI Corporation DOOSAN

PROJECT DOCUMENT No	REV
VP1-C-L1-M-H-00515	C

DOCUMENT TITLE

Operation and Maintenance Manual for Boiler General

EPC	EPC DOCUMENT No.	REV
IHI Corporation	K096-001	B

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配布先	数
Owner	1
CSPJ 統括部	1
CS 基設	1
CS 運技	1
CS 燃部	1
CS 制電部	1
CS 主機	1
CS 鉄配部	2
CS 機器部	1
CS 品管部	1
ｴﾈ調達(豊)	1
CS 建計工	1
CS 建ｴﾝｼﾞ	1
相生技部	1
相工計画	
ｴﾈ調達(相)	
相工技	
相工務	
相品管部	
CS 予算	
CS 海営	
控	
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SCALE ———

1ST ANGLE PROJECTION

3RD ANGLE PROJECTION

Van Phong 1
BOT Thermal Power Plant Project

Operation and Maintenance Manual for Boiler General

IHI
Basic Design Group
Boiler Basic Design Dept.
Engineering Center
Carbon Solution Business Unit
Resources, Energy & Environment Business Area

DRAWING NO.

JOB NO. 5411-F37

CODE NO. K096-001

REV. B

1 / 258

Contents

0. General Precautions

This “General Precautions” chapter (this “Chapter”) describes Conditions of Warranty and matters concerning safety.

0.1. Conditions of Warranty

0.1.1. Conditions of Warranty

The Manuals' purpose is to help the operator and maintenance provider of the boiler safely and efficiently operate and maintain the boiler. Failure to comply with the Manuals can result in damage to the boiler and other property, shut-down of the plant, and injury or even death, and such failure voids any warranties provided by IHI Corporation (the "Company").

0.1.2. Exception for warranty

The followings are not subject to Company's warranty obligation:

- Accident or failure caused by modification or re-installation of the boiler, or caused by operation for modified purpose.
- Failure that occurs due to natural disaster or accident during transfer or related.
- Delivery delay after large delay in supply of the customer supplied item by the reason of the customer.
- Delivery delay when large specification change was requested by the customer.
- Accident, failure or damage due to faulty operation, improper handling or improper maintenance of the boiler, including, but not limited to, damage or rust due to inadequate handling and/or storage.
- Consumption of consumable products and replacement parts whose lifetime is less than the warranty period under the Contract, including, but not limited to, rubber products, grease, and sliding materials.
- Damage caused by goods or materials other than the boiler or other items that the Company delivered.
- Any damage of which cause is unidentifiable (such as in case of loss of the damaged parts).
- Any defects or damage due to inadequate reference, data or information or any materials, equipment or items provided by the customer.
- Erosion or corrosion and secondary damage to the boiler thereby, including, but not limited to, erosion due to ash of the internal prop in the fuel gas duct of the boiler.
- Normal wear and tear.
- Handling, operation or maintenance of the boiler in a way that deviates from the design specification conditions informed to the Customer by the Company, whether in the Contract documents or otherwise.
- Damage caused by, or occurred in relation to, use or incorporation in the boiler of any parts other than the parts supplied by or otherwise specified by the Company.
- Peeling of the paint on the pressure resistant part etc. where heat insulation is applied, or rust on the outer surface at the time of delivery.
- Rust caused by surrounding facilities or peripheral equipment or secondary effects due to rust.
- Deformation without cracking of the casing.
- Damage due to causes which were unknown to cause such damage or otherwise unforeseeable in the coal fired power plant industry at the time of delivery.
- Overhaul or repair of valves, auxiliaries or other equipment being performed by person other than the Company without the Company's presence or not in accordance with the Requirements.
- Any defects or damage caused by fire, earthquake, wind and flood damage, lightning strike and other natural disasters

■ Principal prohibition of firing other than design coal

Any usage of fuels except for design coal shall void all warranties regarding the boiler, whether express or implied.

- The Design Coal is coal for the design of the facility. Design coal characteristics are shown in the document “VP1-C-L1-G-GEN-00502 (K090-055) Fuel Specification for Boiler and Auxiliary Design”.
  The Performance Coal is coal for the calculation of the Plant Performance.

- Proper operation and maintenance of the Facility requires the firing of coals within the range of Design Coal considered by IHI in the design of the Facility, as described in EPC Contract Schedule 8-12 Guaranteed Fuel Specification. The use of coals that are outside the range of Design Coal (i.e., out of specification coals), whether individually or in combination, may damage the Facility and/or negatively affect performance of the boiler system, including, but not limited to, by causing slagging, fouling, reduced efficiency, metal deterioration, and higher maintenance costs. IHI makes no representations or warranties whatsoever regarding the use of out of specification coals in the Facility and any use of such coals shall be at the end user’s sole risk.

Damage and liability

Boiler shall be operated within the specified purpose of use and operating conditions. National or local laws, rules, restrictions and/or regulations (collectively, the “Laws and Regulations”) must be observed when using.

Thoroughly read this manual and other manuals provided by Company, including, but not limited to, this manual and the specifications for the boiler provided by the Company, and any other documents provided by the Company (collectively, the “Manuals”) and receive proper safety training from the appropriate Trainer prior to the commencement of the Relevant Work. Anyone who has not received safety training by the Trainer must not be permitted to perform the Relevant Work. The Trainer must ALWAYS select the safety training contents based on the Manuals, evaluate the personnel skills and confirm how much the personnel understand the contents of safety training. In no event shall the Company does not concern the safety training whatsoever except for disclosure of the basic information. Accidents caused by inappropriate safety training shall be excluded from the coverage of the warranty.

Company is not liable for any damage caused either by modification or change done to boiler-related documents (including the safety manual and OPERATION & MAINTENANCE MANUAL) by anyone other than Company.

The equipment warranty would be waved for the damage and/or deterioration of the performance, and lifetime due to the operation beyond the design limit and the use of the equipment for the not-intended purpose.

The customer shall be responsible for selecting and using fuel and other materials required for boiler operation. Depending on the material selected, there may be risks such as health hazard due to chemical exposure, dust damage, or explosion. Company is not liable for any accidents or health problems of operators caused by the material itself or materials.

Damage may occur by incorporation of materials, parts, or components into the boiler if such materials, parts, or components are acquired from anyone other than the Company or anyone not appointed by the Company. The customer must not modify the boiler or incorporate materials, parts, or components that are acquired from anyone other than the Company into the boiler without prior written approval of the Company.

Furthermore, considering the aforementioned rules, restrictions apply to the installation condition of the boiler, therefore be sure to observe the conditions stipulated in the documents (the specification and the installation manual) provided by Company. Unexpected accidents may occur if an act such as a change of the installation environment or a remounting to a different place was conducted.

In case any contradiction occurs among the aforementioned rules, restrictions or the descriptions on the documents, contact the Company.

Company is not liable for any damage caused by remounting of the equipment to a difference place or modification of the equipment peripheral system or devices at the customer's discretion. (Example: Moving and remounting the equipment of indoor specifications to outdoors, bringing high-temperature exhaust gas outlet around equipment, etc.)

Company is not liable for any damage that was caused by defect of a material or part that was used during a repair or faultiness of the repair work, even when such repair was performed by an instruction given by Company.

0.2. Safety

After this section (hereinafter "Safety Part") describes minimum requirements that need to be complied with to ensure safety during operation and maintenance of IHI-boiler: SOVR SUPER CRITICAL ONCE THROUGH VARIABLE PRESSURE REHEAT TYPE delivered by IHI Corporation (hereinafter "Company"), disposal of consumables (hereinafter "Relevant Work").

The contents of Safety Part are based on the standard specifications of the boiler. Each boiler may have been customized and therefore may differ in several aspects from the description of Safety Part, for instance, usage and work procedure may vary depending on the individual specifications of the boiler as delivered.

Purpose of Safety Part is to provide information on the basic safety requirements that Company observes when doing relevant works. Agreement should be made that warranty of the safety during work is not the intended purpose.

Disclosure of whole or any part of the information contained in Safety Part to any third party without consent of Company is strictly forbidden.

0.2.1. Related Users

■ Safety Manager

A safety manager (“Safety Manager”) refers to the person who is responsible for the safety in boiler operations and maintenance work in the customer’s organization.

■ Operator

An operator refers to the person who is engaged in the boiler operations.

■ Maintainer

A maintainer refers to the person who is engaged in the boiler maintenance work.

0.3. Labels on the Boiler

0.3.1. Boiler nameplate

The boiler is attached with a nameplate stating a model name, rating, serial number, etc.

0.3.2. Hazard Warning Label

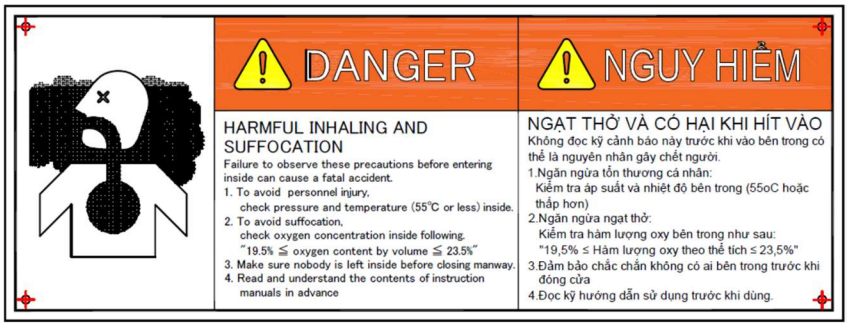
Hazard warning labels that indicate level of hazardous risks stated in section 0.3.2 (“Hazard Warning Labels”) are attached to the sections of the boiler where hazards are potentially present during operation and maintenance activities.

WARNING

- Only personnel who received trainings according to each level of operators, maintainers, and service engineers are allowed to enter each work area.
- Once any of hazard warnings labels peel off/wear out and become unreadable, contact the Company sales representative or the Company service engineer to attach new label to original location by the customer.

■ Types of Hazard Warning Label

An example of a hazard warning label is as follows:

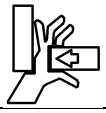
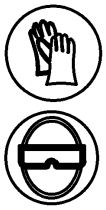


■ Signal words

A signal word shows the severity of the hazard level.

■ Symbols

The Hazard Warning Label uses symbols to indicate type of hazard existing in each equipment. Examples of the hazard symbols used in the equipment are as follows.

	General warning with explanations about hazards.
	Steam blowout hazard There is a danger of steam blowout. Keep out during operations.
	Entanglement/Roller hazard There is a danger of getting caught in the driving part of the robot and getting injured.
	Oxygen deficiency hazard There is a danger of oxygen deficiency due to a decrease in oxygen concentration.
	Hot surface hazard There is a high-temperature section near this symbol, and there is a danger of burn injuries by contact.
	Chemical hazard (Wear protective gear)/Internal fluid hazard (Wear protective gear) Wear protective gear such as rubber gloves and protective eye glasses when working.
	Hearing loss hazard There is a danger of hearing loss due to the internal noise. Wear earplugs.
	Fall hazard There is a danger of fall inside. Pay special care.

0.3.2.1. Text Messages

Text messages describe explanations of hazard, type of injury or damage that may occur, and methods to mitigate the hazard, if relevant.

0.3.3. Hazard Warning Label locations

For the location where the Hazard Warning Label of each device is attached, refer to "VP1-C-L1-M-HA-05008 (K390-111) Arrangement of Safety Labels for Boiler Proper and Duct" submitted separately.

WARNING

- No one should change the location of attaching the Hazard Warning Label.
- When sticking again a label peeled off or deteriorated, make sure to stick it to the strictly same position by the customer.

0.4. Safety Measures

0.4.1. Safety precautions

While the boiler is protected by various safety measures including safety interlocks, the following basic safety precautions need to be observed to ensure safer operations.

The proper operation and maintenance are key for the safe and reliable operation of the boiler. As a nature of the boiler, the operation and maintenance work may sometimes require the personnel to work near hot water/steam, ashes and hot/warm materials, coal dust and start-up fuels. The personnel who would be involved in any work for installation, operation and maintenance must pay the full attention to and be fully equipped, including but not limited to, with heat protection, noise protection, eye protection, safety devices (long sleeve clothes, suitable gloves, protective eye glasses, safety helmets, safety shoes, safety harness, etc.) as required for the intended work.

 **WARNING**

- Read and understand this Manual thoroughly before the actual operation of the boiler.
- Before operating the boiler, alert every personnel who are working near the boiler.
- Use appropriate tools in accordance with proper procedures.
- Wear appropriate protective gears (long sleeve clothes, suitable gloves, protective eye glasses, safety helmets, safety shoes, safety harness, etc.) properly.
- Do NOT perform any hot work alone. Make sure other personnel can visibly or audibly notice that the personnel are working on live circuit.
- Make sure that any heavy lifting is performed by two or more persons.
- After working, check that all parts and screws are returned to the same conditions prior to the work.
- Do NOT remove cover panel as long as maintenance work is not required.

0.4.2. Safety Interlock System

■ About interlocks

For safety protection, the boiler is equipped with the interlock system that shuts down or restricts operation depending on the conditions.
Do not disable or modify the interlock laid in the boiler.
When an abnormality is detected with devices and the interlock within the boiler is working, some or all of the functions may not work. However, error detection criterion varies depending on the interlock settings.
For the overview, refer to the logic diagram provided for in the documents below.

1. VP1-C-L1-I-CA-30014 (K710-404) Function of boiler Protection System
2. VP1-C-L1-I-CA-30015 (K710-421) Boiler Protection System Logic Diagram (IHI Portion)

Eliminate the cause of the interlocking, and perform an appropriate restoring work.

0.4.3. Lockout/Tagout

Lockout means physically preventing switches, valves, etc. from operating to prevent unintended activation during maintenance work.
Tagout means attaching, to a lockout circuit breaker, a tag warning worker not to operate the tagged circuit breaker. By doing so, tagout is intended to prevent other workers from accidentally turning on the operation handle of the lockout device.
This lockout/tagout system ("Lockout/Tagout System") contains a part that the boiler can lockout/tagout and the other part that the power plant can lockout/tagout. Especially when lockout/tagout in the power plant side, check the site condition to perform the maintenance work, etc.

DANGER

- A worker who is going to perform the service work of this Lockout/Tagout System is required to recognize the importance of lockout and thoroughly understand each step of procedures described in this section before start-up of the operation and maintenance.

WARNING

- When the boiler is in operation, make sure that the boiler has completely stopped before carrying out lockout.
- When multiple workers simultaneously perform service work, assign a supervisor who will manage all the workers. The supervisor should always keep track of the overall work situation and perform lockout.

■ General electrical lockout/tagout

DANGER

- When doing work that does not require electricity in the Maintenance and/or Services, make sure to perform lockout / tagout to all main breakers on the upper side of this boiler plant by referring to the following procedures.

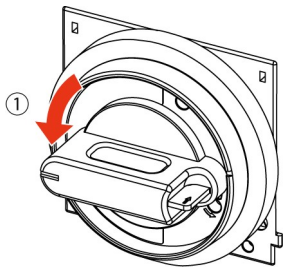
WARNING

- When multiple workers simultaneously perform the maintenance work, attach a tag representing each worker to breakers, valves, etc. In addition, fill in the department name and the name of the worker to the tag.

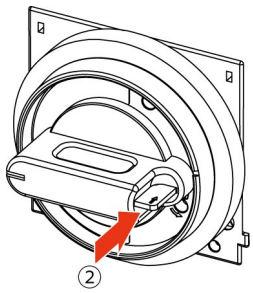
Example 1

The following procedures assume a breaker handle with a general lockout mechanism. Since the actual shape of the handle may be different, make sure to confirm the actual shape / motion with the relevant manual, drawing etc.
For lockout tag and padlock, it is required to prepare and provide for the equivalent ones.

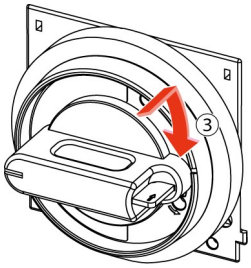
1. Rotate the handle to the reset direction to the position where the lock plate and case mark match.



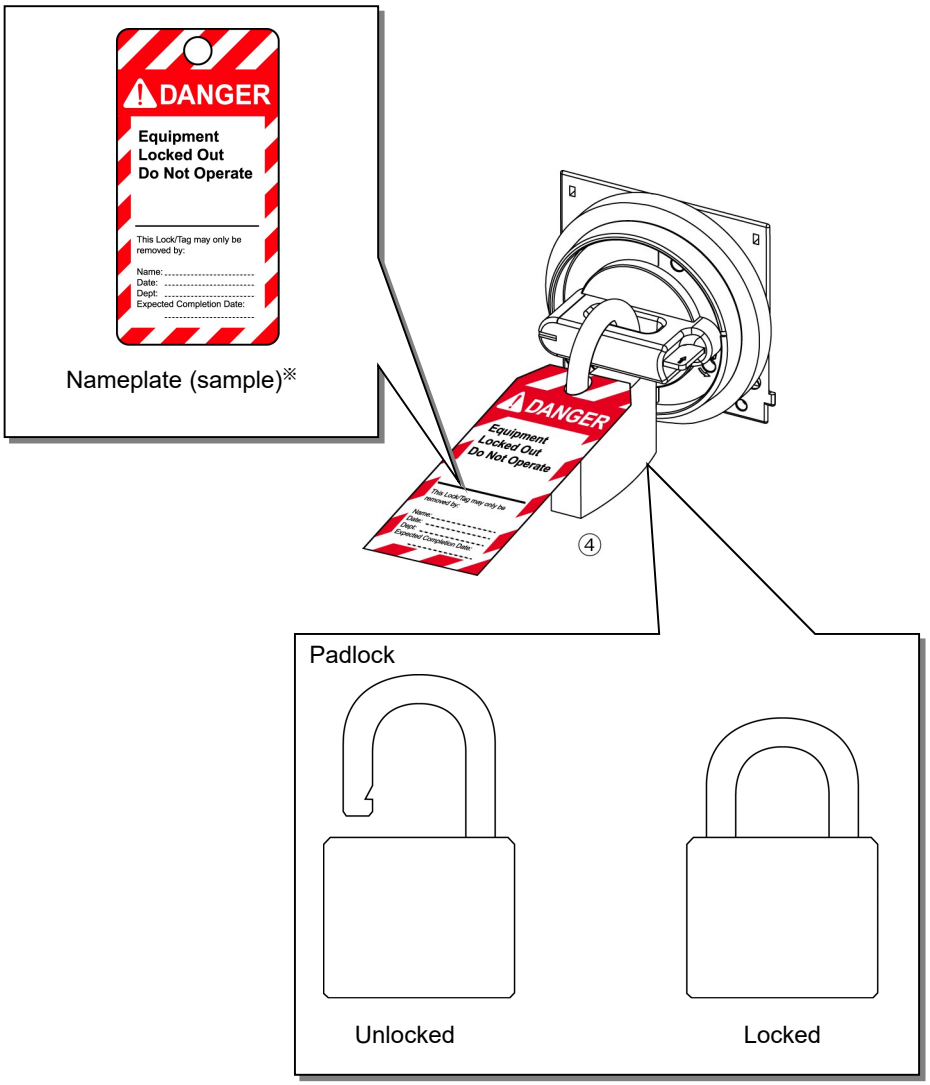
2. Push in the lock plate.



3. **While holding the lock plate pressed, return the handle to the OFF position.**



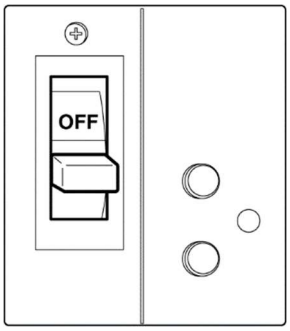
4. **To prevent a third party other than the Maintenance Workers from accidentally turning on the power, attach the tag (nameplate) for reminder as shown in the illustration below to the padlock and lock the handle with the padlock.**



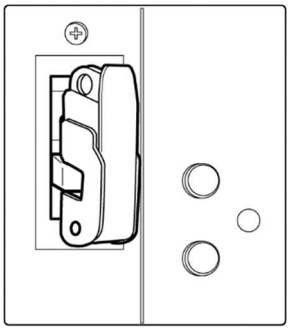
Example 2

The following procedure assumes a breaker handle without a general lockout mechanism. Since the actual shape of the handle may be different, make sure to confirm the actual shape / motion with the relevant manual, drawing etc.
For lockout tag and padlock, the customer is required to prepare and provide for the equivalent ones.

1. Turn the main breaker switch to OFF.



2. Install the breaker lockout jig.



3. To prevent a third party other than the Maintenance Workers from accidentally turning on the power, attach the tag (nameplate) for reminder as shown in the illustration below to the padlock and lock the handle with the jig.

■ Valve lockout/tagout procedure

In order to lockout / tagout piping, the valves on the upstream side of the target piping shall be closed. When performing maintenance of piping, etc., the worker in charge of the maintenance work should check the system diagram to close and lockout/tagout all valves on the upstream side of the target piping.

DANGER

- When performing the maintenance work requiring valves lockout, make sure to follow the procedures below and apply lockout/tagout to the valves upstream sides of the boiler so as to prevent a third party from accidentally opening the valve handle, causing chemicals and/or gas leakage that may adversely affect human body or the equipment.

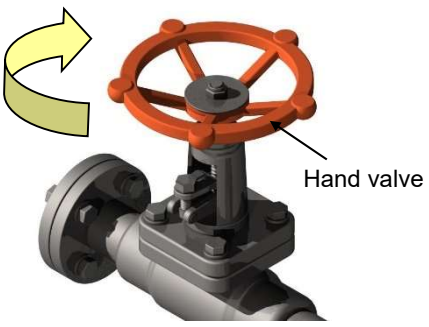
WARNING

- When multiple workers simultaneously perform the maintenance work, attach a tag representing each worker to breakers, valves, etc. In addition, fill in the department name and the name of the worker to the tag.

The following procedures assume a general hand valve. Since the actual shape of the valve may be different, make sure to confirm the actual shape / motion with the relevant manual, drawing etc.
For lockout tag and padlock, the customer is required to prepare and provide for the equivalent ones.

Example

1. Close the hand valve.



2. **Place a lock chain.**

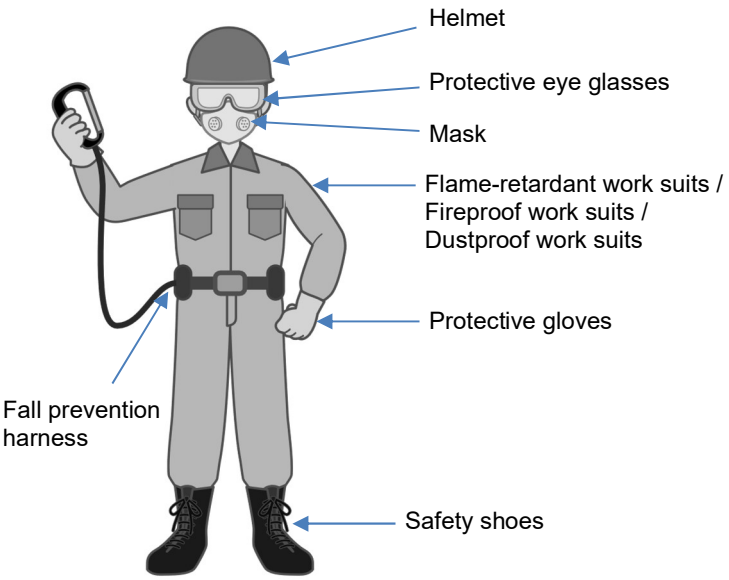
3. **Lock the lock chain with a key.**

4. **To prevent a third party other than the Maintenance Workers from accidentally unlocking the key, attach the tag (nameplate) for reminder as shown in the illustration below to the key.**

0.4.4. Work Suits and Protective Gears

WARNING

- When working in or around the boiler, everyone must wear work suits and protective gears in accordance with rules and regulations of the relevant work site.
  * The following is an example.



Example clothing

Types of protective gears required

- Protective gloves/insulated gloves, safety shoes, helmets, and flame-retardant work suits/fireproof work suits/dustproof work suits, if the Safety Manager deems it necessary.
- When working at a high place, a fall prevention harness.
- When performing work in relation to chemical substances, chemical-resistance armor.
- When performing welding work, safety glasses to protect your eyes and masks to protect your throat. In addition, wear a fire protection apron to prevent burns caused by welding sparks.

0.5. Emergency

0.5.1. MFT (Master Fuel Trip)

If a serious failure occurs in the boiler, the boiler protection system called MFT (Master Fuel Trip) works and immediately shuts off the supply of water and fuel. Then the boiler trips.

MFT is activated when one of more preset MFT set points exceed(s) for the following items:

1) MFT Manual Initiation
2) Loss of Both FD Fan
3) Loss of Both ID Fan
4) Loss of GAH
5) Furnace Pressure High-High
6) Furnace Pressure Low-Low
7) Boiler Outlet Steam Pressure High-High
8) Loss of All Boiler Feedwater Pumps
9) Feedwater Flow Low-Low
10) Complete Flame Failure
11) Partial Loss of Flame
12) All Fuel Input Shut off
13) Total Combustion Air Flow Low-Low
14) RH Protection
15) Separator Inlet Manifold Fluid Temp High-High
16) Separator Drain Tank Level High-High
17) Condenser Protection
18) DCS Controller Abnormal
19) Loss of T-BFP during T/M BFP Parallel Operation

0.6. Hazards for the Boiler

Risks of Hazards cannot be realistically eliminated fully due to the System structure. The Company is not responsible for any accident that is caused by such risks.

0.6.1. Hazards related to driving parts

The boiler includes following driving mechanisms. For operations of each device, refer to the manual supplied with the device.

- Pump
- Fan
- Pneumatic operated damper
- Hydraulic operated damper
- Motor operated damper
- Manually operated damper
- Safety valve
- Pneumatic operated valve
- Hydraulic operated valve
- Motor operated valve
- Manually operated valve
- RH/SH gas damper
- Sootblower

WARNING

- NEVER APPROACH OR TOUCH any rotating parts of the boiler during operation. Loose clothing may be caught in these rotating parts, and it may result in severe injury and/or death.
- ALWAYS lock out main power of the relevant equipment before opening any guard such as a cover.
- Do NOT approach anywhere other than the areas permitted to approach for working.
- Lockout/tagout of the pumps/fans or other driving equipment/components of the boiler are required before replacement of a driving equipment/components or a component of them. The Safety Manager must establish the proper safety management procedure for ensuring the safety by considering the effect on other equipment of the boiler. Refer to the separate relevant manual for the actual procedure of the inspection and maintenance of the relevant equipment.
- Lockout/tagout of the pumps/fans or other driving equipment/components are required before any work is performed for the nearby or upstream/downstream of the line.
- Internal residual pressure of valves may cause release of internal fluid (air/gas, water/steam and others) during the maintenance work. ALWAYS check the internal pressure condition before opening/dismantling.

IMPORTANT
(Valve lockout/tagout procedure)

- In order to lockout / tagout piping, the valves on the upstream side of the target piping shall be closed. When performing maintenance of piping, etc., the worker in charge of the maintenance work should check the system diagram to close and lockout/tagout all valves on the upstream side of the target piping.
- Before executing the Maintenance or other work that is performed for the boiler, shut off the inner fluid at upstream (and downstream, if necessary) by isolating valves, or apply the temporary measures to shut off at the piping and valves at upstream (and downstream, if necessary) of the boiler, in order to avoid the risk that would be caused by the inner fluid condition of the boiler.
- Please be aware that the restrained inner fluid between the upstream and downstream isolation

may cause inner pressure raise. When isolating is applied both at the upstream and the downstream, secure the pressure release by checking the internal pressure during the Inspection and the maintenance work.

- To prevent opening of a valve handle by personnel not in charge of the relevant work and consequent leakage of materials, such as water/steam, gas and chemicals, that adversely impacts personnel/equipment, be sure to apply a lockout and tagout to the valve upstream (and downstream, if necessary) to each of the Boilers before maintenance works.

0.6.2. Hazards related to high voltage sections/electrical equipment

While high voltage live parts in the boiler are protected by protections such as panels and/or guards, comply with the following cautions to prevent any accident.

WARNING

- Do NOT remove panels or doors labeled with high voltage live part warning label without permission by Safety Manager, operate the boiler with any such panel/door removed. Furthermore, do NOT open any cover unless permitted by Safety Manager to do so.
- Do NOT touch live parts without prior full inspection, under any circumstances.
- Do NOT wear metallic objects, including, but not limited to, wristwatches and rings during work, otherwise accidents due to unintended contacts may occur.
- No work shall be carried out on electrical equipment, while power is being supplied to the equipment. Before starting a work, be sure to check all relevant electric drawings and check there is no live part in the work area. Especially, the primary side of the main breaker (a danger warning label is attached to the cover) is still a live part even if the breaker switch is turned OFF, so carry out the upper lockout as occasion demands.
- If it is necessary to open a cover etc. for a work, be sure to lock out the main power supply on upper side of the boiler before opening it.
- Do NOT place any part (such as screws) removed during work, or place any tool above the equipment. Short circuit may occur if such object falls inside or affect circuit by other way.
- Work on new and existing energized (hot) electrical circuits is prohibited until all power is shut off and grounds are attached.
- An effective Lockout/Tagout System must be in place. Suitable warning signs must be prominently displayed when any work is being carried out and precautions taken to ensure that power cannot be inadvertently switched on during work is in progress, or is not complete.
- All electrical tools and equipment are maintained in safe condition and checked regularly for defects and taken out of service if a defect is found.
- Do not bypass any protective system or device designed to protect workers from contact with electrical energy.
- All electrical tools must be properly grounded unless they are of the double insulated type.
- Electrical power must be turned off before connecting to or disconnecting from cables. Do not touch inside of such electrical equipment even after the power of electrical sources has been turned off. They may still keep charged electricity inside.
- All cabling should be carried out with the equipment in position but isolated from any electrical supplies.

IMPORTANT

- The Company shall not be responsible for any accident caused by a defect of design, manufacturing, laying, and maintenance of cables that are not within the Company's work scope stated in the Contract.
- For the joint part with each part of the boiler such as a connector, it is necessary to periodically check that there is no looseness. The Safety Manager must establish the proper maintenance procedure such as additional tightening.

0.6.3. Hazards related to high temperature sections

The electric components in the boiler and the mechanical unit of the boiler become hot because of each burner or burning material accompanied with it or friction between machines, and steam in piping.

The high-temperature part of the boiler is protected with heat insulation material etc. Do NOT touch the high-temperature part in work areas as a measure of precaution.

However, sections that cannot be thermally insulated exist due to nature of the boiler. Put on appropriate protective equipment (for instance heat insulating gloves) before starting work in a location subject to high temperatures.

In addition, it takes long time after the operation is stopped until the boiler cools down to a temperature at which the entire boiler can be operated safely.

Comply with the following cautions to prevent burns by contacting hot surfaces.

WARNING

- The surface temperature of the Relevant Equipment being 60deg C or less does not always mean the boiler internal temperature to be low. Check that the boiler internal temperature is the normal temperature (the temperature almost ambient) before working inside the boiler.
- If a worker is working at high place and contact with a high temperature section there is a risk of falling accident due to a reflexive jump. ALWAYS ensure the safety and apply the protections (for instance a use of a fall prevention harness) necessary to prevent falling accidents when working at a high place.
- When working near a high temperature section, put on appropriate flame-retardant work suits, or fireproof work suits when necessary.
- The boiler surfaces may reach a high temperature condition due to an effect from ambient environment (for instance a direct sunlight) that is not native to any design or operation reason. Check that the boiler surface is 60deg C or colder before contacting the boiler surface to work on.
- ALWAYS ensure safety by responsibility of the responsible personnel against high temperature sections.

0.6.4. Hazards during work at high place

The boiler is partially composed of extremely huge components. Therefore, majority of the works at the boiler are performed at high place. The potential risks in the works at high place are as follows: The Safety Manager is responsible to establish the safe working procedure to prevent accidents caused by the following risks.

Fall risk
When working at a high place in the boiler, the relevant supervisor must ALWAYS establish, under control of the Safety Manager, an appropriate safe working procedure to prevent workers from falling. Use of fall prevention harnesses, accessibility restrictions, and worker training are advisable as the actual example of countermeasures.

Falling object risk
When working at a high place in the boiler, the relevant supervisor must ALWAYS establish, under control of the Safety Manager, an appropriate safe working procedure that protects workers from falling object, and that prevents objects from falling. Work monitoring, ensuring safety in the controlled areas, and personnel training are advisable as the actual example of countermeasures.

*The fall and falling object risks cannot be realistically eliminated fully due to the boiler structure. The Company is not responsible for any accident that is caused by such risks.

WARNING

- DO NOT enter any area other than the work areas defined this manual. Attempt to enter restricted areas may result in a serious accident due to a fall or falling object.
- When working at a high place, ALWAYS put on appropriate device such as a safety belt according to the instructions of the Safety Manager.
- When workers use a work table or step ladder, check the floor surface on which it is installed is horizontal and safe and there is no obstacles.
- PAY ATTENTION to falling from the penthouse and the manhole for the boiler and ducts at insides and outsides.
- PREPARE, AND EQUIP OR LOCATE relevant scaffolding and harness for falling protection at inside and outside of the access of the boiler and its ducts.
- PAY ATTENTION to the falling objects, loose components near working place and overhead, and other works performed nearby in parallel.

0.6.5. Hazards during work in Boiler

The boiler requires a maintenance work inside the boiler such as check of status and cleaning of inside the boiler.

ALWAYS establish an appropriate safety management procedure to ensure safety under control of the Safety Manager considering the following the cautions below.

Lockout / tagout required for a work in the boiler

When you carry out a work in the equipment, it is necessary to carry out the lockout / tagout for the items shown below.

The Safety Manager must establish the proper safety management procedure for ensuring the safety considering the effect on other plant equipment. The Safety Manager should consider the influences that the lockout/tagout may give on other devices of the boiler plant; for example, the lockout of the fan stops the cooling device of other equipment.

Precautions on possible containment

When you carry out a work in equipment of the boiler, other workers have a risk of containment because the entrances of enclosure such as the manholes are blocked.

The Safety Manager must ALWAYS establish an appropriate safety management procedure to ensure safety.

WARNING

- The inside of the boiler is the shielded space. The long-time work may cause fluid deprivation depending on the conditions. The Safety Manager must establish the proper safety management procedure for ensuring the safety.
- Work inside the boiler is allowed only for a worker who received sufficient safety education from the relevant trainer. A worker who did not receive the safety education should not carry out a work inside the boiler.
- Hot vapor leaking from piping may cause injury when working inside the boiler. Workers are required to check the location of the piping before starting to work.
- The works inside the boiler include the high place works.
- When working inside the boiler, certain sections need to be entered from other floor using a gondola or require placement of a special foothold.
- Perform a lockout/tagout on the upper side when working inside the boiler.
- When working inside the boiler, ALWAYS set a Safety Manager in advance who will coordinate all the workers. Supervisor must be aware of the entire working status of all workers inside the boiler all the time, and hold control of the work areas appropriately. The supervisor should also take measures for communicating with remote workers using a transceiver, a wireless intercom etc.
- Regulations on use of radio waves may exist in some countries/regions. Observe the usage conforming to the relevant laws in each country/region.
- Workers are required to ALWAYS attach lockout tags to the manhole they used to enter into the boiler before working inside the boiler. Make sure the number of the attached lockout tags is equal to the number of people working inside.
- Internal residual pressure may cause release of dust and/or hot steam when opening a manhole. ALWAYS check the internal pressure condition before opening a manhole.

- Works around the boiler include valves, dampers, motors, fans, wall deslagger, sootblowers and other driving parts. The workers should refer to and fully understand "0.6.1 Hazards related to driving parts" in advance and confirm the position of the driving parts on each floor diagram and then perform the work.
- Locations with bad illumination exist inside the boiler. The workers are required to obtain sufficient brightness, for instance using a headlamp, before starting any work.
- When working inside the boiler, note that it takes time before room temperature falls after the shut-down. Before entering inside the boiler or other location subject to high temperatures, ALWAYS check that the internal temperature has fallen to room temperature using a thermometer.
- The inside of the boiler is a shielded space. The oxygen concentration may decrease depending on the conditions. When you enter in the boiler, be sure to check the internal oxygen concentration in advance.
- After work, make sure not to leave any tools or debris inside the boiler.

IMPORTANT

- Before carrying out a work in the relevant equipment of the boiler, be sure to notify the surrounding workers that a work is being carried out.
- When you carry out a work in the relevant equipment of the boiler, display a tag notifying a work is being carried out on the door at the entrance of the equipment.
- When you carry out a work in the relevant equipment, allocate a supervisor at the entrance of the equipment.
- Even after the driving power supply lockout / tagout of the ventilation/draft boiler, residual pressure may cause release of dust and/or hot air blow-off. Confirm that the residual pressure has become "0" before working.
- Hand may be pinched when manually opening or closing a door.

0.6.6. Hazards of N_2 System / Other Chemicals

WARNING

- NOTE the leakage of N_2 may cause shortage of oxygen of the personnel who aspirate N_2.
- Use the appropriate PPEs when feeding the Chemicals to chemical dosing system to control the feedwater quality and bottom ash circulating water.

0.6.7. Hazards of Confined Space/Oxygen deficiency

Oxygen deficiency may result from the displacement of oxygen by another gas, or the consumption of oxygen by work etc. Confined spaces or low-lying areas are particularly susceptible to oxygen deficiency and oxygen level should always be monitored prior to entry.

Qualified field personnel should always monitor oxygen levels and the workers should use atmosphere supplying respiratory equipment see section 0.4.4. Work Suits and Protective Gears when oxygen concentrations drop below 19.5 % by volume.

WARNING

- PAY ATTENTION to shortage of oxygen inside of the boiler, pulverizers, duct and other confined spaces within the boiler.
- Internal residual pressure may cause release of coal dust, ash and hot air/gas when opening a manhole. ALWAYS check the internal pressure condition before opening or closing a manhole.
- Wear safety equipment (masks and glasses, etc.) to enter the internal of ducting or other confined spaces to avoid internal ash scatting.
- NEVER enter into the boiler internal, pulverizers, duct and other confined spaces through manholes without confirmation of the oxygen concentration or when the oxygen level is below 19.5 % (except when properly equipped) and safety officer's approval.
- After the confirmation of safe entry, secure the brightness and ventilation for performing the work at confined space.
- NEVER close the manhole without the confirming that no personnel are left inside the boiler, pulverizers, duct and other confined spaces.
- To prevent accidents and injuries caused by blowout of internal high temperature gas, exhaust gas, and ashes, etc., confirm that the manhole is closed before starting the boiler.

0.6.8. Hazards of Fire

The coal-fired power station is high risk area of fire hazard for many reasons, such as, start-up fuel, coal, potential hot spot and the use of electricity and the hot work for maintenance etc. A fire can be caused by the combination of a source of ignition, a source of oxygen, and a source of fuel. Fires at power station can be highly destructive, to cause the damage to equipment, and risk to life of the working personnel. It's important to understand some of the common causes of fire that can be easily avoided by proper care and the attention.

 **WARNING**

- No flammables around start-up fuel piping (light oil/natural gas) to avoid fire caused by the leakage of oil/gas.
- The working area must be clear of flammable and combustible materials. The hot works in the proximity of combustible or flammable materials is prohibited. The hot work must be performed by trained or certified personnel.
- Preventive measures must be made for protection of combustible or flammable materials by using a non-combustible/ thermal barrier or other means.
- The flammable and combustible liquids must be properly stored, handled and used in and around the boiler.
- The area storing combustible materials such as fuels, gas, etc. must be separated from combustible material by at least 3 meters and must have a function of lock and ventilation. Please secure the proper ventilation.
- The containers and/or storage areas must have proper signage/placards.
- The list of dangerous goods on-site such as material safety data sheets (MSDS), as per the Workplace Hazardous Materials Information System (WHMIS), must be always latest and updated.
- Do not smoke and use fire, near either the flammables or the flammable storage area.
- Purge completely inner fluid of flammable (start-up fuels, pulverized coal) from the piping, the burners and pulverizers before inspection, maintenance and hot work/welding work.

1. Overview of the Boiler Plant

1.1. Boiler Plant General Information

1.1.1. Overview of the Boiler Plant Facilities

This sub-section outlines the feature of the coal fired power plant facilities.

The following diagram illustrates the facilities and processes in generating power in the coal fired power plant:

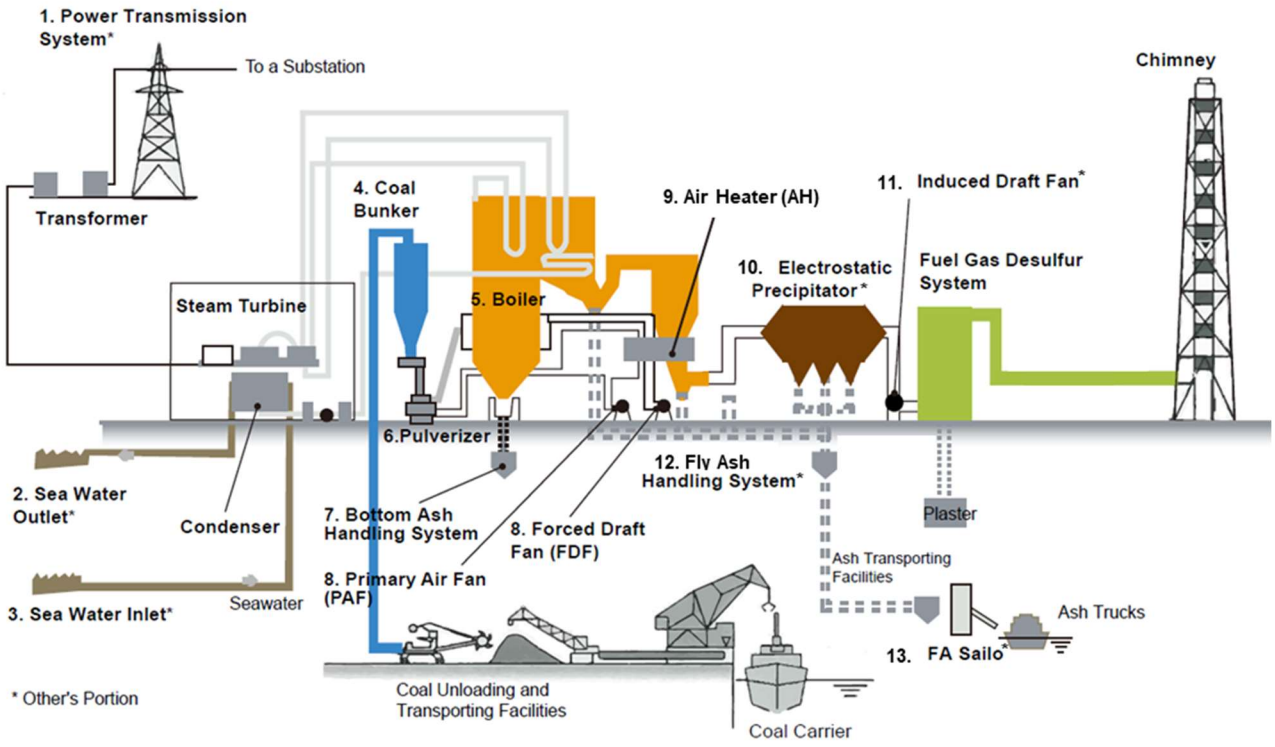


Fig.1.1.1 Overall Feature of Power Station/Pulverized Coal Firing Boiler Plant

Facilities, Services and Systems	Operations
1 Power Transmission System (Other's Portion)	Transmits the electricity generated by the power plant to a power substation with stepping up from the generator voltage level to the power transmission system voltage level by Generator Transformer.
2 Sea Water Outlet (Other's Portion)	Outputs the used main cooling water and the treated waste water via the pipes of the power plant to the sea.
3 Sea Water Inlet (Other's Portion)	Intakes the seawater via the pipes of the power plant as the main cooling water.
4 Coal Bunker	Stores the raw coal conveyed by Coal Handling System.
5 Boiler	Burns the fuel (pulverized coal / light fuel oil) in the boiler furnace. And generates steam with heat exchanging between the flue gas and water/steam in pressure parts piping. Sootblower and Water sootblowers are installed for ash (Slugging/Fouling) removal.
6 Pulverizer	Pulverizes the raw coal into fine powder and dry the pulverized coal with hot air from Primary Air System. And the mixture of pulverized coal and air is fed to burners.
7 Bottom Ash Handling System	Bottom Ash (BA) from the boiler furnace hopper is conveyed by Submerged Chain Conveyor (SCC) to the BA silo.
8 Primary Air Fan (PAF)/ Forced Draft Fan (FDF)	Supplies air to the boiler and pulverizers.
9 Air Heater (AH)	Exchanges heat between cold air and hot flue gas.
10 Electrostatic Precipitator (Other's Portion)	Removes fly ashes from the flue gas by using force of electrostatic charge.
11 Induced Draft Fan (Other's Portion)	Induces the flue gas to the stack.
12 Fly Ash Handling system (Other's Portion)	Conveys Fly Ash (FA) from ESP hopper to FA Silo by the compressed air conveying system.
13 FA Silo (Other's Portion)	Storages the fly ash.

1.2. Abbreviations

Initials	Abbreviations	Explanations
A	AH	Air Heater
	ASME	American Society of Mechanical Engineers
	ASQ	Auxiliary Sequence Control System
B	BA	Bottom Ash
	BFP	Boiler Feed Pump
	BMCR	Boiler Maximum Continuous Rating
	BMS	Burner Management Control System
	BPS	Boiler Protection System
	BSQ	Boiler Sequence Control System
C	CCR	Central Control Room
	CCTV	Closed Circuit Television
	CEMT	Cold End Metal Temperature
	CRP	Cold Reheat Pipe
D	DCS	Distributed Control System
	DF	Dual Flow
E	ECO	Economizer
	ESP	Electrostatic Precipitator
F	FA	Fly Ash
	FDF	Forced Draft Fan
	FGD	Flue Gas Desulfurization
H	HFS	Heat Flux Sensor
	HP	High Pressure
	HRA（H.R.A.）	Heat Recovery Area
I	IDF	Induced Draft Fan
	IES	Ignitor Executive System
	INPACT	IHI NOx Preventing Advanced Combustion Technology
L	LCV	see "SDT LCV".
	LFO	Light Fuel Oil
	LP	Low Pressure
	LPC	Low Pressure Control
M	M-BFP	Motor driven Boiler Feed Pump
	MCR	Maximum Continuous Rating
	MFT	Master Fuel Trip
	MH	Manhole
	min	Minutes

Initials	Abbreviations	Explanations
	mg	Milligram
	mm	Millimeter
	MT	Magnetic Particle Testing
	MW	Megawatt
	MWD	Mega Watt Demand
N	N2	Nitrogen
	NH3	Ammonia
	NOx	Nitrogen Oxide
O	O2	Oxygen
	OAP	Over Air Ports
P	P-valve	Separator drain tank level control valve
	PAF	Primary Air Fan
	PC	Pulverized Coal
	PORV	Power Operated Relief Valve
	PF	Pulverized Fuel
	PID	Proportional Integral Derivative
	PRB	Powder River Basin
	PT	Penetrant Testing
R	RH	Reheater
	rpm	revolution per minutes
S	SAP	Side Air Ports
	SCC	Submerged Chain Conveyor
	SDT LCV	Separator Drain Tank Level Control Valve
	SH	Superheater
	SO2	Sulfur Dioxide
	SPR	Separator
	STC	Steam Temperature Control
T	T-BFP	Turbine driven Boiler Feed Pump
	TMCR	Turbine Maximum Continuous Rating
U	UCS	Unit Coordination & Boiler Modulating Control System
	UT	Ultrasonic Testing
V	VT	Visual Testing
W	WWTP	Waste Water Treatment Plant

2. Outline of Boiler Plant Components

This chapter explains outlines of each component making up the boiler plant.

2.1. Pressure Parts

The boiler is composed of the following pressure parts:

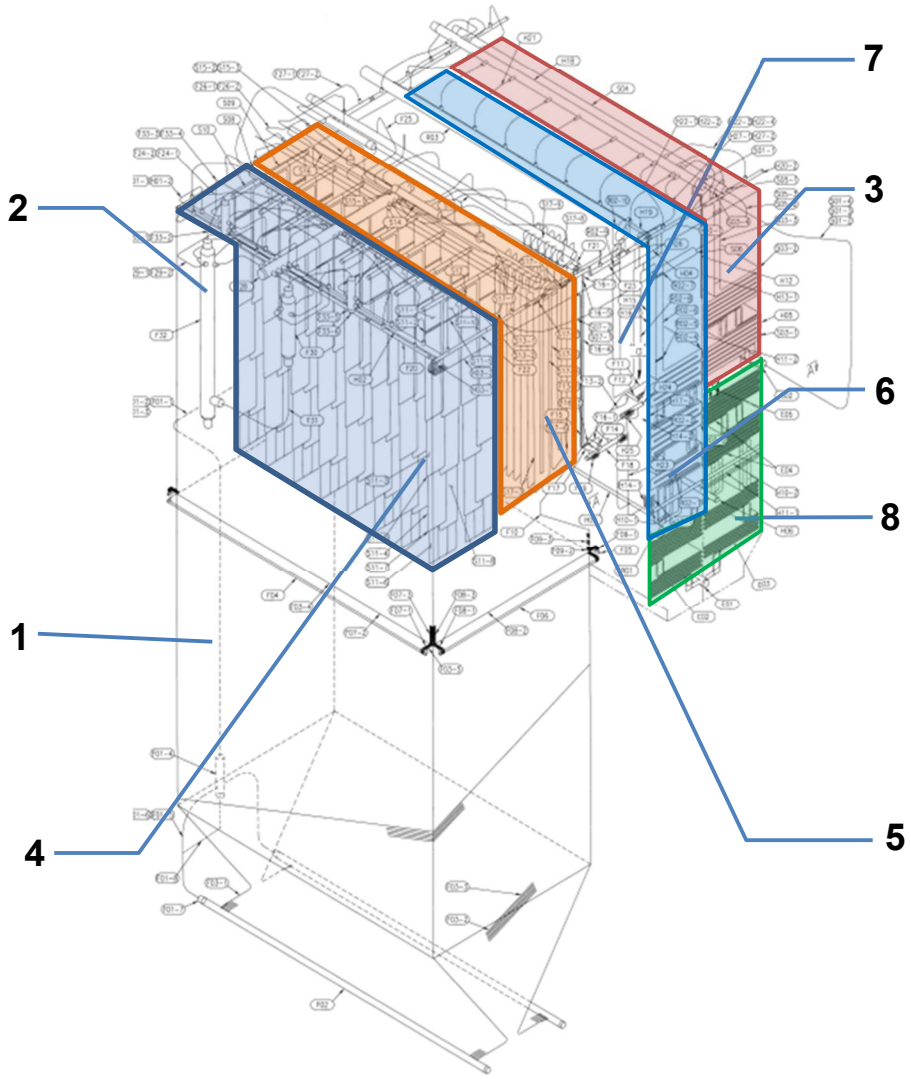


Fig.2.1 Pressure Parts Arrangement

Table 2.1 : Pressure Parts Outline

No.	Component name	Description	Reference section
1	Furnace	Generates heat by burning fuel.	See below
2	Separator	Separates water and steam contained in the boiler furnace water.	Chapter 3.1.2
3	Primary Superheater	Heats the steam generated by the Boiler up to the designated main steam temperature.	Chapter 3.1.3
4	Secondary Superheater		
5	Final Superheater		
6	Reheater	Heats the steam coming from the outlet of the HP turbine (the cold reheat steam) up to the designated hot reheat steam temperature.	Chapter 3.1.4
7	Reheater (Pendant)		
8	Economizer	Heats the boiler feed water to recover the heat in the flue gas and to get the designated boiler outlet flue gas temperature.	Chapter 3.1.5

2.1.1. Furnace

The Furnace consists of the following components.

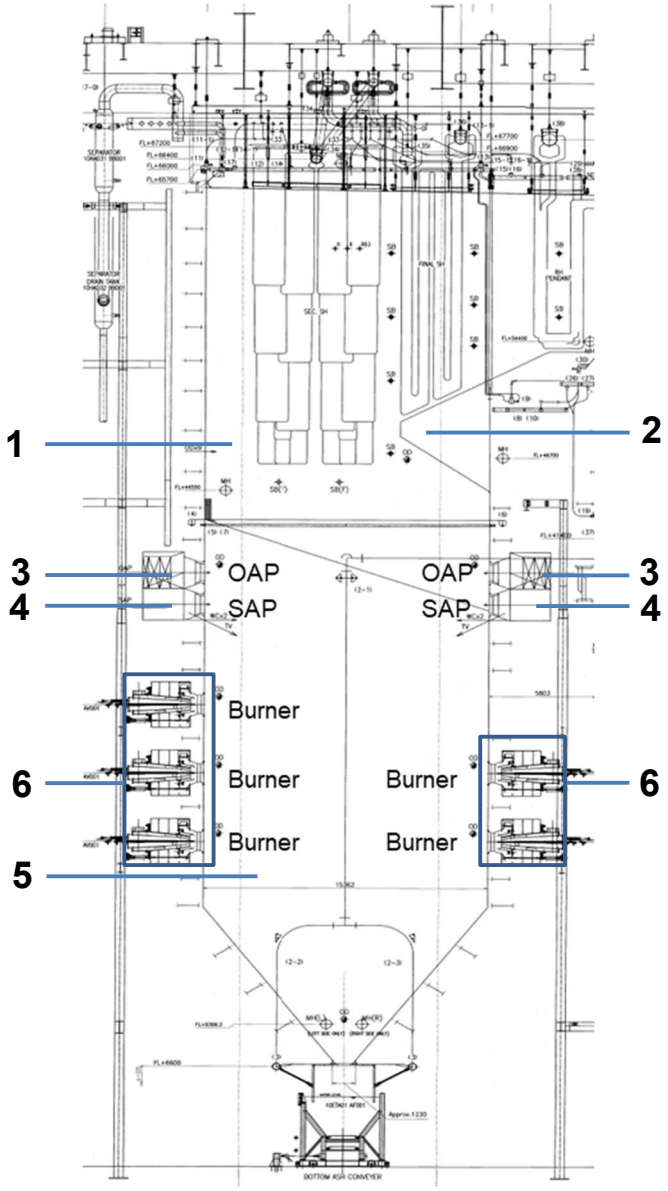


Fig. 2.1.1 Furnace Components Arrangement

Table 2.1.1 : Furnace Components Outline

No.	Component name	Description	Reference section
1	Upper Furnace Path	Consists of vertical tubes that are connected with the lower furnace path through the intermediate headers.	Chapter 3.1.1
2	Furnace Nose	Used for achieving uniform gas temperature and gas velocity in the vertical up and down direction of the Furnace outlet portion.	Chapter 3.1.1
3	OAP (Over Air Ports)	Installed above the top row of Burners for staged combustion to improve combustion. With its staged combustion, it is intended to achieve appropriate NOx level and unburned combustibles in ash.	Chapter 3.1.1
4	SAP (Side Air Ports)	Used for supplying combustion air that is used to improve combustion efficiency.	Chapter 3.1.1
5	Lower Furnace Path	Consists of helically wound tubes that have a certain angle to the horizontal axis and are connected to the upper furnace path through the intermediate headers. The helically wound tubes help in increasing mass flow by reducing the number of the tubes less than the vertical upper path tubes.	Chapter 3.1.1
6	Burner	Arranged in the front and the rear furnace wall for employing the opposed firing system.	Chapter 3.1.1.3 / 3.3

2.1.2. Separator

The Separator consists of the following components:

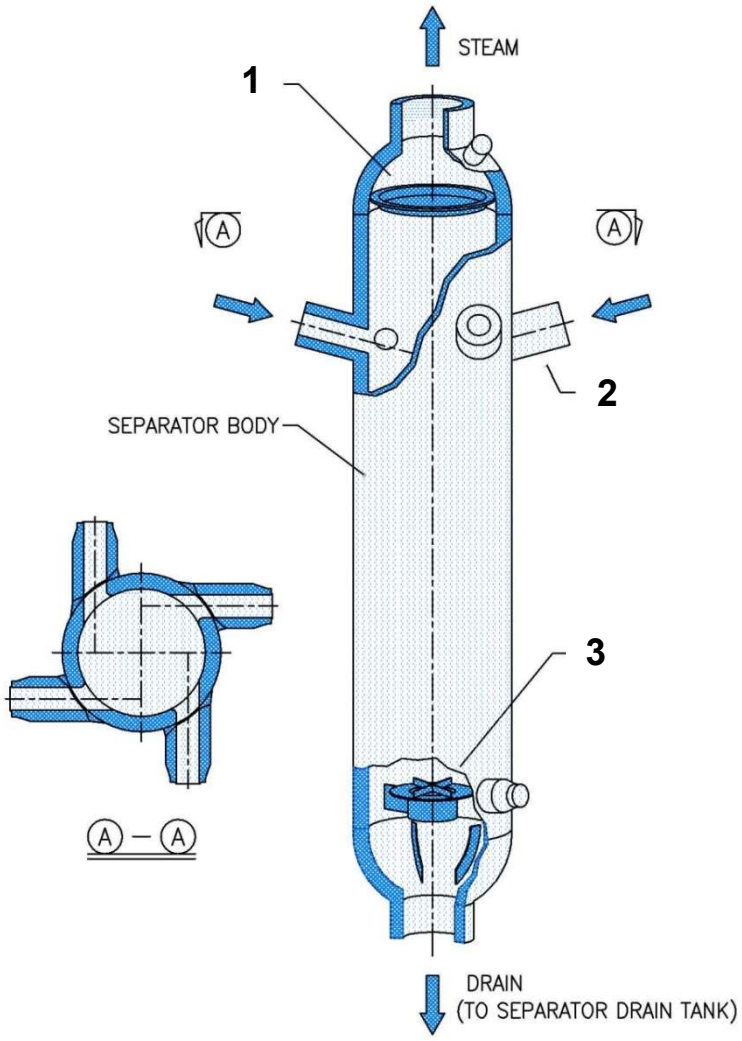


Fig.2.1.2 Name and Arrangement of Each Separator Parts

Table 2.1.2 Separator Component Outline

No.	Component name	Description	Reference section
1	Drip Ring	Prevents droplets from entering to the Superheater.	Chapter 3.1.2
2	Inlet Connecting Pipe	Arranged tangentially for creating centrifugal fluid flow into the Separator.	Chapter 3.1.2
3	Vortex Eliminator	Prevents bubbles from entering to the pipe to the separator drain tank.	Chapter 3.1.2

2.1.3. Separator Drain Tank

The Separator Drain Tank consists of the following components:

The upper part of the Separator Drain Tank has the same construction as the Separator and the lower part is longer than the Separator so as to act as a reservoir.

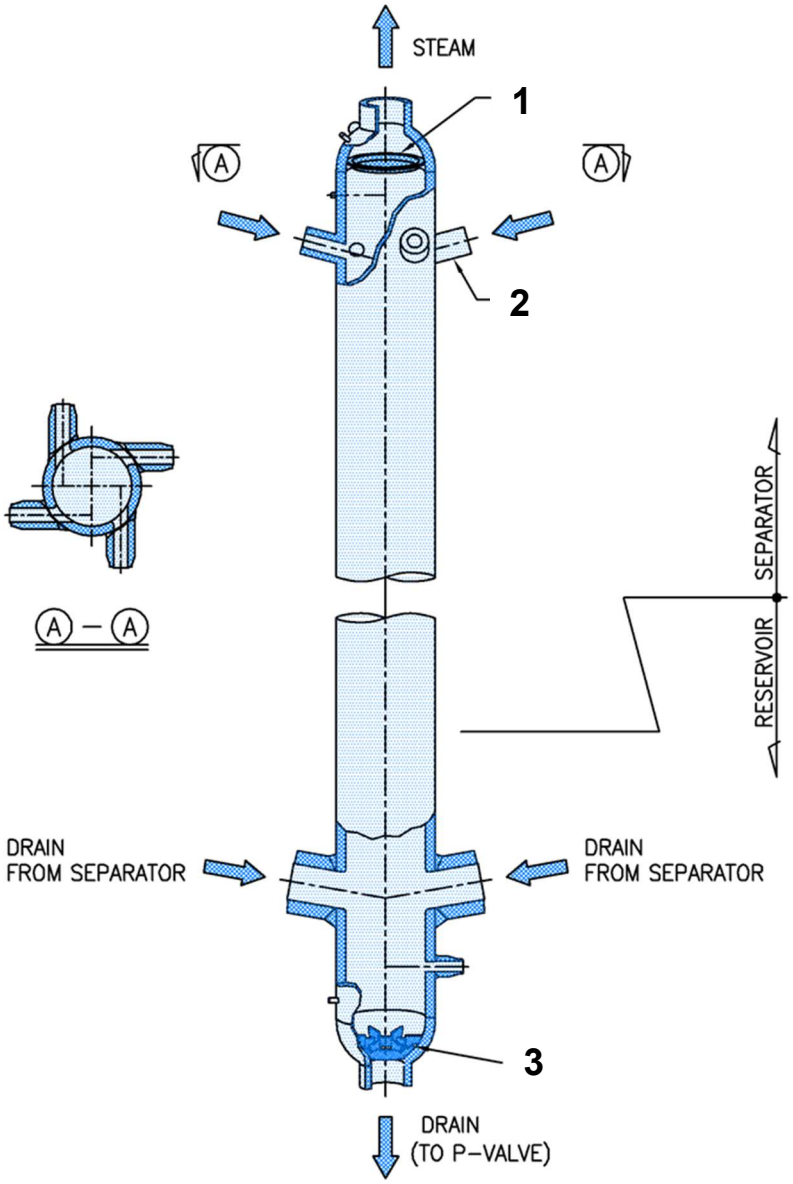


Fig.2.1.3 Name and Arrangements of Each Separator Drain Tank Parts

Table 2.1.3 Separator Drain Tank Component Outline

No.	Component name	Description	Reference section
1	Drip Ring	Prevents droplets from entering to the Superheater.	Chapter 3.1.2
2	Inlet Connecting Pipe	Arranged tangentially for creating centrifugal fluid flow into the Separator.	Chapter 3.1.2
3	Vortex Eliminator	Prevents bubbles from entering to the pipe to the P-valve.	Chapter 3.1.2

2.2. Boiler Cleaning System

The boiler is equipped with the Steam Sootblowers and the Water Sootblowers to remove deposited ash (slag) from the inner walls of the furnace.
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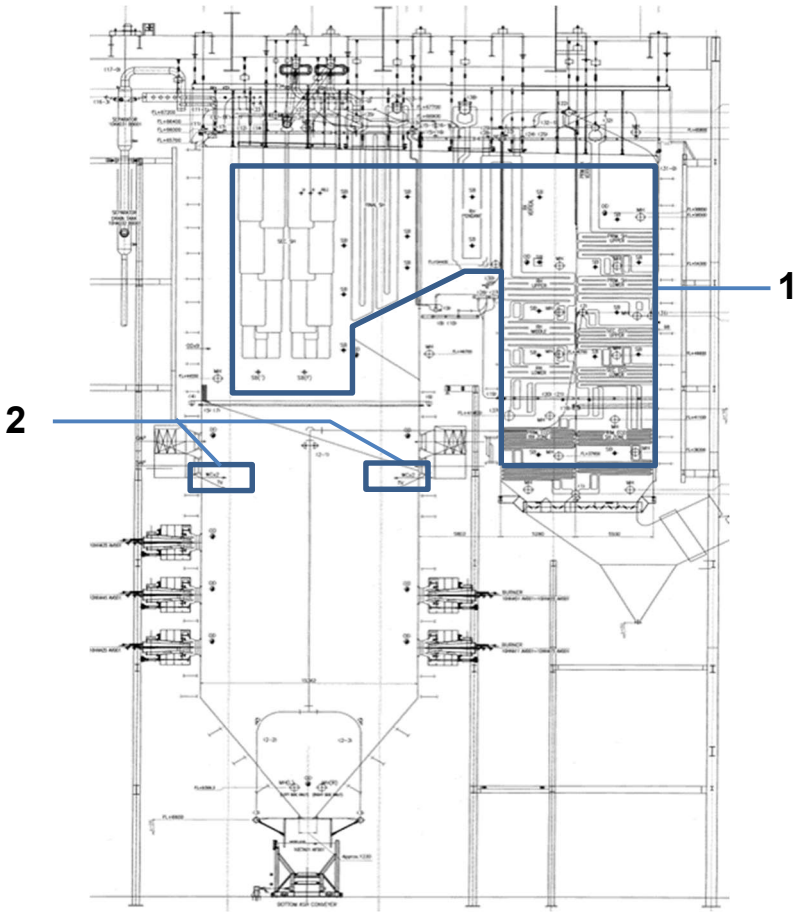


Fig.2.2 Boiler Cleaning System Arrangement

Table 2.2 : Boiler Cleaning System Outline

No.	Component name	Description	Reference section
1	Sootblowing System	The Sootblowing System is for removing deposited ash (slag) and fly ash deposited on the heating surfaces of superheater or reheater, thus maintaining thermal efficiency and preventing increase in the draft loss.	Chapter 3.2.2
2	Water Sootblower System	The Water Sootblower System is equipped for maintaining the thermal efficiency by removing slags on the furnace wall.	Chapter 3.2.3

2.3. Burners

The boiler is equipped with the Pulverized Fuel Burner for combustion of pulverized coal-air mixture and ignition (oil) burner.

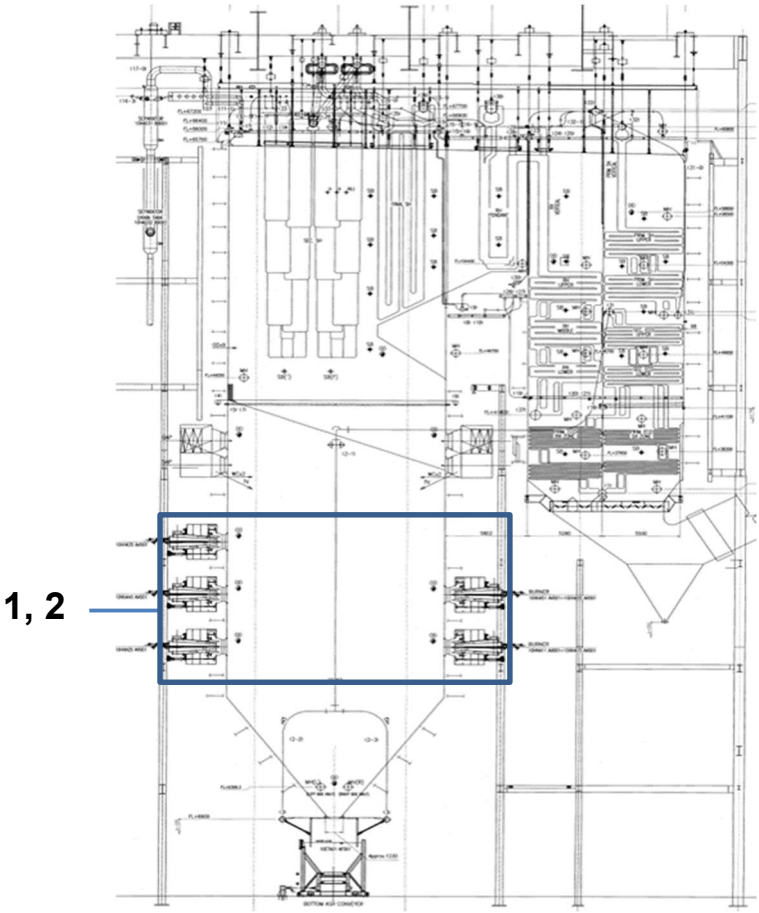


Fig.2.3 Burner Arrangement

Table 2.3 : Burner Outline

No.	Component name	Description	Reference section
1	Pulverized Fuel Burner	The burner for combustion of pulverized coal-air mixture within the boiler furnace.	Chapter 3.3.1.1
2	Ignitor	The ignition oil burner for the Pulverized Fuel Burner.	Chapter 3.3.1.2

2.4. Safety Valves

The boiler is equipped with the spring loaded safety valves for the superheater and the reheater system respectively to prevent the system from over pressure beyond the maximum allowable working pressure. The popping pressure of the safety valves is set above the maximum working pressure plus a certain pressure specified in the ASME code.

In addition to the spring loaded safety valves, the boiler is equipped with the PCV (power actuated relief valve) installed at the outlet of the superheater which popping pressure shall be same as the maximum working pressure of the main steam pipe.

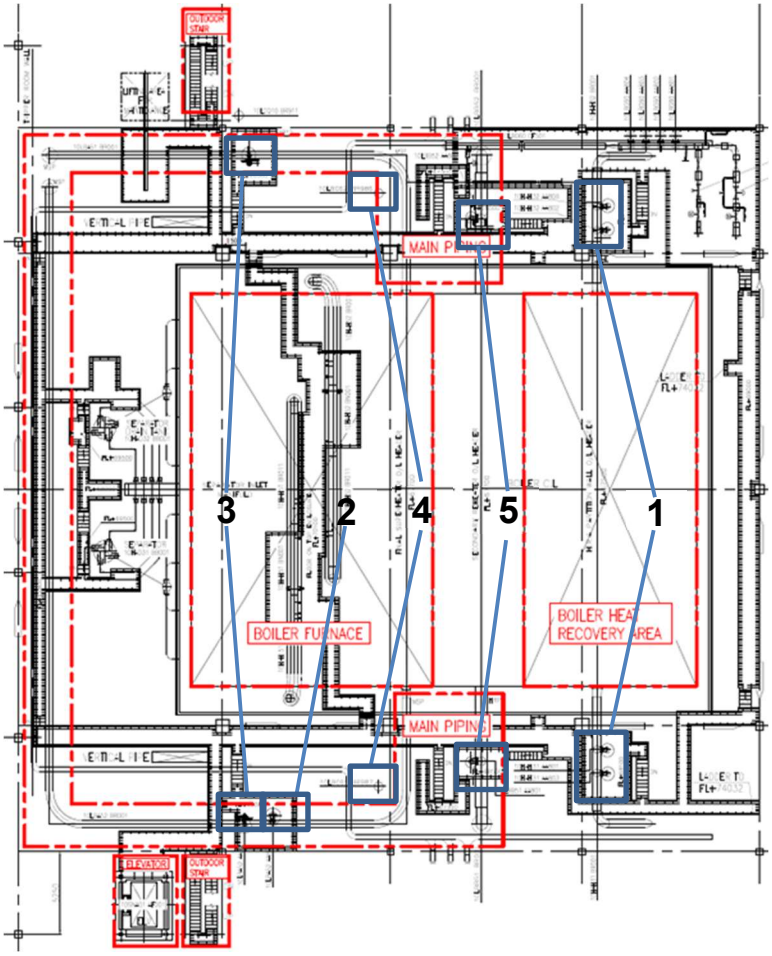


Fig.2.4 Safety Valve Arrangement

Table 2.4 : Safety Valve Outline

No.	Component name	Description	Reference section
1	SH Inlet Safety Valve	Installed at the inlet of the superheater. (spring loaded)	Chapter 3.4.1
2	SH Outlet Safety Valve	Installed at the outlet of the superheater. (spring loaded)	Chapter 3.4.1
3	SH Outlet PCV	Installed at the outlet of the superheater (power actuated relief valve).	Chapter 3.4.1
4	RH Inlet Safety Valve	Installed at the inlet of the reheater. (spring loaded)	Chapter 3.4.1
5	RH Outlet Safety Valve	Installed at the outlet of the reheater (spring loaded)	Chapter 3.4.1

2.5. Superheater, Reheat Steam Temperature Control System

The boiler is equipped with various systems and equipment to control steam temperature.

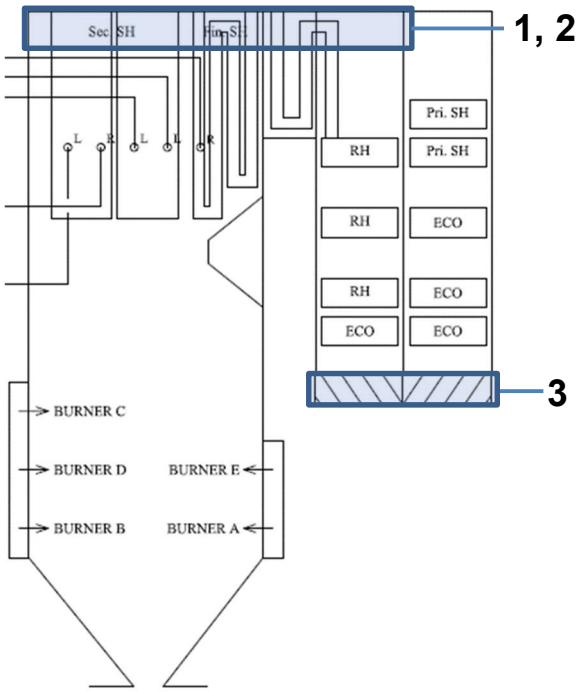


Fig.2.5 Steam Temperature Control System Arrangement

Table 2.5 : Steam Temperature Control System Outline

No.	Component name	Description	Reference section
1	Superheater Spray	Used to control the main steam temperature in the turbine inlet under the set point.	Chapter 3.1.3.1
2	Reheater Spray	Used as the backup system for the Reheat Steam Temperature Control System by STC damper. The RH Spray is used in emergency when the reheat steam temperature exceeds the set point.	Chapter 3.1.4.2
3	STC damper	Controls the reheater outlet (hot reheat) steam temperature by adjusting the Reheater/Superheater gas flow.	Chapter 3.1.4.2

2.6. Steam and Feedwater System

This section explains the boiler feedwater system, steam flow control system, feedwater flow control system, and other related systems.

2.6.1. Main Steam, Reheat Steam, Feedwater System

The boiler feedwater and steam flow as follows:

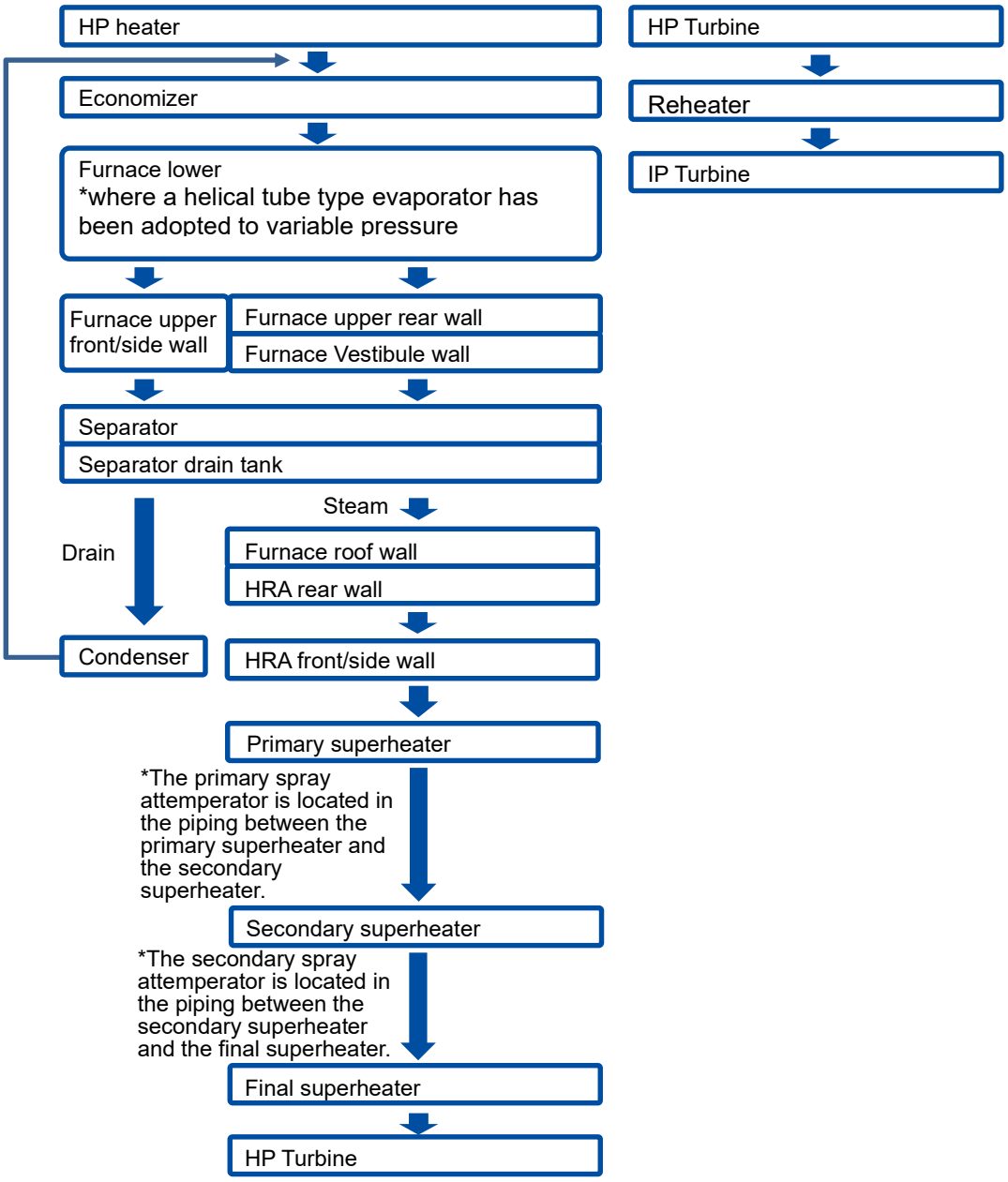


Fig.2.6.1 Boiler SH/RH steam and Feedwater Flow

Each component details are shown in Table 2.1, 2.1.1, 2.1.2, 2.1.3.

2.6.2. Valves (motor, control)

The boiler feedwater system has multiple valves to control feedwater flow.

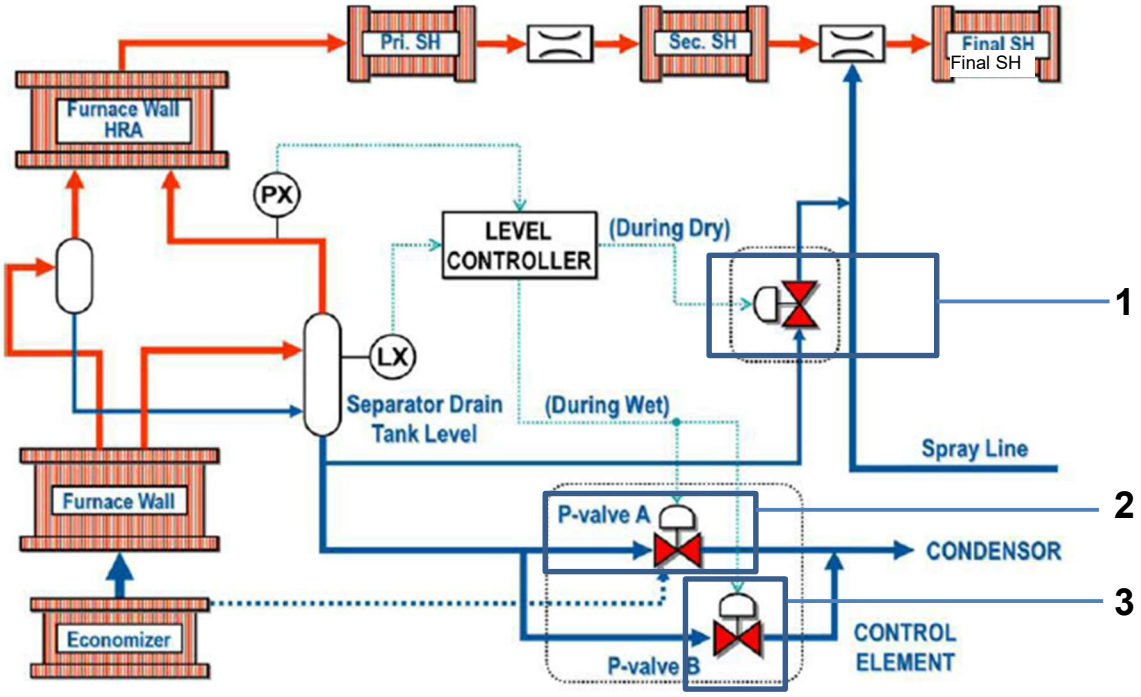


Fig.2.6.2 Valves Arrangement

Table 2.6.2 : Valves Outline

No.	Component name	Description	Reference section
1	Separator Drain Tank Water Relief Valve	The valve to protect P-valve from damage that may be caused by hot drain water.	Chapter 3.5.2
2	P-valve	The valve to maintain the separator drain tank level.	Chapter 3.5.2

2.6.3. Start-up Bypass System

The start-up bypass system relieves the surplus water flow coming from the difference between feedwater flow to furnace and steam flow from water-steam separator.

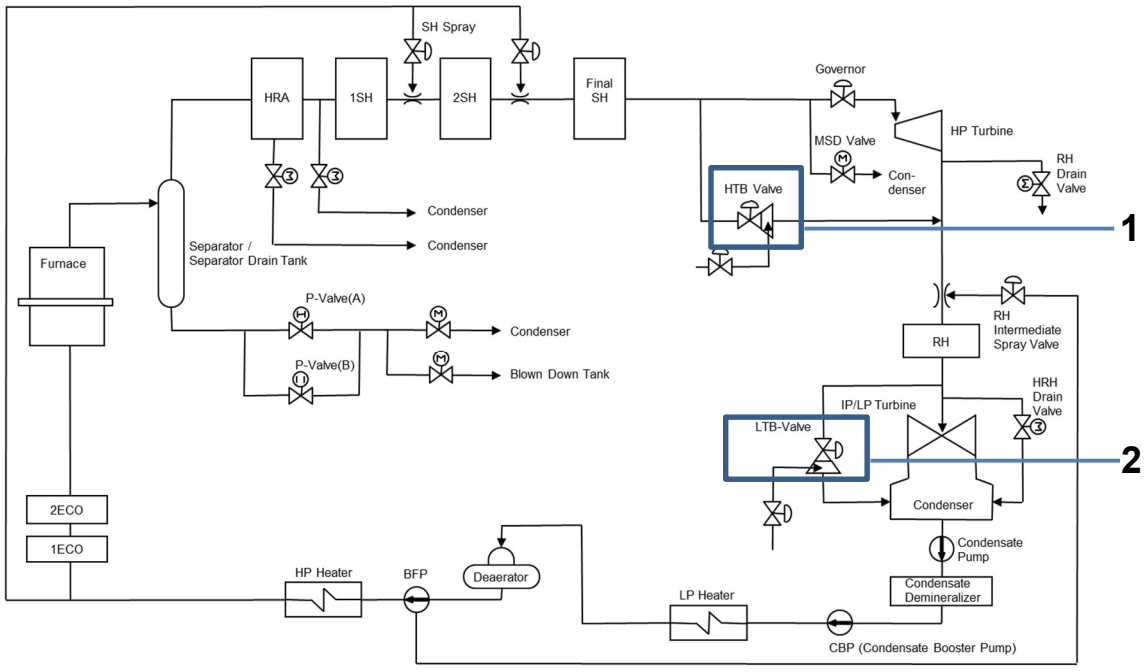


Fig.2.6.3 Start-up Bypass System Arrangement

Table 2.6.3 : Start-up Bypass System Outline

No.	Component name	Description	Reference section
1	HP Turbine Bypass Valve	The valve to bypass the HP Turbine and return the main steam to the Cold Reheat Pipe after reducing pressure and temperature to protect the RH of the Boiler.	Chapter 3.5.3
2	LP Turbine Bypass Valve (Other's scope)	The valve to bypass the LP Turbine and return the hot reheat steam to the Condenser after reducing pressure and temperature.	Chapter 3.5.3

2.7. Air and Flue Gas System

The boiler is equipped with the air and flue gas system.
Flue gas flowing in the boiler plant is exhausted to the atmosphere via the Air Gas system. The Air Flue Gas system is equipped with the following equipment:

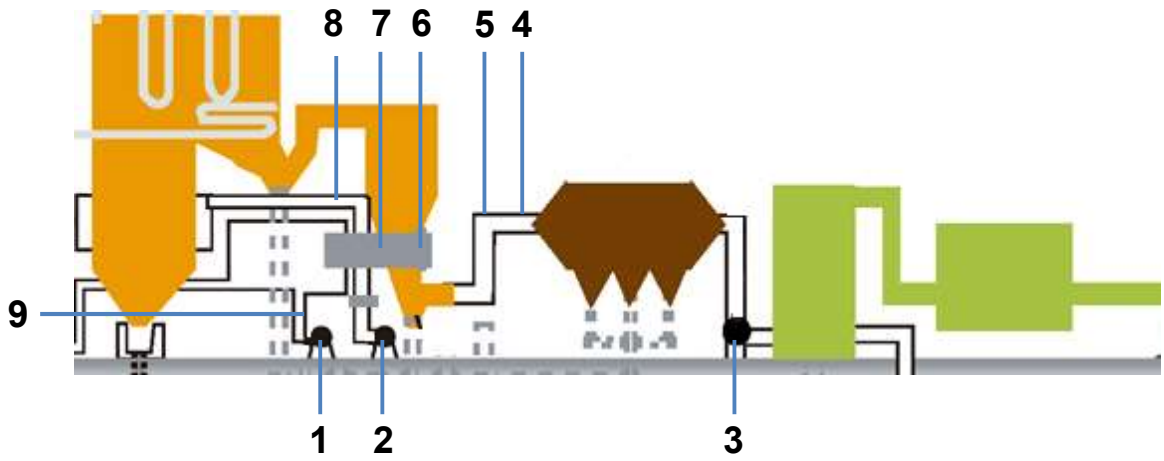


Fig.2.7 Air and Flue Gas System Arrangement

Table 2.7 : Air and Flue Gas System Outline

No.	Component name	Description	Reference section
1	PAF (Primary Air Fan)	Used to convey primary air to pulverizers through AH (Air Heater) so as to make hot air required by the pulverizer.	Chapter 3.6.2
2	FDF (Forced Draft Fan)	Used to convey secondary air to pulverized-coal burners, OAP (Over Air Ports), and Boundary Air System through AH.	Chapter 3.6.1
3	Induced Draft Fan (Other's scope)	Used to convey flue gas to the chimney.	-
4	Flue Gas Duct	To convey flue gas.	Chapter 3.6.5
5	Damper (including control drive) and Expansion Joints	Used to protect Flue Gas Duct.	Chapter 3.6.6
6	AH Bypass	Used to bypass secondary air flow passing AH.	Chapter 3.6.4
7	AH (Air Heater)	The heater is for reducing gas temperature to recover heat energy waste of flue gas at boiler outlet.	Chapter 3.6.3
8	Secondary Air Duct	For conveying secondary air from FDF to the furnace.	Chapter 3.6.5
9	Primary Air Duct	For conveying primary air from PAF to Palverizers.	Chapter 3.6.5

2.8. Auxiliary Steam System (Boiler Portion)

The auxiliary steam is extracted from the HRA outlet header of the boiler, CRP or others to the auxiliary steam mother pipe at a constant pressure and then supplied to each plant equipment. In order to ensure adequate auxiliary steam supply, the steam source is switched depending on the boiler plant operation status.

2.9. Pulverizer System

In the coal-fired boiler plant, a set of pulverizers is equipped to pulverize coal for fuel.
The Pulverizer System is composed of Coal Bunker, Coal Feeder and Pulverizer.

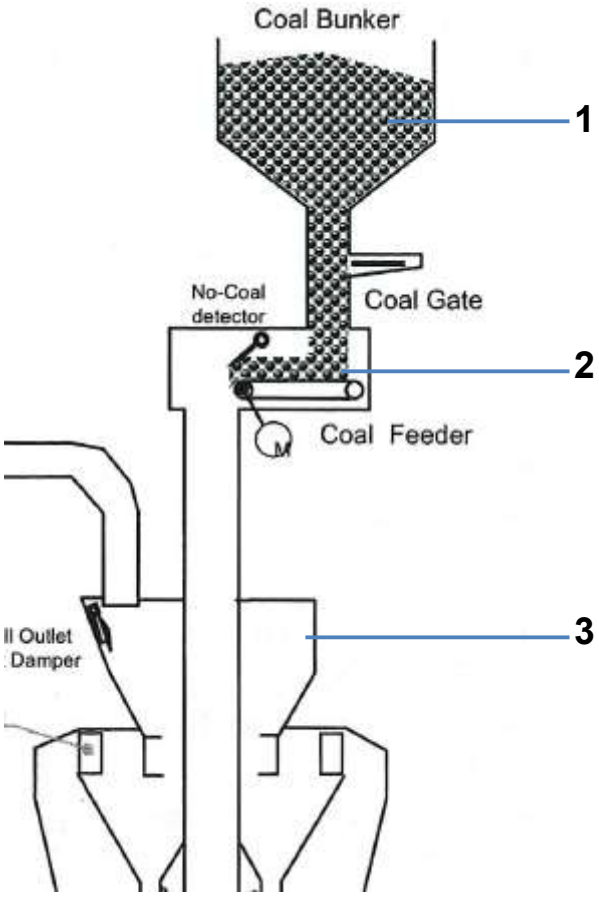


Fig.2.9 Pulverizer System Arrangement (Typical arrangement example)

Table 2.9 : Pulverizer System Outline

No.	Component name	Description	Reference section
1	Coal Bunker	Used to store coal and supply it to the pulverizer.	Chapter 3.8.1
2	Coal Feeder	Used to feed coal conveyed from the Coal Bunker to the pulverizer.	Chapter 3.8.2
3	Pulverizer	To dry up and to pulverize the coal conveyed from the Coal Feeder. The classifier is to produce fine coal powder, which has two fixed type or rotary type. Fixed type is adopted for this plant.	Chapter 2.9.1

2.9.1. Pulverizer

The Pulverizer consists of the following components.

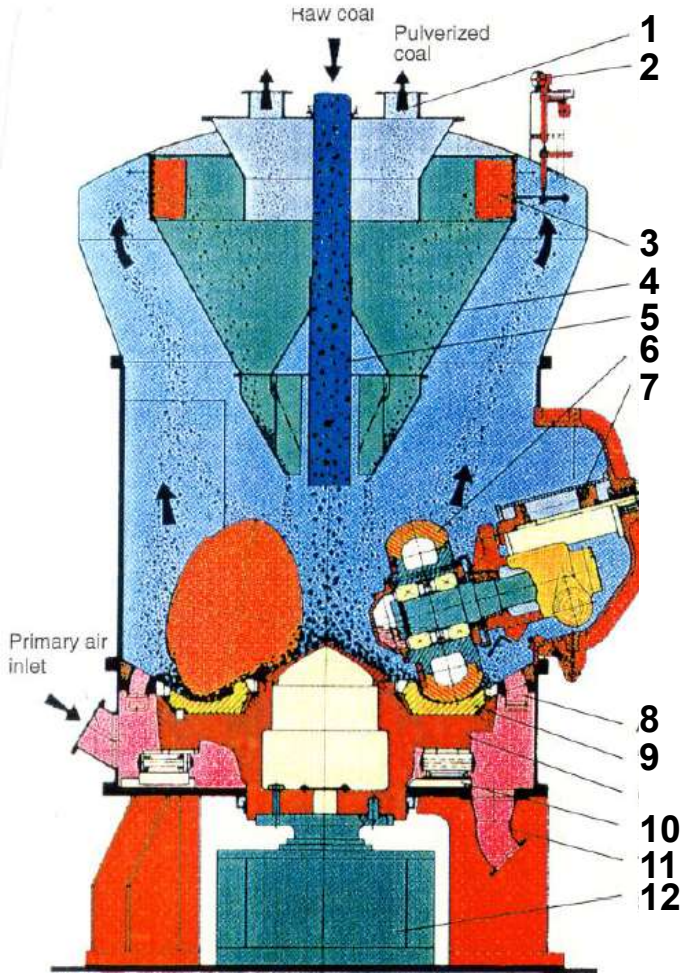


Fig.2.9.1 Location of Pulverizer with Fixed Classifier Vanes (Typical arrangement example)

Table 2.9.1 : Structure and Description of Pulverizer

No.	Component name	Description	Reference section
1	Pulverized Coal Pipe	Transfers the pulverized coal to the burner, after passing through the Classifier Vane	Chapter 3.8.3
2	Vane operating mechanism	Controlling Opening of Classifier Vane.	Chapter 3.8.3
3	Classifier Vanes	Vane portion of a static type classifier.	Chapter 3.8.3
4	Reject Chute	Flow path used for sending back the coarse pulverized coal classified by the classifier vane to the grinding table.	Chapter 3.8.3
5	Coal Feed Pipe	Flow path used for supplying coal to the pulverizer.	Chapter 3.8.3
6	Grinding Roller	Bites and pulverizes the coal between the grinding table and grinding roller.	Chapter 3.8.3
7	Spring loading for Roller	Spring tension loading roller.	Chapter 3.8.3
8	Air Ports	Ring of the air port from which the primary air is blown out at high speed.	Chapter 3.8.3
9	Grinding Table	Bites and pulverizes the coal between the grinding table and grinding roller.	Chapter 3.8.3
10	Scraper	Used for removing foreign objects that fall into the primary air chamber and are not pulverized.	Chapter 3.8.3
11	Pyrite Chute	Used for discharging the pyrite.	Chapter 3.8.3
12	Speed Reduction Drive	Reduces the mill motor rotation speed and transmits the power for pulverizing coal to the grinding table.	Chapter 3.8.3

2.10. Fuel Oil System (Boiler Portion)

The Fuel Oil System supplies fuel oil to oil burner at the boiler plant during boiler plant start-up / shut-down.

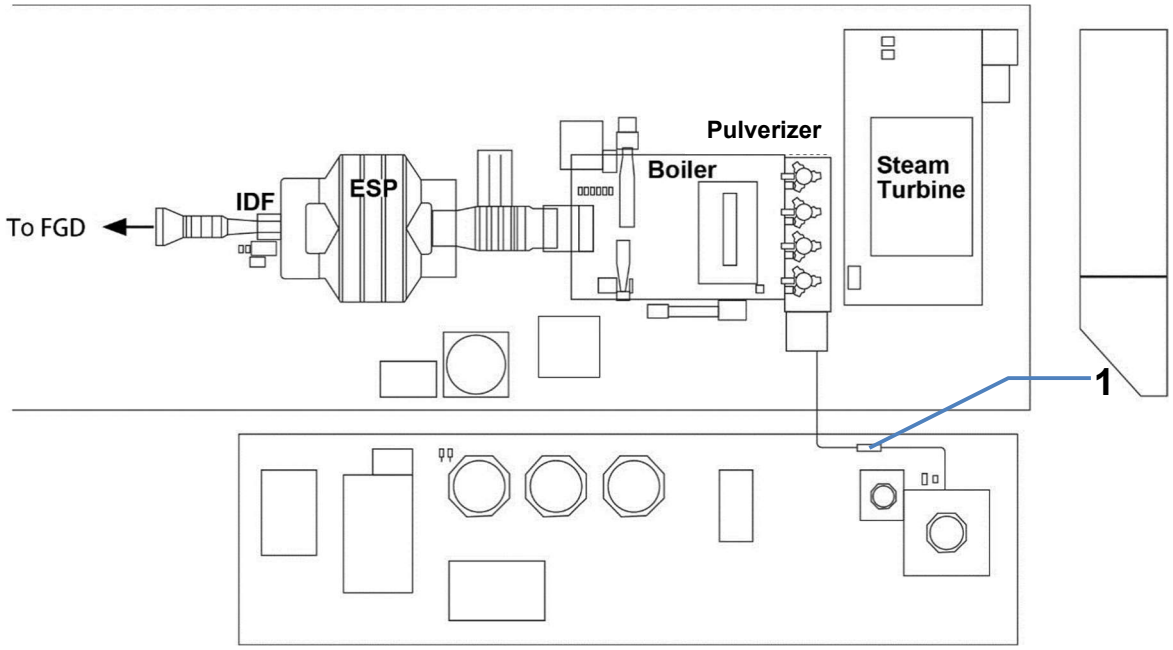


Fig.2.10 Fuel Oil System Arrangement (Typical arrangement example)

Table 2.10 : Fuel Oil System Outline

No.	Component name	Description	Reference section
1	Accumulator	The accumulator controls the oil pressure at the burner inlet at a constant level at burner ignition.	Chapter 3.9.1

2.11. Furnace CCTV and Flame Detector

CCTV (Closed Circuit TV) is to monitor the combustion status in the furnace.
Flame Detector is equipped to each burner to sense the flame of the burners.

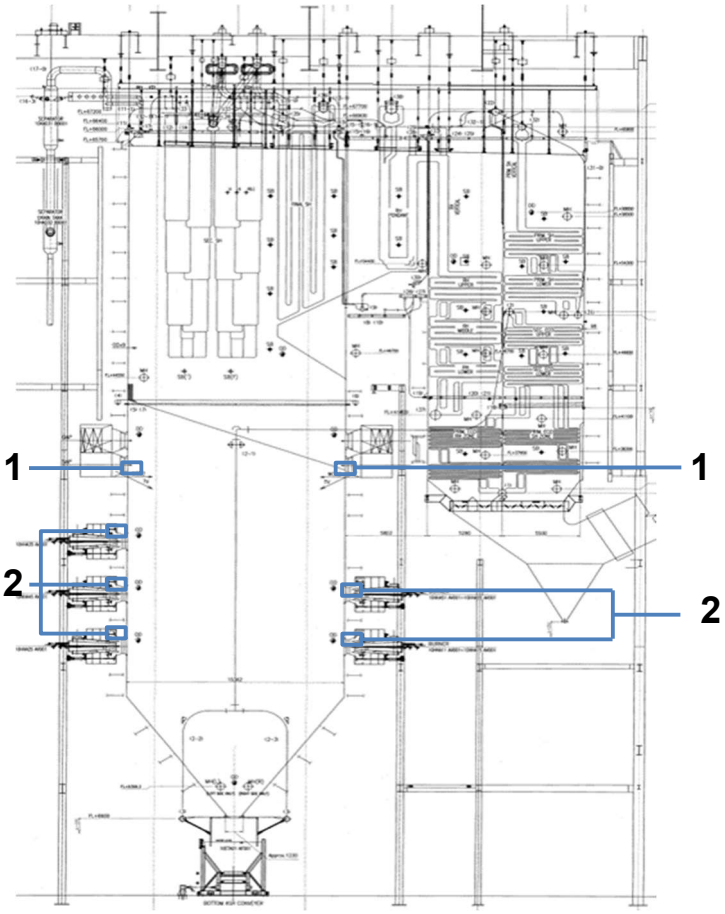


Fig.2.11 Furnace Interior Monitoring Apparatus Arrangement (Typical arrangement example)

Table 2.11 : Furnace Interior Monitoring Apparatus Outline

No.	Component name	Description	Reference section
1	Furnace CCTV	To monitor the combustion status of the burners and formation of the slag in the furnace.	Chapter 3.1.1.5
2	Flame Detector	To detect existence of flame of the burner.	Chapter 3.1.1.5

2.12. Waste Water System (Boiler Portion)

The Waste Water System is to recover and transfer waste water discharged from plant equipment and facility.

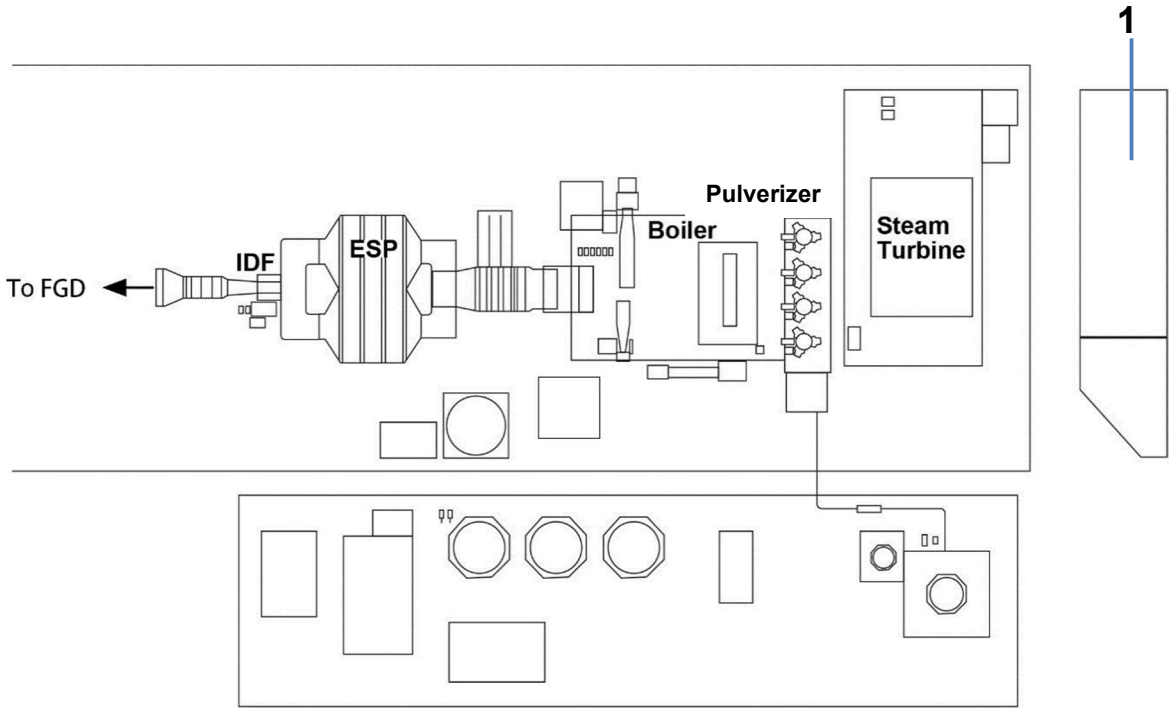


Fig.2.12 Waste Water System Arrangement (Typical arrangement example)

Table 2.12 : Waste Water System Outline

No.	Component name	Description
1	Waste Water System	The Waste Water system is to recover and transfer the various kind of waste water discharged from plant equipment and facility. Waste water discharged to Boiler Buffer Sump is transferred to WWTP (Waste Water Treatment Plant) which is Other's portion.

2.13. Ash Handling System

The Ash Handling System is for processing ash accumulated in the furnace bottom or in each hopper, and foreign objects discharged from the pulverizer.

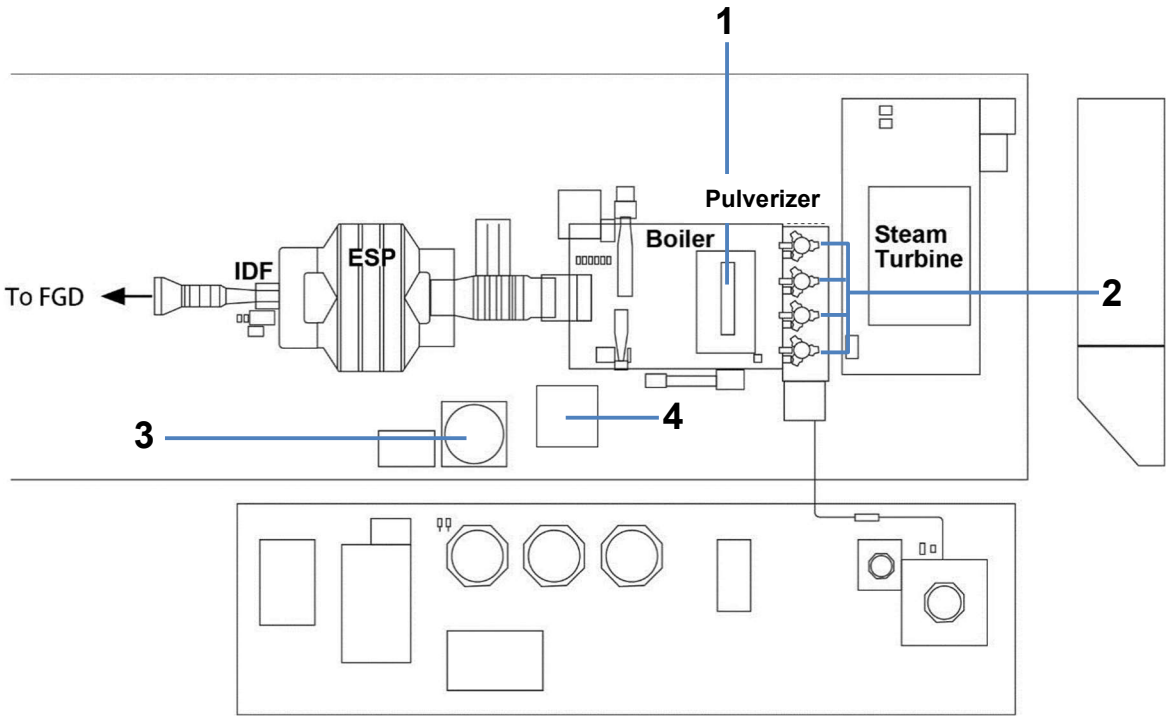


Fig.2.13 Ash Handling System Arrangement (Typical arrangement example)

Table 2.13 : Ash Handling System Outline

No.	Component name	Description
1	BA (Bottom Ash) Handling System	BA from the Boiler furnace hopper is conveyed to the bottom ash storage area by SCC (Submerged Chain Conveyor) .
2	Mill Pyrite Handling System	The system is for collecting foreign objects that may be contained in coal discharged from the pulverizer and discharging them out of the system.
3	FA (Fly Ash) Handling System	FA from ECO hopper, AH hopper and ESP hopper is conveyed to FA Silo by the compressed air conveying system which is Other's portion.

2.14. Service Water System (Boiler Portion)

Service Water supplied from Other's portion is distributed to each equipment in Boiler Portion.

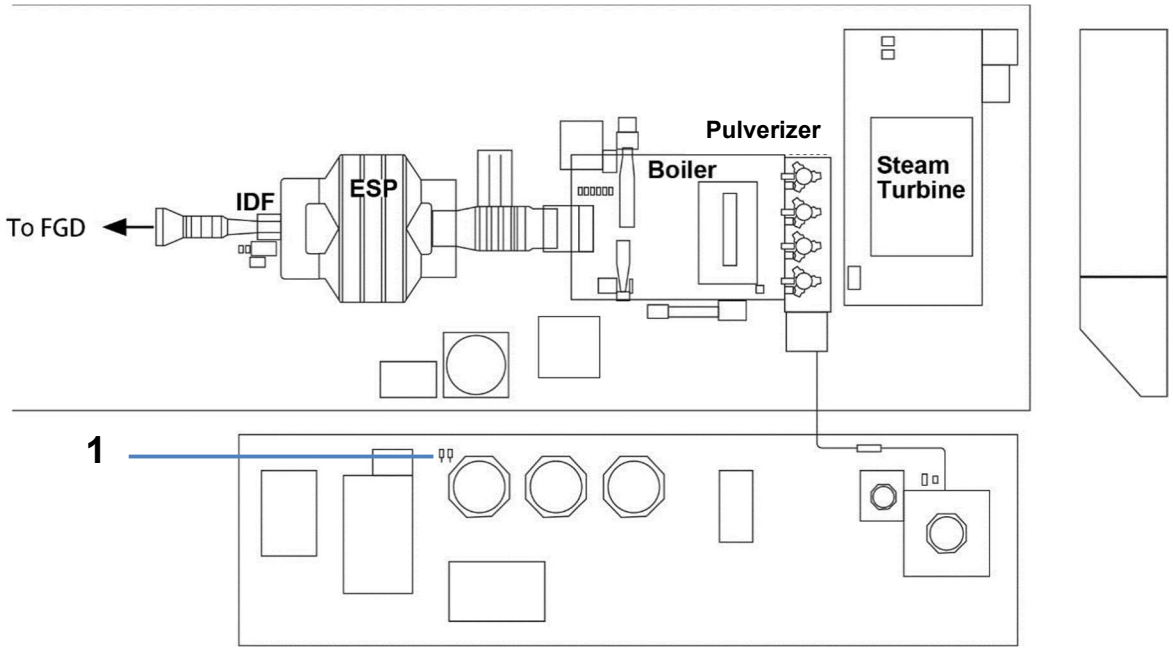


Fig.2.14 Service Water System Arrangement (Typical arrangement example)

Table 2.14 : Service Water System Outline

No.	Component name	Description	Reference section
1	Service Water System	Service Water supplied from Other's portion is distributed to each equipment in Boiler Portion.	Chapter 3.10

2.15. Closed Cycle Cooling Water System (Boiler Portion)

The cooling water supplied from Other's portion is distributed to various rotating devices in the boiler plant.

2.16. Cooling and Sealing Air System

Flame Detector and camera Cooling Fan supply air for cooling, sealing and purging the relevant parts of the Flame Detector and CCTV.

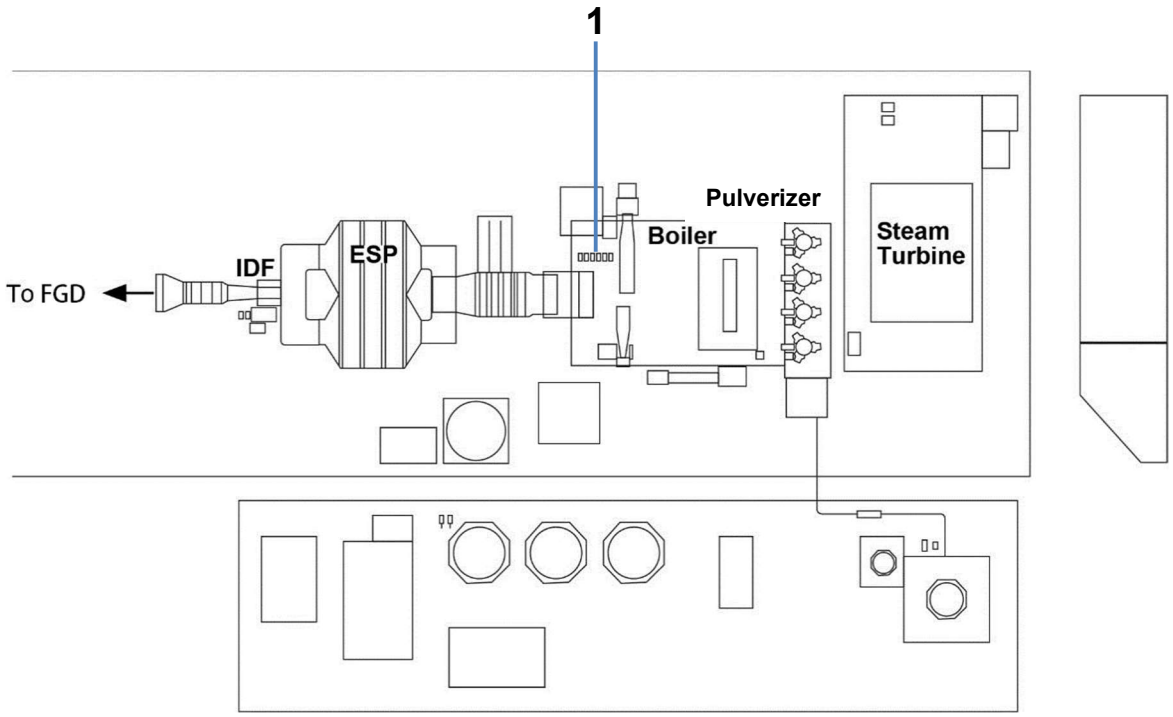


Fig.2.16 Cooling and Sealing Air System Arrangement (Typical arrangement example)

Table 2.16 : Cooling and Sealing Air System Outline

No.	Component name	Description	Reference section
1	Flame Detector Cooling Fan	The fan is for cooling, sealing and purging the relevant parts of the Flame Detector, CCTV, Sootblower, Water Sootblower and Ignitor.	Chapter 3.12.1

2.17. Compressed Air System (Boiler Portion)

The Compressed Air System supplies the control and in-house air in the plant.

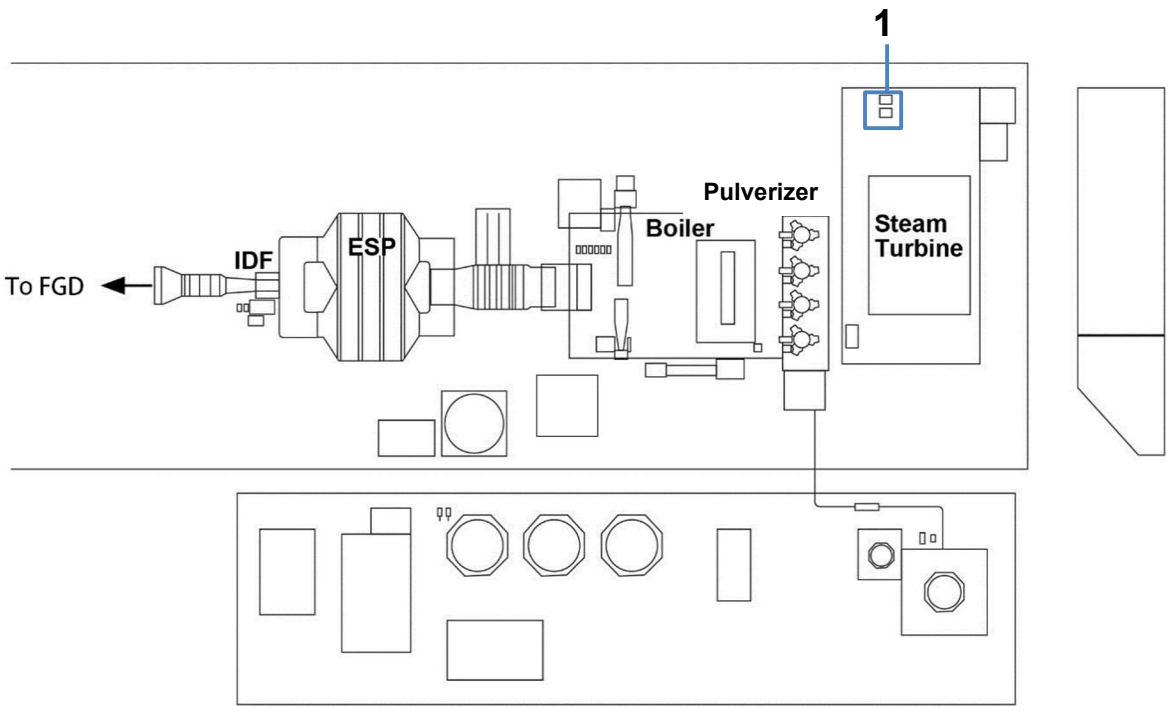


Fig.2.17 Compressed Air System Arrangement (Typical arrangement example)

Table 2.17 : Compressed Air System Outline

No.	Component name	Description	Reference section
1	Instrument Air System	The system is for supplying compressed air from Other's portion to instrumentation and control system in the boiler plant, the turbine plant and the other Balance of Plant.	Chapter 3.13.1
2	Station Air System	The system is for supplying compressed air from Other's portion to each of users in the boiler plant, the turbine plant and the other Balance of plant.	Chapter 3.13.2

2.18. Blowdown Drain System

The Blowdown Drain System collects the blowdown drain discharged from each equipment in the boiler plant and separates it into steam and water at atmospheric pressure.

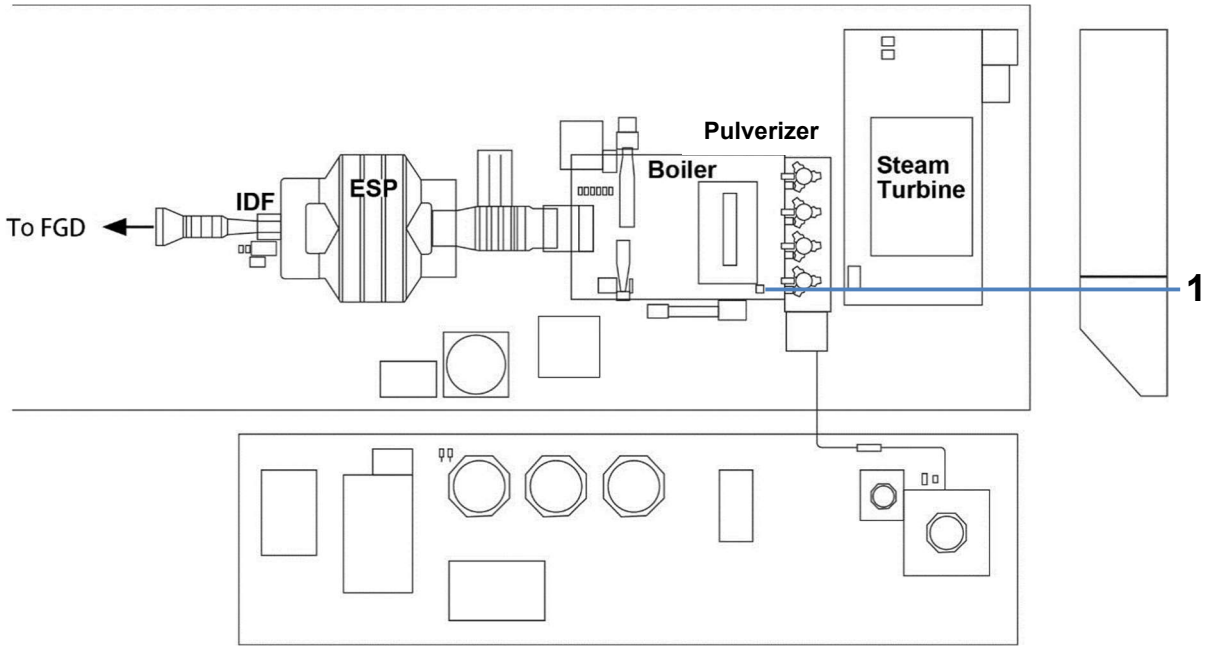


Fig.2.18 Blowdown Drain System Arrangement (Typical arrangement example)

Table 2.18 : Blowdown Drain System Outline

No.	Component name	Description	Reference section
1	Boiler Blowdown Tank	To collect the drain discharged from the steam and water system during the boiler start-up, shut-down and operation.	Chapter 3.14.1

2.19. Air Vent and Nitrogen Gas System

The Air Vent and Nitrogen Gas System prevents each pipe in the boiler plant from deteriorating.

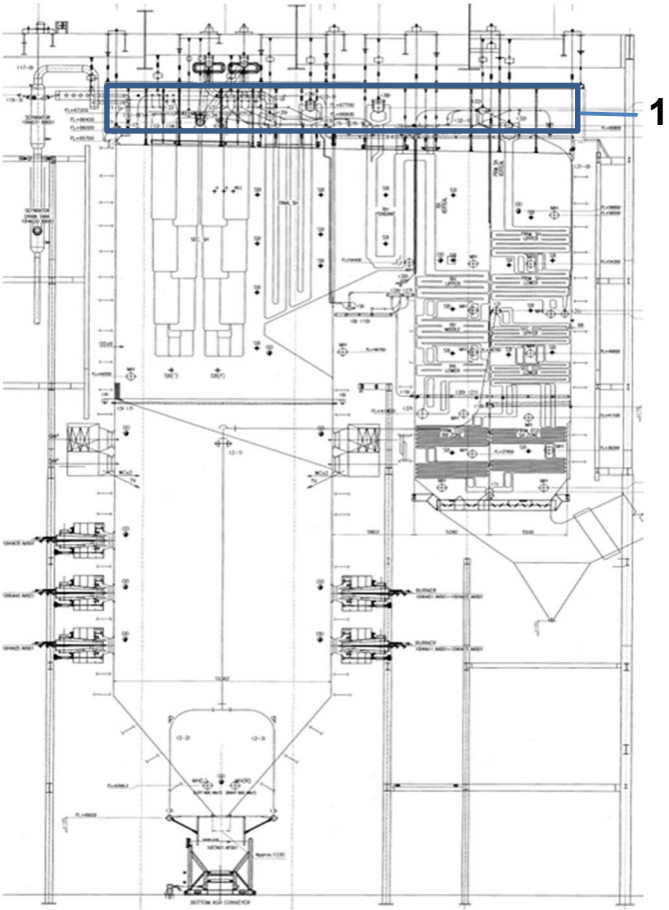


Fig.2.19 Air Vent and Nitrogen Gas System Arrangement (Typical arrangement example)

Table 2.19 : Air Vent and Nitrogen Gas System Outline

No.	Component name	Description	Reference section
1	Air Vent and Nitrogen Gas System	The system is for preventing deterioration inside piping by putting nitrogen gas from the air vent.	Chapter 3.15

2.20. Fire Fighting System (Boiler Portion)

For fire fighting system, refer to the following document.

“VP1-C-L1-M-SG-30046 (F533-101) Specification and Drawing for Fire Fighting System (IHI Portion)”.

2.21. Boiler Steel Structures

For boiler steel structures, refer to the following documents:

VP1-C-L1-C-UHA-20006 (K100-221) Boiler Steel Structure Elevation Drawing ROW-B1, B11
VP1-C-L1-C-UHA-20007 (K100-222) Boiler Steel Structure Elevation Drawing ROW-B1a, B11a
VP1-C-L1-C-UHA-20008 (K100-223) Boiler Steel Structure Elevation Drawing ROW-B1b, B11b
VP1-C-L1-C-UHA-20009 (K100-224) Boiler Steel Structure Elevation Drawing ROW-B2～B2a, B12～B12a
VP1-C-L1-C-UHA-20010 (K100-225) Boiler Steel Structure Elevation Drawing ROW-B2b, B12b
VP1-C-L1-C-UHA-20011 (K100-226) Boiler Steel Structure Elevation Drawing ROW-B3, B13
VP1-C-L1-C-UHA-20012 (K100-227) Boiler Steel Structure Elevation Drawing ROW-B3a, B13a
VP1-C-L1-C-UHA-20013 (K100-228) Boiler Steel Structure Elevation Drawing ROW-B3b, B13b
VP1-C-L1-C-UHA-20014 (K100-229) Boiler Steel Structure Elevation Drawing ROW-B4, B14
VP1-C-L1-C-UHA-20015 (K100-230) Boiler Steel Structure Elevation Drawing ROW-B5～B5a, B15～B15a
VP1-C-L1-C-UHA-20016 (K100-231) Boiler Steel Structure Elevation Drawing ROW-B5b, B15b
VP1-C-L1-C-UHA-20017 (K100-232) Boiler Steel Structure Elevation Drawing ROW-B6, B16
VP1-C-L1-C-UHA-20018 (K100-233) Boiler Steel Structure Elevation Drawing ROW-B6a, B16a
VP1-C-L1-C-UHA-20019 (K100-234) Boiler Steel Structure Elevation Drawing ROW-B6b, B16b
VP1-C-L1-C-UHA-20020 (K100-235) Boiler Steel Structure Elevation Drawing ROW-BA
VP1-C-L1-C-UHA-20021 (K100-236) Boiler Steel Structure Elevation Drawing ROW-BB
VP1-C-L1-C-UHA-20022 (K100-237) Boiler Steel Structure Elevation Drawing ROW-Bba
VP1-C-L1-C-UHA-20023 (K100-238) Boiler Steel Structure Elevation Drawing ROW-BC
VP1-C-L1-C-UHA-20024 (K100-239) Boiler Steel Structure Elevation Drawing ROW-Bca
VP1-C-L1-C-UHA-20025 (K100-240) Boiler Steel Structure Elevation Drawing ROW-BD
VP1-C-L1-C-UHA-20026 (K100-241) Boiler Steel Structure Elevation Drawing ROW-Bda
VP1-C-L1-C-UHA-20027 (K100-242) Boiler Steel Structure Elevation Drawing ROW-BE
VP1-C-L1-C-UHA-20028 (K100-243) Boiler Steel Structure Elevation Drawing ROW-BF
VP1-C-L1-C-UHA-20029 (K100-244) Boiler Steel Structure Elevation Drawing ROW-BG
VP1-C-L1-C-UHA-20030 (K100-245) Boiler Steel Structure Elevation Drawing ROW-BH

2.22. Hoists (Fan, Pump, Pulverizer….)

The boiler is equipped with hoists to raise Fans, Pump, Pulverizer, and other devices to be transported in the boiler.

For maintenance using hoists, refer to “VP1-C-L1-M-SM-30047 (F544-001) Specification and Drawing for Electrical Hoist (IHI Portion)”

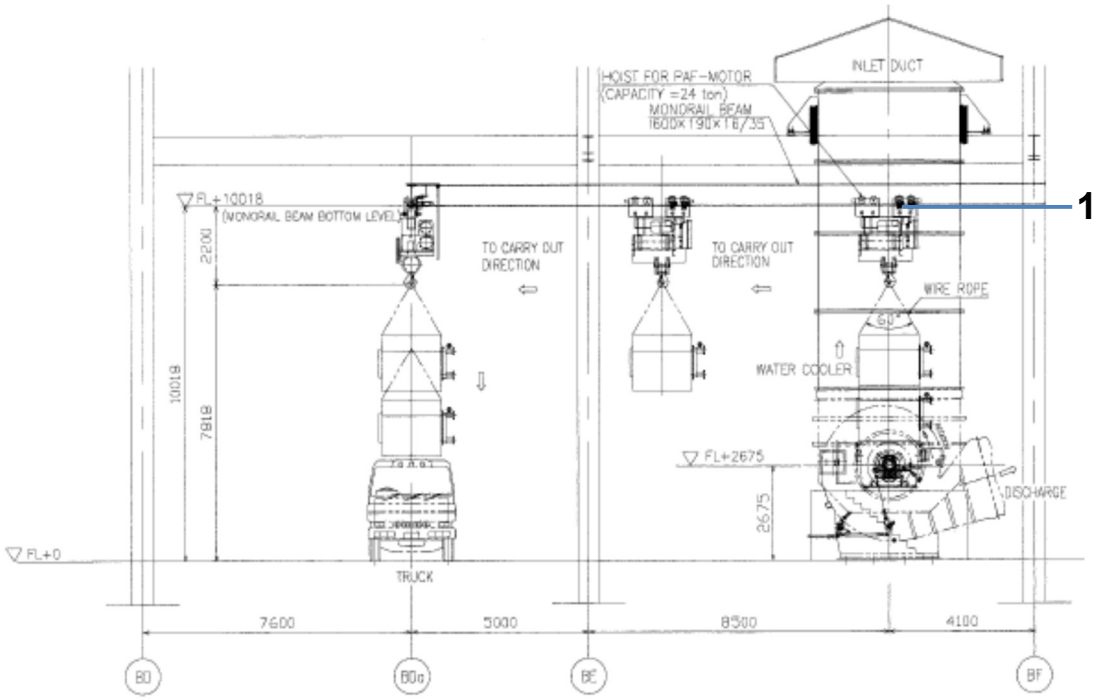


Fig.2.22 Hoist Arrangement (Typical arrangement example)

Table 2.22 : Hoist Outline

No.	Component name	Description
1	Electrical driven hoist	The Electrical driven hoist is the device to raise and transport various devices for maintenance.

2.23. Elevator (Boiler Portion)

The boiler is equipped with an elevator to carry personnel and goods transportation.

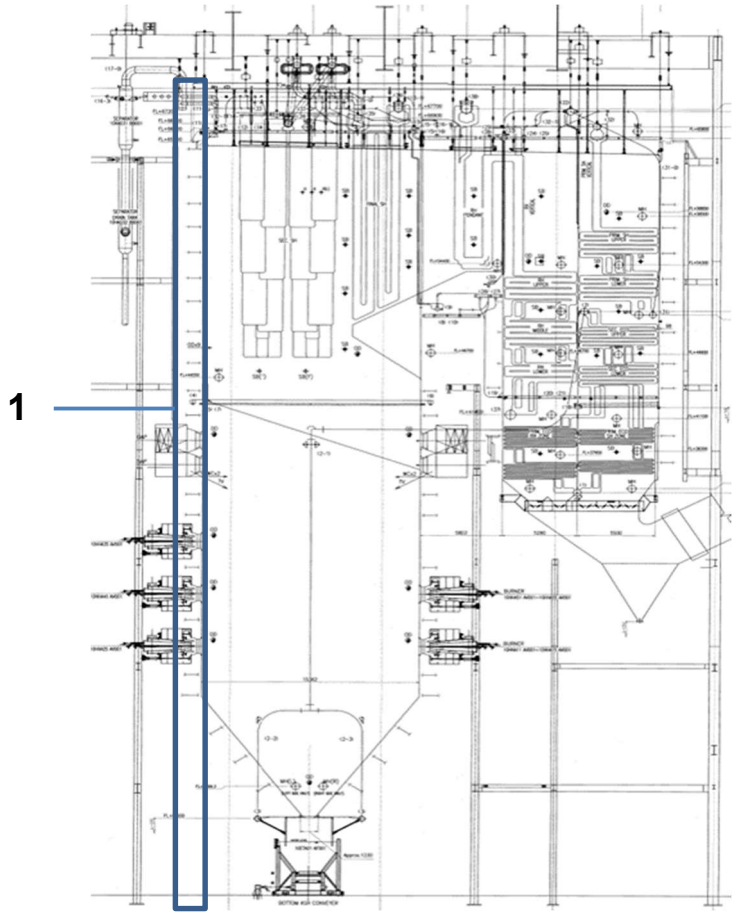


Fig.2.23 Elevator Arrangement

Table 2.23 : Elevator Outline

No.	Component name	Description
1	Boiler Elevator	The boiler elevator is for transporting personnel and goods.

3. Functions of Boiler Plant System

This chapter explains the functions of each equipment and system composing the boiler plant.

3.1. Pressure Parts

This section explains the various pressure parts functions of the boiler plant.

3.1.1. Furnace

This subsection provides the arrangement of the furnace components of the boiler.

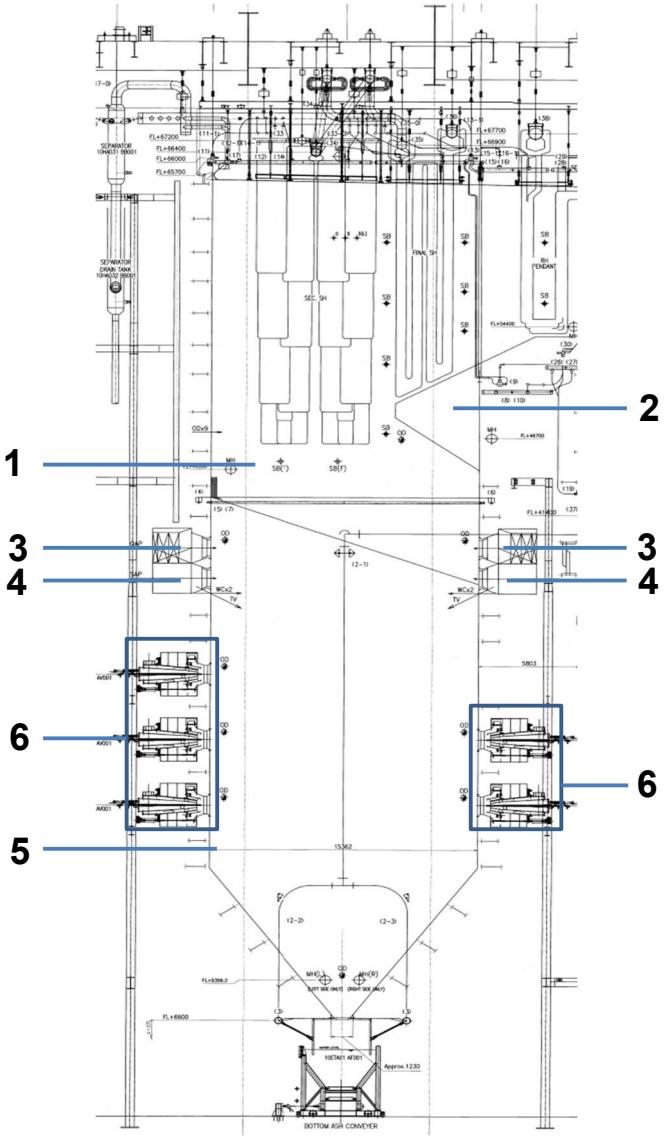


Fig. 3.1.1 Furnace Components Arrangement

No.	Component name
1	Upper Furnace Path
2	Furnace Nose
3	OAP (Over Air Ports)
4	SAP (Side Air Ports)
5	Lower Furnace Path
6	Burners

3.1.1.1. Furnace Functional Description

The Boiler Furnace is designed as described below so that excessive slagging does not affect the performance of the coal-fired Boiler.

The Furnace is enclosed by the front, rear and both side water-walls and has the radiant platen superheaters in the upper Furnace portion. It is also equipped with the various kinds of air ports having the Nitrogen Oxides (NOx) emission control function.

Conservative Furnace design

Subbituminous coal such as PRB (Powder River Basin) coal in USA has severe slagging characteristics. The Furnace of the Boiler is designed to prevent it from slagging trouble.

Optimum placement and clearance of Burners

Enough clearance is made between the water-wall surfaces and the Burners to prevent deposits of ash and slag caused by impingement between the flames and Furnace walls. For the large boilers, the Burners are arranged on the front and the rear walls so called as the opposed firing system.

Minimizing slagging on the Furnace Walls applying a Boundary Air System

An oxidizing (air rich) atmosphere is maintained in the vicinity of the Furnace Walls by introducing a small amount of air from the hopper bottom section which comes up along the Furnace walls. This arrangement is called the "Boundary Air system".

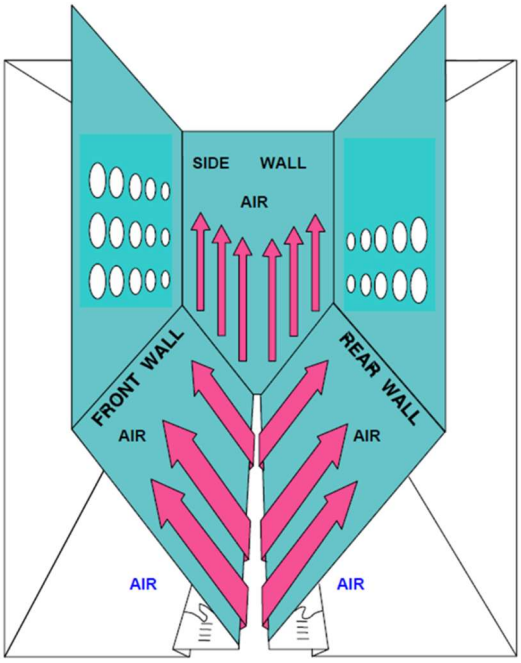


Fig. 3.1.1.1 (a) Boundary Air System

Minimizing use of the refractory castable

The Furnace is designed with minimum use of refractory castable (such as Burner throats and observation ports) which could cause slagging as a result of the high surface temperature during operation.

Gas-tight construction of fin-welded tubes

The furnace walls are composed of membrane wall in which all the tubes are welded to the fins placed between tubes. The membrane wall enables simplifying the construction of the furnace wall by eliminating possibility of gas leaking through the walls. Therefore, only the outer casing of the boiler is required on top of the sufficient insulation. The simple construction of the boiler wall helps to keep high reliability in the boiler operation.

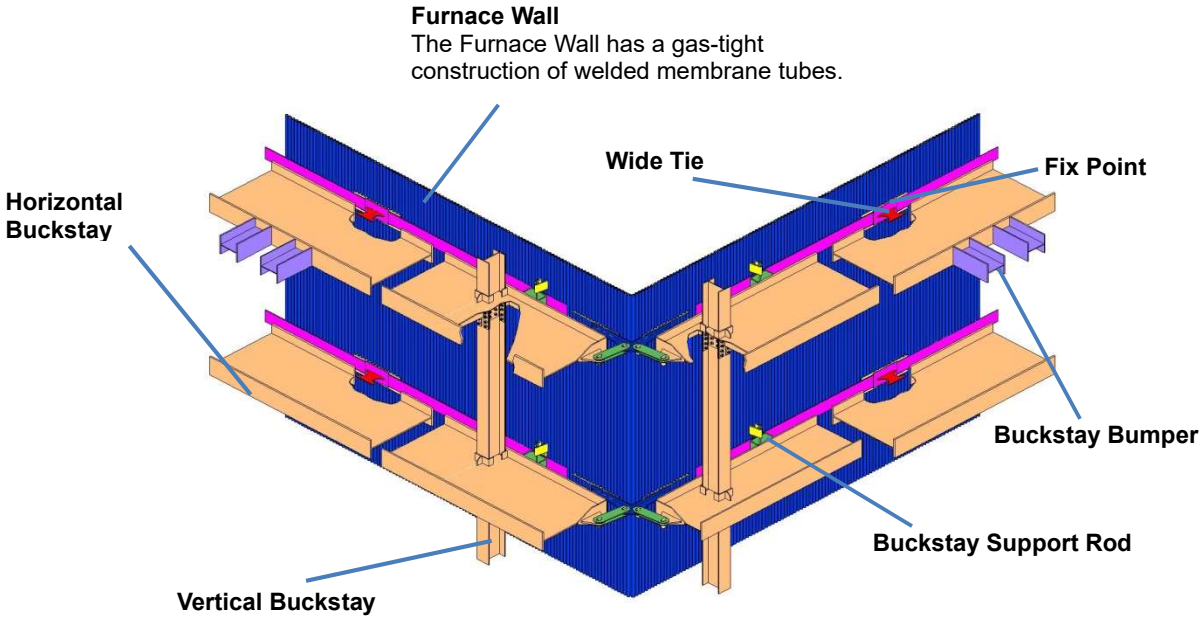


Fig. 3.1.1.1 (b) Gas-tight Construction of the Furnace Wall

The advantages of the Boiler Furnace Wall construction design are as follows:

- Robust Furnace Wall construction ensures a gas-tight Furnace and reduces maintenance cost of the Boiler.
- Assures gas leakage-free operation.
- It is possible to clean the furnace easily by water washing.

Combination of helical and vertical tube design

The furnace wall is so called as the Evaporator and consisted of the Lower and Upper Furnace Paths and intermediate headers.

The Lower Furnace Path has a construction of the helical tube wall. The helical tube wall is introduced in the high heat flux zone around the Burner. This zone shall have the two-phase flow; mixture of water and steam, at subcritical pressure operation during start-up and low load in the variable pressure operation. The helical tube wall construction enables to increase mass flow in the tubes keeping stable flow for eliminating overheating.

The Upper Furnace Path has a construction of the vertical tubes in considering a state of relatively low heat absorption. The mass flow can be lowered by increasing the number of the wall tubes which helps in minimizing the pressure drop through the Furnace Path.

The Intermediate Headers are installed between the Upper and Lower Furnace Paths which is designed to connect the two paths having different number of the tubes and helps to distribute the two-path flow evenly by equalizing the pressure.

Anti-erosion feature in the HRA (Heat Recovery Area)

The various kinds of the anti-erosion baffles and protectors are installed in the HRA (Heat Recovery Area) to prevent the heating element tubes from accumulation of the ashes on the tubes and erosion of the tubes by the ashes in the flue gas with combination of soot blowing steam forces.

Furnace Nose structure design

The furnace nose is installed in the upper part of the furnace rear wall to diverse the flue gas flowing evenly into the super heater zone located at top of the furnace and prevent the flue gas from entering the HRA directly and eliminating the potential for erosion.

INPACT (IHI NOx Preventing Advanced Combustion Technology)

For the two-stage combustion technology, OAP is positioned just above the combustion zone so as to reduce the air/fuel ratio for reduction of NOx in combustion of pulverized coal.

For the INPACT technology, sufficient distance is provided between the Burner and OAP so that fuel-NOx value can be reduced in the de-oxidizing zone created by the Low NOx Burner in which the pulverized coal shall be combusted in a fuel rich condition.

3.1.1.2. Furnace and HRA Wall Design

This subsection provides the features of the design of the Furnace Walls.

The Furnace and the HRA Walls are gas-tight construction of welded membrane tubes.
The furnace walls consist of front, rear, both sides and roof walls. The HRA walls consist of front, rear, both sides, intermediate and roof walls.

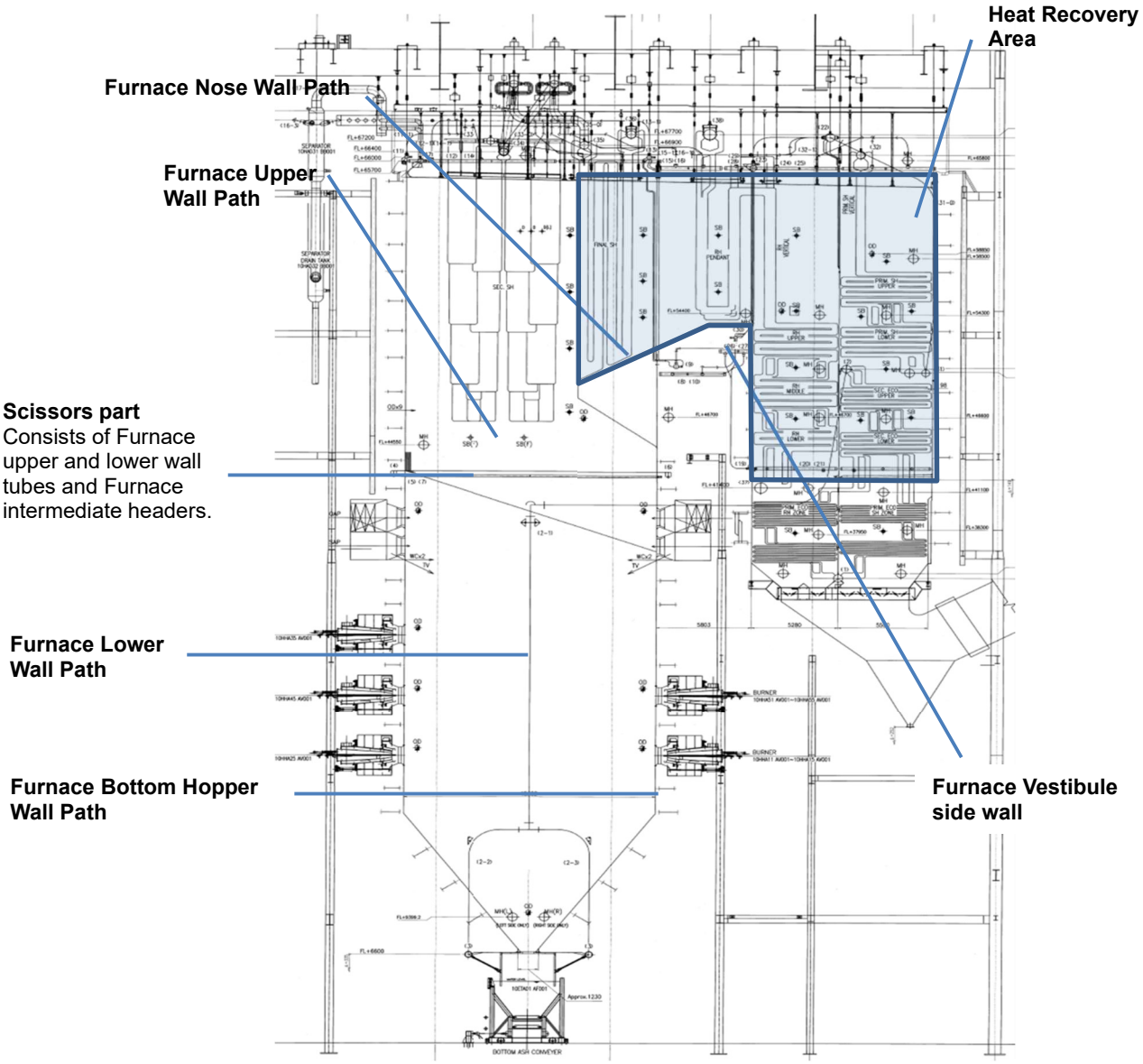


Fig. 3.1.1.2 Furnace and HRA Wall Design

Furnace Wall

The Furnace wall has the following paths.

- **Furnace Upper Wall Path**
  The Furnace Upper Wall Path is constructed with vertical tubes.
- **Furnace Lower Wall Path**
  The Furnace Lower Wall Path is constructed with helically wound tubes that has an angle of 21.32 degrees to the horizontal axis.
- **Furnace Nose Wall Path**
  The Furnace Nose Wall Path is upper section of the Furnace rear wall.
- **Furnace Bottom Hopper Wall Path**
  The slope of the Furnace Bottom Hopper wall is 55 degrees for ash and clinker discharge.

Scissors part (connection between Furnace Upper and Lower walls)

The fluid (mixture of boiling water and steam) coming up from the helical path is led to the Intermediate Headers where the fluid is mixed and flows to the Upper path.

It is so called ‘Scissors’ that this part is separating the furnace wall into the upper part and the lower part. The intermediate headers can connect the both parts which have different number of membrane wall tubes.

Furnace Vestibule side wall

The furnace vestibule is positioned above the furnace nose and connecting the Furnace and the HRA.
To reduce the thermal stress on the Furnace Vestibule side wall during start-up and shut-down, the front part of the side wall tubes is connected to the outlet of the Furnace Upper Path, the middle part of the side wall tubes is connected to the outlet of the Furnace Nose Path and the rear part of the side wall tubes are connected to the outlet of the HRA rear wall.

Roof wall and boundary and partition walls of Heat Recovery Area

The roof wall, rear wall, side wall, and partition wall of the HRA are constructed by welding of the tubes to the fins. The screen tubes part is arranged at the inlet of the SH zone and RH zone of the HRA for the flue gas flowing to the zone respectively.

The saturated steam from the separator flows into the furnace roof inlet header through the separator outlet steam pipes and flows downward the HRA rear wall through the roof wall tubes. The heated steam is collected in the HRA partition wall inlet header and the part of the steam is distributed to the HRA front and side wall inlet headers through the connecting pipes.

All the steam passing through the front, side and intermediate walls of the HRA is collected in the HRA intermediate outlet header before flowing into the primary super heaters.

3.1.1.3. Arrangement of Burners

This subsection provides the arrangement of the Burners installed on the lower furnace wall.

Burner placement and opposed firing

The Furnace is enclosed by the front, rear and both side walls in which the boiling water is flowing upward, so called as ‘water cooled wall’.

The radiant platen Superheaters are arranged at the upper furnace above the burner zone. This arrangement is called an "open furnace design" in which the entire furnace is enclosed by the front, rear, both sides and the radiant platen Superheaters.

Radiant platen Superheaters at the upper furnace

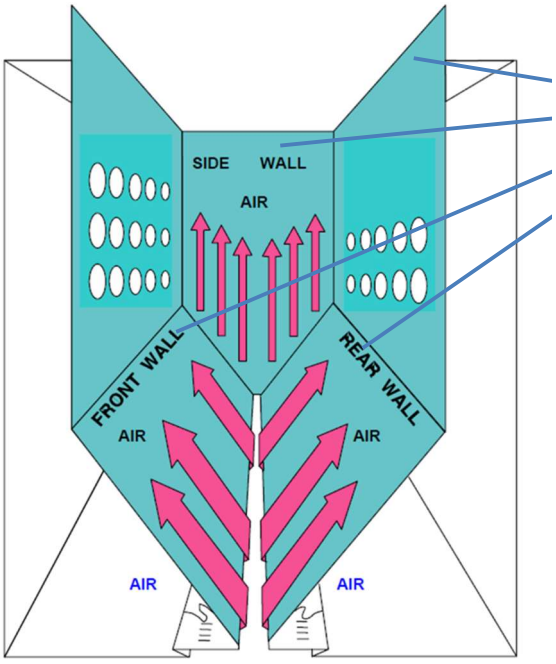


Fig.3.1.1.3 (a) Open Furnace Design

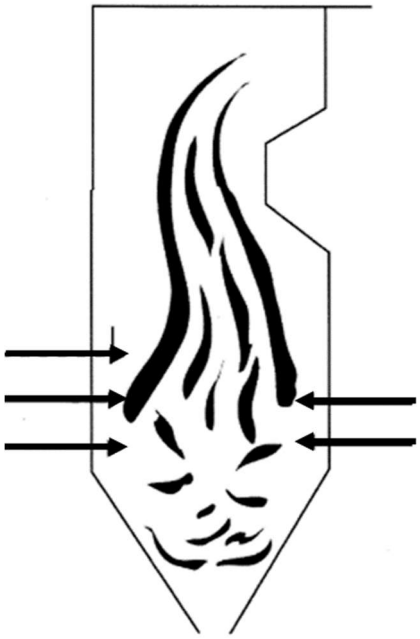
The Burners are arranged both in the front and the rear wall which is called an ‘opposed firing system’.

Sufficient distance is provided between the top-stage Burners and the Furnace Nose section for the flue gas flowing smoothly to the radiant platen Superheaters.

Advantages of Opposed Firing System

The uniform gas flow distribution in the Furnace and HRA enables a uniform distribution of ash concentration in the combustion gas and less possibility of erosion due to coal ash.

Also, uniformity of the temperature of gas leaving the furnace can reduce fouling in the HRA and lowers the local peak-metal temperature of the heating surface tubes.



- - - - - - High combustion efficiency
- Low unburned carbon
- Wide heat distribution
  The heat around the burners is distributed over a wide range. Therefore, uniform distribution of the heat-absorption rate can be achieved with respect to each furnace wall.

---------- Uniform gas flow and temperature distribution along the Furnace width
- Less inconsistency of steam temperature
- Lower maximum temperature of tube metal
- Safe and reliable heating element
- Easy and reliable combustion performance
- Uniform dust distribution
- Uniform gas-flow distribution and gas-temperature at the furnace exit.

====== Superior flame stability (individual firing)
-- Stable minimum load
-- Safe and reliable operation

Fig.3.1.1.3 (b) Advantages of an Opposed Firing System

3.1.1.4. Separate Duct System for Burners and Over Air Port

This subsection provides the features of the Separate Duct System and OAP System.

Separate Duct System used for Burners

Separate Duct System for secondary air duct is adopted to assure adequate combustion conditions.

Figure shows the arrangement of the burner inlet secondary air duct called “Separate Duct System”.

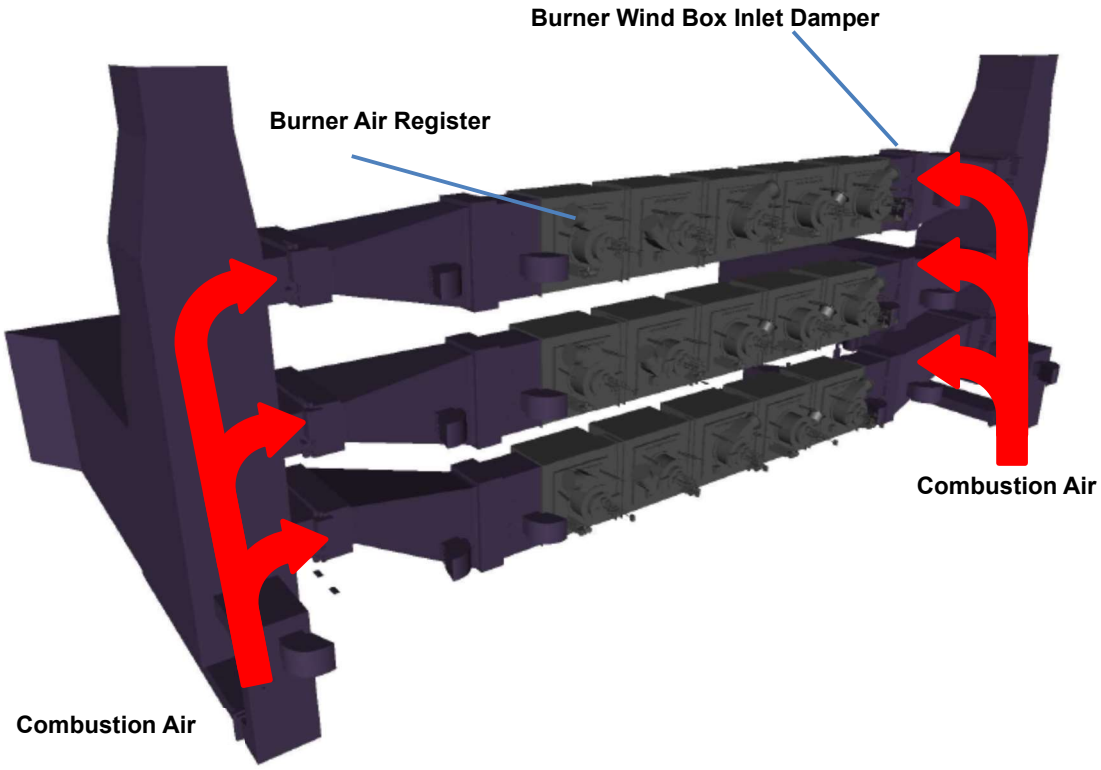


Fig.3.1.1.4 (a) Separate Duct System Used for Burners

Over Air Port System

OAP and SAP are arranged above the top row of the Burners through which a part of the combustion air is injected into the Furnace. OAP and SAP air is branched from the secondary air duct for the staged combustion.
The structure is shown in Fig.3.1.1.4 (d). OAP and SAP consists of tube, castable and throat ring.

- **OAP (Over Air Ports)**
  To complete the combustion for the staged combustion, OAPs are installed at above the top row of the Burners.

- **SAP (Side Air Ports)**
  To control the oxygen concentration in the flue gas evenly at the furnace exit, SAPs are installed at the side of OAP. SAPs are useful to complete combustion between OAP and the side wall and to reduce the unburned carbon.

Branched from Secondary Air Duct
Air distribution of OAP and SAP is established using a manual damper in the combustion tuning part.

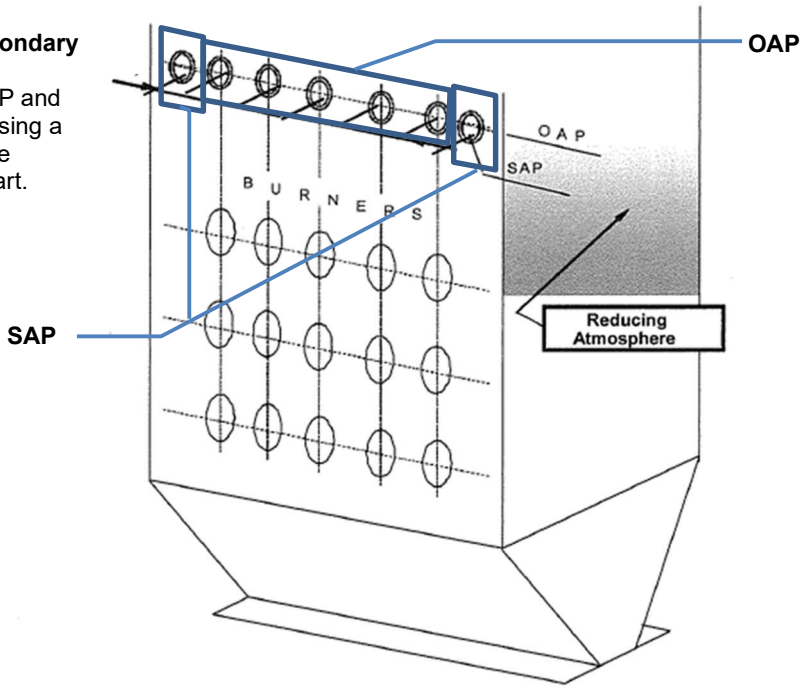


Fig.3.1.1.4 (b) Arrangement of Over Air Ports and Side Air Ports

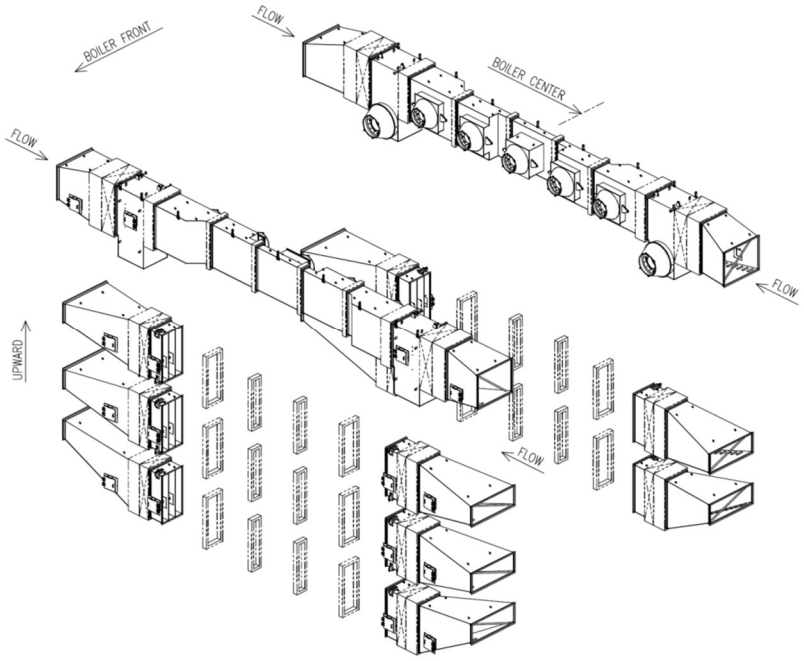


Fig.3.1.1.4 (c) Specific drawing of Over Air Ports and Side Air Ports

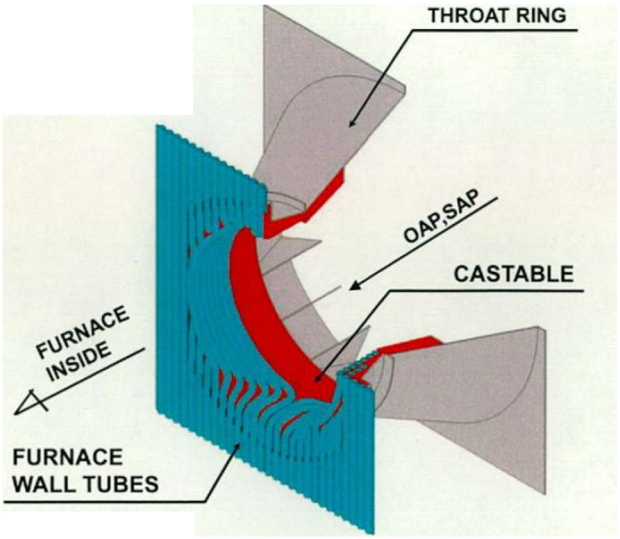


Fig.3.1.1.4 (d) Outline drawing of OAP, SAP

3.1.1.5. Furnace Monitoring Equipment Design

This subsection provides the features of the monitoring devices equipped in the furnace and the burners.

■ Furnace CCTV (Closed Circuit TV)

The furnace CCTV is the device to monitor the furnace combustion status and the slagging status in the furnace.

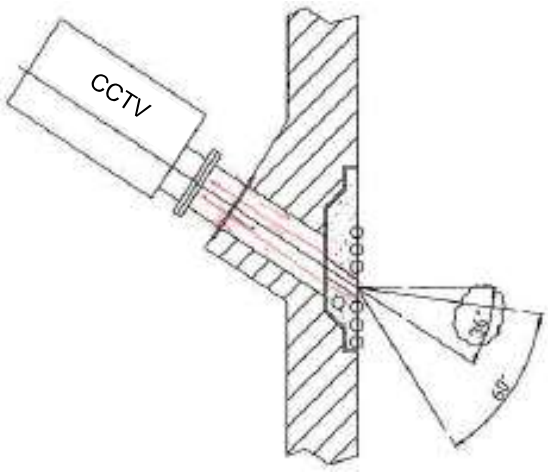


Fig.3.1.1.5 Furnace CCTV

■ Furnace Flame Detector

The flame detector is the device to detect flame intensity of the burner and installed on each pulverized fuel burner which detects the burner putting on fire, by detecting glittering and/or flickering.

3.1.2. Separator

This subsection describes the functions of the Separator and Separator Drain Tank, both equipped in the boiler.

The Separator and Separator Drain Tank separate the water-steam mixture into saturated steam and saturated water during the start-up.

3.1.2.1. Separator

The Separator is of the cyclone type and is provided with four inlet connecting pipes in tangential and downward direction installed on the Separator body. The inside diameter of the connection pipe is selected to get the maximum efficiency of steam and water separation in the Separator. A Drip Ring is installed at the steam outlet to prevent the droplets from entering to the Superheater.

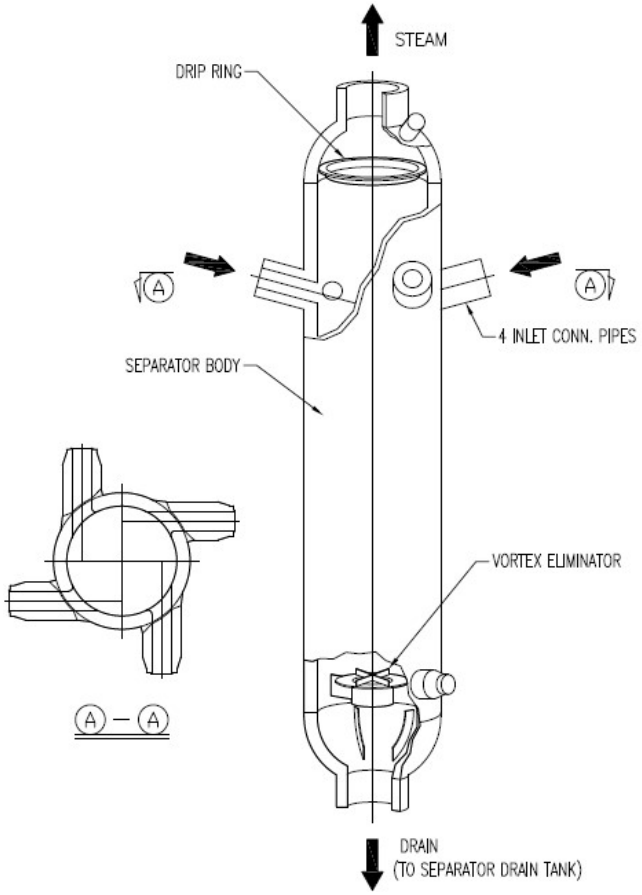


Fig.3.1.2.1 Arrangement of Separator

3.1.2.2. Separator Drain Tank

The Separator Drain Tank has a function of the Separator. The upper portion of the Separator Drain Tank has the same construction as the Separator. The lower portion of the Separator Drain Tank is longer than the Separator and acts as a reservoir receiving the drain from the other Separator. A Vortex Eliminator is installed at the bottom of the Separator Drain Tank to prevent bubbles from entering to the drain tank level control valve.

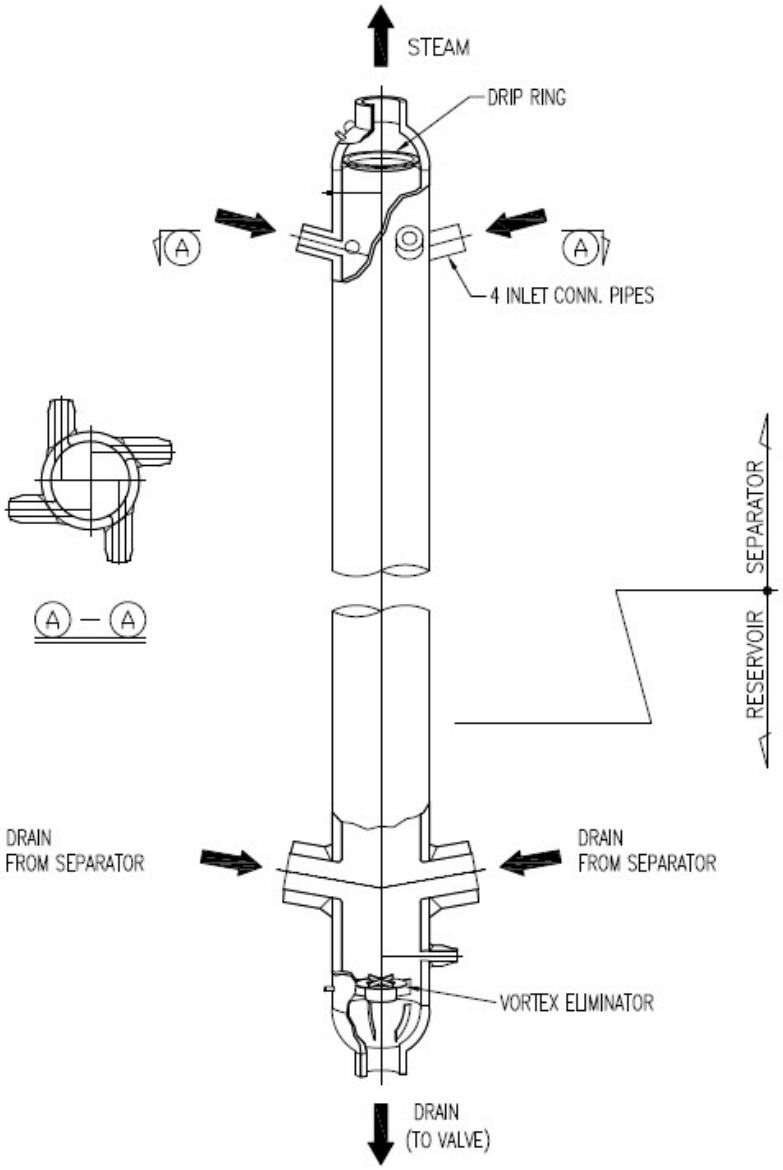


Fig.3.1.2.2 Arrangement of Separator Drain Tank

3.1.3. Superheater

This subsection describes the function of the Superheaters.

3.1.3.1. Superheaters

The Superheaters consist of the Radiant Superheater and the Convection Superheater. The Radiant Superheaters consist of the Secondary Superheater and Furnace roof wall. The Convection Superheaters consist of HRA walls, Primary Superheater and Final Superheater.

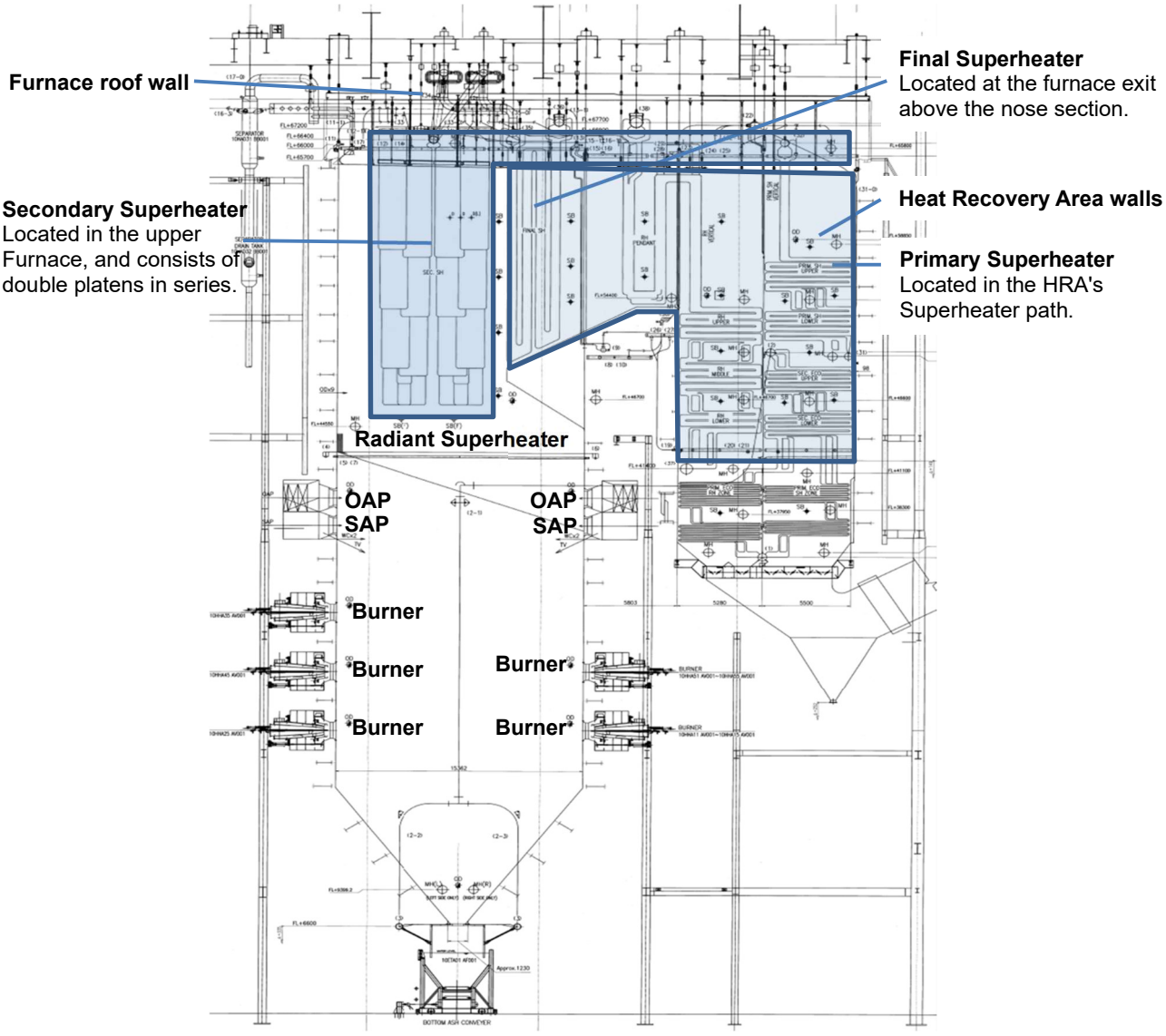


Fig.3.1.3.1 (a) Arrangement of Superheaters

■ Primary Superheater

The Primary Superheater is located in the rear path of the HRA section.
The Primary Superheater consists of the horizontal loop elements arranged across the boiler's width, the inlet and the outlet headers. Steam flows through the tubes opposed to the flow of the flue gas. The Primary Superheater is connected to the Secondary Superheater by the connecting pipe having the spray type attemperators.

Secondary Superheater

The Secondary Superheater is platen pendant type.

Steam flows down through the outer loops of each panel, and then up through each panel's inside loops. The Superheater consists of inlet manifold, inlet and outlet header. The Secondary Superheater is connected to the Final Superheater by the connecting pipes having the spray type attemperators.

Final Superheater

The Final Superheater consists of vertical elements suspended from the roof and arranged across the Furnace's width. The Final Superheater consists of the inlet and the outlet headers.

Superheater steam temperature control equipment (Spray type attemperator)

The temperature of steam leaving the Secondary Superheater and the Final Superheater is controlled by spray type De-superheaters (Attemperators). The Primary and Secondary De-superheaters are located between the Primary Superheater outlet header and the Secondary Superheater inlet header, and between the Secondary Superheaters outlet header and the Final Superheater inlet header, respectively.

The De-superheater (Attemperator) consists of a spray nozzle and inner sleeve.

The sleeve has a function to reduce thermal shock and stress on the pipe made by the spray water and to mix the water and steam.

The spray nozzle is inserted into the De-superheater through the pipe nozzle welded on the De-superheater pipe and connected with the water supplying pipe. The pipe nozzle has a sleeve to reduce the thermal shock and stress made by the spraying water.

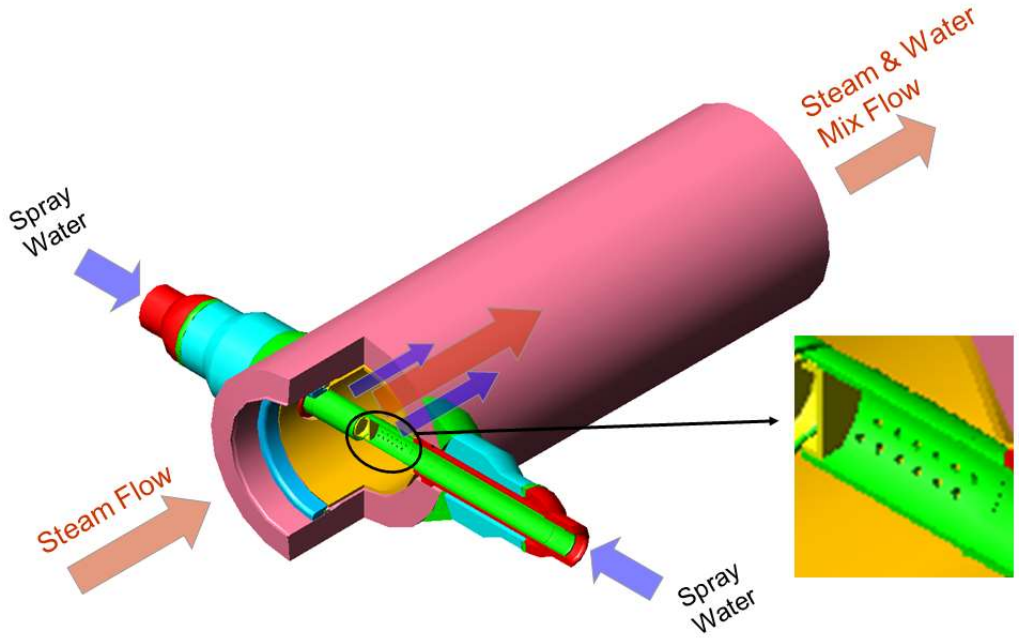


Fig.3.1.3.1 (b) Arrangement of Spray-type De-Superheaters

3.1.4. Reheater

This subsection describes the function of the Reheater.

3.1.4.1. Reheater

The Reheater is located in the RH gas path of the HRA section. The reheater consists of the horizontal tubes at the inlet/lower section and the vertical tubes at outlet/upper section.

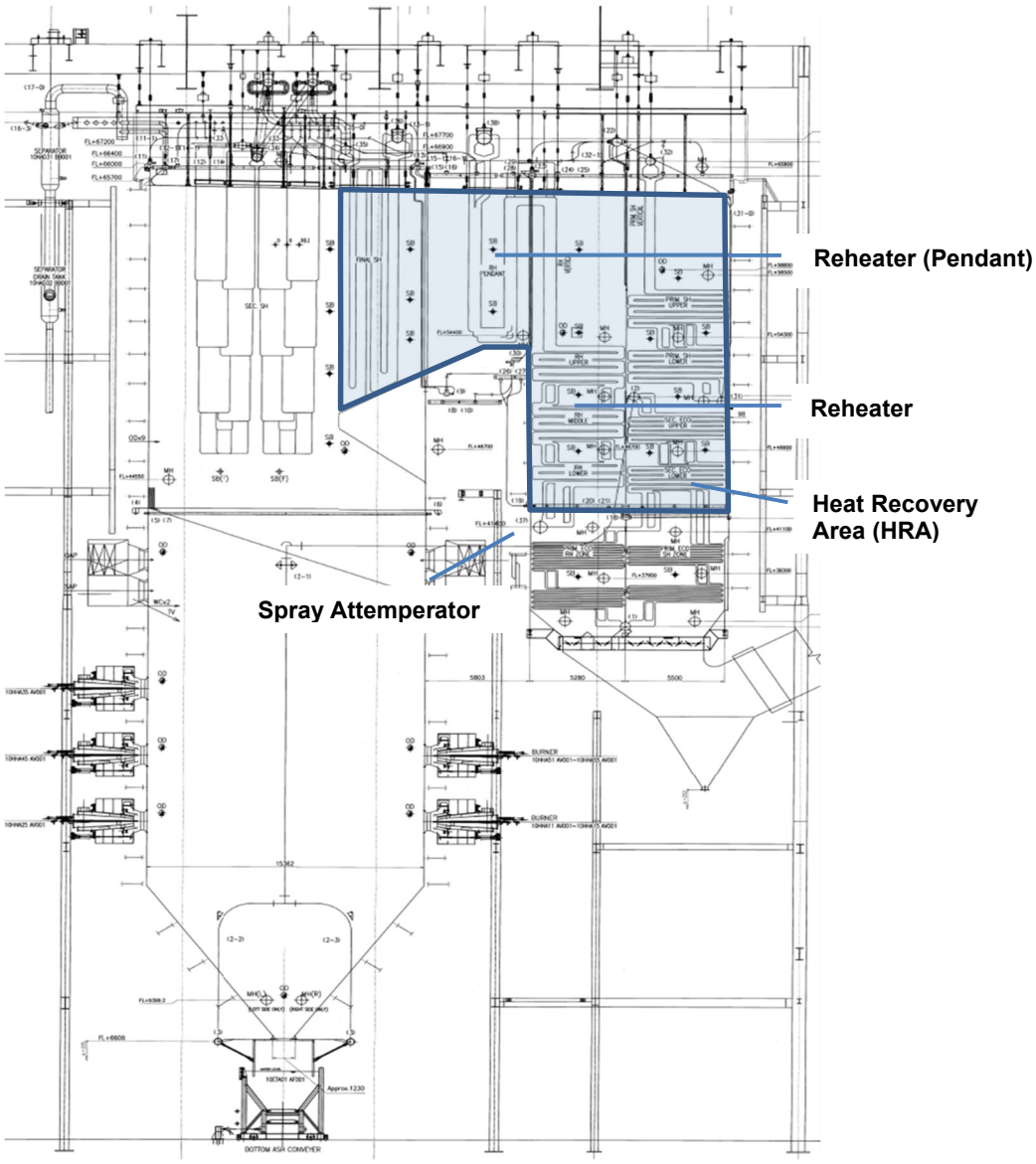


Fig.3.1.4.1 Arrangement of Reheaters

The steam discharging from the HP turbine enters the reheater inlet header located at the bottom of the RH gas path. It flows upward in the horizontal tubes as a counter flow to the flue gas and flows in the vertical tubes as a counter flow to the flue gas. The Hot Reheat steam is led to the LP turbine through the Hot Reheat Pipe from the reheater outlet header.

3.1.4.2. Parallel-Path Design for Reheater Temperature Control

This subsection provides the feature of the parallel-path design for the temperature control of the Reheater.

The HRA is divided into the RH and SH gas paths in which the flue gas flows in each path in parallel. Ratio of the flue gas flow in the both paths can be changed by the Parallel Path Gas Damper to control the RH outlet steam temperature.

The parallel path design for the Reheater assures high controllability of the steam temperature and auxiliary power saving in comparison with a gas recirculation system.

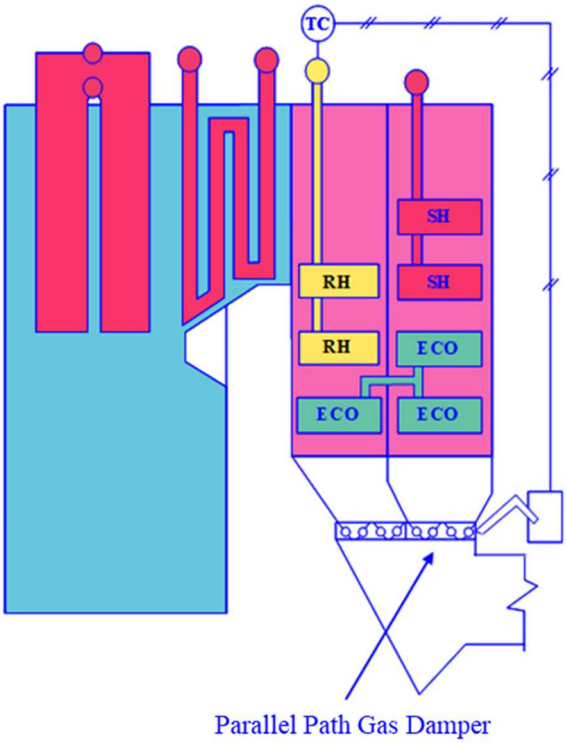


Fig.3.1.4.2 (a) Parallel Path Design for Reheat Steam Temperature Control

Advantages of the parallel path design

The parallel path design does not require the Gas-Recirculation Fan (GRF) and Spray De-superheater (Attemperator) to reheater system.

Other advantages are as follows:

- Stable Reheater temperature control without affecting the combustion conditions.
- Highly efficient temperature control due to no RH water spray and no power consumption for GRF is required.
- Low maintenance cost is required because of no GRF, which is susceptible to erosion.

STC Dampers with parallel path design

The parallel path gas damper is called STC (Steam Temperature Control) damper which is operated by a pneumatic drive unit receiving a signal from the temperature control system.

Reheater (water) spray

To improve a transient response characteristic of the steam temperature at the RH outlet during load change, water is sprayed to the inlet part of the Reheater. For normal operation, the target of reheat steam temperature is decreased during load change to improve the control of reheat steam temperature by using reheater spray proactively.

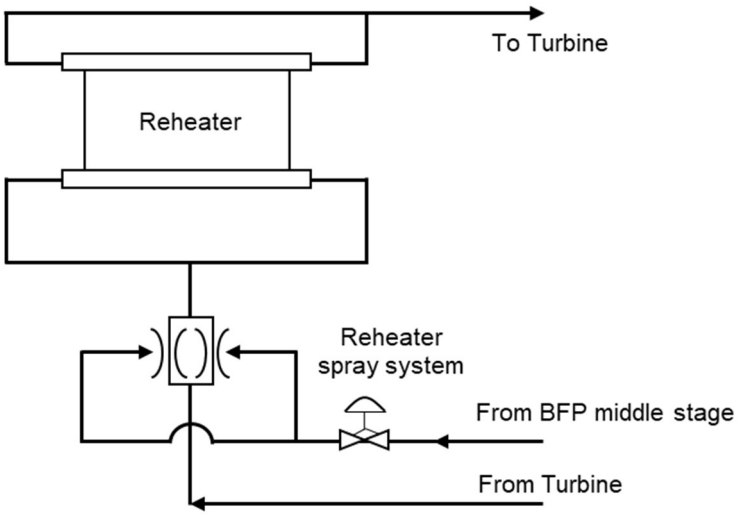


Fig.3.1.4.2 (b) Reheater (Water) Spray

3.1.5. Economizer

This subsection describes the function of the Economizer.

3.1.5.1. Economizer

The Economizer consists of the Primary and Secondary Economizers which are located in the HRA.

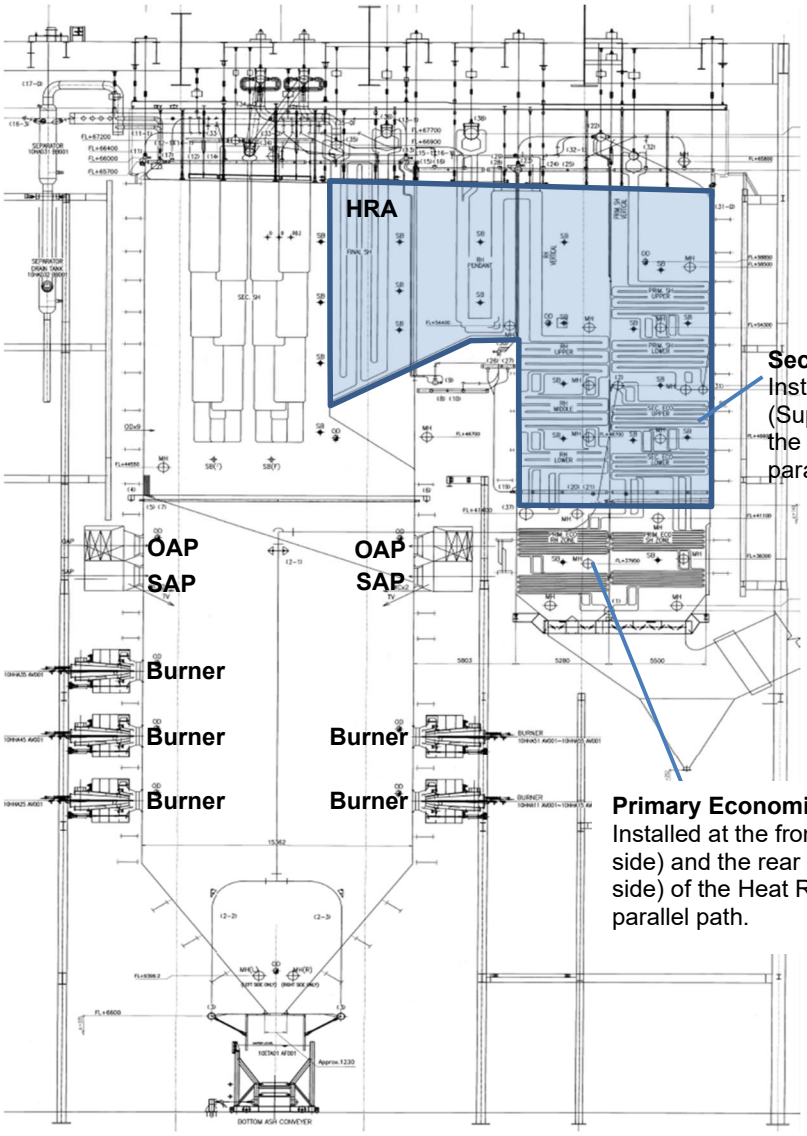


Fig.3.1.5.1 Arrangement of Economizers

The Feedwater from the outlet of the HP heater enters the Economizer inlet header and flows to the Economizer outlet header. The flue gas flows across the Economizer tubes in a direction opposite to the water flow. It is essential to design of the Economizer to avoid steaming at the outlet of the Economizer before entering the Furnace path.

- **Primary Economizer**
  Primary Economizer consists of bare tubes.
- **Secondary Economizer**
  Secondary Economizer consists of bare tubes.

3.2. Boiler Cleaning System

This section describes functions of the Boiler Cleaning System.

3.2.1. Boiler Cleaning System

This subsection provides information on the structures and functions of the Sootblower and Water Sootblower that are used for removing substances adhered in the Furnace.

3.2.2. Boiler Sootblowing System

The Boiler Sootblowing System is for removing adhered ash (slagging) or deposited ash (fouling) on the heating surfaces of superheater, reheater or economizer maintaining thermal efficiency and preventing an increase in draft loss.

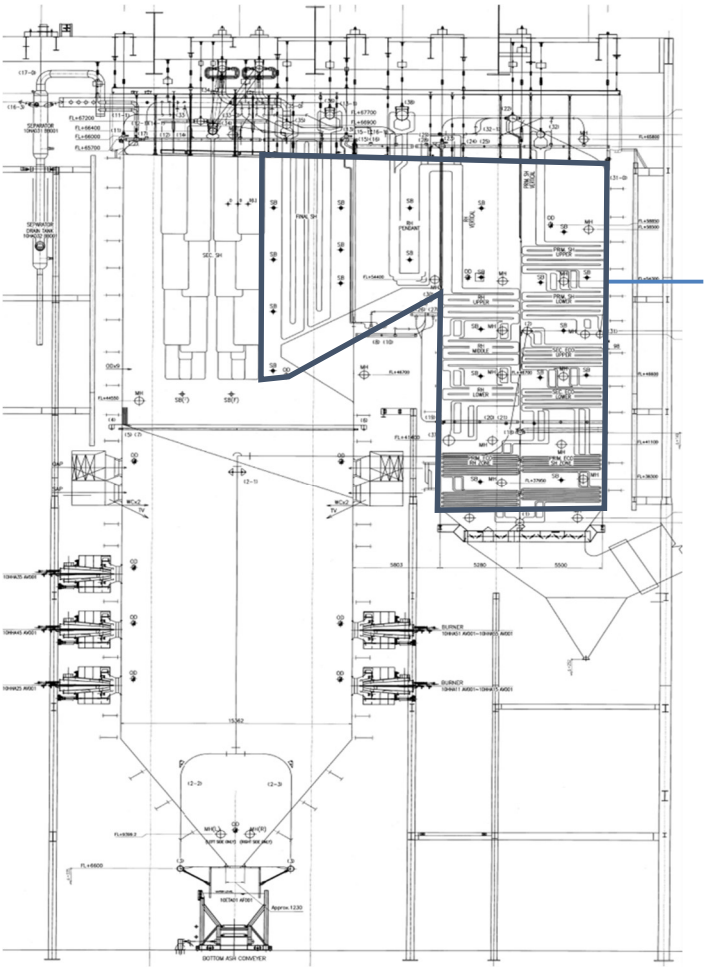


Fig. 3.2.2 Sootblowing System Arrangement

The Boiler is equipped with Steam-blowing type Sootblowers for cleaning the heating surfaces of the Superheater, Reheater and Economizer. 42 long retractable sootblowers are installed as per boiler, on the right and left wall of Pendant Area and Heat Recovery Area.

The boiler Sootblower make use of steam extracted from two (2) steam lines which are the HRA Outlet Header and Cold Reheat Piping. These two (2) steam source are switched according to boiler load to give steam to sootblowers with appropriate steam condition.

Sootblowers are operated using electric motors. A Sootblowing System removes ash deposits by means of variable group selection of individual or groups of blowers. Since Sootblowers are equipped with isolation valves, they can clean a target surface independently on a blower group basis even when the Boiler System is operating. In other words, the operation of the Boiler System can be continued even if Sootblowers are operated.

3.2.3. Water Sootblower System

The Water Sootblower System is for maintain the thermal efficiency by removing slagging on furnace wall.

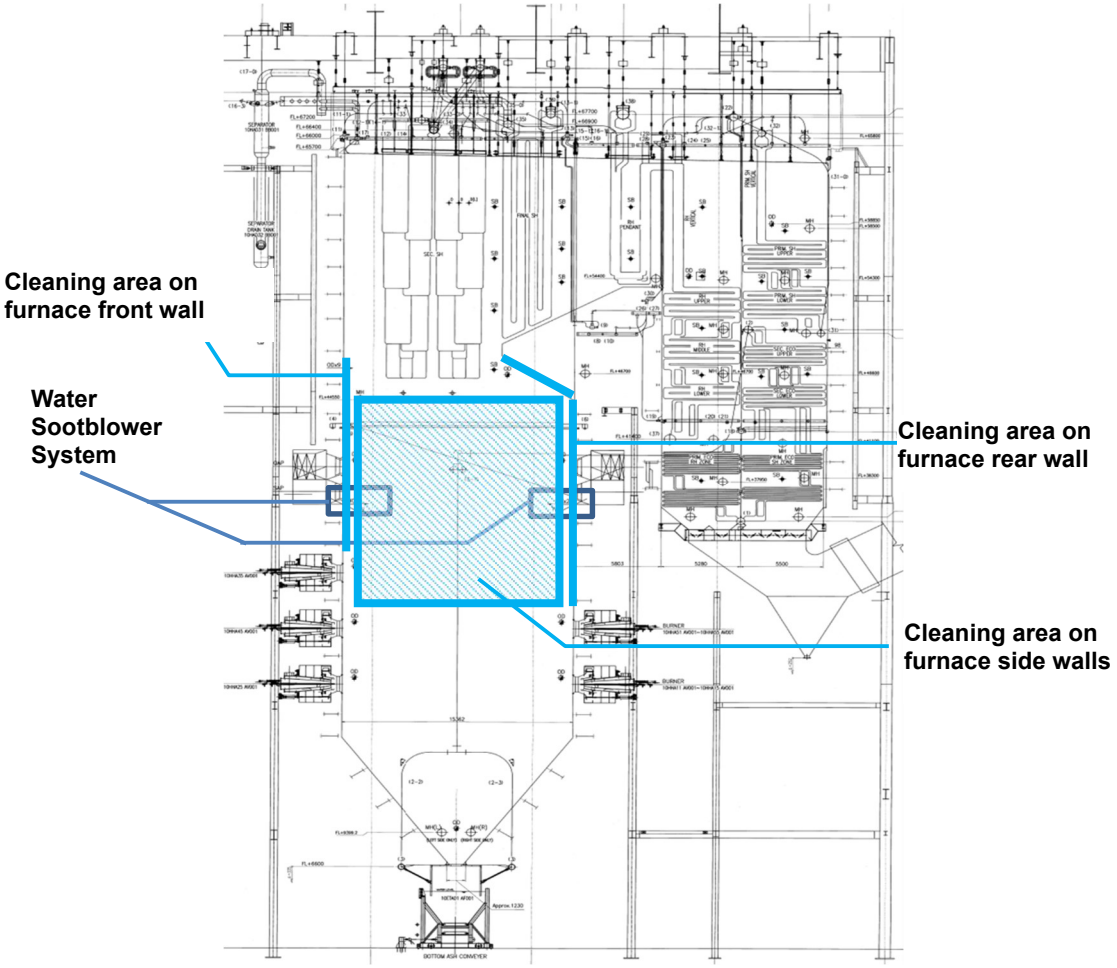


Fig. 3.2.3 (a) Water Sootblower System Arrangement

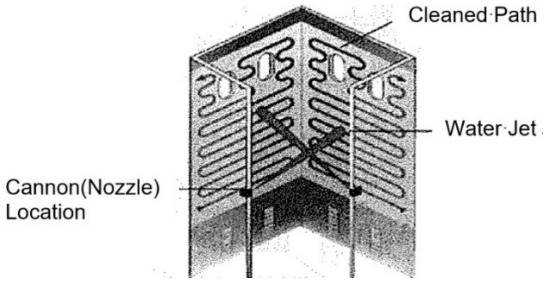


Fig. 3.2.3 (b) Cleaning by Water Sootblower System

The Water Sootblower System is provided for removing slag incrustations on the furnace walls in place of Wall Deslaggers with steam blowing. This concentrated water jet produces a spray pattern on the opposite wall being cleaned using a special nozzle located on the head of the lance tube.

The Water Sootblower's frame is firmly connected to the Boiler wall using a wall box. The drive module makes the lance tube travel horizontally and vertically inside the Furnace in a manner that allows the water jet to clean the Furnace wall in a winding path.

Water Sootblower's injection range is shown as cleaning areas in the Fig. 3.2.3 (a) Water Sootblower System Arrangement. For the Water Sootblower System operations, the injection range is divided into several sections. Corresponding to each section, the HFS (Heat Flux Sensor) is installed in the furnace wall tube. By monitoring decrease in heat flux value of the HFS, ash deposition on the furnace wall can be judged. For the details, refer to the document “VP1-C-L1-P-HCC-30070 (F411-BC1) System Description and Operation Philosophy for Water Sootblower”.

3.3. Burners

This section describes the functions of multiple burners equipped in the furnace.

3.3.1. Burners Functional Description

This subsection provides information on the functions of the following burners:

- Pulverized Fuel Burner (DF Burner)
- Ignitor

3.3.1.1. Pulverized Fuel Burner (DF Burner)

The type of pulverized fuel burner is IHI-dual flow type low NOx burner.

The Boiler is equipped with a total of 25 DF burners (5 burners per row).

The type of burner arrangement is opposed arrangement (3 rows on boiler front wall and 2 rows on boiler rear wall).

The primary air transports PC (Pulverized Coal) to the Burners.

The locations of DF Burner components are shown below.

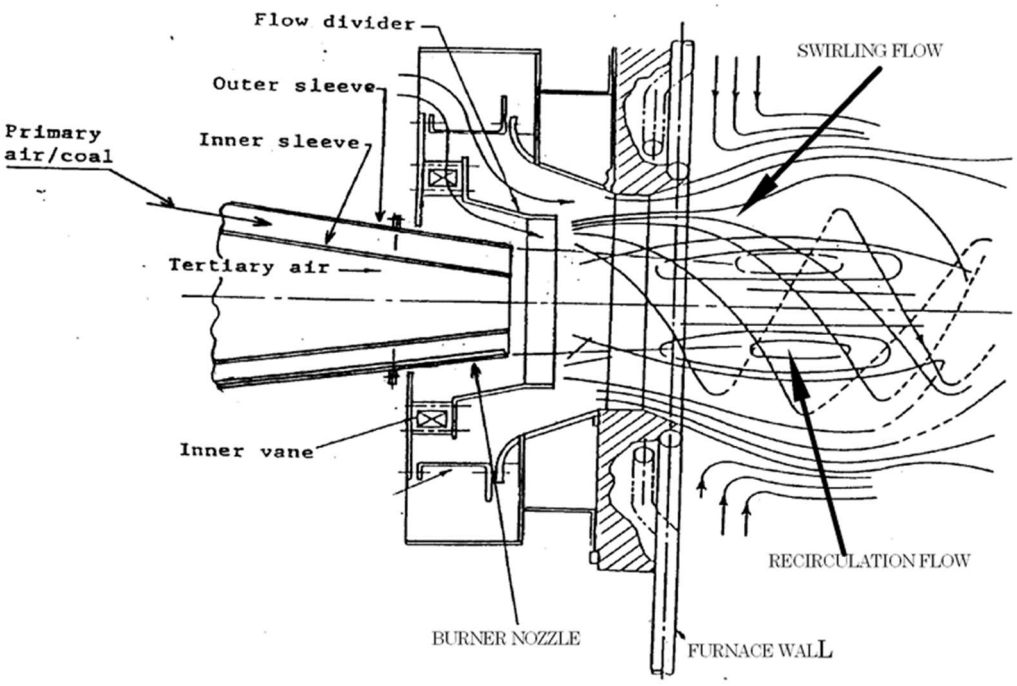


Fig.3.3.1.1 Components Inside the DF Burner

The features of DF Burner are as follows

Air Register

The air register employs the DF (Dual Flow) type inter-vanes.
To gain combustion suitable for the boiler operation, the air register consists of secondary air outer vane composing of multiple movable vanes (blades) for a wide range of adjustment, as well as secondary air inner vane, flow divider, and throat ring.

The secondary air flow passing through the air register divides into outer vane side and inner vane side, gains rotation force by multiple movable vanes, and utilizes the hydrodynamic characteristics of these rotating airflows to reduce the NOx level.

Tertiary Air Damper

The tertiary air damper is the device to supply cool air (atmospheric suction) into the burner internal cylinder to reduce metal temperatures in the cylinder and prevent inflow and accumulation of combustion ash in the internal cylinder.

The tertiary air damper installed in parallel with the air register performs auxiliary combustion adjustment. In case adjusting the opening degree of the outer and inner vanes of the air register does not improve the flame rewinding phenomenon, adjustment using the tertiary air damper is effective.

3.3.1.2. Ignitor

The Boiler is equipped with a total of 25 Ignitors coaxially with pulverized fuel burners. (5 ignitors per row, 3 rows of front wall and 2 rows rear wall as per boiler)
Light Fuel Oil is supplied to Ignitor.
Ignitor has steam atomizing type oil burners with electric ignitors. Ignitors are used for following purposes.

- During unit start-up and shut-down.
- During pulverizer individual start-up and shut-down.

3.4. Safety Valve

This section describes functions of various safety valves equipped in the boiler.

3.4.1. Safety Valve Functional Description

The safety valves are installed for pressure parts protection.

Table. 3.4.1 : Specification of Boiler Safety Valves

Location	SH Inlet Safety Valve	SH Outlet Safety Valve	PCV	RH Inlet Safety Valve	RH Outlet Safety Valve
Quantity	4	1	2	5	2
Type	Spring Loaded				

Spring loaded safety valve and Electrical Relief Valve / PCV (Power Actuated Relief Valve) is installed for boiler protection in accordance with ASME code requirement.

The “safety valve” is the final safeguard between a controlled boiler and a catastrophic explosion. In an over-pressure situation, the pressure in the valve inlet increases until the force on the disc exerted by the system pressure equals the force exerted by the spring. This causes the safety valve to pop, or lift, relieving the excess steam until the system pressure is reduced to the desired level.

- **Close Position of Safety Valve**

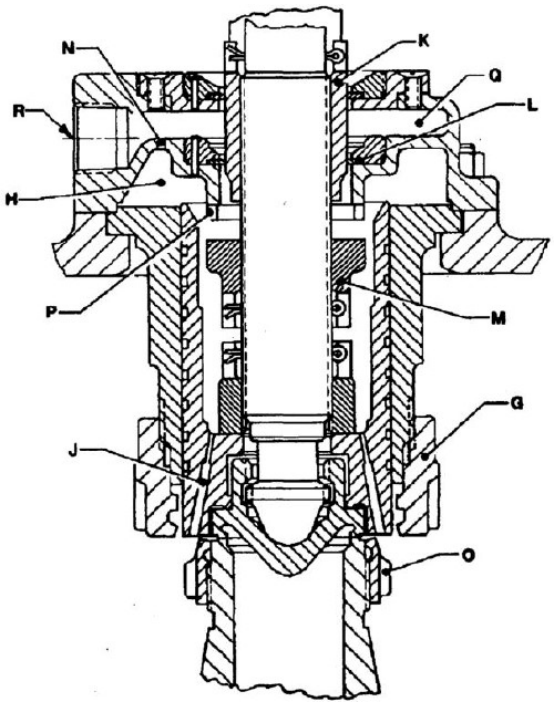


Fig.3.4.1 (a) Close Position of Safety Valve

- **Open Position of Safety Valve**

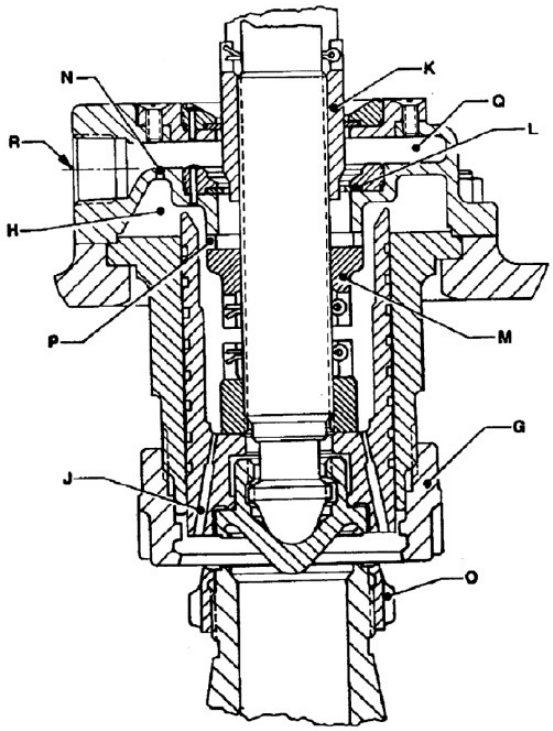


Fig.3.4.1 (b) Open Position of Safety Valve

3.5. Steam and Feedwater System

This section describes functions of the boiler steam and feedwater systems including the various valve system for controlling the water and steam flow.

3.5.1. Feedwater, Main Steam, Reheat Steam System

Feedwater is supplied into the boiler via the economizer. After passing through the economizer section, water flows through external unheated pipes to the furnace lower path. Downstream of the evaporator consist of the lower and upper furnace paths there are the separators, which separates the saturated steam and water when the plant is operated at load below around 40% MCR. After the steam separators, the steam paths through the roof tubes and the several superheater sections.

Water-spray type attemperators are provided for controlling the superheater steam temperature.
In addition to the parallel-gas path arrangement for reheater steam temperature control, the water spray type attemperator is also provided for emergency use.
Typical Flow of Boiler feedwater and steam is as shown in the following.

1. Boiler feed water flows through Main Feed Water Pipe and enters the primary Economizer inlet header.

↓

2. Water flows through the Primary economizer, Secondary economizer, Furnace lower path, Furnace upper path and Separators.

↓

3. The dry steam leaving the separators passes through the furnace roof, HRA roof and HRA rear wall and distributed to HRA partition wall, HRA front wall, HRA side walls and Furnace vestibule side walls, then collected at the HRA partition wall outlet header.

↓

4. The steam from this header passes through the primary superheater, installed in parallel with the reheater, and enters the secondary superheater through connecting pipes with the primary attemperators. The steam from the secondary superheater passes to the secondary attemperators, then flows into the final superheater.

↓

5. The steam leaving the final superheater outlet header flows to the turbine through Main Steam Pipe.

↓

6. The steam from HP turbine outlet passes through Cold Reheat Pipe and the attemperator and enters the reheater. The steam leaving the reheater outlet header flows to the turbine through Hot Reheat Pipe.

3.5.2. Valve (motor, control)

The functions of various valves equipped in the boiler feedwater system are as follows:

Separator Drain Tank Water Relief Valve

During dry-mode operation, there is no boiler water from separator drain tank to condenser. However, drain is accumulated in the pipe between separator drain tank and P-valve as a result of the warming. Separator Drain Tank Water Relief Valve is provided to discharge this drain to SH spray piping when the drain reaches to the inside of separator drain tank.

During wet-mode operation, Separator Drain Tank Water Relief Valve is fully closed.

P-valve

Specific gravity of drain in the separator drain tank changes in accordance with the separator drain tank pressure. Therefore, separator drain tank level signal is compensated by this pressure. And gain correction for the deviation of separator drain tank level is provided based on separator drain tank pressure, because the specific gravity of the drain which go through the P-valve also changes in accordance with separator drain tank pressure.

3.5.3. Start-up Bypass System

In Wet-mode operation, the feedwater flow to the boiler larger than the steam flow from water-steam separator because the feedwater is kept above minimum feedwater flow. The start-up bypass system is required to relieve the surplus water flow to the condenser.

The start-up bypass system is also used for the clean-up cycle to keep water purity in the boiler for establishment of prerequisite condition both for the light-off and for the pressure rising of the boiler.

P-Valve line that is one of start-up bypass system consist of one (1) water-steam separator, one (1) drain tank, drain water line to condenser, two (2) separator drain tank level control valves (P-valve).
HP and LP turbine bypass line is also start-up bypass system. Each line has control valve with spray system.

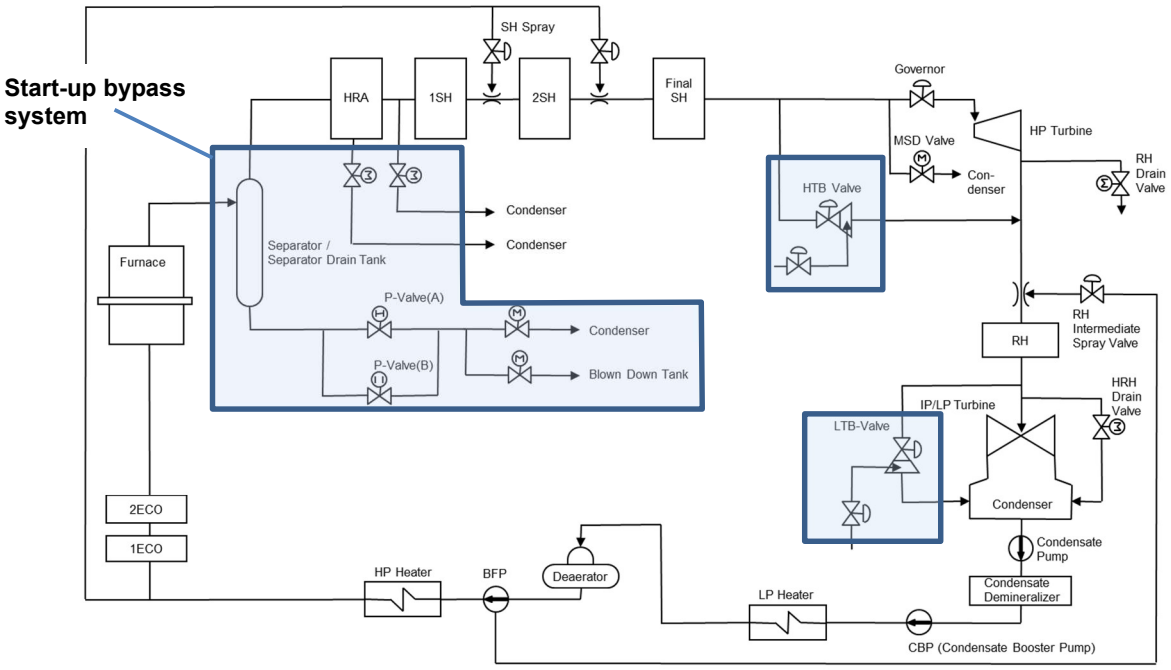


Fig.3.5.3 Start-up Bypass System Arrangement

The water-steam separator is located between outlet of the furnace path and inlet of the roof wall path (superheater) to separate the water-steam mixture into the saturated water and the saturated steam.

The separator drain tank is to storage the water drain from the water-steam separator to ensure the certain controllability of P-valves to avoid the water ingress to roof wall tubes and the high-enthalpy steam ingress to condenser. The separator drain tank also has the same function the water-steam separator installed at upper part of the drain tank.

P-valves are located in the drain line between the separator drain tank and condenser, and physically close to condenser.

HP turbine bypass line connects main steam pipe to cold reheat pipe, and LP turbine bypass line connects hot reheat pipe to condenser.

HP and LP turbine bypass line are used during boiler start-up or special operation such as runback, HLO and BSO to meet the steam flow rate which is required by turbine.

3.6. Air and Flue Gas System

This section describes the function of the air and flue gas system to exhaust flue gas to the atmosphere. The hot flue gas that results from combustion, at first, gives heat to the furnace walls. At the top of the furnace, the flue gas flows across the final superheater section and the screen tubes of the furnace rear wall, then into the HRA.

In the HRA section, the flue gas is divided by a partition wall into front and rear vertical sections providing two parallel gas paths. In the front HRA section, the flue gas heats the vertical and horizontal reheater and the economizer, and in the rear HRA section, it heats the vertical and horizontal primary superheater and economizer. All walls of the HRA up to the secondary economizer gas outlet are composed of the tubes carrying superheated steam outlet of the water-steam separator. The combustion gas transfers heat to these sections flowing through the area.

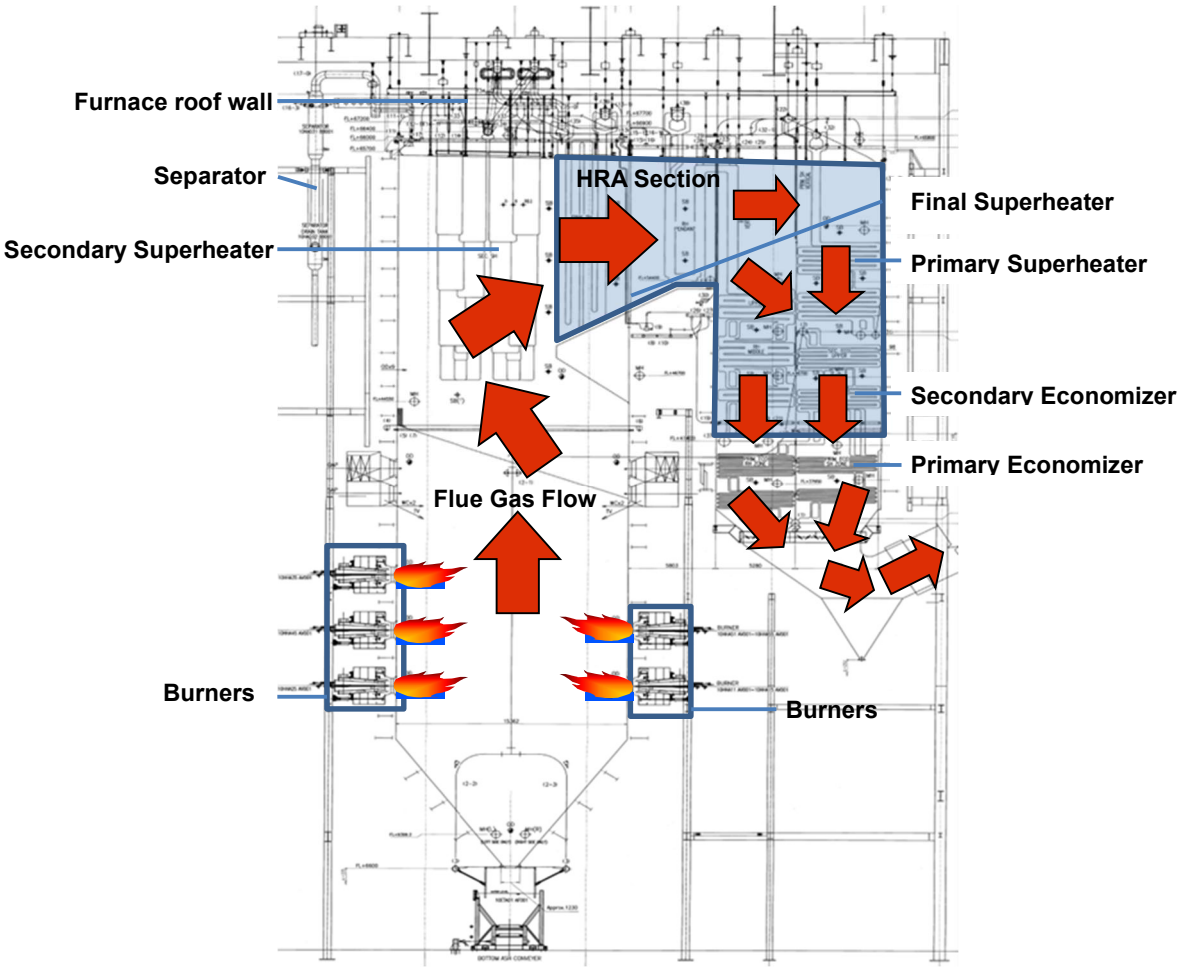


Fig.3.6 Flue Gas Flow in Furnace and HRA

3.6.1. Forced Draft Fan

Two (2) FDFs (Forced Draft Fans) with 50% capacity are provided to the Secondary Air System.

The secondary air system provides hot air for combustion to the furnace. Atmospheric air is taken through a silencer into the inlet of FDFs. Secondary air pressurized by the FDFs passes through AH's secondary air section, then through the secondary air duct and the wind-box to the burners.

The secondary air will be distributed as follows, before entering the furnace.

Air to the burners

The main part of air will be injected through burners. This system is adopted to ensure adequate combustion condition adjusted by two (2) kinds of dampers; the outer vane and the inner vane, and air register for optimization of the combustion turning for not only each burner, but also whole of furnace combustion.

Air to the OAP

To control NOx formation at the furnace, a part of secondary air will be injected to the OAP located above the top row of burners, described hereinafter.

Air to the boundary air system

A limited amount of secondary air will be introduced to the boundary air system to minimize slagging on the lower part of furnace walls.

3.6.2. Primary Air Fan

The PAFs (Primary Air Fans) with 50% capacity are applied to Primary Air System.
The primary air flow is as follows:

1. Atmospheric air enters PAFs through inlet silencers.
Inlet vanes are used for pressure control of primary air header located at pulverizer inlet across the load range. And flow control dampers are installed at inlet of each pulverizer to control the preset ratio of coal-air mixture.

2. From the discharge of PAFs, the air will flow through AH and into pulverizers.
The principle flow stream of primary air is through the air heater, where it will recover heat energy from flue gas to be sufficient to dry moisture in coal. A parallel flow path which bypasses AH is used to temper the outlet temperature of pulverizer at constant value. The tempering air is blended with the principle flow stream through the use of control dampers in order to regulate the temperature of the air-coal mixture leaving the pulverizers.

3. Primary air will deliver the pulverized coal through the coal piping to the furnace.
Eventually primary air is used to support the combustion. No flow control device of coal-air mixture in pulverized coal piping is installed, since the flow is balanced to perform flow balance analysis upon the changing of routing, number of bends, etc.

4. A part of the tempering air is led to pulverizer and coal feeder for sealing and associated dampers.

3.6.3. AH (Air Heater)

AH (Air Heater) is provided for reducing the flue gas temperature to recover the heat energy of the flue gas at the boiler outlet and to raise the primary air temperature to dry up the moisture in the coal and to raise the secondary air (e.g. combustion air) temperature.

The air heater of Regenerative and Normal rotating (Ljungstrom System) type is applied so as to dry specified high-moisture content coal suitably.

The air is heated by exchanging heat with the high temperature boiler outlet flue gas through the regenerative heat exchange element.

While the rotor is slowly rotating around the vertical axis, the heating area exposed to flue gas picks up heat, and at the same time the heating areas present in the air streams release heat to the fresh air. The flue gas and air flow in opposite direction in the heater. The cold fresh air flows through the heat exchanger from the bottom upward when the hot flue gas flows through the heat exchanger from the top downwards.

To avoid dropping of the dew point temperature of the cold heating surface during normal operations, the entry air temperatures of the secondary air side are trimmed by Air Heater Bypass Duct System.

Air Heater is driven by an electrical motor for normal operation and provided with an auxiliary air drive motor for emergency operation (trip/outage of electrical motor). The changeover from electrical drive motor to air motor will be done automatically.

Heating element is packed into basket at applicable sizing to handle easily at maintenance or installation. And heating element basket can be replaced / installed from basket removal doors installed at ducting or AH casing. The hoisting facilities are provided to replace or install the baskets.

3.6.4. AH Bypass System

The functions of AH Bypass follows:

■ AH Bypass

The Bypass uses AH bypass damper to bypass the secondary air flow passing the AH.

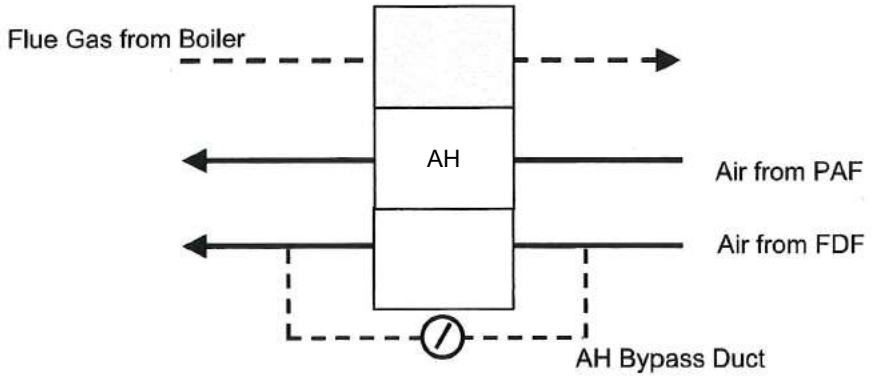


Fig.3.6.4 (a) AH Bypass

AH bypass dampers, which bypass secondary air flow passing AH, control AH CEMT (*1) when AUTO permissive conditions are met (*2). Setpoint of CEMT is generated by MWD.

During start-up period these damper position as per position demand generated by AH inlet air temperature.

*1: CEMT: Cold End Mean Temp
Averaged temperature between AH inlet air and AH outlet gas.
*2: AH on AUTO requires following conditions are met.

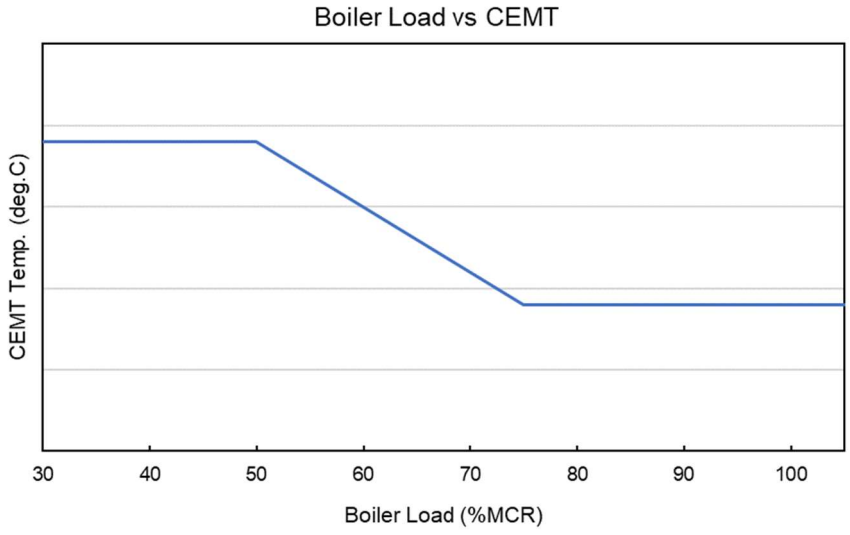


Fig.3.6.4 (b) MWD vs CEMT (sample)

3.6.5. Air and Flue Gas Ducts

The functions of the ducts are as follows:

Primary Air Duct

The Primary Air Duct is the duct for conveying primary air from PAF.

PAFs are provided in parallel, and each lines are connected to make the common primary air duct at fan outlet. The common line consists of cold primary air line and hot primary air line.

Secondary Air Duct

The Secondary Air Duct is the duct for conveying secondary air from FDF.

Secondary air pressurized by the FDFs passes through AH's secondary section, then through the secondary air duct and the wind-box to the burners.

Flue Gas Duct

The Flue Gas Duct is the duct for conveying flue gas exhausted from the boiler.

The air and flue gas duct are designed to keep the resistance to flow as low as possible and to give proper distribution of flow to the various parts of the boiler and to minimize localized accumulation of ashes.

The air and flue gas duct are adequately supported and suitably arranged with expansion joints to allow the design thermal movement. Some expansion joints are provided, where necessary, with internal plates to avoid vibration of bellows and erosion from ash.

3.6.6. Dampers and Expansion Joints

This subsection provides the features of the Dampers and Expansion Joints in the Boiler plant.

The dampers are utilized to open/shut or to control the air and flue gas flow and the expansion joints are provided to absorb thermal expansion and/or vibration caused in the ducting system.

The Boiler is equipped with the following Dampers and Expansion Joints.

Metallic type expansion

The expansion bellow is made of metal and used normally for absorbing thermal expansion mainly in axial direction. Material of the metal expansion is carbon steel/stainless steel for air duct and low alloy steel for gas duct.

Fabric type expansion

The expansion bellow is made of fabric and used for absorbing thermal expansion both in axial and vertical/horizontal direction. Material of the fabric expansion is glass fiber which is also suitable for corrosive gas.

Damper

The damper is consisting of several numbers of blades, shafts, bearings, linkages and kinds of drives assembled in a steel frame.

The damper is operated manually or driven by an electric motor or pneumatic/ hydraulic cylinder.

3.7. Auxiliary Steam System (Boiler Portion)

This section explains function of the Auxiliary Steam System.

The auxiliary steam system is to supply the required auxiliary steam for each equipment can be obtained from the main boiler or other steam sources during start-up, shut-down and normal operation of the power plant.

The auxiliary steam is extracted from the HRA outlet header of the boiler, CRP or others to the auxiliary steam header at a constant pressure and then supplied to each plant equipment from the header. Although the application differs depending on the plant operation, the auxiliary steam system itself can be used irrespective of plant operating condition (start-up, shut-down and normal operation).

In order to ensure appropriate auxiliary steam conditions, the auxiliary steam source is switched depending on the plant operation.
The auxiliary steam is supplied from CRP at high load, from HRA outlet header at low load, and from other unit or auxiliary boiler when steam supply from the main boiler is not available at plant start-up operation.

Refer to the document “VP1-C-L1-P-LBG-25008 (K600-312) P&ID for Auxiliary Steam System”.

3.8. Pulverizer System

This section describes the function of the Pulverizer System and each device composing the System.

3.8.1. Coal Bunker

Raw coal is supplied to the boiler units via belt conveyors (supplied by others), to the coal bunkers. Each pulverizer must be fed raw coal from one (1) coal bunker and one (1) coal feeder.

The following equipment/systems are provided with the coal bunkers.

- Sufficient protection and indication system on low and high level of coal for automatic tripper conveyor and belt operation with indication and alarm in the coal handling control room and CCR.
- Water injection system as suitable anti-bridging devices
- One (1) motor operated slide gate valve at each bunker outlet
- Access Gallery

NOTE

- The bunkers are provided with a total reserve corresponding to a minimum of eight (8) hours operation with minimum calorie coal at BMCR with one (1) pulverizer as standby.
- The lining with stainless steel is considered for the conical hopper.

3.8.2. Coal Feeder

The raw coal is fed to the pulverizers by a variable speed gravimetric feeder with sufficient margins. The coal feeders are dust-proof and pressure-tight. They are equipped with automatic coal feeding rate indication. Coal feeding rate is controlled to provide a continuous flow of fuel to the pulverized coal to the burners at all load ranges.

The coal feeders are also equipped with a belt tensioning system and a belt or chain cleaning device. Inspection doors are provided at each end of the feeder body as well as coal dust scraper equipment and air seal equipment.

Coal feeding pipe from the feeder to the pulverizers is designed for vertical or near vertical direction. Following equipment/systems are provided with each coal feeder.

- One (1) no coal switch on conveyor belt
- One (1) manual type coal sampling device
- One (1) set of inspection window with observation light and inspection door
- One (1) temporary chute to permit bunker emptying in emergency

NOTE

- The capacity is with a total amount of fuel coal corresponding to the operation with minimum calorie coal at BMCR with one (1) pulverizer as standby.
- 15% margin is considered for suitable plant operation.

3.8.3. Pulverizer

In the pulverizer, the coal is dried, pulverized and classified. The system will operate continuously, within the specified design conditions and the coal feeding can vary rapidly and widely as required by the combustion process.

The Boiler is provided with five (5) Ring-Roller Vertical Spindle (VS) Pulverizers.

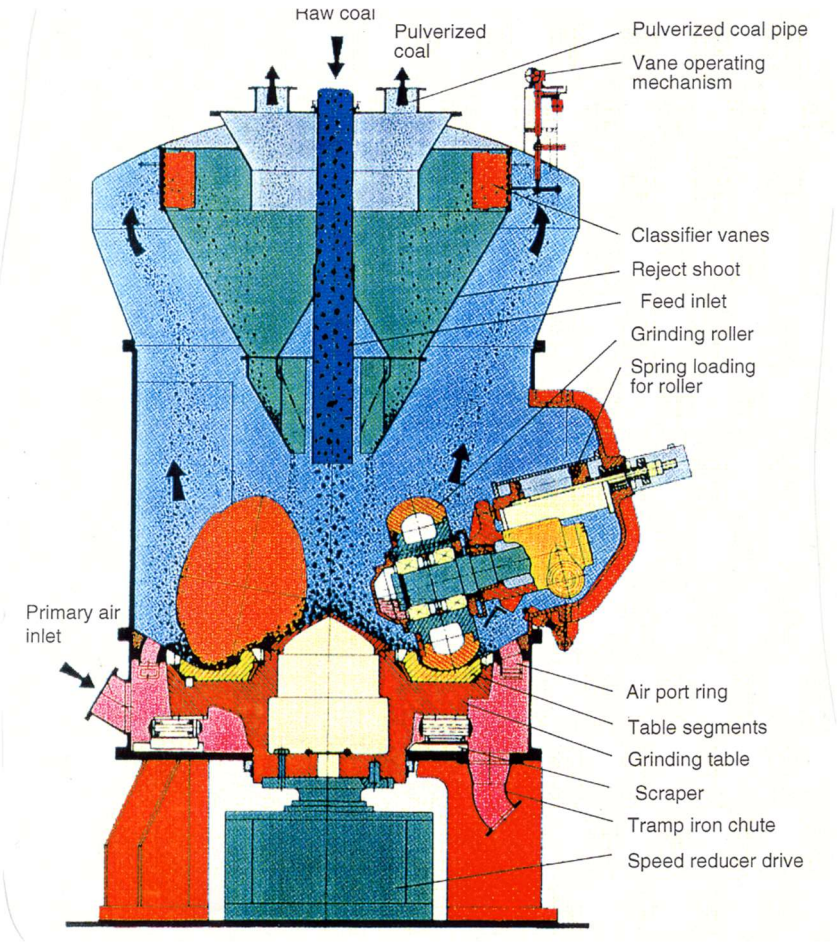


Fig.3.8.3 Location of Coal Pulverizer

3.9. Fuel Oil System (Boiler Portion)

This section explains function of the Fuel Oil System to supply fuel oil to the oil burner during the boiler plant start-up, shut-down and normal operation.

Steam atomizing type oil burners with an electric ignitor are installed in each coal burner.

Fuel oil is used for the following purposes in addition to the plant start-up/shut-down.

- To ignite coal burners at the time of pulverizer start and stop during load change

Coal firing with fuel oil support is not considered for normal operation of steam generator. (In case of one pulverizer stop for maintenance or any incident during normal plant operation, one (1) pulverizer in stand-by will switch over.)

Capacity of Fuel Oil Firing System is designed to cover 30%NDC operation. (The fuel oil burners have the total capacity to supply 30%NDC heat input to ensure quick unit start-up.)

Operation of the ignitors is incorporated with the BMS (Burner Management System). All required control devices for the ignitors are furnished, including the high voltage transformers.

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3.9.1. Accumulator

The Accumulator is to maintain the burner allowable minimum oil pressure so that the combustion does not become unstable or no misfire occurs because of a sudden drop in the burner inlet oil pressure at ignition of the burner.
The following is the piping system diagram of the Accumulator.
Refer to the document “VP1-C-L1-P-HJF-25009 (K600-313) P&ID for Fuel Oil System”.

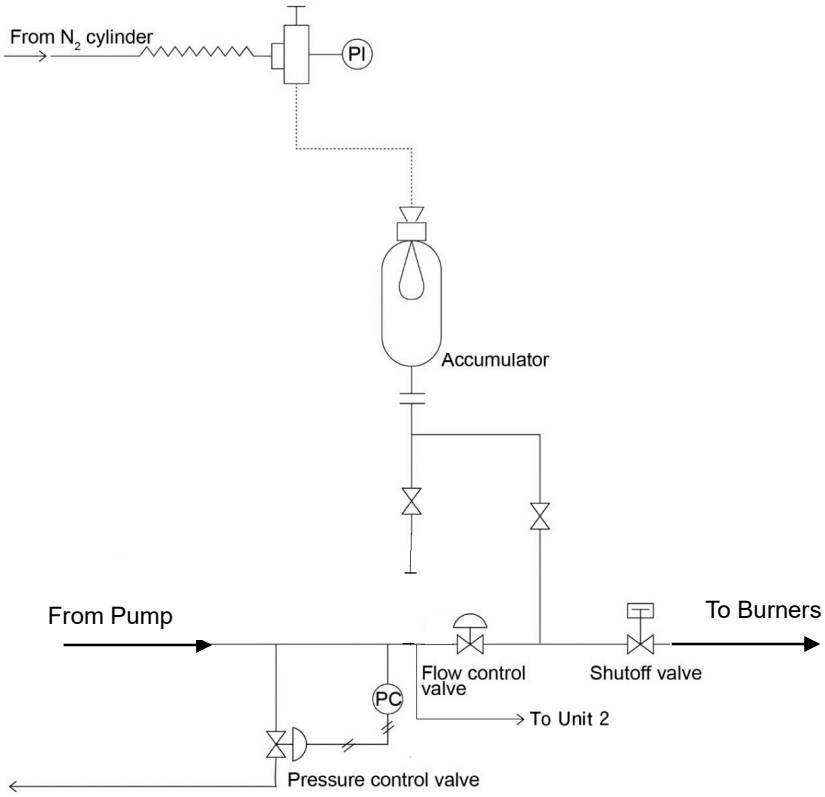


Fig.3.9.1 Accumulator Piping System Diagram

3.10. Service Water System (Boiler Portion)

This section describes the Service Water System.

Service Water supplied from Other's portion is distributed to each equipment in Boiler Portion.
Service water is used for washing of AH, Water Sootblower, SCC (Submerged Chain Conveyor) system, and so on.

Refer to the document "VP1-C-L1-P-GAF-25011 (K600-315) P&ID for Service Water Supply System".

3.11. Closed Cycle Cooling Water System (Boiler Portion)

This section describes function of the Cooling Water System.

The Closed Cycle Cooling Water System is for cooling various rotating devices in the boiler plant by distributing cool water to the pipes.

The cooling water supplied from Other's portion is distributed to various rotating devices in the boiler plant.

Main Cooling Water System, circulating water pump, re-cooling system are of Other's portion.

Refer to the document "VP1-C-L1-P-PG-25010 (K600-314) P&ID for Closed Cycle Cooling Water System".

3.12. Cooling and Sealing Air System

This section describes functions of the various cooling devices and sealing air system.

3.12.1. Flame Detector and Camera Cooling Fan

The Flame Detector and Camera Cooling Fans is for cooling and purging the relevant parts of the Flame Detector and CCTV.

The Flame Detector and Camera Cooling Fan start up immediately after the start-up of the FDF and stop when the flue gas temperature at the ECO outlet becomes 70°C or lower.

NOTE

- Be careful about the overload of the motor while the Flame Detector Cooling Fan is operating (rated current: 54.6A).
- In the following cases, the spare fan for the Flame Detector Cooling Fan starts automatically:
  - When the fan trips during driving.
  - When the discharge pressure drops below the default value.

3.13. Compressed Air System (Boiler Portion)

This section describes function of various cooling devices and the Compressed Air System.

3.13.1. Instrument Air System

Refer to the document “VP1-C-L1-P-QE-25014 (K600-320) P&ID for Instrument Air Supply System”.

3.13.2. Station Air System

Refer to the document “VP1-C-L1-P-QE-25015 (K600-321) P&ID for Station Air Supply System”.

3.14. Blowdown Drain System

This section describes the Blowdown drain system.

The Blowdown Drain System collects the blowdown drain discharged from each equipment in the boiler plant and separates it into steam and water at atmospheric pressure.

The drain from boiler and piping system is discharged to the boiler blowdown tank and condenser.

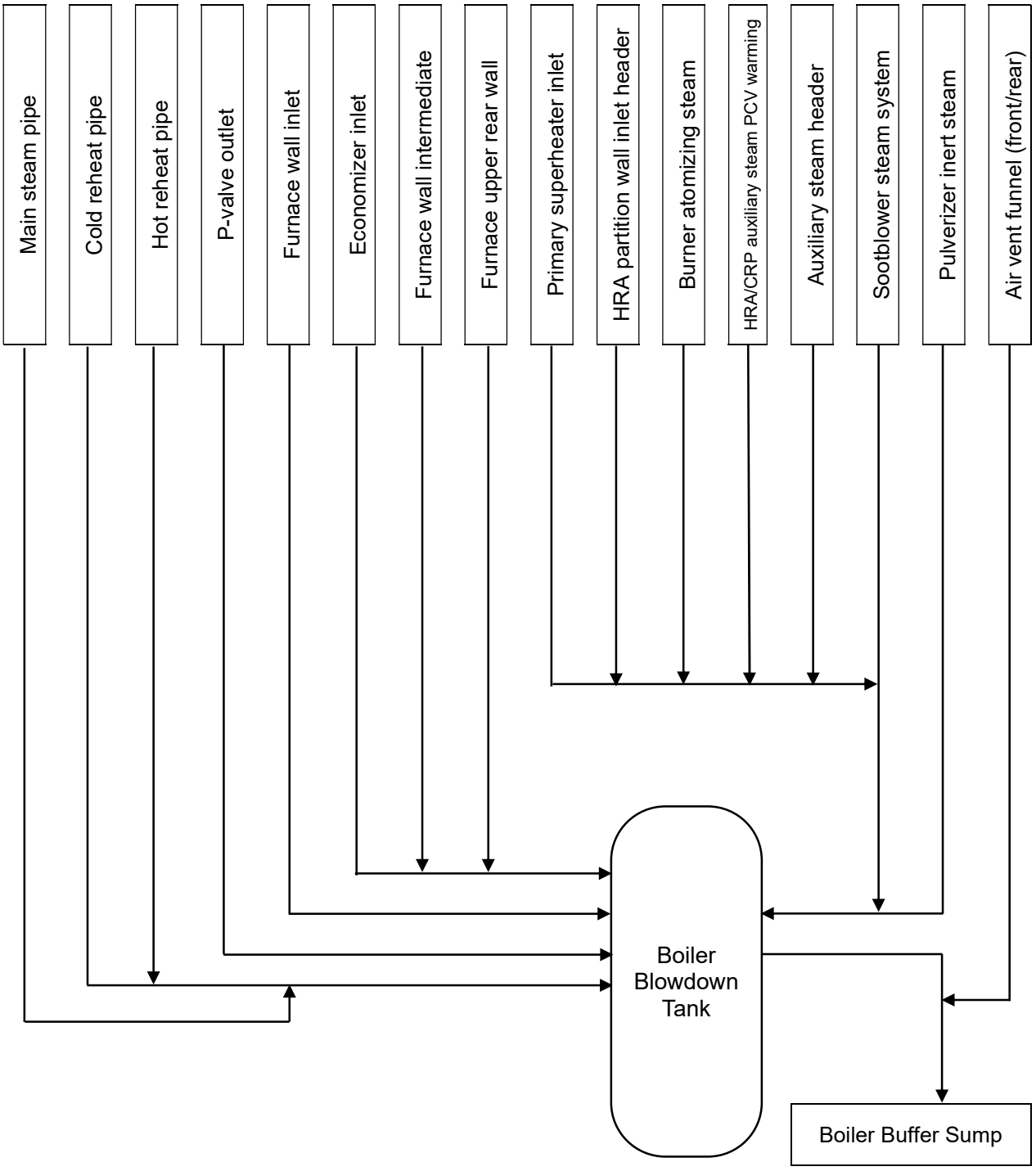


Fig.3.14 Blowdown Drain System

3.14.1. Boiler Blowdown Tank

The Boiler Blowdown Tank collects drain discharged from steam and water system during the boiler start-up or operation and separates it into water and steam at atmospheric pressure.

Separated steam is discharged to the atmosphere by an exhaust pipe. Separated water is discharged to Boiler buffer sump after being cooled to 68°C.

Service water supplied from Other's portion is used for cooling in the Boiler Blowdown Tank.

3.15. Air Vent and Nitrogen Gas System

This section describes function of the Air Vent and Nitrogen Gas System.

The Air Vent and Nitrogen Gas System prevents deterioration inside piping by putting nitrogen gas from the air vent.

The boiler plant is equipped with the following vents:

- Boiler Auxiliary Steam Vent
- CRP Auxiliary Steam Vent
- Economizer Outlet Vent
- HRA Partition Wall Outlet Vent
- Reheater Outlet Vent
- Final Superheater Outlet Vent
- Secondary Superheater Inlet Vent (L/R)
- Final Superheater Inlet Vent (L/R)
- Separator Outlet Vent

Refer to the document “VP1-C-L1-P-H-25019 (K600-325) P&ID for Air Vent and Nitrogen Gas System”

4. Boiler Operation

This chapter explains operation of the boiler, including the boiler start-up and shut-down operation overview, major procedures, and other general information. For further details, refer to the relevant operation diagrams, documents on control systems, and set points lists.

4.1. General

4.1.1. Coal Specification

This sub-section explains the Coal Specification to be fired for this Project.

4.1.1.1. Design Coal Specification

The Design coal specification is specified in Table 1 of VP1-C-L1-G-GEN-00502 (K090-055) Fuel Specification for Boiler and Auxiliary Design.

The boilers were designed based on this Design Coal Specification. Burning coals not identified in the Design Coal Specification and not evaluated by IHI can seriously damage the boiler. IHI and EPC contractors shall not be responsible for problems resulting from burning coals that do not meet the coal specification for which the boiler was designed.

4.1.1.2. Coal Brand and Coal / Ash Properties

Coals are normally named or branded for the location where they are mined. The coal's composition, while variable, is normally defined by the commercial specification for the specific brand. A coal's brand is important information for the boiler operator. While ultimately it is critical to know the specific physical and chemical properties and characteristics of the coal, the boiler operators also need to know the brand because typical coal and ash analysis cannot determine the combustion and slagging/fouling characteristics precisely.

4.1.1.3. Use of Non Listed Coal

The Owner should not fire any coals not specified in the Project Coal Specification. If the Owner nevertheless does fire coals not specified in the Project Coal Specification shall take all risks related to firing such coals.

4.1.1.4. Coal Blending

Many properties of coal are pure physical properties, and when coals are blended with other coals, the resulting property of the blended coal, such as heating value, moisture content, total ash content, and ash chemical composition, is the weighted average of the individual coal properties. However, some properties and characteristics of coals, such as ash fusion temperatures, fouling index, sintering temperatures and grindability, cannot be confidently predicted by the weighted average of the individual coal properties. Therefore, when coal is blended, the analysis of the actual blended coal is necessary. Blending coals can lead to unpredictable results and should only be done with great caution. The boiler operator cannot and should not rely on the mathematical weighted prediction of the analysis of the blended coal.

Especially, when two different coal brands are blended, the ash of this blended coal may have characteristics completely different from the weighted average of these characteristics for the individual coal brands. Ash fusion temperatures of a blended coal can be lower than either of the individual constituent coals.

Therefore, if coals are to be blended a coal and ash (including ash fusion temperature) analysis should be carried out on both the individual constituent coals and the blend. Coals should be blended before bunkering and not in the boiler furnace.

4.1.1.5. Test Burn

Burning a coal brand for the first time at the boiler and which has not undergone thorough testing requires a test burn. Burning new coal brand without a test burn can have detrimental effects on boiler operation and component reliability. Also, a test burn is required whenever a blend of new combination of coal brands are envisaged.

The test burn is to determine whether firing at full load is achievable while keeping within the emission limitation and to determine the potential for deterioration of boiler performance and slagging/fouling/sintering.

The sintering test was developed by IHI and provides practical and useful information concerning the sub-bituminous coal. The Owner should consider conducting a sintering test prior to firing a new coal or a new blending combination, and consult with IHI.

4.1.1.6. Record of Coal Used

Record of Coal used at each pulverizer (flow rate, blending ratio if any, coal/ash properties before/after blending) must be kept in record. Such record should be provided to IHI in case IHI is required to conduct any analysis on an abnormal boiler condition or investigation on any problem.

4.1.2. Boiler Operation

The responsibility for control and care of the boiler passes to the Owner as provided for in the Contract.

The boiler is expected and designed to be operated by an experienced boiler operation team.
The function of the boiler operators includes:

a) Managing the coal pulverizers to ensure the burner input into the furnace is well balanced and adjusted to minimize flow and temperature imbalances.

b) Monitoring steam pressures and temperatures along with critical tube metal temperatures and flue gas temperatures.

c) Monitoring ash deposit build-up in the furnace, the radiant tube panels and the convection tube panels and, as required, selecting the frequency and sequence of sootblower operation based on the conditions of the boiler while the optimum SB operating function is implemented.

d) Selecting the appropriate soot blowing schedule is critical to both avoid ash deposit build up and to “encourage” heat transfer in the appropriate section of the heat transfer surface.

Several examples of when manual operation intervention would be required include:

i. Indications that one or more tube metal temperatures is higher or lower than the rest of the tubes in the same bank, which is indicative of fouled tubes or potential restricted flue gas flow.

ii. Indications that Superheater sprays have increased above normal, which can indicate excessive furnace water wall slagging, which results in more heat absorbed in the Superheater surfaces and potentially higher temperature flue gas reaching the rear path.

iii. Evidence that flue gas temperatures exiting the Economizer are trending upwards which indicates fouling of the upstream heat transfer sections and/or deposits in the Economizer.

e) The consequences of not controlling excessive furnace slagging can lead to higher flue gas temperatures resulting in ash fouling and deposits within the boiler. If excess furnace slagging is observed, one solution is to temporarily reduce load.

f) Monitoring any alarms occurred and finding the causes of the alarm and then taking the necessary actions to solve the problems immediately.

g) Monitoring to be not out of any operation limits such as Power Output, Steam Flow, ramp rate and water qualities etc.

The other critical role of the boiler operator and the operations supervision team is the on-line diagnosis of abnormal conditions which, if detected and responded to early, can reduce the amount of damage that occurs. Examples of these on-line diagnoses would include:

a) Early detection of boiler tube failures (“BTF”) through monitoring of process conditions such as boiler make-up water rates, steam temperatures, induced draft damper settings, observations of abnormal loud noises, and falling boiler pressure, can minimize the secondary damage caused by the BTF.

b) Early detection of ash deposit build-up and diligent (not excessive) use of sootblowing.

c) Early detection of temperature imbalances within critical tube sections such as the Reheater or Superheater.

4.2. Boiler Start-up and Shut-down Operation Overview

This section provides the overview of boiler start-up and shut-down operations as follows:

- About automatic operation
- How to read operation flow charts
- Unit start-up mode

4.2.1. About Automatic Operation and How to Read Operation Flow Charts

This sub-section explains automatic operation for boiler start-up and shut-down and how to read flow charts for each automation operation.

4.2.1.1. Automatic Operation

Each master group control (group level sequence) of boiler start-up and shut-down operation is automated to be started or stopped by operator from DCS graphic screen (OPS).

For details, refer to

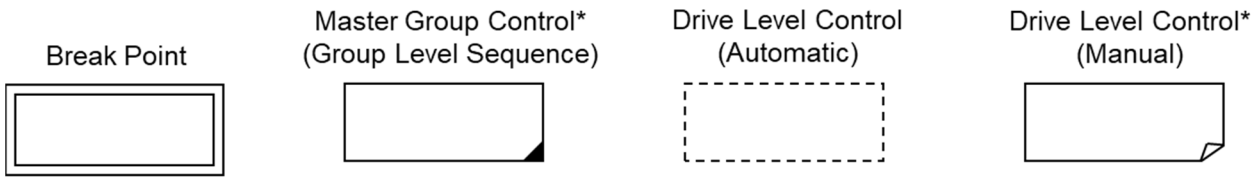
- “VP1-C-L1-I-CJF-40053 (K700-5A3) Boiler Start-up and Shut-down Operation Diagram”.
- “VP1-C-L2-I-GEN-00006 Basic Concept of Plant Automation System (PAS)”

4.2.1.2. How to Read Operation Flow Charts

An operation flow chart includes the following three phases of operation:

- **Break Point:** A group of master group and drive level controls for showing each operation phase.
- **Master Group Control**: A sequence group of operations for a major task
- **Drive Level Contro**l: A single or simple operation for a drive-level

The above two items in a flow chart are described as follows:



(Note) *Operator action is required to initiate group level sequence or drive level control.

Fig.4.1.1.2 Operation Block

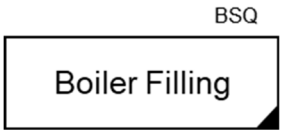
4.2.2. Boiler Control System's Configuration

The boiler control systems to be operated from the CCR (Central Control Room) consist of the following:

- BMS: Burner Management Control System
- BPS: Boiler Protection System
- BSQ: Boiler Sequence Control System
- UCS: Unit Coordination & Boiler Modulating Control System

In a flow chart, an abbreviation on upper right of each step flow shows which control system the step belongs to:

Example: A stop flow belonging to the BSQ control system



4.2.3. Unit Start-up Modes

This sub-section describes the unit start-up modes. Depending on the start-up conditions, there are 4 unit start-up modes available: Initial Cold, Cold, Warm and Hot.

4.2.3.1. Unit Start-up Modes Selection

The unit start-up mode is automatically selected according to the start-up period after shut-down and temperature of Separator Inlet Manifold fluid as follows:

Unit Start-up Mode	Start-up period after shut-down	Temperature of Separator Inlet Manifold fluid (°C)	Predicted start-up time (Unit: minute)			
			From light-off to turbine run	From turbine run to synchro-nous	From synchro-nous to full load	Total
Initial Cold	after more than 72 hours	Less than 120 (at the timing of boiler light-off)	270	115	330	720
Cold	after more than 56 hours	120-150 (at the timing of boiler light-off)	270	40	280	590
Warm	after more than 8 hours	150-200 (at the timing of boiler light-off)	160	30	225	415
Hot	after less than 8 hours	200 or more (at the timing of boiler light-off)	60	15	145	220

For the predicted start-up time, ramp rate during unit start-up, planned steam pressure/temperature at Turbine Roll-off for each unit start-up mode, refer to “VP1-C-L1-M-H-00519 (K090-067) Predicted Boiler Start-up Curve”.

NOTE

- Unit start-up mode selection is decided according to the turbine condition. If the boiler condition does not match the turbine condition, the set points for each mode differ from actual required values.

4.2.3.2. Unit Start-up Mode Selection Set Points

Basically, Unit start-up mode is decided in accordance with the turbine condition. If the boiler condition does not match the turbine condition, the excess fuel may be input to the boiler or the boiler cannot generate the high temperature steam required for turbine. Therefore, the set points for Fuel Flow and Drain Valve are decided based on below table.

Condition		Fuel flow Set Point	Drain Valve Set Point
Boiler	**Turbine**		
Initial Cold	Initial Cold	Initial Cold	Initial Cold
	Cold	Initial Cold	Cold
	Warm	Initial Cold	Warm/Hot
	Hot	Initial Cold	Warm/Hot
Cold	Initial Cold	Cold	Initial Cold
	Cold	Cold	Cold
	Warm	Cold	Warm/Hot
	Hot	Cold	Warm/Hot
Warm	Initial Cold	Initial Cold	Initial Cold
	Cold	Cold	Cold
	Warm	Warm	Warm/Hot
	Hot	Hot	Warm/Hot
Hot	Initial Cold	Initial Cold	Initial Cold
	Cold	Cold	Cold
	Warm	Warm	Warm/Hot
	Hot	Hot	Warm/Hot

4.2.4. Break Point for Unit Start-up and Shut-down Automatic Operation

The Unit start-up and shut-down automatic operation is available in a break point as a trigger.
The following are the break points starting the unit start-up and shut-down automatic operations:

4.2.4.1. Break Point for Unit Start-up Automatic Operation

In Unit start-up operation, the following 6 break points start automatic operations for boiler:

1 Boiler Cold Clean-up
➔Boiler Filling ➔ Boiler Blow ➔Boiler Circulation

2 Boiler Light off Preparation
➔FAH System ➔ ESP/FGD System start ➔ BAH System ➔ Draft System
➔ Furnace Purge
Fuel Oil system start
} Leak Check Start
➔(When start-up after hot banking) FW system start
} ➔ MFT Reset ➔ IDLE AR control
➔ATM system

3 Boiler Light-off
➔ Initial light off ➔ Ignitor Executive System Start
➔ Hot Clean-up (when separator inlet manifold temp. 195~205 degC)
➔ Auxiliary Steam System Start (if MSP > 8.0 MPa)

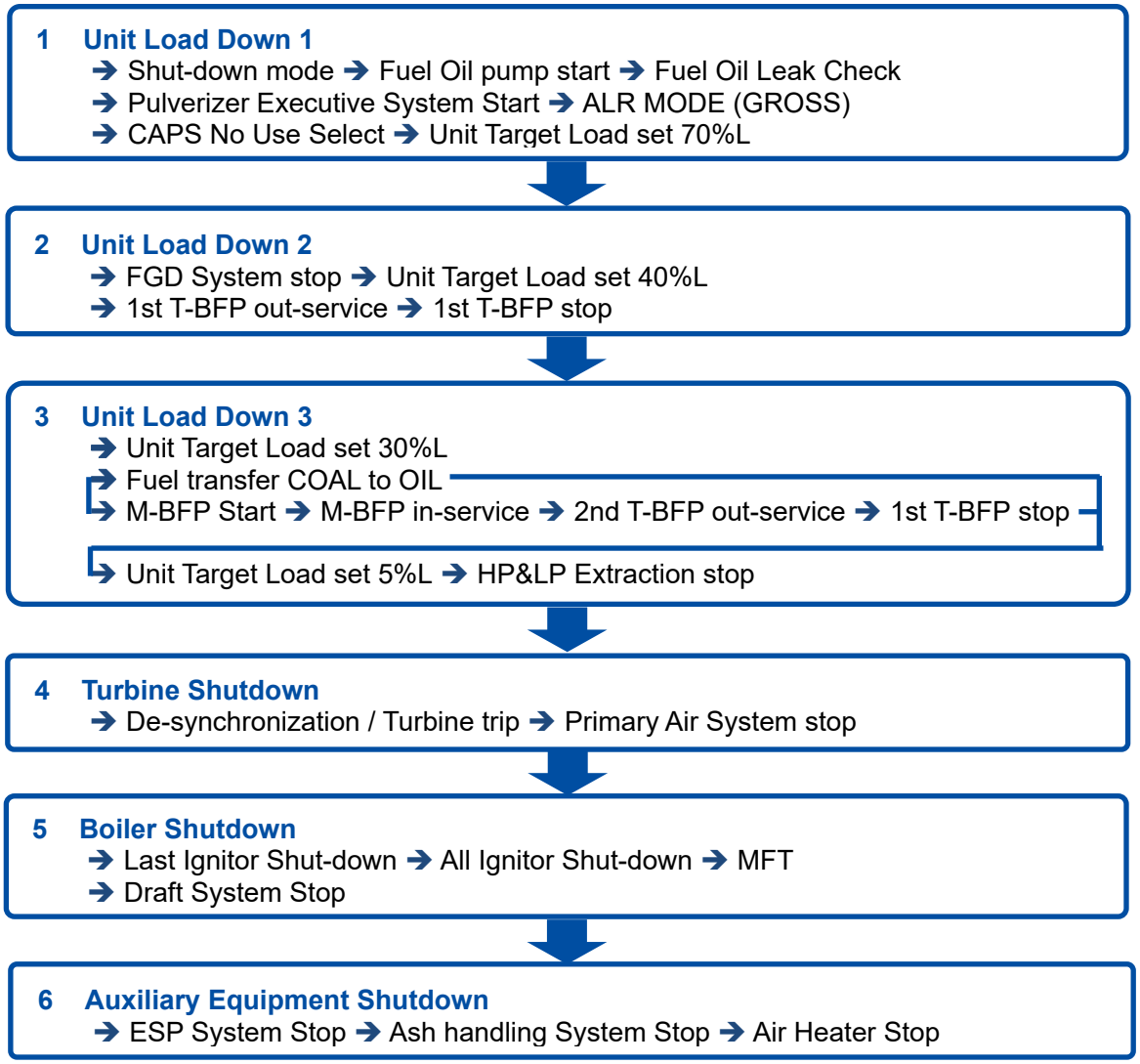
4 Turbine PreStart/ACC Boiler PreLoad-UP
➔ HP Turbine Warming start ➔ HP Turbine Warming stop ➔ Turbine Reset
➔ Turbine start
➔ 1st T-BFP reset ➔ 2nd T-BFP reset
➔ PA System Start ➔ Pulverizer warming start
➔ Rub check at 400

5 Synchronization/Unit Load Up 1
➔Synchronize
➔ FGD System Start ➔ Fuel transfer OIL to COAL
➔Heat soak completed ➔ MT DEHC UCS Mode ➔ Unit Target Load set 15%L
➔ LP Extraction start ➔ HP Extraction start ➔ 1st T-BFP start-up
➔ 1st T-BFP in-service ➔ M-BFP out-service ➔ M-BFP stop

6 Unit Load Up 2
➔ Unit Target Load set 50%L ➔2nd T-BFP start
➔ 2nd T-BFP in-service ➔ LPH drain to condenser ➔ HPH drain to condenser
➔ HPH drain to deaerator ➔ Unit Target Load set 100%L
➔ SB Optimum Mode start ➔ AH SB Cycle Mode start

Break Point for Unit Shut-down Automatic Operation

In Unit shut-down operation, the following 5 break points start automatic operations for boiler:



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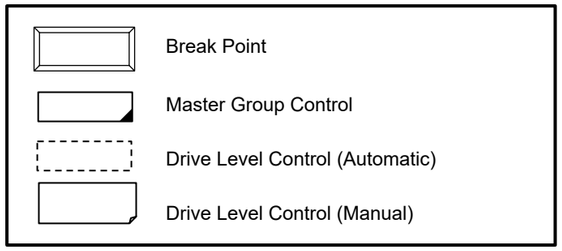
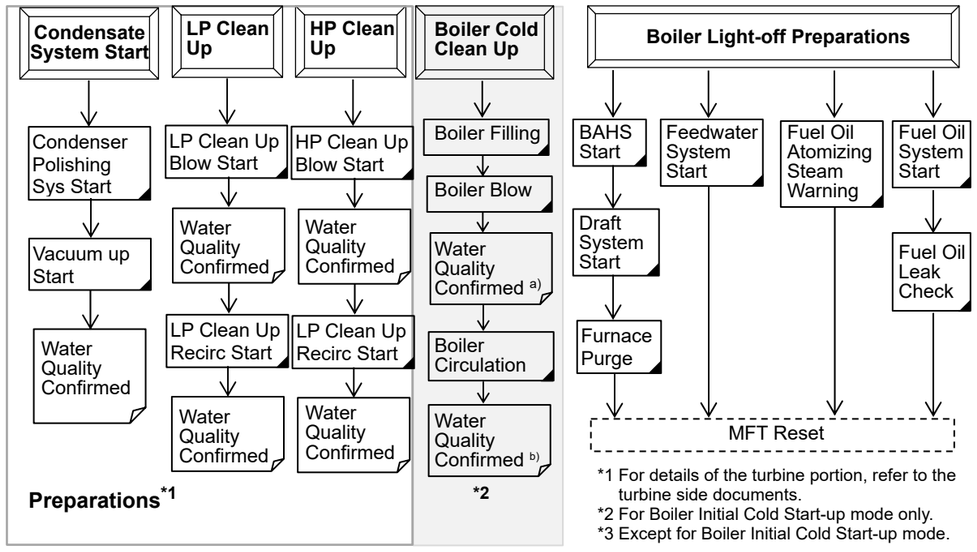
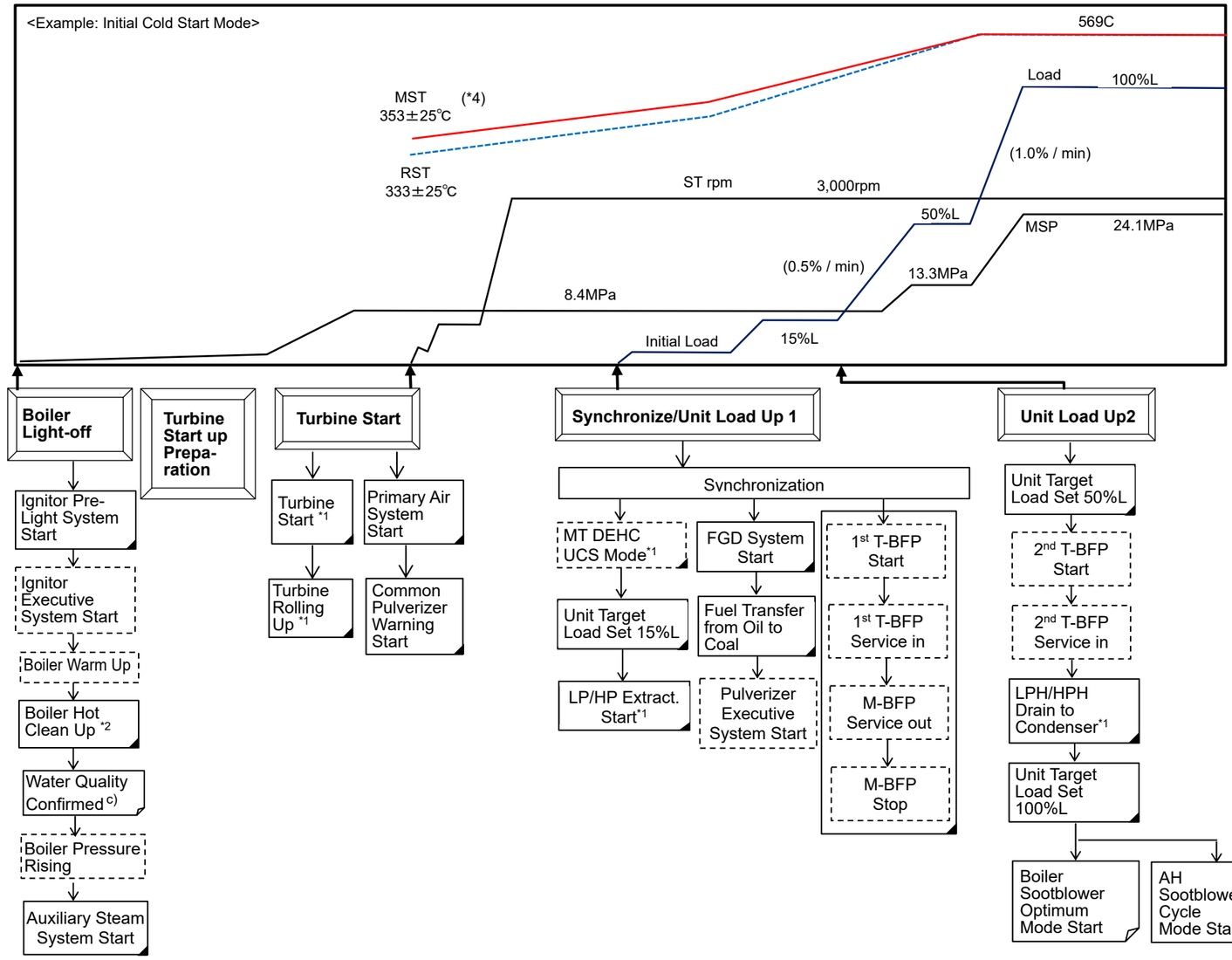
Boiler Start-up Operation Diagram





*1 For details of the turbine portion, refer to the turbine side documents.
*2 For Boiler Initial Cold Start-up mode only.
*3 Except for Boiler Initial Cold Start-up mode.



Start-up Modes

Unit Start-up Mode	Start-up period after shut-down	Temperature of Separator Inlet Manifold fluid (°C)	Predicted start-up time (Unit: minute)			
			From light-off to turbine run	From turbine run to synchro	From synchro to full load	Total
Initial Cold	after more than 72 hours	120 (at the timing of boiler light-off)	270	115	330	720
Cold	after more than 56 hours	120 - 150 (at the timing of boiler light-off)	270	40	280	590
Warm	after more than 8 hours	150 - 200 (at the timing of boiler light-off)	160	30	225	415
Hot	after less than 8 hours	200 or more (at the timing of boiler light-off)	60	15	145	220

a) Water Quality Required for Completing Boiler Cold Clean-up

Monitoring item	Criteria	Sampling point	Remark
pH	9.3 ~ 9.5	Economizer inlet	
Oxygen (O_2)	< 20 µg/kg	Economizer inlet	
Hydrazine(N2H4)	>20 µg/kg	Economizer inlet	
Cation conductivity	< 1 µS/cm	Economizer inlet	
Silica (SiO_2)	< 30 µg/kg	Economizer inlet	
Iron (Fe), total	< 100 µg/kg	Economizer inlet	
Iron (Fe), total	< 150 µg/kg	Separator Outlet	
Cation conductivity	< 1 µS/cm	Separator Outlet	

(*This table shows case of AVT with hydrazine. Refer to Chapter 4.7 for requirement for AVT without hydrazine.)

b) Water Quality Required for Completing Boiler Hot Clean-up

Monitoring item	Criteria	Sampling point	Remark
pH	9.3 ~ 9.5	Economizer inlet	
Oxygen (O_2)	< 20 µg/kg	Economizer inlet	
Hydrazine(N2H4)	>20 µg/kg	Economizer inlet	
Cation conductivity	< 1 µS/cm	Economizer inlet	
Silica (SiO_2)	< 30 µg/kg	Economizer inlet	
Iron (Fe), total	< 100 µg/kg	Economizer inlet	
~~Copper (Cu)~~	~~< 2 µg/kg~~	~~Economizer inlet~~	
Iron (Fe), total	< 100 µg/kg	Separator Outlet	
Cation conductivity	< 1 µS/cm	Separator Outlet	

(*This table shows case of AVT with hydrazine. Refer to Chapter 4.7 for requirement for AVT without hydrazine.)

***4 Estimated MST and RST at Turbine Start-up**

Start-up Mode	MST (°C)	RST (°C)
Ambient Cold	353	333
Cold	403	353
Warm	443	403
Hot	503	453

(*Temperature is Boiler Outlet base)

MW Demand for Pulverizer Start-up During Start-up

MW Demand	1st Pulverizer	2nd Pulverizer	3rd Pulverizer	4th Pulverizer
MWD for Pulverizer Start sequence Start	(Synchroni zation)	Above 14%TMCR	Above 35%TMCR	Above 63%TMCR
Start command signal by	"Fuel Transfer from Oil to Coal" sequence		Pulverizer Executive System	

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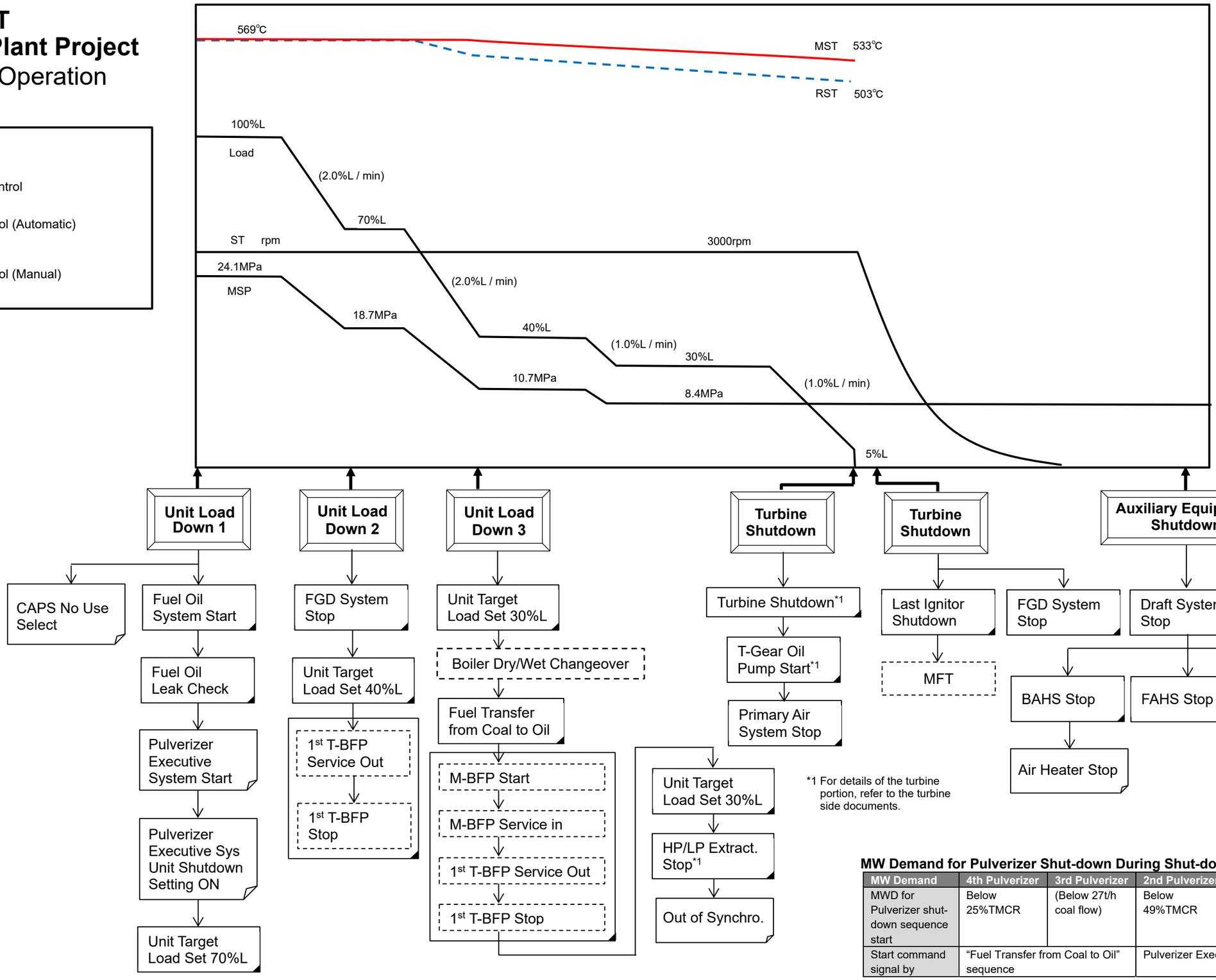
Boiler Shut-down Operation Diagram

- Break Point
- Master Group Control
- Drive Level Control (Automatic)
- Drive Level Control (Manual)



*1 For details of the turbine portion, refer to the turbine side documents.

MW Demand for Pulverizer Shut-down During Shut-down

MW Demand	4th Pulverizer	3rd Pulverizer	2nd Pulverizer	1st Pulverizer
MWD for Pulverizer shut-down sequence start	Below 25%TMCR	(Below 27t/h coal flow)	Below 49%TMCR	Below 77%TMCR
Start command signal by	"Fuel Transfer from Coal to Oil" sequence		Pulverizer Executive System	

4.3. Boiler Start-up Operation

This section provides flow charts for 6 Break Points for Unit Start-up Automatic Operation for boiler, and explanations for Major Master Group Control or Drive Level Control step(s) included in each flow.

4.3.1. Boiler Cold Clean-up

The automatic operation starting with Boiler Cold Clean Up break point is for improving the water quality before the light-off of burner. This break point is carried out only in the Initial Cold Start-up mode. When the boiler is in Cold, Warm, Hot and Very Hot Start-up mode, this break point is skipped.

This automatic operation is as follows:

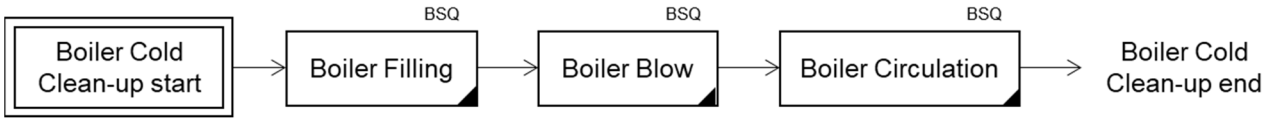


Fig.4.2.1. Boiler Cold Clean-up

4.3.1.1. Boiler Filing (BSQ)

The Boiler Filing (BSQ) is for filling the water in the boiler after the clean-up of pre-boiler system is completed.

The automatic operation flow of Boiler Filling Master Group Control Sequence is as follows:

Flow	Automatic Operations
1	☐ Separator Drain Tank Level Control Valve (SDT LCV) Outlet Valve are closed.
2	☐ SDT LCV Outlet Drain Valve is opened for discharging the excess water.
3	☐ The following are opened: - Economizer Outlet Line Vent Valve - SPR and SDT Outlet Line Vent Stop Valve
4	☐ M-BFP Outlet Flow Control Valve Controls Feedwater Flow around 10%TMCR.
5	☐ After the water level reaches 6.1m, Separator Drain Tank Level Control Valves start the level control and the excess water is discharged to Boiler Blowdown Tank via SDT LCV Outlet Drain Valve.
6	☐ After Economizer Outlet Vent finished, Economizer Outlet Line Vent Valve is closed.

4.3.1.2. Boiler Blow (BSQ)

The Boiler Blow (BSQ) is for improving the water quality to an acceptable level so that the drain can be returned from Separator Drain Tank to the condenser.

The automatic operation flow of Boiler Blow Master Group Control Sequence is as follows:

Step	Automatic Operations
1	☐ HRA Rear Wall Outlet Header Drain Valve, PRISH Inlet Line Drain Valve and Main Steam Line Drain Valve are opened to minimize the vacuum degree of the condenser at initial firing.
2	☐ Feedwater Flow to the furnace is increased up to 25%TMR.
3	☐ Feedwater Flow is controlled by M-BFP Outlet Flow Control Valve until the water quality at the outlet of Separator Drain Tank is improved to the required value.
4	☐ Water quality is checked.

4.3.1.3. Boiler Circulation (BSQ)

The Boiler Circulation (BSQ) is for improving the water quality to an acceptable level for light-off of burners (temperature rise of evaporator).

The boiler circulation consists of two processes: the clean-up of boiler circulation system and boiler unit system. The automatic operation flow of Boiler Circulation Master Group Control Sequence is as follows:

Step	Automatic Operations
1	☐ SDT LCV Outlet Valve is opened and SDT LCV Outlet Drain Valve is closed for returning the water from Separator Drain Tank to the condenser.
2	☐ Clean-up of boiler unit system is carried out by circulating 25%TMCR feedwater through the furnace to the condenser.
3	☐ When the water quality reaches to the specified conditions, boiler circulation is completed.

For the required water quality conditions to complete the boiler circulation, refer to Chapter 4.7 “Boiler Water Chemistry Control”.

4.3.2. Boiler Light off Preparation

The automatic operation starting with Boiler Light off preparation break point is for start-up of feedwater, air and flue gas, fuel and auxiliary steam systems. Those systems are required for boiler light off operation.

This automatic operation is as follows:

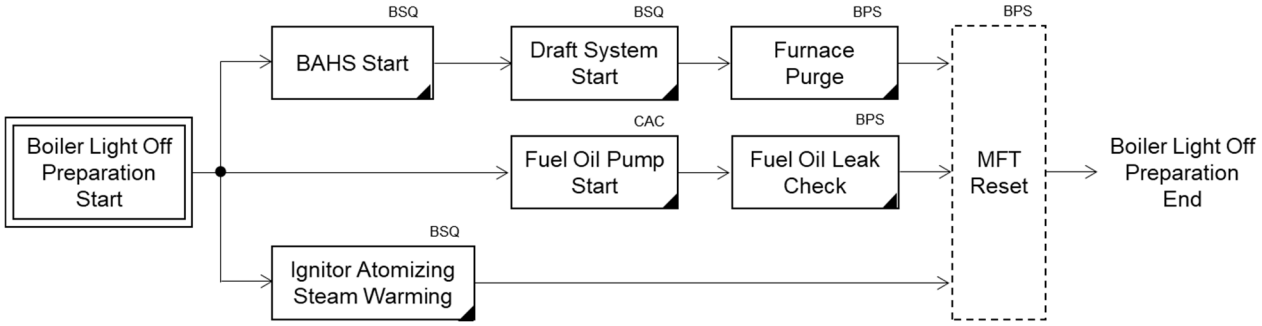


Fig.4.2.2. Boiler Light-off Preparation

4.3.2.1. Draft System Start (BSQ)

The Draft System Start (BSQ) is for starting the draft system which supplies the combustion air and exhausts the flue gas to the stack.

The automatic operation flow of Draft System Start Master Group Control Sequence is as follows:

Flow	Automatic Operations
1	☐ AH starts running.
2	☐ Air path from the FDF inlet through the stack is established.
3	☐ The first IDF starts running.
4	☐ IDF Inlet Guide Vane starts controlling Furnace Pressure.
5	☐ The first FDF starts running.
6	☐ FDF Inlet Vane starts controlling the combustion air flow. The combustion air flow is kept at the purge flow rate until the initial firing is completed.
7	☐ The succeeding IDF and FDF starts running.
8	☐ The succeeding IDF and FDF Inlet Vane starts operations in the same way as the first ones.

4.3.2.2. Boiler Furnace Purge (BPS)

The Boiler Furnace Purge (BPS) is for purging the combustibles from the furnace before light-off.
The automatic operation flow of Boiler Furnace Purge Master Group Control Sequence is as follows:

Flow	Automatic Operations
1	☐ The Boiler Furnace Purge Sequence could be started when the required purge air flow rate and the block of all fuel inputs to the furnace are proved.
2	☐ The purging will continue for 8 minutes.

4.3.2.3. Fuel Oil Leak Check (BPS)

The Fuel Oil Leak Check (BPS) is for ensuring the tightness of the Fuel Oil Shut-off Valve and individual Ignitor Fuel Oil Shut-Off Valve.
The automatic operation flow of Fuel Oil Leak Check Master Group Control Sequence is as follows:

Flow	Automatic Operations
1	☐ The Fuel Oil Check sequence could be started after Fuel Oil Pump is in service and the fuel oil pressure at the inlet of Fuel Oil Shut-off Valve reaches 1.0 MPa.
2	☐ Fuel Oil Leak Check Valve is opened. ☐ The position of Fuel Oil Flow Control Valve is fixed at 10% for charging fuel oil in the piping up to ignitors.
3	☐ Fuel Oil Leak Check Valve is closed after the ignitor inlet fuel oil pressure reaches 1.0 MPa.
4	☐ When the ignitor inlet fuel oil pressure is kept above 0.9 MPa and above for 120 seconds, the leak check completes successfully.
5	☐ Fuel Oil Shut-off Valve is opened.

4.3.2.4. Feedwater System Start (BSQ)

The Feedwater System Start (BSQ) is for supplying the boiler feedwater.
The automatic operation flow of Feedwater System Start Master Group Control Sequence is as follows:

Flow	Automatic Operations
1	☐ Furnace Lower Wall Inlet Header Drain Valve is opened for a fixed period to discharge the cold water stood in the furnace lower part.
2	☐ Furnace Lower Wall Inlet Header Drain Valve is closed.
3	☐ M-BFP is in service and M-BFP Outlet Flow Control Valve keeps the feedwater flow around 25%TMCR.

4.3.2.5. MFT Reset (BPS)

After all the MFT conditions are reset, and Boiler Furnace Purge and Fuel Oil Leak Check are completed, and feedwater system is established, MFT is reset automatically to complete the preparations for light-off.

4.3.3. Boiler Light-off

In the automatic operation starting with Boiler Light-off break point, the ignitors are in service and the boiler is warmed up. The pressure rises for the steam turbine start.

Except for the Initial Cold Start-up mode, the source of auxiliary steam system changes from auxiliary boiler to main boiler.

This automatic operation is as follows:

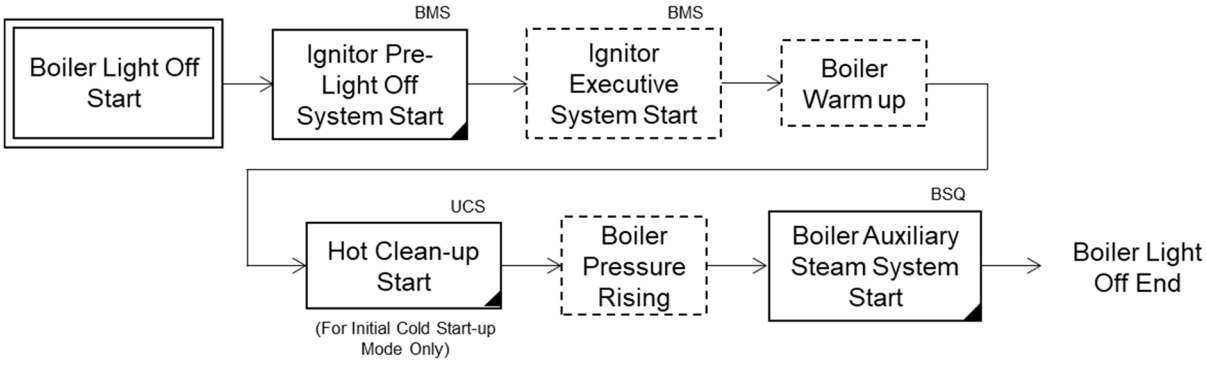


Fig.4.2.3 Boiler Light-off

4.3.3.1. Initial Firing (BMS)

The Initial Firing (BMS) is for stable light-off of 1st and 2nd ignitor pairs. The Master Group Control Sequence is programmed in BMS and proceeds with the UCS.

The automatic operation flow of Initial Firing Master Group Control Sequence is as follows:

Flow	Automatic Operations
1	☐ Before the light-off of 1st ignitor pair, Fuel Oil Flow Control Valve is fixed at the initial firing position to avoid the fluctuation of fuel oil pressure.
2	☐ Initial firing in BMS starts to light off 1st and 2nd ignitor pairs sequentially.
3	☐ Fuel Oil Flow Control Valve starts to control the ignitor inlet oil pressure at 1.1 MPa after 1st ignitor pair is light off.
4	☐ Fuel Oil Flow Control Valve starts to control the fuel oil flow after 1st and 2nd ignitor pairs are in service.

4.3.3.2. Ignitor Executive System Start (BMS)

The Ignitor Executive System Start (BMS) is for controlling the quantity of ignitors in accordance with the fuel oil flow demand from UCS.

The automatic operation flow of Ignitor Executive System Start Master Group Control Sequence is as follows:

Flow	Automatic Operations
1	☐ Ignitor Executive System (IES) in BMS starts to operate after the Fuel Oil Flow Control Valve starts to control fuel oil flow.
2	☐ IES initiates the ignitor light-off and shut-down command in accordance with the fuel oil flow demand.

4.3.3.3. Hot Clean-up (UCS)

The Hot Clean-up (UCS) is for improving the water quality to the level acceptable for boiler pressure rise. This operation is carried out in case the boiler is Initial cold condition at the initial light-off (Separator Inlet Manifold Fluid Temperature is less than 120 °C).

The automatic operation flow of Ignitor Hot Clean-up Drive Level Control Sequence is as follows:

Flow	Automatic Operations
1	☐ Hot clean-up sequence could be started when separator Inlet Manifold Fluid Temperature reaches 195°C.
2	☐ The fuel flow demand is decreased to around 4% MCR.
3	☐ The HP Turbine Bypass Valve starts the main steam pressure control. The main steam pressure set point is held at the fixed value.
4	☐ By keeping Separator Inlet Manifold Fluid Temperature at around 200 °C, the deposition of iron is accelerated, and the water quality is improved.
5	☐ The above operation is completed when the water quality reaches the specified conditions.

4.3.3.4. Boiler Auxiliary Steam System Start (BSQ)

The Boiler Auxiliary Steam System Start (BSQ) is for changing the steam source:

- When the main steam pressure is low (the steam generation is small), the auxiliary steam is supplied from Auxiliary Boiler or another unit.
- When the boiler can generate enough steam, the source of the auxiliary steam is changed to the own boiler.

In Initial Cold Start-up mode, this operation is performed after the completion of synchronization.

The automatic operation flow of Boiler Auxiliary Steam System Start Master Group Control Sequence is as follows:

Flow	Automatic Operations
1	☐ Boiler Auxiliary Steam System Start Sequence could be started after main steam pressure reaches the preset value.
2	☐ Auxiliary Steam Line Drain Trap Bypass Valve is opened.
3	☐ Boiler Auxiliary Steam Stop Valve is opened to supply auxiliary steam from boiler HRA.
4	☐ The position of Boiler Auxiliary Steam Pressure Control Valve is fixed at 20% for warming.
5	☐ Unit1 & Unit2 Turbine Auxiliary Header Interconnection Isolation Valve is closed to stop supply of auxiliary steam from auxiliary boiler or the other unit.
6	☐ The Boiler Auxiliary Steam Pressure Control Valve starts the steam pressure control at 2.0MPa Auxiliary Steam Header.
7	☐ Auxiliary Steam Line Drain Trap Bypass Valve is opened after warming is completed.

4.3.4. Turbine Start

The automatic operation starting with Turbine Start break point is for starting steam turbine after the main steam pressure reaches 8.4 MPa and the temperature is kept in the required range.

In the boiler portion, preparations of coal firing including Primary Air System starts.

This automatic operation is as follows:

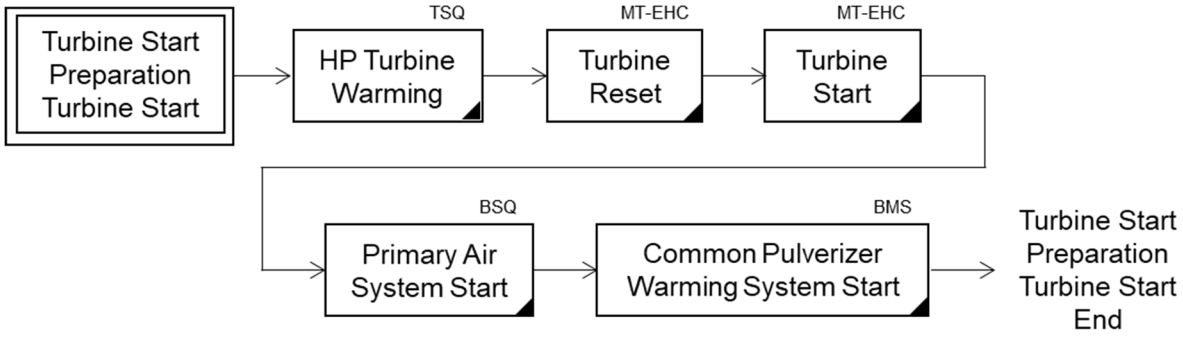


Fig.4.2.4. Turbine Start

4.3.4.1. Primary Air System Start (BSQ)

The Primary Air System Start (BSQ) is essential for Pulverizer operation. The 1st pulverizer will start after the synchronization, but it takes long time to warm up the pulverizer system and the related duct. Therefore, Primary Air System starts in this phase.

The automatic operation flow of Primary Air System Start Master Group Control Sequence is as follows:

Flow	Automatic Operations
1	☐ All the related dampers are closed.
2	☐ The 1st Primary Air Fan starts.
3	☐ The corresponding PAF Outlet Damper is opened.
4	☐ PAF Inlet Vane starts to control the hot primary air pressure.
5	☐ The succeeding Primary Air Fan starts in the same manners as flows 2 thorough 4.

4.3.4.2. Common Pulverizer Warming Start (BMS)

The Common Pulverizer Warming Start (BMS) is for warming up the pulverizer system to minimize the start-up time of pulverizer system.

To produce the pulverized coal, the raw coal needs to be dried in the pulverizer system by using hot primary air.

However, it will take much time to start 1st and 2nd pulverizer because the pulverizer and related ducts are cold and the fuel gas temperature is relatively low at the low load. To minimize the start-up time of pulverizer system, the Common Pulverizer Warming is in service before the pulverizer system starts.

The automatic operation flow of Common Pulverizer Warming Start Master Group Control Sequence is as follows:

Flow	Automatic Operations
1	☐ The positions of Pulverizer Hot Primary Air Control Damper and Pulverizer Cold Primary Air Control Damper are set at the preset value.
2	☐ Pulverizer PF Cut Damper and Pulverizer Sealing Air Shut-Off Valve are opened.
3	☐ After the sealing of Pulverizer is confirmed, Pulverizer Primary Air Inlet Shut-Off Damper is opened.
4	☐ Pulverizer Primary Air Auxiliary Flow Control Damper is opened from 0% to 85%. (After Pulverizer Primary Air Flow is increased, the position of this control damper is increased gradually until 100%)
4	☐ When Pulverizer Inlet Primary Flow reaches 50 t/h, Pulverizer Primary Air Flow Control Damper starts to control Pulverizer Inlet Primary Flow at 99.4 t/h.
5	☐ Pulverizer Hot/Cold Primary Air Tempering Damper starts to control Pulverizer Inlet Primary Air Temperature at 75 °C.
6	☐ The above (flow 5) Pulverizer warming continues until the Pulverizer starts.

4.3.5. Synchronization /Unit Load Up 1

The automatic operation starting with Synchronization/Unit Load Up 1 break point includes the following:

- The generator is in service (synchronization).
- The unit load is increased up to 15%TMCR.
- Turbine BFP starts to operate and Motor BFP is shut down.
- In boiler portion, the master fuel is changed from fuel oil to coal.

This automatic operation is as follows:

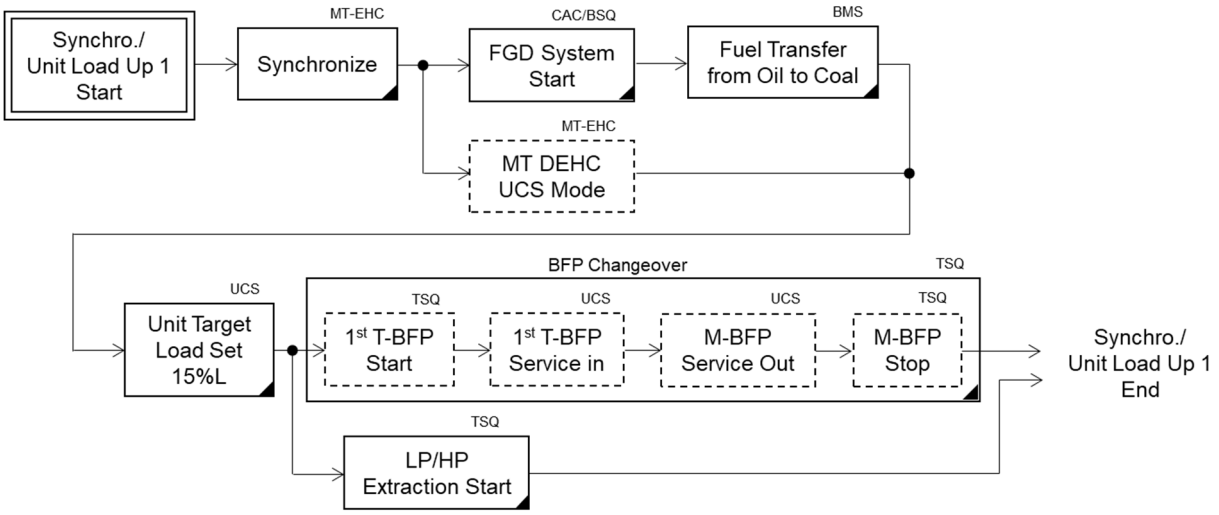


Fig. 4.2.5. Synchronization /Unit Load Up1

4.3.5.1. Fuel Transfer from Oil to Coal (BMS)

The Fuel Transfer from Oil to Coal Start (BMS) is for changing the master fuel from light fuel oil to coal.

The master group control sequence is programmed in BMS and proceeds with the UCS.

The automatic operation flow of Fuel Transfer from Oil to Coal Start Master Group Control Sequence is as follows:

Flow	Automatic Operations
1	☐ After synchronization, the 1st pulverizer start sequence command is output.
2	☐ When the 1st pulverizer starts, Fuel Oil Flow Demand decreases to keep the total fuel flow because the minimum coal flow for each pulverizer is 25t/h.
3	☐ The start command for the 2nd pulverizer is initiated when unit load reaches 15%L.
4	☐ After the 1st and 2nd pulverizers start-up is completed, Ignitor Executive System stops.
5	☐ In UCS, Pulverizer Master is placed into auto control and coal becomes the master fuel after the 2 pulverizers are ready to follow the load change.
6	☐ The target of Fuel Oil Flow Demand is set to 0t/h and decreases gradually.
7	☐ The ignitor shut-down command is output.
8	☐ All ignitors are shut down.

4.3.5.2. Pulverizer Executive System Start (BMS)

After the completion of 2 pulverizers start-up, Pulverizer Executive System Start command is output, because the pulverizer system can follow the fuel flow demand stably.

Pulverizer Executive System outputs the command signal of pulverizer start or pulverizer shut-down sequence, in accordance with MW demand signal. The set point for pulverizer start during unit start-up is different from the set point during normal operation (after the completion of unit start-up), because the unit start-up time is limited and pulverizer needs to be started in advance, considering the required time for pulverizer start-up.

The automatic operation flow of Pulverizer Executive System Start Master Group Control Sequence during unit start-up is as follows:

Flow	Automatic Operations
1	☐ When the MW demand is above 35% TMCR, the 3rd Pulverizer start sequence starts.
2	☐ When the MW demand is above 63% TMCR, the 4th pulverizer start sequence starts.

4.3.5.3. 1st T-BFP Service In (UCS)

M-BFP is only used for the unit start-up and shut-down. Therefore, M-BFP needs to be changed over to T-BFP and the T-BFP is required to be in service before the unit load increase.

4.3.6. Unit Load Up 2

The automatic operation starting with Unit Load Up 2 break point is the final phase for the unit start-up operation. The unit load is increased from 15%TMCR to the full load.

During this operation, the other T-BFP in the boiler portion and 2 pulverizers start operation. The boiler operation mode changes from Wet Mode to Dry Mode.

This automatic operation is as follows:

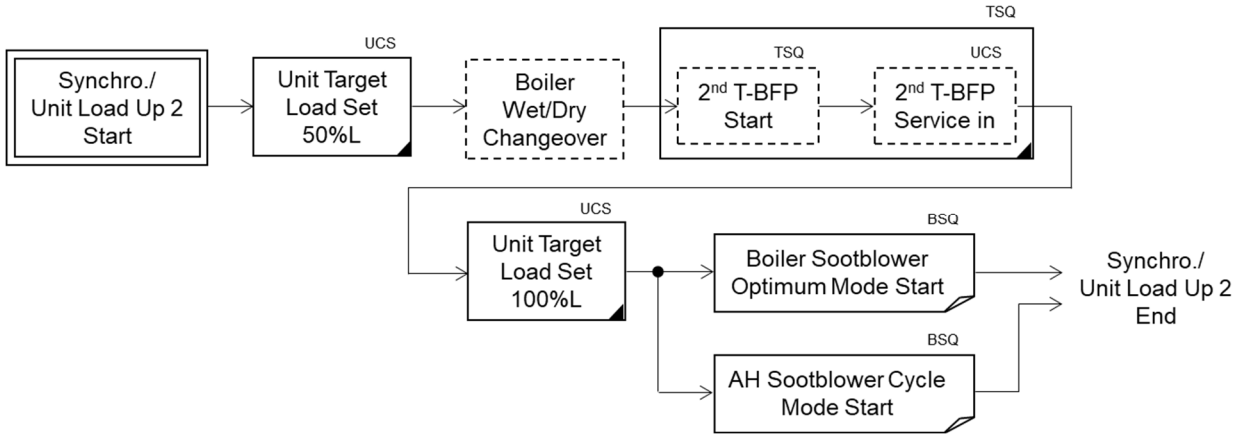


Fig. 4.2.6. Unit Load Up 2

4.3.6.1. Wet/Dry Changeover

The boiler changes from Wet Mode to Dry Mode around 35 to 40%TMCR. The boiler condition is unstable around this load. Therefore, Wet/Dry Changeover is executed when the unit load is increased from 15%TMCR to 50%TMCR to pass this region as soon as possible.

The Wet/Dry Changeover is related to several major control loops:

- MW Demand/Boiler Master controls in Load Control system
- Separator Drain Tank Level Control Valve / Separator Drain Tank Drain Water Relief Control Valve
- Feedwater/Fuel Ratio Control/Calorie Compensation in Fuel System.
-

The following are major operations during Wet Mode and Dry Mode:

During	Operations
Wet Mode	• The minimum feedwater flow is set above the normal set point to keep the boiler condition wet. • Economizer Inlet Feedwater Flow and Fuel Flow Set Point are set based on only MW Demand to stabilize the boiler condition. Therefore, Main Steam Pressure is controlled by Feedwater/Fuel Ratio and Boiler Master just tracks MW Demand. • Separator Drain Tank Level Control Valve (P-valve) controls to keep the separator drain tank level around 6.1m. • The minimum feedwater flow is set to get close to the normal set point, as the load increase to 35 to 40%TMCR. • As the dryness of boiler increases, the drain flow to Separator Drain Tank decreases and P-valve closes gradually. When P-valve position becomes less than 3%, DCS judges the boiler condition is dry and changes the boiler control to “Dry Mode”.
Dry Mode	• Boiler Master starts to control Main Steam Pressure. • Feedwater / Fuel Ratio starts to control Main Steam Temperature instead of Main Steam Pressure. • Separator Drain Tank Drain Water Relief Valve is used to discharge the accumulated water in Separator Drain Tank.

4.4. Boiler Shut-down Operation

This section provides flow charts for 5 Break Points for Unit Shut-down Automatic Operation for boiler, and explanations for Major Master Group Control and Drive Level Control step(s) included in each flow.

4.4.1. Load Down 1

The automatic operation starting with Unit Load Down 1 break point is the first phase for the unit shut-down operation. The unit load is decrease to 70%TMCR.

In accordance with the load change,

- If the fuel oil system is not in service, Fuel Oil Leak Check is carried out for pulverizer shut-down.
- If Pulverizer Executive System is not in service, it is started before unit load change.
- Setting of Pulverizer Executive System for unit shutdown operation is turned ON.
- The number of running Pulverizer is decreased by Pulverizer Executive System.

This automatic operation is as follows:

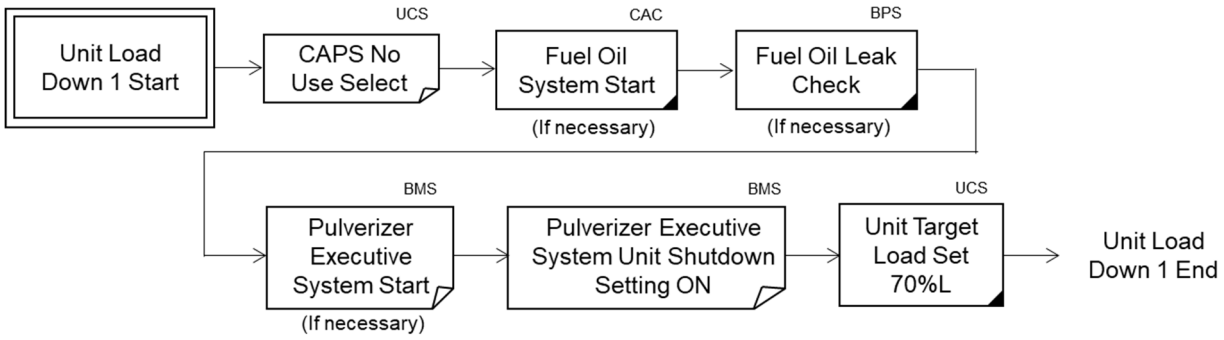


Fig. 4.5.1 Unit Load Down 1

4.4.1.1. Pulverizer Executive System Start (BMS)

The Pulverizer Executive System outputs the start command to shut down the 1st to 2nd pulverizers.

The following table shows the initial set point for the 1st to 2nd pulverizers shut-down during the unit shut-down.

	1st Pulverizer	2nd Pulverizer
MWD for Pulverizer Shut-down Sequence Start (For Normal Operation)	Below 63% TMCR	Below 35% TMCR
MWD for Pulverizer Shut-down Sequence Start (For Unit Shutdown*)	Below 77% TMCR	Below 49% TMCR

(Note) *MW setting for unit shutdown mode could be selected by operator.

4.4.2. Unit Load Down 2

In the automatic operation starting with Unit Load Down 2 break point, the unit load is decreased to 40%TMCR.

In this phase,

- First T-BFP is shutdown.

This automatic operation is as follows:

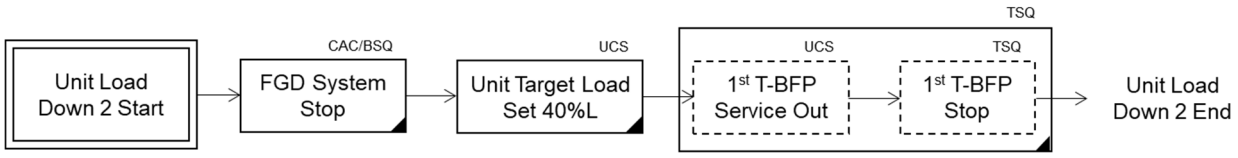


Fig. 4.5.2. Unit Load Down 2

4.4.3. Unit Load Down 3

In the automatic operation starting with Unit Load Down 3 break point, the unit load is decreased to 5%TMCR for de-synchronization.

In this phase,

- The boiler operation mode is changed from Dry Mode to Wet Mode at 25%TMCR.
- The master fuel is changed from coal to oil.
- All T-BFP are shut down and M-BFP starts running.

This automatic operation is as follows:

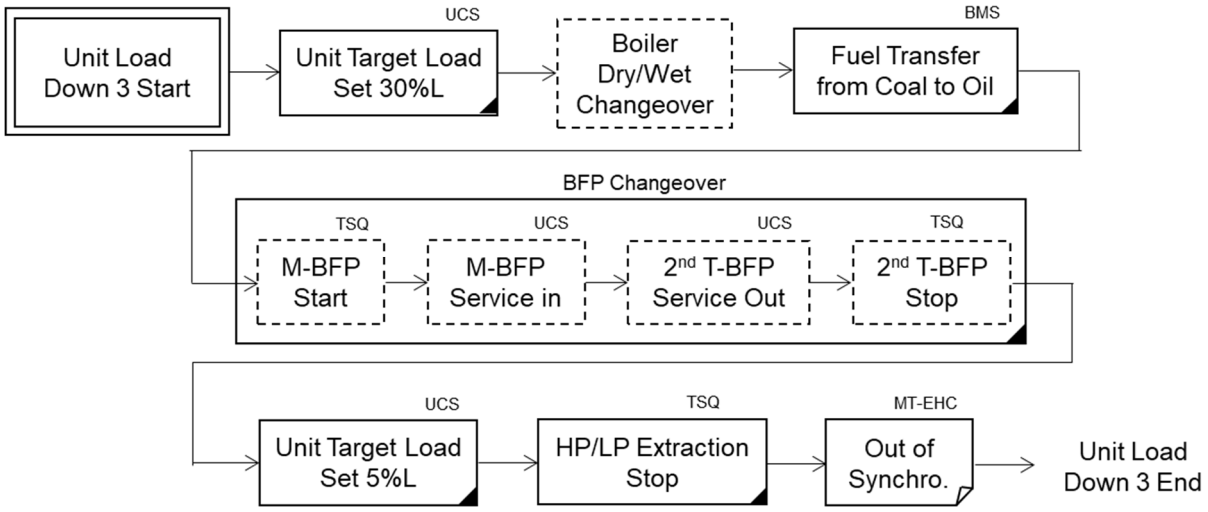


Fig. 4.5.2. Unit Load Down 3

4.4.3.1. Fuel Transfer from Coal to Oil Start (BMS)

The Fuel Transfer from Coal to Oil Start (BMS) is for changing the master fuel from coal to light fuel for unit shutdown.

During this process, 3rd and 4th pulverizers shut-down sequence starts as follows:

	3rd Pulverizer	4th Pulverizer
MWD for Pulverizer Shut-Down Sequence Start	Pulverizer Coal Flow < 27t/h	Below 25% TMCR

The automatic operation flow of Fuel Transfer from Coal to Oil Start Master Group Control Sequence is as follows:

Flow	Automatic Operations
1	☐ After the unit load is decreased to 30%TMCR, the light-off command for the 1st and 2nd ignitor pairs is output.
2	☐ When 2 ignitor pairs are in service, Fuel Oil Flow Control Valve is changed to Flow Control Mode and Ignitor Executive System (IES) starts. At this time, light fuel oil is the master fuel and Fuel Oil Flow demand signal changes in accordance with Firing Rate Demand.
3	☐ The Coal Flow Demand is fixed at the previous value and then decreased to 25t/h to make a margin for fuel oil flow control and decrease the pulverizer load for shutdown.
4	☐ The 4th pulverizer shut-down sequence starts.
5	☐ After the pulverizer cooling is completed (approximately 15 to 20 minutes), the coal feeder is stopped.
6	☐ “Fuel Transfer from Coal to Oil” sequence is completed.

4.4.3.2. Dry/Wet Changeover (UCS)

The boiler is changed from Dry Mode to Wet Mode around 35%TMCR during the unit shut-down, because the balance of metal temperature of furnace during the unit shut-down is stable, comparing with the unit start-up.

The automatic operation flow of Dry/Wet Changeover is as follows:

Flow	Automatic Operations
1	☐ The firing rate demand decreases, as the unit load decrease from 40% to 30%TMCR.
2	☐ The feedwater flow reaches the minimum set point (35%TMCR) and the boiler is forced to wet condition.
3	☐ The level of Separator Drain Tank starts to rise to 6.1m.
4	☐ Separator Drain Tank Level Control Valve (P-valve) starts the level control and the boiler control mode is changed to “Wet Mode”.

4.4.3.3. 1st T-BFP Shut-down and BFP Changeover

In accordance with the unit load down, one of the T-BFPs is stopped to ensure the minimum control limit.

When the unit load is decreased again, M-BFP is started to shut down the final T-BFP.

4.4.4. Turbine Shutdown

In the automatic operation starting with Turbine Shut-down break point, the Steam Turbine/Generator is shut down after the unit load reaches 5%TMCR.

In this phase,

- The boiler continues running until the next break point.
- The excess steam which occurs after the turbine shutdown is released by HP Turbine Bypass Valve to the condenser via LP Turbine Bypass.
- Primary Air System is shut down since the purging of the final pulverizer is completed.

This automatic operation is as follows:

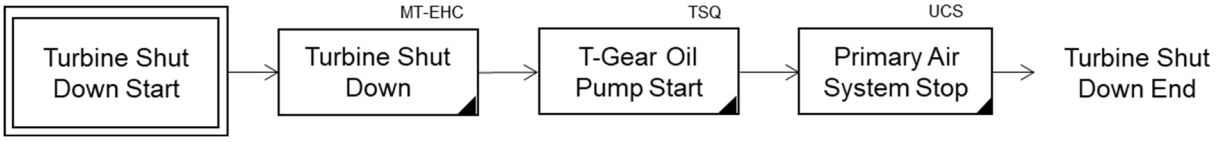


Fig. 4.5.3. Turbine Shutdown

4.4.4.1. Primary Air System Stop (BSQ)

After the shut-down sequence of all Pulverizers is completed, Primary Air System is stopped one by one as follows:

Flow	Automatic Operations
1	☐ The inlet vane of PAF which is in shut-down sequence is closed.
2	☐ PAF stops.
3	☐ The corresponding PAF Outlet Damper is closed.
4	☐ The last PAF is shut down in the same manner.

4.4.5. Boiler Shutdown

In the automatic operation starting with Boiler Shut-down break point, all ignitors are shut down (MFT).

After the boiler is shut down and M-BFP is stopped, some steam is generated due to the residual heat of boiler furnace. The excess steam is released by HP Turbine Bypass Valve to the condenser via LP Turbine Bypass. Since the coal firing system is shut down, ESP system is shut down.

This automatic operation is as follows:

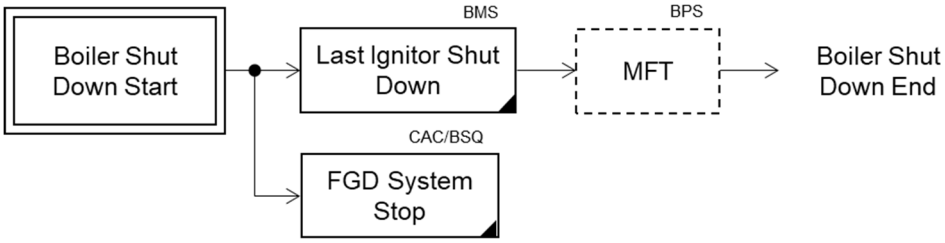


Fig. 4.5.4. Boiler Shutdown

4.4.5.1. Last Ignitor Shutdown (BMS)

This operation is provided to shut down all ignitors as follows:

Flow	Automatic Operations
1	☐ Ignitor Executive System is stopped.
2	☐ Fuel Oil Flow Control Valve is changed from Flow Control Mode to Pressure Control Mode.
3	☐ Ignitor Inlet Fuel Oil Pressure is controlled at 0.6 MPa.
4	☐ This sequence is programmed to shut down ignitors in the reverse order.
5	☐ When Ignitor Inlet Fuel Oil Pressure is less than 0.7 MPa, all ignitors are shut down in the reverse order for ignitor light-off sequence.

4.4.5.2. MFT (BPS)

When MFT is initiated, all fuel input to the furnace is blocked compulsively. The boiler draft system continues to operate for boiler enclosure purge after MFT.
FDF inlet vane is controlled to maintain the purge air flow rate and IDF inlet is controlled to maintain the furnace pressure at constant value.

4.4.6. Auxiliary Equipment Shutdown

In the automatic operation starting with Auxiliary Equipment Shut-down break point, the plant auxiliary equipment is shut down.

This automatic operation is as follows:

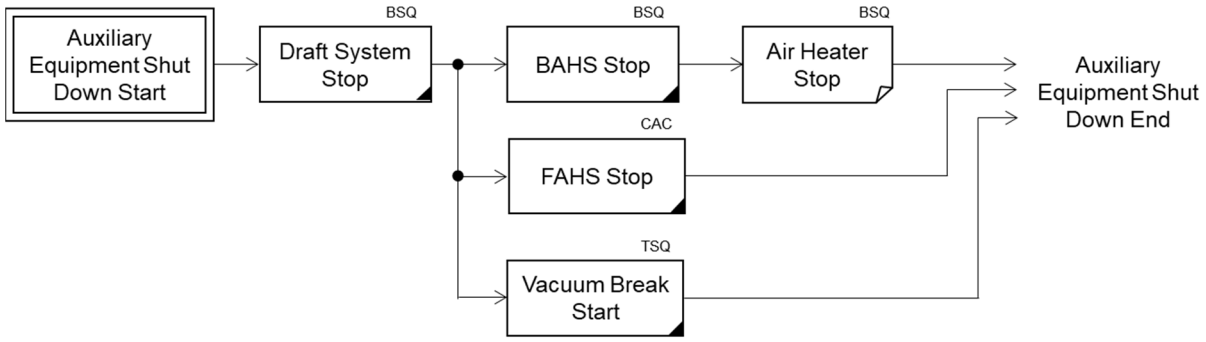


Fig. 4.5.5. Auxiliary Equipment Shutdown

4.4.6.1. Draft System Shutdown (BSQ)

This operation is carried out to shut down the draft system for boiler as follows:

Flow	Automatic Operations
1	☐ The inlet vane of FDF is closed and FDF is stopped.
2	☐ The outlet damper for FDF is closed.
3	☐ The inlet guide vane of the corresponding IDF is closed and IDF is shut down.
4	☐ The outlet damper for IDF and AH Inlet Flue Gas Isolation Damper are closed.
5	☐ The succeeding IDF and FDF are shut down and related dampers are closed in the same manner.
6	☐ AH can be shut down after the flue gas temperature at ECO Outlet decreases less than the permitted value. (AH shut-down operations are executed by operator.)

4.5. Boiler Normal Operation

This section provides the operational concept for the Boiler during normal operation.

No.	Item	Operational Concept
1	Minimum Stable Load with No Support Fuel	Minimum load of coal fired operation without support fuel is designed as 40%NDC (Net).
2	Dry/Wet Mode	Dry mode to wet mode change over point is designed around 35%NDC (Net). During normal operation between 40%NDC (Net) and BMCR, it is operated by dry mode.
3	Turbine Operation Mode	Constant Pressure Operation :90%NDC (Net) to BMCR Variable Pressure Operation : 31.6%NDC (Net) to 90%NDC (Net) (During start-up from turbine-roll to 31.6%NDC (Net), it is operated at constant floor pressure.)
4	Control Range of Rated Steam Temperature at Boiler Outlet.	Rated Main Steam Temp. : 566degC at HP Turbine Inlet. Control Range of MST : from 40%NDC (Net) to BMCR Rated Reheat Steam Temp.: 566degC at IP Turbine Inlet Control Range of RST : from 75%NDC (Net) to BMCR
5	Load Change Rate	Load Change Rate at normal operation is applied as follows; 40%NDC (Net) to 50%NDC (Net) :7.16 MW/min (1%NDC/min) 50%NDC (Net) to 100%NDC (Net) :14.32 MW/min (2%NDC/min) Note: Load change rate is defined as the inclination of actual generated MW.

No.	Item	Operational Concept
6	Load Band Operation for Pulverizer System* *:Pulverizer Executive System	Five (5) Pulverizers/Pulverizers are totally provided. During normal operation under BMCR condition with specified coal firing, four (4) pulverizers in service, one (1) pulverizer is stand-by. In case of emergency (unforeseen circumstances), five (5) pulverizers operation is also considered. Basically, the storage of sub-bituminous coal in the bunker for the standby Pulverizer for long duration is prohibited from the viewpoint of preventing fire, but in actual operation short time storage of sub-bituminous coal in the bunker (for example Pulverizer change over) may be acceptable with careful attention to the occurrence of fire. Load band operation for Pulverizer system is applied to optimize pulverizer start /stop timing and maintain start-up/shut-down schedule. Following is the basic operating band depending on the Nos. of operating pulverizers. 4 pulverizers band : 65%NDC (Net) ~ 100%NDC (Net) 3 pulverizers band : 40%NDC (Net) ~ 65%NDC (Net) For actual operation, pulverizer change over point can be flexibly changed within the range of the pulverizer maximum/minimum capacity.
7	Pulverizer Start Operation after Pulverizer Trip	Pulverizer start operation after pulverizer tripped is depended in accordance with the characteristics of the coal from the viewpoint of safety operation. The pulverizer start operation after pulverizer tripped should not be applicable without clearing of the remaining coal in the pulverizer to avoid pulverizer fire.

No.	Item	Operational Concept
8	Coal Blending	Coal blending should be performed at coal stockpile. Coal feeding into each pulverizer should be the same coal characteristics and the different coal feeding into each pulverizer is prohibited due to the imbalance of combustion and heat absorption to heating surface.
9	Fuel Oil Fired Operation	Fuel oil (Ignitor) is used for following purposes. a. Fuel oil is used during unit start-up and shut-down. b. Fuel oil is used during pulverizer individual start-up and shut-down. c. Fuel oil is possible to use for supporting running pulverizers combustion at loads below 30%NDC (Net). Coal firing with fuel oil support is not acceptable for normal operation of the boiler more than 40%NDC (Net). (In case of one pulverizer stop for maintenance or any incident during normal plant operation, the one (1) pulverizer in stand-by is provided.) Capacity of fuel oil firing system is designed to cover 30%NDC (Net) operation.
10	Application of Coal Adaption Control System for Power Station (CAPS)	In order to ensure suitable operation on the SOVR steam generator with firing various coals such as bituminous, sub-bituminous coal as specified, the CAPS will be applied. The basic principles of the CAPS are to correct control parameters automatically at the time of changing the operational status of a plant by coal change. Activation of CAPS needs initial tuning of control system by engineer during plant operation with various loads and types of coal.

4.5.1. Impermissible and Recommended Coal Burner Pattern

This section provides impermissible and recommended coal burner pattern.

■ Coal Burner Pattern

This boiler consists of five (5) pulverizers and five (5) burners for each pulverizer. The operation philosophy of coal burner pattern is provided from the following viewpoints:

- **Balanced coal burner pattern**

Unbalanced coal burner pattern to one side (rear or front) should be avoided.

- **Making of “opposed firing” level**

The coal firing system in furnace is designed based on “opposed firing” system.

Accordingly, it is essential to make one set of “opposed firing” level for the stable combustion.

- **Selected set of “opposed firing level**

Among the various pattern of coal burners, minimum one set of “opposed firing” level should be made. Additional burner row should be selected closed to “opposed firing” level to establish stable combustion in furnace.

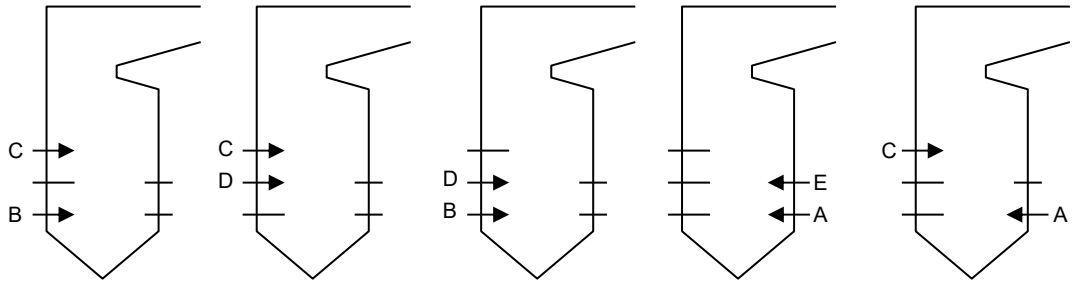
4.5.1.1. Unbalanced Coal Burner Pattern (Impermissible pattern)

The unbalanced coal burner pattern, which has two or more un-opposed coal burner rows, leads negative impacts on Boiler operation. Fig.0 provides impermissible burner pattern as unbalanced coal burner pattern based on our experienced operation. They shall be avoided unless emergency (i.e. load runback) condition.

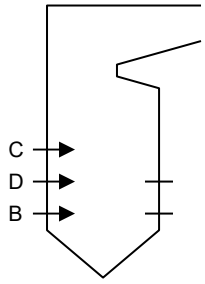
The negative impact on Boiler is provided below.

- Increasing of the potential of furnace tube malfunction caused by biased heating on furnace wall.
- Increasing of the potential of lopsided combustion gas flow distribution in furnace which leads excessive LOI (Loss of Ignition) and unbalanced metal temperature distribution at superheater and reheater.

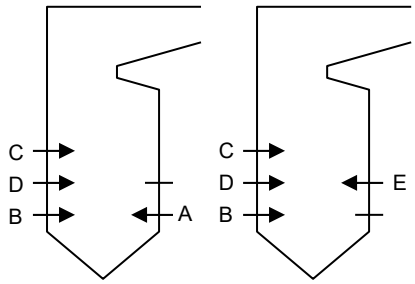
For 2 Coal Burner Rows



For 3 Coal Burner Rows



For 4 Coal Burner Rows*



* During maintenance of Pulverizer A or E, these coal burner patterns are admitted to apply.

Fig. 0 Unbalanced Coal Burner Pattern A (Impermissible)

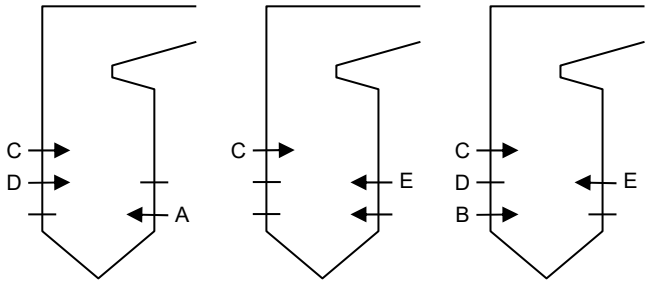
4.5.1.2. No “Opposed Firing” level (Pattern which Needs Careful Attention)

The coal burner pattern without “opposed firing” level leads the negative impact to boiler operation as described below.

- Increasing of potential of lopsided combustion gas flow distribution in furnace which leads excessive LOI (Loss of Ignition) and unbalanced metal temperature distribution at superheater and reheater.
- The following coal burner pattern needs careful attention on boiler operating conditions such as tube metal temperature, Boiler outlet O2 and NOx, etc.

  The following coal burner pattern should be avoided unless emergency (i.e. load runback) condition.

For 3 Coal Burner Rows (Pattern which needs careful attention)



For 2 Coal Burner Rows (Pattern which needs careful attention)

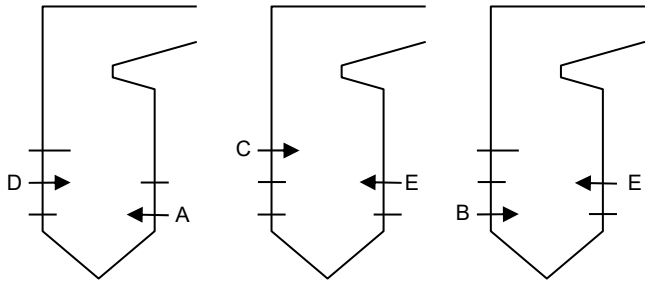


Fig. 0 Unbalanced Coal Burner Pattern B
(Pattern which needs careful attention)

4.5.1.3. Selection of Set of “Opposed Firing” level (Pattern which Needs Careful Attention)

The selection of set of “opposed firing” level should be made with consideration of combustion stability in furnace. Especially at low load of Boiler and/or pulverizer, the combustion has less stability, so the selection of set of “opposed firing” level is important to ensure stable combustion in furnace. Fig. 0 describes the recommendation for reference.

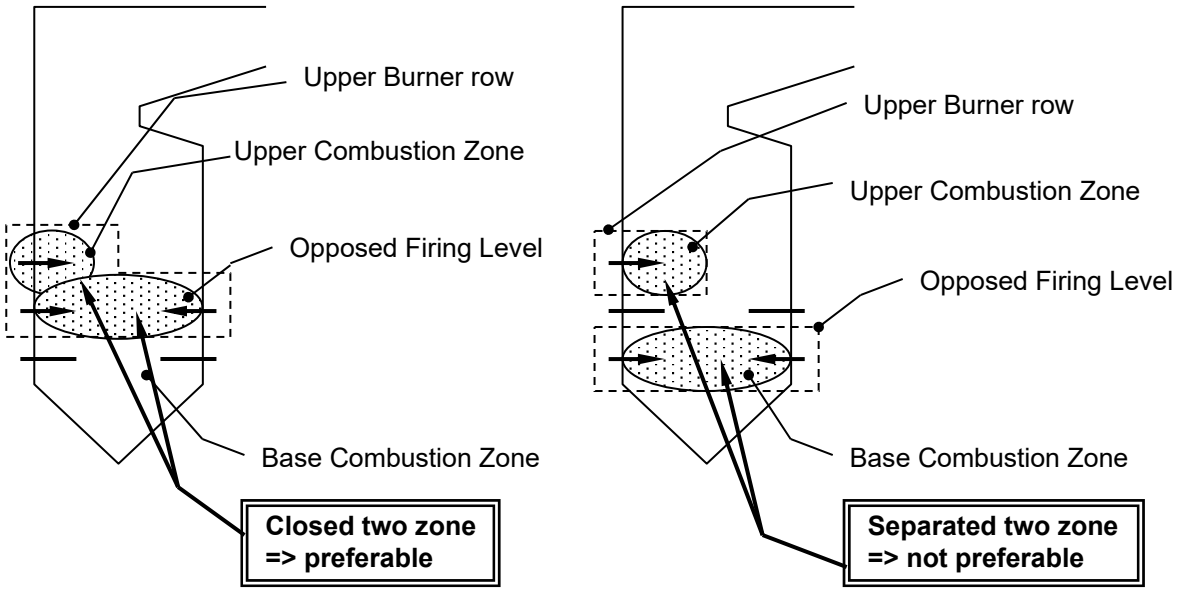


Fig.0 Explanation of Opposed Firing Level

From the viewpoint of the above explanation, following coal burner pattern needs careful attention.

For 3 Coal Burner Rows (Pattern which needs careful attention)

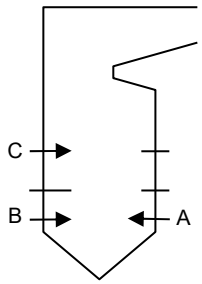


Fig. 0 Unbalanced Coal Burner Pattern C (Pattern which Needs Careful Attention)

4.6. Boiler Emergency Operation

This section provides the operational concept for the Boiler during Boiler special operation.

No.	Item	Operational Concept
1	Peak Load Operation	Not Applicable
2	Runback Operation caused by Boiler	(1) Runback items - Pulverizer Trip Runback (4 sets to 3 sets) - Pulverizer Trip Runback (3 sets to 2 sets) - Draft System Trip Runback (Both path to Single path) (2) Pulverizer Trip Runback Operation When pulverizer runback happens, coal flow rate of remaining pulverizers is maintained and MWD is reduced to the load which is equivalent to the coal flow rate of remaining pulverizers. MWD is controlled not falling below 40%NDC. (3) Draft System Trip Runback The air and flue gas system consists a pair of draft paths including a pair set of FDF, IDF, PAF (except AH). For example, in case of one (1) FDF trip, the draft paths which tripped FDF belong to, are entirely tripped. And plant operation continues with the remaining draft path, while unit load is reduced until target load, (Target load of FDF and IDF is 40%NDC(Net) and target load of PAF is 30%NDC(Net).) Runback items caused by other BOP are described separately.
3	Runback Operation caused by Turbine	(1) Runback items - BFP Trip Runback (2BFPs Operation, One BFP Tripped) - CWP Trip Runback - HTR HHWL (2) BFP Trip Runback In case of one (1) BFP trip, plant operation continues with the remaining BFP, while unit load is reduced until target load (Target load is 40%NDC (Net)). (3) CWP Trip Runback In case of one (1) CWP trip, plant operation continues with the remaining BFP, while unit load is reduced until target load (Target load is 40%NDC (Net)). (4) HTR HHWL In case of any HTR level reaches HHWL, unit load is reduced until target load (Target load is 90%NDC (Net)). After runback to target load, condensate or feedwater will bypass the HTRs automatically. NOTE: Maximum Load for HP or LP heater bypass operation is defined in “VP1-C-L2-M-GEN-00005 Basic Operation Concept for Turbine and Auxiliary Plant”.

4	House Load Operation	House Load Operation after the failure of the grid system is considered for the design of power plant. Maximum performing time of House Load Operation is 1 hour. In order to prevent damage in the Steam Turbine, the trend of the monitoring values must be observed (especially the ones mentioned below). In case the monitoring values, especially those mentioned below exceed the alarm value and this condition persists, the turbine shall be tripped, even though performing time of House Load Operation is less than 1 hour. - HP exhaust temperature - Bearing metal temperature - Casing differential temperature for inner and outer - Casing differential temperature for upper and lower - Lube oil tank level - Main steam temperature - Frequency Refer to the following documents for further detail of house load operation, - VP1-0-EPC-E-GEN-00012 Electrical Operation Philosophy - VP1-C-L2-M-GEN-00005 Basic Operation Concept for Turbine and Auxiliary Plant
5	Boiler Single Operation	Boiler Single Operation after steam turbine generator trip is considered for the design of power plant.
6	Turbine Bypass System	(1) The Turbine Bypass System is supplied for the following purposes. - To coordinate the conditions between boiler and turbine during start-up and shut-down safely and efficiently. - To protect the boiler against overpressure at emergency. - To realize the boiler single operation and house load operation. (2) The turbine bypass system consists of HP turbine bypass system and LP turbine bypass system. (3) 60%BMCR of capacity at BMCR steam condition is considered for the design of each system.
7	Start-up in Blackout Condition	Plant Start-up in Blackout Condition is not considered for the design of power plant.

4.7. Boiler Water Chemistry Control

4.7.1. Introduction

Water/steam side corrosion and accumulation of scale are the largest causes of Boiler pressure parts' failures. Improper Boiler water chemistry maintenance and treatment may result in reducing system life, reliability, efficiency and safety. Therefore, it is vital to control Boiler water/steam side chemistry within a range so as to reduce the potential of damages on Boilers, turbines, and other plant components caused by corrosion, fouling in heat transfer surfaces.

4.7.2. Boiler Water Chemistry Requirements

To control the boiler feedwater quality, three methods are used: AVT-O (All Volatile Treatment without Hydrazine), AVT-R (All Volatile Treatment with Hydrazine) and CWT (Combined Water Treatment). These three feedwater control methods by AVT-O, AVT-R and CWT are switched depending on the operating conditions.

In normal operation, Boiler operates with CWT mode. After long term shut-down and chemical cleaning, during start-up and shut-down of the plant, Boiler operates with AVT-O mode, AVT-R mode is applied only when first 500hr after construction.

AVT-O, AVT-R and CWT have the following features:

■ AVT-O（All Volatile Treatment without Hydrazine）

This method increases pH to 9 or more by adding volatile substances ammonia (NH_3) to feedwater, and perform mechanical degassing with a deaerator. These suppress the solubility of magnetite (Fe_3O_4), which is the surface coating of carbon steel making up the boiler tube, to prevent overall corrosion and to control local corrosion such as pitting, thereby preventing carbon steel from corrosion.

Since magnetite has a coarse crystal lattice and a high generation rate, the scale attached to inside the tube grows excessively large, causing a problem of an increase in boiler differential pressure and impeding stable operation of the feedwater system control valve. As a countermeasure for this problem, it is necessary to remove the scale by periodic chemical cleaning (every 4 years).

■ AVT-R（All Volatile Treatment with Hydrazine）

This method increases pH to 9 or more and perform mechanical degassing with a deaerator. In addition to ammonia, an oxygen scavenger such as hydrazine is used to promote dearetion.

Since hydrazine destroy the hematite layer which is made by CWT operation and is firmer than magnetite layer, AVT-R mode is applied only during the beginning of commissioning before formed magnetite layer.

■ CWT（Combined Water Treatment）

This method forms the hematite (Fe_2O_3) protective coating over the magnetite (Fe_3O_4), which is the surface coating of carbon steel making up the boiler tube, by adding a trace amount of oxygen in high purity water or high purity water containing low concentration of ammonia. This protective coating on the surface prevents overall corrosion and controls local corrosion such as pitting to prevent carbon steel from corrosion.

Compared to magnetite, hematite has a dense crystal lattice and extremely low solubility in water, making it possible to suppress scale overgrowth and boiler differential pressure rise.

CWT requires no hydrazine and its pH is lower than AVT, providing such advantages as reducing the amount of ammonia to be used and extending chemical cleaning intervals.

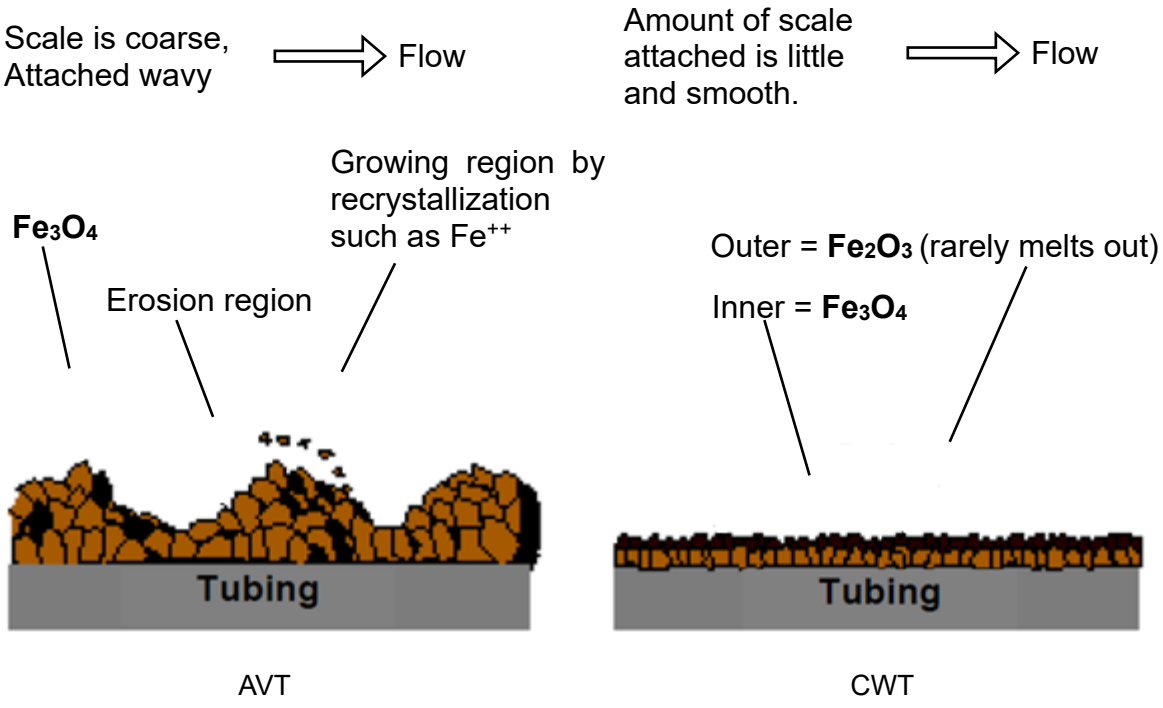


Figure 4.7.1. Difference in Scale Attachment between AVT and CWT

4.7.2.1. Boiler Filling

The water quality requirements shall be referred to the requirement listed in this clause. Operation guidance shown in this clause provides the general caution during this Boiler filling step.

- **Constitution of system**
  Refer to Start-up system diagram Fig.4.7.2.

- **Operation guidance**
  Operators can initiate Boiler filling when the water quality at Boiler inlet complies with the value in Table 4.7.1.

  Efforts shall be made to meet the water quality requirement during Boiler filling. Otherwise, the water quality may exceed the value in Table 4.7.1.

  Operators shall note several concerns for corrosive conditions on Boiler such as a condenser leakage, an increasing ingress of aerated make up and a high air in leakage during start-up operation. Operators shall conduct immediate shut-down when these conditions appear in start-up operation.

  Then operators may proceed to cold clean-up after completion of Boiler filling.

Table 4.7.1. Water Quality Requirement for Boiler Filling

Item	Unit	Quality	Quality	Monitoring Point
Treatment	-	AVT-R	AVT-O	
pH	-	9.3 to 9.5	9.3 to 9.5	at ECO Inlet
Cation Conductivity	μS/cm	below 1	below 1	at ECO Inlet
Desolved Oxygen (O2)	ppb	below 10	below 100	at ECO Inlet
Iron (Fe)	ppb	below 100	below 100	at ECO Inlet
Hydrazine (N2H4)	ppb	more 20	-	at ECO Inlet

4.7.2.2. Boiler Cold Cleanup

The water quality requirements shall be referred to the requirement listed in this clause. Operation guidance shown in this clause provides the general caution during this Boiler cold cleanup step.

- **Constitution of Boiler cold cleanup system**
  Refer to Start-up system diagram Fig. 4.7.2.

- **Operation guidance**
  Operators can initiate the cold cleanup when the water quality at Boiler inlet comply with the value in Table 4.7.1. Also during the cold cleanup, operators shall monitor and control the water quality at economizer inlet to meet the value in Table 4.7.2.

  Efforts shall be made to meet the water quality requirement during cold cleanup. Otherwise, the water quality may exceed the value in Table 4.7.2.

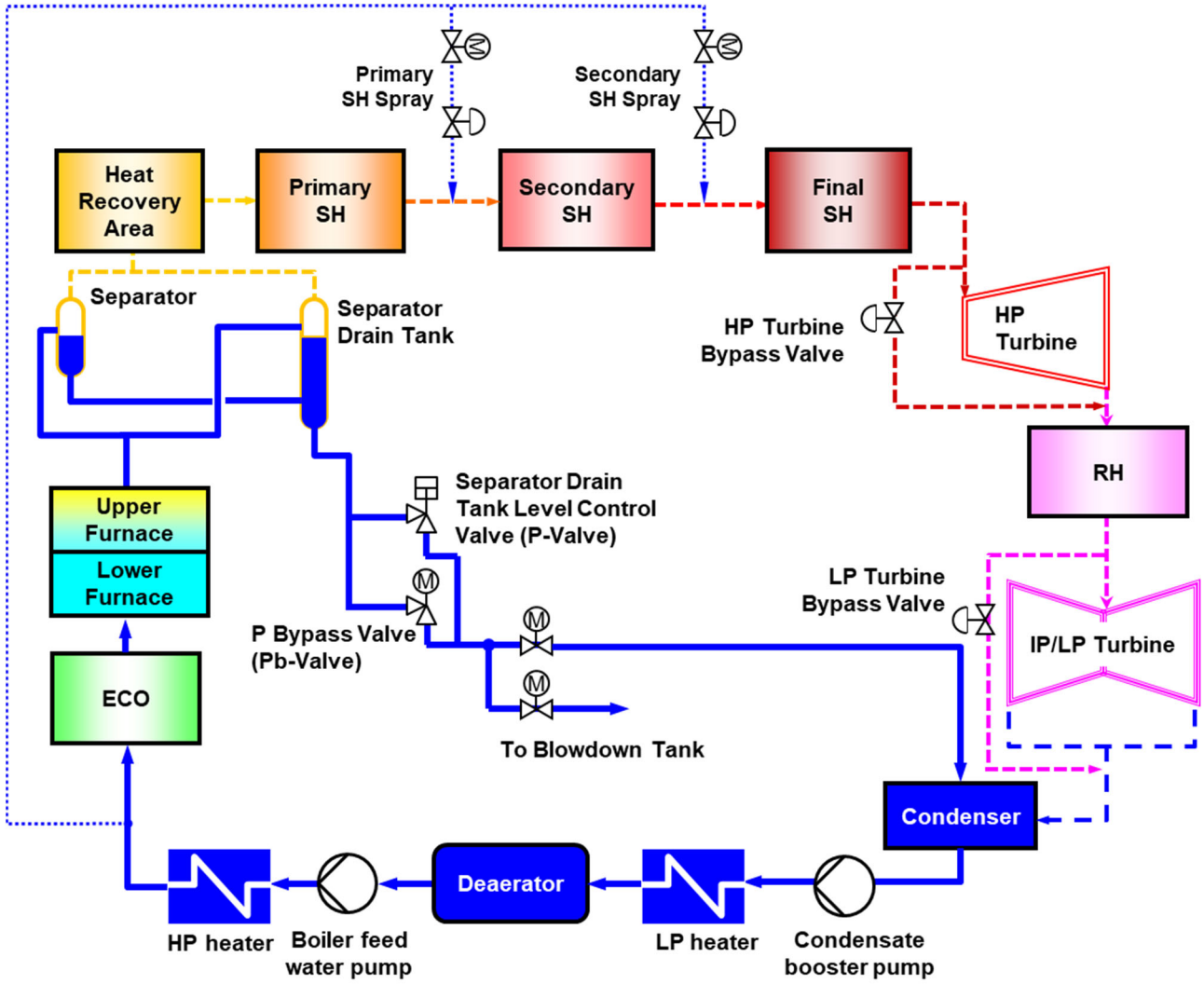
  Operators shall note several concerns for corrosive conditions on Boiler such as a condenser leakage, an increasing ingress of aerated make up and a high air in leakage during start-up operation. Operators shall conduct immediate shut-down when these conditions appear in start-up operation.

  Operators can proceed to the next step of hot cleanup when the water quality complies with the value in Table 4.7.2 and is tending to be better.

Table 4.7.2. Water Quality Requirement for Cold Cleanup Completion

Item	Unit	Quality	Quality	Monitoring Point
Treatment	-	AVT-R	AVT-O	
pH	-	9.3 to 9.5	9.3 to 9.5	at ECO Inlet
Cation Conductivity	μS/cm	below 1	below 0.5	at ECO Inlet
Desolved Oxygen (O2)	ppb	below 10	below 100	at ECO Inlet
Iron (Fe)	ppb	below 100	below 100	at ECO Inlet
Hydrazine (N2H4)	ppb	more 20	-	at ECO Inlet
Silica (SiO2)	ppb	below 30	below 30	at ECO Inlet
Iron (Fe)	ppb	below 150	below 150	at Separator Drain Tank Outlet

Fig-4.7.2. START-UP SYSTEM DIAGRAM (BOILER FILLING AND COLD CLEAN UP)



4.7.2.3. Boiler Light Off and Hot Cleanup

The water quality requirements shall be referred to the requirement listed in this clause. Operation guidance shown in this clause provides the general caution during this step.

- **Constitution of hot cleanup system**
  Refer to Start-up system diagram Fig.4.7.3.

- **Operation guidance**
  Operators can light off the first start-up burner and initiate the hot cleanup when the water quality at Boiler inlet comply with the value in Table 4.7.2. Also during the hot cleanup, Operators shall monitor and control the water quality at economizer inlet to meet the value in Table 4.7.3.

  Efforts shall be made to meet the water quality requirement during this stage. Otherwise, the water quality may exceed the value in Table 4.7.3. In that case, operators shall make corrective action according to Table 4.7.4.

  Operators shall note several concerns for corrosive conditions on Boiler such as a condenser leakage, an increasing ingress of aerated make up and a high air in leakage during start-up operation. Operators shall conduct immediate shut-down when these conditions appear in start-up operation.

  Operators can proceed to the next step of pressurization to normal operation through turbine rolling when the water quality complies with the value in Table 4.7.3 and is tending to be better.

Table 4.7.3. Water Quality Requirement for Boiler Light off and Hot Cleanup Completion

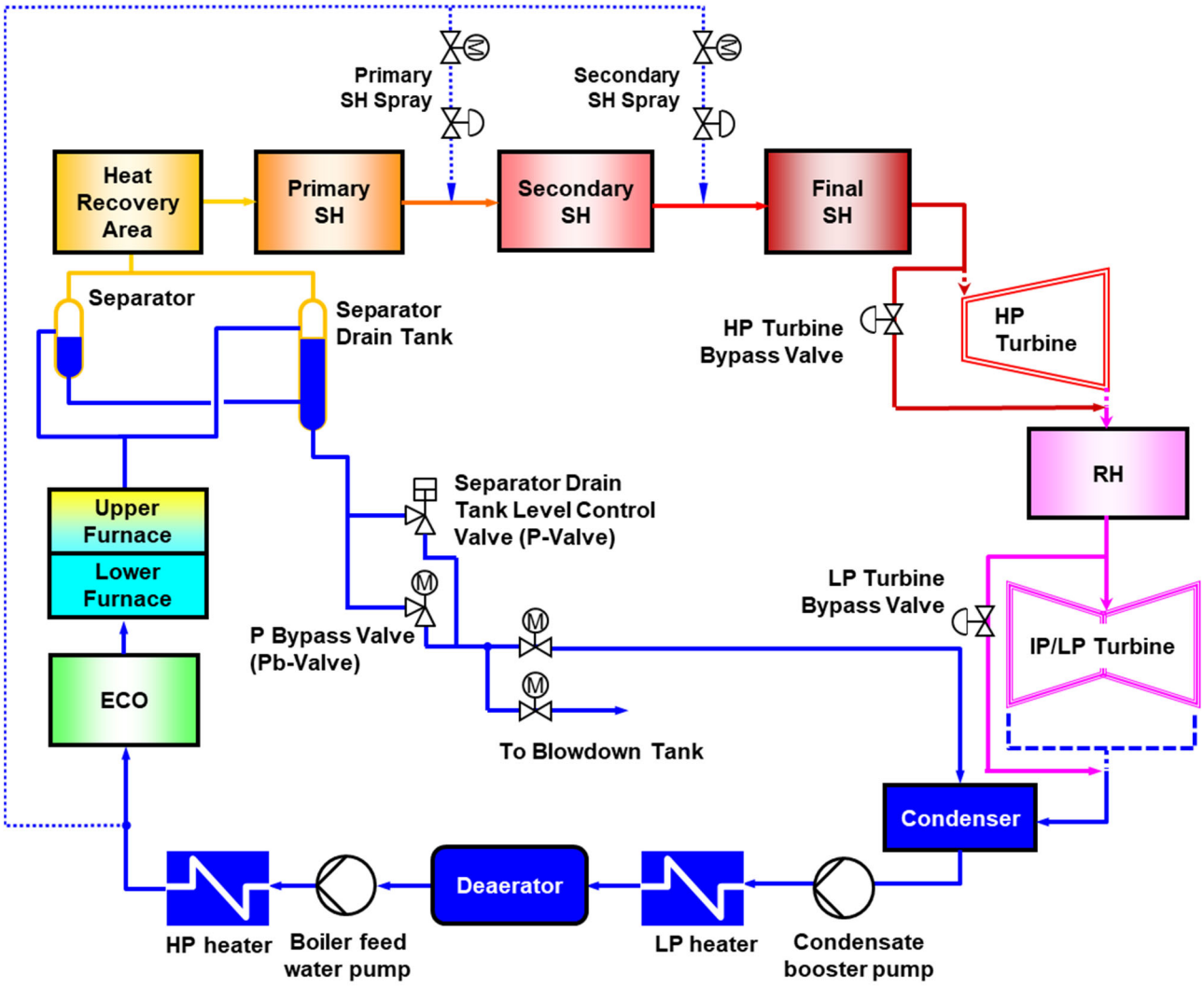
Item	Unit	Quality	Quality	Monitoring Point
Treatment	-	AVT-R	AVT-O	
pH	-	9.3 to 9.5	9.3 to 9.5	at ECO Inlet
Cation Conductivity	µS/cm	below 1	below 0.3	at ECO Inlet
Desolved Oxygen (O2)	ppb	below 10	below 100	at ECO Inlet
Iron (Fe)	ppb	below 50	below 50	at ECO Inlet
~~Copper (Cu)~~	~~ppb~~	~~below 2~~	~~below 2~~	~~at ECO Inlet~~
B Hydrazine (N2H4)	ppb	more 20	-	at ECO Inlet
Silica (SiO2)	ppb	below 30	below 30	at ECO Inlet
Iron (Fe)	ppb	below 100	below 100	at Separator Drain Tank Outlet

Table 4.7.4. Required corrective action during the hot cleanup

Action level	Water quality	Required action
Level-1	N/A	N/A
Level-2	<Feedwater at economizer inlet> Iron ; more than 100ppb and tends to uptrend.	Immediate turn off the burner and go back to the cold cleanup step.
	<Feedwater at economizer inlet> Oxygen Concentration ; more than 20 ppb (AVT-R) more than 200 ppb (AVT-O) Cation Conductivity ; more than 1 µS/cm (AVT-R) more than 0.5 µS/cm (AVT-O)	Immediate shut-down and perform cause investigation once either cation conductivity or dissolved oxygen exceeds from the limits of Level-2.

(Note)
Action Level 1: There is a potential for the accumulation of contaminants and corrosion. Return values to normal levels within 1 week.
Action Level 2: The accumulation of impurities and corrosion will occur. Return values to normal levels within 24 hours.

Fig-4.7.3. START-UP SYSTEM DIAGRAM (LIGHTOFF (incl. PREPARATION) / PRESSURIZE)



4.7.2.4. Boiler pressurize to Normal Operation through turbine rolling

The water quality requirements shall be referred to the requirement listed in this clause. Operation guidance shown in this clause provides the general caution during this step.

- **Constitution of system**
  After the establishment of water steam cycle on normal operation is completed.

- **Operation guidance**
  Operators can proceed to the pressurization to normal operation through turbine rolling when the water quality at Boiler inlet complies with the value in Table 4.7.3. Also, during Boiler pressurization to normal operation, Operators shall monitor and control the water quality of economizer inlet to meet the required value.

  Efforts shall be made to meet water quality requirement during this stage. Otherwise, the water quality may exceed the required value. In that case, operators shall make corrective action according to Table 4.7.5.

  Operators shall note several concerns for corrosive conditions on Boiler such as a condenser leakage, an increasing ingress of aerated make up and a high air in leakage during start-up operation. Operators shall conduct immediate shut-down when these conditions appear in start-up operation.

  Operators shall immediately control the water quality to meet the value in Table 4.7.6 in AVT operation once the establishment of water-steam cycle in normal operation is completed.

  Besides the required value provided by IHI, the steam purity requirement submitted by turbine supplier also shall be taken into consideration before turbine rolling. Thus the water impurities at economizer inlet shall be controlled to meet the steam impurities of main steam requirement for turbine rolling.

Table 4.7.5. Required corrective action during the pressurization to normal operation through turbine rolling

Action level	Water quality	Required action
Level-1	<Feedwater at economizer inlet> Oxygen Concentration ; more than 10 ppb (AVT-R) more than 100 ppb (AVT-O) Iron ; more than 50 ppb	Increase system pH and monitor exceeded value carefully
Level-2	<Feedwater at economizer inlet> Oxygen Concentration ; more than 20 ppb (AVT-R) more than 200 ppb (AVT-O) Cation Conductivity ; more than 1 μS/cm	Immediate shut-down and perform cause investigation once either cation conductivity or dissolved oxygen exceeds the limits of Level-2

4.7.2.5. AVT-O/R operation

The water quality requirements shall be referred to the requirement listed in this clause. Operation guidance shown in this clause provides the general caution during this step.

- **Constitution of system**
  After the establishment of water steam cycle on normal operation is completed.

- **Operation guidance**
  Operators shall immediately control the water quality to meet the value in Table 4.7.6 in AVT operation once the establishment of the water-steam cycle on normal operation is completed. During AVT operation, operators shall monitor and control the water quality at economizer inlet to meet the value in Table 4.7.6.

  Efforts shall be made to meet water quality requirement during this stage. Otherwise, the water quality may exceed the value in Table 4.7.6. Operators shall make corrective action according to Table 4.7.6.

  Operators shall note several concerns for corrosive conditions on Boiler such as a condenser leakage, an increasing ingress of aerated make up and a high air in leakage during start-up operation. Operators shall conduct immediate shut-down when these conditions appear in start-up operation.

  Operators can proceed to transition to CWT operation when operation hour with AVT exceeds 500hrs (*) and the water quality at economizer inlet complies with the initiation value of transition to CWT operation and is tending to be better.

  (*) This condition is required for initial commissioning. After regular outage, the transition condition is only the water quality at economizer inlet and expected to take about 48 hrs to be met with CWT operation.

Table 4.7.6. Required corrective action during AVT-O/R operation

Item	Unit	Quality	Monitoring Point
Treatment	-	AVT-O/R	
pH	-	9.2 to 9.5	at ECO Inlet
Cation Conductivity	µS/cm	below 0.2	at ECO Inlet
Desolved Oxygen (O2)	ppb	below 7	at ECO Inlet
Iron (Fe)	ppb	below 10	at ECO Inlet
~~Copper (Cu)~~	~~ppb~~	~~below 2~~	~~at ECO Inlet~~
Hydrazine (N2H4)	ppb	more 10	at ECO Inlet
Silica (SiO2)	ppb	below 10	at ECO Inlet
Sodium (Na)	ppb	below 3	at ECO Inlet
Chloride (Cl)	ppb	below 3	at ECO Inlet
Total Solid	ppb	below 50	at ECO Inlet

B

4.7.2.6. Transition to CWT operation

The water quality requirements shall be referred to the requirement listed in this clause. Operation guidance shown in this clause provides the general caution during this step.

- **Constitution of system**
  After the establishment of water steam cycle on normal operation is completed.

- **Operation guidance**
  Operators may initiate the transition to CWT operation when preconditions shown in Table 4.7.7 are fulfilled. Also during the transition to CWT operation, Operators shall monitor and control the water quality at economizer inlet to meet the value in Table 4.7.6.

  Efforts shall be made to meet water quality requirement during this stage. Otherwise, the water quality may exceed the value in Table 4.7.6. In that case, operators shall make corrective action according to Table 4.7.8.

  Operators shall note that the additional concern for the corrosive condition of the condenser leaks, increased ingress of aerated make up, and high air in leakage during start-up operation. Otherwise, operators shall conduct immediate shut-down when these conditions appear in normal operation.

  Note

  For detail procedure, refer to “VP1-C-L1-M-HAY-00506 (K090-059) Boiler Feedwater Quality Requirement”.

Table 4.7.7. Precondition for AVT/CWT changeover

No.	No. Preconditions
1	Operation hour with AVT exceeds 500hrs. (counted from reaching the minimum load of 40%L)
2	Required water qualities for AVT are fulfilled.
3	CC at Economizer inlet is below 0.18 μS/cm.
4	Boiler and feedwater systems have no critical trouble and their operating conditions are stable.
5	Boiler is in steady state load operation and Boiler load is 40%L and over.
6	Unit shut-down is NOT planned during the changeover. (Shut-down is only allowed in case of emergency)
7	Chemical dosing systems have no trouble and their operating conditions are stable
8	Sampling systems have no trouble and their operating conditions are stable.
9	Oxygen dosing systems is ready for operation.
10	Calibration of oxygen sampling system is completed.
11	Check and share countermeasures in case of emergency

Table 4.7.8. Required corrective action during the transition to CWT operation

Action level	Water quality	Required action
Level-1	<Feedwater at economizer inlet> Cation Conductivity ; more than 0.18 μS/cm Iron; more than 5 ppb	Increase system pH or reduce O2 injection and monitor exceeded value carefully
Level-2	<Feedwater at economizer inlet> Cation Conductivity; more than 0.2 μS/cm	Terminate oxygen feed and change to AVT (**without** Hydrazine) operation. Once cation conductivity deviate into level 2

(Note)
Action Level 1: There is a potential for the accumulation of contaminants and corrosion. Return values to normal levels within 1 week.
Action Level 2: The accumulation of impurities and corrosion will occur. Return values to normal levels within 24 hours.

4.7.2.7. CWT operation

The water quality requirements shall be referred to the requirement listed in this clause. Operation guidance in this clause provides the generally caution during this step.

- **Constitution of system**

After the establishment of water steam cycle at normal operation is completed.

- **Operation guidance**

Operators shall immediately control the water quality to meet the target value in CWT operation once the CWT operation water quality requirement is established. During CWT operation, operators shall monitor and control the water quality at economizer inlet to meet the value in Table 4.7.9.

Efforts shall be made to meet water quality requirement during this stage. Otherwise, the water quality may exceed the target value except for the condition given in the Table 4.7.9. Operators shall make corrective action according to Table 4.7.10.

Operators shall note that the additional concern for the corrosive condition of the condenser leaks, increased ingress of aerated make up, and high air in leakage during start-up operation. Otherwise, operators shall conduct immediate shut-down when these conditions appear in normal operation.

Table 4.7.9. Water Quality Requirement for CWT

Item	Unit	Quality	Monitoring Point	Target
Treatment	-	CWT		
pH	-	8.8 to 9.4	at ECO Inlet	Target: 9.0 and over[*1].
Cation Conductivity	µS/cm	below 0.15	at ECO Inlet	Target: below 0.1 µS/cm.
Desolved Oxygen (O2)	ppb	30 to 150	at ECO Inlet	Target: below 100 ppb.
Iron (Fe)	ppb	below 2	at ECO Inlet	Target: below 1 ppb.
~~Copper (Cu)~~	~~ppb~~	~~below 2~~	~~at ECO Inlet~~	
Hydrazine (N2H4)	ppb	N/A	at ECO Inlet	
Silica (SiO2)	ppb	below 10	at ECO Inlet	
Sodium (Na)	ppb	below 3	at ECO Inlet	
Chloride (Cl)	ppb	below 3	at ECO Inlet	
Total Solid	ppb	below 50	at ECO Inlet	

1. After changing over from AVT operation to CWT operation, pH shall be controlled at 9.3 t
by the time the Dissolved Oxygen is detected at the drain downstream of the steam turbine

Table 4.7.10. Required corrective action during CWT operation

Action level	Water quality	Required action
Level-1	<Feedwater at economizer inlet> Cation Conductivity; more than 0.10 µS/cm Iron; more than 5 ppb	Increase system pH and monitor exceeded value carefully
Level-2	<Feedwater at economizer inlet> Cation Conductivity; more than 0.15 µS/cm	Terminate oxygen feed and change to AVT operation once cation conductivity exceeds the limit of Level-2.

(Note)
Action Level 1: There is a potential for the accumulation of contaminants and corrosion. Return values to normal levels within 1 week.
Action Level 2: The accumulation of impurities and corrosion will occur. Return values to normal levels within 24 hours.

4.7.3. Routine Maintenance & Inspection

4.7.3.1. Manual Analysis

For reliable operation of Boiler, the items mentioned in the section 4.7.2 of Boiler water chemistry requirements shall be proved by manual analysis in the laboratory as a routine work.

Some of the listed items can be monitored by on-line analyzer. However, they shall be measured by manual analysis which may have higher accuracy.

Minimum required frequency to analyze Boiler water chemistry is tabulated below. However, more frequent analysis is required during early commissioning period and start-up operation since the water quality and ferrous reaction is unstable.

Operators shall note an abnormal water condition, if any, can firstly be observed by cation conductivity and pH of the feedwater and/or Boiler water.

Table 4.7.11. Water Quality Sampling Point

Sampling Point	CC	pH	Hydrazine	DO2	Na	Total Fe
ECO inlet	■	○	○	○	N.R.	○
Main steam	■	N.R.	N.R.	N.R.	○	N.R.
Reheat steam	■	N.R.	N.R.	N.R.	○	N.R.
Separator drain	■	N.R.	N.R.	N.R.	N.R.	○

○: Analysis
■: Analysis after cation resin flowed
N.R.: Not Required

Table 4.7.12. Frequency of Water Quality Sampling

Period *1	Frequency of water quality sampling
Day 1 to Day 4	Four(4) times / day for Temporary and Permanent measurement
Day 6 to Day 11	Two(2) times / day for Temporary and Permanent measurement
Day 11 or later *2	One(1) times / day for Temporary Measurement Two(2) times / day for Permanent Measurement

*1 Date counted from starting oxygen injection
*2 including CWT operation (after AVT to CWT changeover completion)

4.7.4. Boiler Preservation Procedure

4.7.4.1. Introduction

To preserve Boiler properly during outage period is vital to maintain Boiler tubes in good condition for long time and extending Boiler tube life. Improper preservation may result in occurrence of corrosion on inner surface of Boiler tubes. Operators shall consult following preservation procedure when Boiler shuts down and turns outage condition.

4.7.4.2. Preservation Method Guidelines

Following preservation methods shall be performed depending on the length of time Boiler will be out of service. Operators shall note that the wet preservation method shall not be chosen when there is a possibility of freezing. Boiler water chemistry shall be checked before the completion of Boiler shut-down to assure that pH, dissolved oxygen and cation conductivity are on the proper levels (see Table 4.7.13). This is important if the water is to be left in Boiler after shut-down.

Table 4.7.13. Requirement of Boiler water Quality for wet preservation

Item	Unit	Criteria
Dissolved Oxygen (O2)	ppb	below 10
Cation Conductivity at 25deg.C	μS/cm	below 0.2
pH at 25deg.C	-	9.3 to 9.5

(a) Shut-down period : 72 hours or less
Preservation method : Hot Banking

Conditions of each part of Boiler Tubes
- **Economizer : filled with hot water**
- **Furnace : filled with hot water**
- **Superheater : filled with residual steam**
- **Reheater : drained out and dried**

If the system is to be shut down for 72 hours or less, “hot banking method” can be selected. Boiler can be bottled up with residual steam pressure, and this is accomplished by closing the steam stop valve, blowdown valves, all vent valves, drain valves and all air/gas dampers.

If it is difficult to keep residual pressure for a long time, operators shall choose the preservation method (b).

(b) Shut-down period : more than 72 hours but 240 hours or less
Preservation method : Wet preservation with nitrogen gas blanketing or Dry preservation with nitrogen gas blanketing

When Boiler is to be shut down for more than 72 hours but not more than 240 hours and must be returned to service on short notice, “wet preservation with nitrogen gas blanketing method” or “dry preservation with nitrogen gas blanketing method” shall be performed to expel air and prevent oxygen ingress.

(1) Wet preservation with nitrogen gas blanketing

Conditions of each part of Boiler Tubes

- **Economizer : filled with hot water**
- **Furnace : filled with hot water**
- **Superheater : filled with nitrogen gas**
- **Reheater : drained out and dried**

Even though Boiler is preserved with Hot Banking method, residual steam pressure is gradually decreased by natural cooling after shut-down. When the separator outlet pressure drops below 0.05MPa(g), inject pressurized nitrogen gas into Boiler via the nitrogen gas injection ports provided on separator outlet and final superheater. Pressurize Boiler up to 0.05MPa(g) with nitrogen gas to exclude air in-leakage. Maintain this positive nitrogen pressure throughout preservation period. The pressure shall be checked periodically, and additive nitrogen gas shall be injected to maintain Boiler pressure between 0.02MPa(g) and 0.05MPa(g). Seal all openings to prevent excessive use of nitrogen.

As for Reheater part, all the drain valves of boiler reheater system shall be opened to drain out all condensed water, and then reheater tubes and pipes shall be dried out by residual heat. The dry out process shall be carried out while reheater metal temperature is 150degC or higher.

Boiler water chemistry, which is sampled at Economizer inlet and Separator drain tank drain line, shall be periodically checked during the preservation. Recommended frequency is one per a day. If the water chemistry exceeds criteria shown in Table 4.7.13, operators shall change the preservation method to (b)-(1) “Dry preservation with nitrogen gas blanketing”.

(2) Dry preservation with nitrogen gas blanketing

Conditions of each part of Boiler Tubes
- **Economizer : filled with nitrogen gas**
- **Furnace : filled with nitrogen gas**
- **Superheater : filled with nitrogen gas**
- **Reheater : filled with nitrogen gas**

Even though shut-down period is within 240hours, if Economizer inlet water chemistry exceeds criteria shown in Table 4.7.13, operators shall change the preservation method to “Dry preservation with nitrogen gas blanketing”

The procedure of “Dry preservation with nitrogen gas blanketing” is specified in 4.7.4.2 (c).

(c) Shut-down period : more than 240 hours
Preservation method : Dry preservation with nitrogen gas blanketing

Conditions of each part of Boiler Tubes
- **Economizer : filled with nitrogen gas**
- **Furnace : filled with nitrogen gas**
- **Superheater : filled with nitrogen gas**
- **Reheater : filled with nitrogen gas**

When Boiler shuts-down for more than 240 hours, “Dry preservation with nitrogen gas blanketing method” shall be performed to expel air and prevent oxygen ingress.

When the separator outlet pressure drops below 0.05 MPa(g) after the completion of shut-down operation, nitrogen gas shall be charged to Economizer, Evaporator, Superheater and Reheater. Inject pressurized nitrogen gas via nitrogen gas injection ports provided on Economizer outlet, Separator outlet, Final Superheater outlet and Reheater outlet. Open all drain valves during nitrogen gas injection. Charged N2 pushes out water from Economizer and Evaporator to the blowdown tank via the drain valves. If the water in Boiler is completely drained out, close all drain valves.

Pressurize all circuits up to 0.05MPa(g) with nitrogen gas to exclude air in-leakage. Maintain this positive nitrogen pressure throughout preservation period. The pressure shall be checked periodically, and additive nitrogen gas shall be injected to maintain Boiler pressure between 0.02MPa(g) and 0.05MPa(g). Seal all openings to prevent excessive use of nitrogen.

Important
Operators shall start injecting nitrogen prior to start of water draining out, not after draining out Boiler water.

Warning
Do not enter Boiler pressure part that have been filled with nitrogen gas until oxygen level is confirmed to be enough for work. Entering chamber with low oxygen level can be fatal.

(d) Shut-down period : for maintenance
Preservation method : Dry preservation

Conditions of each part of Boiler Tubes
- **Economizer : drained out and dried**
- **Furnace : drained out and dried**
- **Superheater : drained out and dried**
- **Reheater : drained out and dried**

When the system is to be shut-down for inspections, tube samplings, repairs or cleanings (including chemical cleaning) which may introduce air into the pressure parts, “Dry preservation method” shall be performed*. Dry preservation is only practical when Boiler can be drained out while Boiler has enough residual heat to promote drying out.

When the separator outlet pressure drops below 0.05 MPa(g) after the completion of the shut-down operation, open all the air vent valves, drain valves and blowdown valves to drain out Boiler water completely. The dry out process shall be carried out while their metal temperature are 150degC or higher. Keep Boiler metal surfaces completely dry and free of moisture.

Warning
Extreme caution must be taken when opening drain valves. The water is under high pressure and is still very hot. The flow will flash into steam and anyone coming in contact with the steam can be severely burned.

* If any works which may lead the air introduction are NOT scheduled during an outage for maintenance, appropriate preservation method shall be chosen depending on the shut-down period as specified in 4.7.4.2(a), (b) or (c).

4.7.5. Water Treatment for Shut-down and Re-start up

(a) Shut-down

During the shut-down process, the water treatment mode is changed from "CWT" to "AVT-O". In the mode, oxygen dosing is stopped and pH in feedwater is increased to 9.5 with ammonia dosing at CBP (Condensate Booster Pump) outlet. Meanwhile, Hydrazide shall not be dosed to protect hematite layer. This changeover of the water treatment mode shall be conducted four (4) hours before De-Synchronization.

(b) Re-start up from Hot Banking, Wet Preservation with Nitrogen Gas and Dry Preservation with Nitrogen Gas

When Boiler re-starts from Hot Banking, Wet Preservation with Nitrogen Gas and Dry Preservation with Nitrogen Gas, the chemical dosing system starts to operate under "AVT-O" mode. The water quality requirements for each start-up steps are shown in 4.7.2 and “VP1-C-L1-M-HAY-00506 (K090-059) Boiler Feedwater Quality Requirement”. The changeover from "AVT-O" to "CWT" can be conducted under steady load operation after start-up completion.

(c) Re-start up from Dry Preservation

When Boiler re-starts from Dry Preservation, the chemical dosing system starts to operate under "AVT-O" mode. The water quality requirements for each start-up steps are shown in 4.7.2. The changeover from "AVT" to "CWT" can be conducted after 500hrs AVT operation.

4.8. Alarms

This section describes alarms for the following items that may be issued when a boiler trip or other problems on operations occur.
- MFT（Master Fuel Trip）

For details of Alarm list, refer to “VP1-C-L1-I-GEN-30055 (K710-411) Set Point List (IHI Portion)”.

NOTICE

- If an alarm occurs, identify the cause and take action to stop the alarm.
- When an alarm persists, contact the prescribed management staff.

4.8.1. MFT (Master Fuel Trip)

If a serious failure occurs in the boiler, the boiler protection system called MFT (Master Fuel Trip) works and immediately shuts off the supply of water and fuel then the boiler trips.

For details of MFT, refer to “VP1-C-L1-I-CA-30014 (K710-404) Function of Boiler Protection System”.

1) MFT Manual Initiation
2) Loss of Both FD Fan
3) Loss of Both ID Fan
4) Loss of AH
5) Furnace Pressure High-High
6) Furnace Pressure Low-Low
7) Boiler Outlet Steam Pressure High-High
8) Loss of All Boiler Feedwater Pumps
9) Feedwater Flow Low-Low
10) Complete Flame Failure
11) Partial Loss of Flame
12) All Fuel Input Shut off
13) Total Combustion Air Flow Low-Low
14) RH Protection
15) Condenser Protection
16) DCS Controller Abnormal
17) Separator Inlet Manifold Fluid Temp High-High
20) Separator Drain Tank Level High-High
21) Loss of T-BFP during T/M BFP Parallel Operation

4.8.2. Other Alarms

4.8.2.1. Sensor related alarm

If the field sensors of each device detect an error, a “Bad Quality” alarm will be displayed.
The operator should check the sensor and immediately recover the signal status.

4.8.2.2. Control Element related alarm

If the deviation between the position command of each device and the feedback signal becomes large, a "Deviation High" alarm will be displayed.
The operator should check the status of the device and immediately recover the status.

4.9. Guide for Operations in Accidents

This section lists typical accidents and operations against them.

4.9.1. Boiler Tube Leakage

Tube ruptures occur for a number of reasons. Improper chemical treatment procedure and operation will be great cause of occurrence of boiler tube failure. If tube ruptures are suspected during operation, it is recommended that the operator shall shut the boiler down as quickly as possible so as to minimize number of damaging tubes, by following normal shutting down procedure if possible. First step that the operator should take is identifying where the rupture occurs during operation or shutting down the boiler. (water wall tubes, near burners, primary superheater, secondary superheater, etc.)

Cause

1. Drain cutting by sootblower
2. Ashes cutting
3. Local overheating by tube inner scaling
4. Local overheating caused by decrease in flow velocity inside the tube
5. Material defect and welding defect

Alarm names

1. Furnace draft High/Low
2. Boiler metal temperature High
   - Furnace lower wall outlet
   - Furnace upper wall outlet
   - Secondary and final superheater outlet
   - Primary and secondary reheater outlet

Status

1. Flow rate of make-up water and feedwater increase.
2. Economizer outlet flue gas temperature decreases.
3. Furnace draft fluctuates.
4. IDF inlet guide vane position increases.
5. A blowing sound is heard from a safety valve.
6. Water leakage from boiler casing or furnace bottom.
7. Economizer outlet flue gas O_2 meter (WET detection) fluctuates.

Operations

1. If sootblower is in operation, stop the sootblower and check the leaking location. (At this time, do not open the observation door inadvertently.)

2. If a tube leakage is detected, immediately perform the unit shut-down operations in accordance with the normal shut-down operations. Incidentally, if the amount of leakage is large, quickly reduce load / de-synchronization or perform unit trip to prevent possible secondary damage.

3. In case tube leakage occurs in the economizer, furnace wall, or the superheater, perform following operation after shut-down.

(1) Perform boiler forced cooling.
In the case of tube leakage of economizer, furnace wall, pay attention to change in leak amount.
If the amount of leakage seems to increase rapidly, stop the feedwater circulation operation and perform cooling with only draft system.

(2) Perform the full blowdown after forced cooling of the boiler is completed.

(3) Continue to operate AH until the boiler forced cooling is completed. (Stop when boiler outlet flue gas temperature becomes ≤100°C)

(4) If moisture is present on the AH element, start draft system to dry it.

4. In the case of a tube leakage of reheater, perform following operations after shut-down.

(1) Immediately perform condenser vacuum break so as not to suck the ash into the reheater tube. Also stop the boiler circulation operation.

(2) Perform boiler cooling only with draft system.

(3) Full blowdown of the boiler is not required.

4.9.2. Condenser Leakage

Condenser Leakage may cause the large extent of the catastrophic damage of the boiler pressure part (evaporator, super heater) such as hydrogen attack, and result in the large extent of the furnace and superheater replacement. Therefore, the special attention for the operation shall be paid to protect the boiler pressure parts.

There is JIS B8223: 2015 edition, Water conditioning for boiler feed water and boiler water, in which the following excerption is described for the operation for the sea water;

<Excerpt from JIS B8223 2015>

D.6 Handling method for leakage of sea water in condenser

The handling method for leakage of sea water in condenser shall be as follows.

a) Hindrance by leakage of sea water

When sea water is used as cooling water of a condenser, the following hindrance may occur due to the corrosion/damage on a condenser tube or a tube plate part, sea water contamination due to the corrosion on a condensate pump, and contamination with sea water or impurities of the drain tank recovered to a condenser.

1) Scaling inside the boiler tube due to calcium and magnesium components, and heat transfer disturb

2) pH decrease of boiler water due to magnesium chloride, and corrosion

$$MgCb+2H2O \Rightarrow Mg(OH)2 +2HCl \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (D.1)$$

3) Contamination and corrosion in a superheater tube, on a turbine blade, etc. due to carryover of salts, etc.

4) Corrosion of stainless steel due to chloride ions in spray water for desuperheater (stress corrosion cracking)

b) Detection of leakage of sea water

Leakage of sea water can be detected by a condenser hot well (salinometer) firstly, and the rise of conductivity after cation exchanger or conductivity of condensed water (at outlet of pump), feed water and boiler water. Also, chloride ions shall be analyzed when conductivity rises. An example of the acceptance criteria of leakage of sea water by the conductivity after cation exchanger of condensed water and feed water is given in Table D.1.

Table D.1 Example of acceptance criteria of leakage of sea water (condensed water and feed water)

	Conductivity after cation exchanger mS/m (μS/cm)	Chloride ions mg/L
Normal value	0.03 max. (0.3 max.)	0.05 max.
Monitoring required (alarm value)	0.03 to 0.05 (0.3 to 0.5)	
Small amount of leakage	0.05 to 0.2 (0.5 to 2)	0.05 to 0.2
Large amount of leakage	0.2 min. (2 min.)	0.2 min.

c) Handling method for leakage of sea water

When leakage is detected, a superheater and reheater spray water shall be suspended. When it is judged as large amount of leakage, it is necessary to shut down the plant, promptly.

1) Water tube boiler

As the measure for preventing the hindrance by leakage of sea water, for the water tube boiler, the blow-down of boiler water, injection of sodium phosphate as a hardness

removing agent, control of pH of boiler water, etc. shall be promptly performed according to the leakage amount of sea water and the change in water conditioning for boiler water. Even if the leakage amount is small, at the time of injection of phosphate, when the water conditioning for boiler water deteriorates (pH 8.5 or under) at the maximum blow-down of boiler water, the plant operation shall be promptly shut-down.

2) Once-through boiler
A condensate demineralizer shall be set as H type operation, and the total amount of water shall be passed. Even if the leakage amount is small, when it exceeds the allowable amount of the condensate demineralizer, the plant operation shall be promptly shut-down.

The operator shall follow the operation in accordance with D.6 section in JIS B8223: 2015 edition, Water conditioning for boiler feed water and boiler water.

4.9.3. Clinker Trouble

Cause

1. In cases of abnormal steam temperature, high metal temperature
   (1) Bad coal quality
   (2) Generation of hard clinker
   (3) Large furnace thermal load
2. In case of bottom ash handling system failure
   (1) Inability in pumping up caused by a mechanical accident
   (2) Electric accidents
   (3) Inability in operation caused by an accessory equipment failure

Alarm names

1. Main steam temperature High/Low
2. Reheat steam temperature High/Low
3. Boiler metal temperature High
   Furnace lower wall outlet
   Furnace upper wall outlet
   Secondary and final superheater outlet
   Primary and secondary reheater outlet

Status

1. When steam temperature is abnormal and metal temperature is high
   (1) The combustion becomes unstable, the spray amount of the superheater and the reheater is increased, and flue gas temperature rises.
   (2) Too much clinker has deposited on burner throat.
   (3) Too much clinker has deposited on bottom ash handling system.

2. When bottom ash handling system is defective
   (1) Bottom ash handling system stops, causing the clinker handling impossible.
   (2) Clinker too much accumulation in bottom ash handling system.
   (3) Blockage in recirculation line.

Operations

1. When steam temperature is abnormal and metal temperature is high
   (1) Reduce load.
   (2) If too much clinker on burner throat or boiler bottom hopper cannot be removed, shut down the boiler.

2. When bottom ash handling system is defective
   (1) Remove the cause of stopping bottom ash handling system, restart it, and then start ash processing procedure.
   (2) If bottom ash handling system cannot be restarted, estimate the possible time for coal firing. If the estimated recovery time of bottom ash handling system exceeds the estimated time for coal firing, switch to oil firing. Depending on the situation, reduce load and shut down.

4.9.4. Ignition/Explosion in Pulverizer

For operations in accidents of Ignition/Explosion in Pulverizer, refer to “VP1-C-L1-M-HFC-50016 Operation and Maintenance of Pulverizer”.

4.9.5. Pulverizer Overcharge

For operations in accidents of Pulverizer Overcharge, refer to “VP1-C-L1-M-HFC-50016 Operation and Maintenance of Pulverizer”.

4.9.6. AH Element Burnout

■ Cause

Ignition of unburned fuel accumulated on AH element

■ Status

1. AH outlet or inlet gas temperature rises
2. AH inlet or outlet secondary air temperature rises

■ Operations

When AH fire is confirmed visually or from the temperatures during the unit operation

1. Contact each relevant department in charge and take off-limit measures around the site to prevent secondary disasters.
2. While checking the internal situation from the AH inspection window, blow out the fire and remove the attached combustion source with the AH sootblower.
3. If the fire is not extinguished, stop the unit.

When AH fire is confirmed during the boiler natural ventilation

1. Contact each relevant department in charge and take off-limit measures around the site to prevent secondary disasters.
2. If the black smoke is generated or the IDF inlet gas temperature exceeds 150°C and tends to rise further, close the AH inlet/outlet dampers and wait for the fire to be extinguished in the banking status.

When AH fire is confirmed during boiler banking

1. Contact each relevant department in charge and take limit-off measures around the site to prevent secondary disasters.

5. Boiler Plant Maintenance

This chapter describes boiler plant maintenance. In the event of an unforeseen situation other than those listed here, take appropriate actions under the instructions of Safety Manager.

5.1. General

A structured inspection and regular maintenance plan for maintaining a modern coal-fired boiler in a safe and non-degraded condition is very important. The Owner must hire a reliable maintenance specialist and prudently conduct maintenance even when this may cause the plant to require more down time off the grid.

A care must be exercised to ensure that its operation limits are not exceeded. The unit is maintained and operated in accordance with recognized good practice, the service will be satisfactory. When faulty operation, excessive temperatures, or other abnormal conditions cause the safe limits of the material to be exceeded, failures will occur rapidly, and the equivalent of years of normal deterioration may take place in a short time.

By conducting a program of routine maintenance on a boiler and other power plant equipment, the production and life of the equipment are optimized. At one time, maintenance focused on the repair of damaged equipment; however, this operating philosophy has evolved into a sophisticated set of programs that include assessing the condition of the equipment, techniques for predicting the life of the equipment, developing corrective measures, preventing future problems, and evaluating the overall operation. It is the goal of a maintenance program to optimize production, availability, and safety, while at the same time to minimize operating costs and any effect on the environment.

In any power plant, maintenance activities should include preventive maintenance procedures, which are activities performed for the purpose of avoiding or at least minimizing the probability of failure of a piece of equipment or a portion of a system. They are usually performed on a component that has a fairly clear defined life expectancy. By preparing a good history record of maintenance, a good preventative maintenance program can be developed that can anticipate potential failures.

5.2. Equipment subjected to Maintenance

This section describes the maintenance for the Boiler Proper.
Maintenance should be carried out for all facilities and equipment. The following table shows the maintenance described in Chapter 5 and in the instruction manual of the manufacturer.

Table 5.2 List of Reference to Maintenance

No.	Equipment Name		Refer to:
1	Pressure Parts	Tube of Furnace, Separator & Drain Tank, Tube of Superheater, Reheater, and Economizer, Header, Manhole, Observation Door, etc.	Chapter 5
2	Steam and Feedwater System (except Pressure Parts)	Main Piping, Spray system, etc. Safety Valve, Valve for Start-up, etc.	Chapter 5 Individual manual
3	Air and Flue Gas System	Duct, STC Damper, etc. Fans, AH, Damper, Expansion Joint, etc.	Chapter 5 Individual manual
4	Coal Firing System	Pulverized coal piping Coal Bunker, Coal Gate, Coal Feeder, Pulverizer, Burner, Pyrite Handling Facilities, etc.	Chapter 5 Individual manual
5	Boiler Cleaning System	Sootblower, Water Sootblower	Individual manual
6	Furnace CCTV and Flame Detector		Individual manual
7	Air Vent, Nitrogen Gas System, Drain System and Waste Water System	Valve, Piping, etc. Vent Valve, N2 Gas Facilities, Boiler Drain Tank, Waste Water Handling Facilities	Chapter 5 Individual manual
8	Boiler House	Floor, Stairs, Steel Frames, Roofs and Walls	Chapter 5
9	Elevator (Boiler Portion)		Individual manual
10	Auxiliary Steam System (Boiler Portion)	Header, Tube, Valve, etc.	Chapter 5
11	Fire Fighting System (Boiler Portion)	Valve, Piping, etc. Fire Fighting System	Chapter 5 Individual manual
12	Service Water System (Boiler Portion)	Valve, Piping, etc.	Chapter 5
13	Cooling Water System (Boiler Portion)	Valve, Piping, etc.	Chapter 5
14	Cooling and Sealing Air System	Valve, Piping, etc. Fan, etc.	Chapter 5 Individual

			manual
15	Hoists		Individual manual
16	Ash Handling System	Bottom Ash Handling Facilities	Individual manual
17	Other Equipment		Individual manual
18	Hoists		Individual manual
20	Ash Handling System	Bottom Ash Handling Facilities	Individual manual
21	Other Equipment		Individual manual

5.3. Precautions for Maintenance

The following is a list of boiler plant maintenance precautions:
Check the hazards in the list, understand the hazards in “0.6. Hazards for the Boiler”, and take appropriate action.
Depending on the work, situation, and laws and regulations, the person doing the work may be required to be qualified. Please confirm and do it.

Table5.3.1. Precaution of the daily and regular inspection work

No.	Work item	Precaution
	At Boiler in Service	
1	Manual valve operation of the steam system when system isolation and power recovery.	⚠**WARNING** ・ Falling during work at high place. ・ Burns due to steam leaks in joint part. ・ Pinched by moving parts. ・ Fuel oil leak.
2	Re-start operation of the steam system	▲**NOTICE** ・ Properly discharge the drain. ・ Warming slowly and adequately. ・ Be careful with water hammering.
3	Open the boiler observation door and check the burner flame status in the furnace.	⚠**WARNING** ・ Falling during work at high place. ・ Hand pinch by manual opening and closing of door. ・ Dust leak at positive pressure. ・ Burns due to hot air leaks in positive pressure. ▲**NOTICE** ・ Check the seal air is available before opening. ・ Stand except the direction in which flue gas may flow out when open the door.
4	Inspection work of pulverizer and burner.	⚠**WARNING** ・ Falling during work at high place. ・ Burns due to high temperature. ・ Touch, pinch with driving parts. ・ Oxygen deficiency due to closed space and/or dust.

No.	Work item	Precaution
5	Open the observation door and observe the inside of the furnace and remove the deposited molten ash (or clinker).	▲**NOTICE** ・ If the observation door is blocked by a strong clinker, do not force it down with a push rod or the like. ⚠**WARNING** ・ Spout the flame from the observation door due to temporary positive pressure of the furnace. ・ Intense light and heat from inside the furnace. ・ In case of the clinker is a large block, the reaction force applied to the rod when the clinker drops is so large that cannot be tolerated by human power. Furthermore, the flame is ejected because of the pressure in the furnace temporarily becomes positive due to the water rebounds and evaporates with a large block falling on the water surface of SCC.
6	Handling manholes while boiler in service	▲**NOTICE** ・ Do not open. ・ Do not touch. ⚠**WARNING** ・ Burns due to the high-temperature gas or touch high temperature part. ・ Oxygen deficiency due to exhaust gas suction, etc.
7	Tightening of gland packing.	▲**NOTICE** ・ Do not overtighten the gland packing. ⚠**WARNING** ・ Burns caused by leaking high temperature internal fuids from gland packing.
8	Supply of lubricating oil and grease.	▲**NOTICE** ・ Make sure that there is no other works such as high temperature, high heat, fire, grinder, etc. nearby. ・ In order to prevent the spread of damage in the case of spilling lubricating oil, cover the surroundings with a vinyl sheet etc. in advance. If spilled, wipe off immediately. ⚠**CAUTION** ・ Spilled oil catch fire by contacting the hot parts.
9	Double strainer switching work, filter cleaning, replacement work when strainer differential pressure indicator rises.	⚠**WARNING** ・ Pinched. ・ Fuel oil leak.
	At Boiler out of service	

No.	Work item	Precaution
10	Installation of temporary scaffolding for check, inspection, repair and etc. Patrol after power generation restoration process and power generation restoration	▲**NOTICE** ・ Check that temporary scaffolding does not interfere with the boiler due to boiler heat elongation. ⚠**WARNING** ・ Collapse or pinch of temporary scaffolding in the case of interference in power generation restoration process or after power generation restoration.
11	Internal inspection of the boiler, ceiling enclosure and duct immediately after the boiler stops.	▲**NOTICE** ・ Do not step into the deposited ash in the boiler and ceiling enclosure when internal inspection immediately after the boiler stops. ・ Pay attention for the temperature of the accumulated ash inside the boiler, ESP and other ash handling system after cooling the boiler and entering for the inspection. Since inside the ash pile may remain hot, make sure of the entire ash pile is enough cooled down for the inspection and cleaning work. ⚠**WARNING** ・ Burns due to high temperature ashes accumulated in the boiler and ceiling enclosure. ・ Slipping and falling due to accumulated ash inside the duct. ・ Burns due to touch the high temperature part. ・ Oxygen deficiency due to closed space and/or dust.
12	Use of handrails and stairs in the duct.	▲**NOTICE** ・ There is a possibility that handrails and stairs may be damaged due to deterioration over time, fully check safety before use. Especially pay attention to the areas exposed to corrosive environments. ⚠**WARNING** ・ Falling.
13	Inspection work of coal bunker	▲**NOTICE** ・ When coal discharge from the bunker suspected of fire, there is a risk of explosion in the bunker. ・ If abnormal temperature rise (about over 50degC as a guide) or CO generation is observed in the bunker, contact with the equipment manager and evacuate the coal bunker. ⚠**WARNING** ・ CO intoxication by leaking CO from bunker.
14	Use of the top board when bunker inspection (on the top board).	▲**NOTICE** ・ If corrosion is found on the top plate of the bunker, keep away from it. Before use, check the safety sufficiently ⚠**WARNING** ・ Falling.

No.	Work item	Precaution
15	Maintenance work inside the boiler and inside the vessel with opening and closing the manhole	⚠**WARNING** ・ Falling during work at high place. ・ Hand pinch when closing the manhole. ・ Dust blowout and hot air blowout when manhole open ・ Burns due to residual heat when manhole close. ・ Oxygen deficiency.

Table5.3.2. Precaution of the repair and replacement work

No.	Work item	Precaution
1	Pump, fan, or motor replacement work when there is a defect with the pump, fan, or motor.	⚠**WARNING** ・ Falling during work at high place. ・ Pinched. ・ Touch to the rotating part due to the isolation defect. ・ Burns due to residual heat. ▲**NOTICE** ・ Start work after turned off the power and make sure the isolation of the system.
2	Welding work when there is a defect in the piping, boiler pressure parts, duct etc.	⚠**NOTICE** ・ Remove combustible materials thoroughly before using firearms. ・ Make sure of the earthing before starting welding work. ⚠**CAUTION** ・ Welding spark may cause a fire of nearby combustible material. ⚠**WARNING** ・ Electrical shock.
3	Dismantling of the heat insulating material in the case where there is a defect in the piping or pressure part due to deterioration or damage of the heat insulating material, installation work.	⚠**WARNING** ・ Falling during work at high place. ・ Inhale heat insulation material. ・ Burns due to residual heat.
4	Motor disconnection and reconnection work when replacing the motor.	⚠**WARNING** ・ Touch to the rotating part due to the isolation defect. ・ Electric shock due to contact with conductive parts.

Table5.3.3. Precaution of the other related work

No.	Work item	Precaution
1	Cleaning of the dust accumulation area of equipment related to fuel transportation.	▲**NOTICE** ・ Clean the dust accumulation area regularly. ⚠**CAUTION** ・ Fire.
2	Transportation of equipment, materials and parts.	▲**NOTICE** ・ Make sure that the center of gravity of each unit does not tilt more than 10 degrees to the vertical of the floor, not to make the center of gravity out of the footprint, so that the equipment and materials do not fall down when the system is being transported or not fixed to the floor. ⚠**CAUTION** ・ Fall down or unexpected movement of the equipment, materials and pinch by the equipment.
3	Disposal of waste generated during maintenance work.	▲**NOTICE** ・ Since boiler plant use chemical substances that are harmful to the human body, when disposing of chemical substances generated during maintenance work, properly treat them as hazardous waste. ⚠**CAUTION** ・ Toxic material spills out.
4	Dismantling and relocation of equipment, materials and parts.	▲**NOTICE** ・ For the dismantling and transfer of equipment, materials and parts, understand the contents of the hazard and handle it appropriately. ・ Turn off the equipment and all peripheral devices before starting disassembly. ・ Make sure that the temperature of equipment, materials and parts has dropped before starting work. ⚠**WARNING** ・ Burns due to residual heat.

5.4. Boiler Inspection

This section describes boiler inspection recommendations.

- Daily : During power generation
- Regular : In a scheduled power generation shut-down
- Irregular : Sudden or unplanned power outages

In this section, as an Irregular inspection, the scene of tube leak and earthquake and cold wave is described in addition to daily and regular inspection, but other natural disasters may also occur. In that case, please carry out the similar inspection accordingly.

Please refer to Chapter 3 for the location of inspection items.
The boiler lay down procedure for the regular shut-down shall follow the description in Chapter 5.6.

The following are the major tasks that may need to be done and/or before the inspection/repair.
Depending on the content of the inspection/repair, other works may be also required.
Please understand the contents of Chapter 0 and Chapter 5.3, and carry out the work after taking necessary safety measures for the work.

- Cooling of boiler pressure parts
- Opening and closing of a manhole to accelerate the cool down inside the boiler etc.
- Ensuring oxygen concentration (ventilation with boiler inside and outside air), with oxygen concentration measurement
- Make sure of the entry/exit control to the confined space during the maintenance work
- Installation and dismantling of scaffolding and/or gondola
- Cleaning (vacuum, blast)
- Lighting
- Temporary removal and restoration of heat insulation
- Temporary removal and restoration of outer casing
- Temporary removal and restoration of objects that interfere with work

Keep the inspection records whether repaired after inspection or not, and reflect them in the plan for subsequent repairs.

■Inspection method

- VT (Visual)

  It detects abnormalities such as erosion, bulging, corrosion, and color changes from the appearance.

  As they progress, they may develop into steam leaks in the case of pipes, or cracks and defects in the case of metal, which may impair the function of the metal and may lead to further damage.

- Palpation

  Touch and sense damage, such as erosion, bulging, and corrosion.

  As they progress, they may develop into steam leaks in the case of pipes, or cracks and defects in the case of attachment, which may impair the function of the attachment and may lead to further damage.

  We recommend further inspection and/or repair.

- PT (Penetration inspection)

  PT detects open surface cracks on the outer surface.

  If the operation is performed with the crack left, the crack may grow, and if it is a pipe, it may develop into steam leakage, or if it is broken, it may deteriorate the function of the metal and cause further damage.

  We recommend further inspection and/or repair.

  When applying to austenitic stainless steel, it is necessary to select an osmotic solution that does not contain chloride ions.

NOTICE

- MT (Magnetic particle inspection)

  MT detects external surface and surface flaws.

  If this flaw is left to operate, the flaw may grow, and if it is a pipe, it may lead to steam leakage, and if it is broken, it may deteriorate the function of the concerned metal piece and progress to further damage.

  We recommend further inspection and/or repair.

  It cannot be applied to SUS materials.

- UT (Ultrasonic flaw inspection)

  UT detects internal flaws and internal surface flaws. It is suitable for detecting volumetric flaws or surface flaws.

  If this flaw is left to operate, the flaw may grow, and if it is a pipe, it may lead to steam leakage, and if it is broken, it may deteriorate the function of the concerned metal piece and progress to further damage.

  We recommend further inspection and/or repair.

- **Thickness measurement**
  Measure the thickness of the tube etc.
  It is recommended to feed back to the new and/or repair plan after considering the thickness required for strength and the excess thickness and corrosion loss rate with age for corrosion reduction etc.

- **Sample tube inspection**
  When you want to analyze in detail the appearance, metallographic structure, composition, hardness, cross-sectional shape and dimensions, scale thickness, fracture surface condition, etc., the sample tube is cut out and surveyed.
  The length to be cut out as a sample is the length necessary after determining the items to be investigated, and the workability of pipe cutting and pipe welding, etc. Please decide in consideration of ease of use.
  Before the sample tube is collected, it is recommended to cut it out after describing the location of the tube to be collected and front and behind of the boiler, the right can, and the vertical direction.

- **Curvature measurement**
  In the furnace wall, bending in the form of a panel may occur, and in the heat transfer tube, misalignment of the tube may occur.
  Set a reference point that does not change in position over time, and measure the amount of bending based on that reference point. Although the degree of certainty is inferior, it is also possible to carry out visual check of trends.
  If the operation is performed with the curve left, stress concentrates on a certain part and damage progresses in that part, leading to troubles due to further bending progress or excessive temperature rise due to heat absorption imbalance, leading to steam leakage There is a possibility.
  It is recommended to perform additional inspections and/or bends and repair of those areas where stress may be concentrated.

- **Scale thickness measurement**
  Measure the thickness of the pipe scale.
  As the scale in the pipe increases in thickness, the flow of water vapor is impeded and the metal temperature of the pipe rises at the downstream side of the location, or exfoliates and clogs at the downstream side, and further scatters out of the boiler system, damaging the turbine blades There is a possibility of giving
  As a general precaution, it is recommended to chemically clean the pressure part before that happens. Therefore, it is recommended to measure scale thickness in a planned manner.

- **In each inspection, consider the necessary equipment and procedures, and perform in an appropriate manner.**

5.4.1. Daily

For daily inspection, please refer to the following.

Inspect regularly the boiler and its auxiliary equipment at least once or twice every day for any abnormal noise, odd smell, vibration, discoloration/deformation of the insulation casing, rain leaking, leaking lubricant oil, leaking air/flue gas and leaking water/steam. If such anomaly is found, find the root cause and fix the problem according to the equipment maintenance manual and ask OEM supplier for the advice and recommendation. In worst case, such fixing problem may require the unit shut-down.

If an abnormality is confirmed, it is strongly recommended that the operator do not leave it, consider the repair method, timing, etc., and take immediate respond such as repair.

The operator of the boiler shall utilize the daily inspection to obtain the status of the boiler operating condition, prepare the maintenance work plan and minimize the maintenance work during the periodic maintenance shut-down.

Table5.4.1.1. Daily Inspection Item List (Central Control Room)

No.	Item
1	Monitor the amount use of make-up water. If the amount of make-up water flow rate increases, check for tube leaks.
2	Monitor the water chemistry and Check if condeser leakage do not happen and water entering boiler is not deteriorated (see 4.9.2 : Condenser leakage).
3	Check that there is no change in the gas temperature, gas pressure at IDF inlet or O2 concentration at the boiler outlet (such as left-right balance or numerical abnormalities).
4	Check that there is no change in metal temperature.
5	Check that there is no change in furnace pressure.
6	Check if an abnormal alarm is issued from the alarm device.
7	Check if any abnormal balance around the pulverizer, such as inlet/outlet pressure, differential pressure of the pulverizer and make sure of the control damper position not reach full open or completely close during the pulverizer in service.

Table5.4.1.2. Daily Inspection Item List (Site)

No.	Item
	BOILER
1	Check for abnormal noise.
2	Check for an offensive odor.
3	Check for leaks from the casing.
4	Check for blowout of steam from the blow tank. (Drain valve leak)
5	Check for white smoke from the chimney.
6	Check the piping and piping support devices and their surroundings for abnormalities.
7	Monitor the combustion condition of the boiler from the observation door.
8	Open the boiler observation door and check the burner flame status in the furnace.
9	Check the panel (heat transfer element) for shaking (by the sound or view from the observation door).
10	Check that there are no steam leaks or drain leaks from any part of the external insulation outer casing that covers the boiler pressure parts.

No.	Item
11	Check each pressure indicator or pressure transmitter display.
12	Check each level indicator or level transmitter display.
13	Check each draft pressure indicator or pressure transmitter display.
14	Visually check the appearance of the sootblower and the operating condition.
15	Visually check the appearance of the water sootblower and the operating condition.
16	Clean the dust accumulation part of equipment related to fuel transportation.
17	Control the level of equipment that defines lubricating oil and grease levels.
18	Check lubricating oil and grease from the viewpoint of white turbidity, foreign matter inclusion, and level reduction.
19	Check the vibration and temperature of the rotating equipment bearings.
20	Inspect for drain dripping, water, steam and gas leakage.
21	Check the accumulation of ash in the furnace from the observation door. If extensive ash accumulation which will be obstacles of operation is found, reducing operating load or boiler shut-down shall be considered.
22	Check for leaks of gas or air from ducts and flanges, and accumulation or ejection of fine powder and ash around them.
23	Check that there is no looseness in the bolt on the flange of dampers or expansion joints of the duct.
24	Check that there is no deformation in the hydraulic isolator or hanger. Also, make sure that they are within the travel range.
25	After changing the fuel, check the following items for changes in condition. ・ Check if there is any abnormality in the adhesion of slag to the furnace wall of the boiler. ・ Check that molten slag does not stick to the furnace wall. ・ Check if there is any abnormality in the shape of the flame from the flame outlet of the burner. Check if the flame shape is not offset to the left and right, up and down.
26	Clear the slag lump of the throat part of the burner generated by unplanned fuel etc. Conduct the clearing work while the slag is as small as possible. Untreating the slag block may cause damage to the furnace wall and burners. Furthermore, there is also a possibility that slag lumps may be exfoliated due to temperature change of the furnace wall due to load change. If slag lumps in the throat part peel off, the large slag lumps will fall into the clinker conveyor, so watch them for clogs on the clinker conveyor.
	BOTTOM ASH SYSTEM
27	Check that the clinker conveyor is free of large block and jams and strange noises.
28	When crushing a large clinker mass in the clinker conveyor by hand work, be careful because the inside is red hot even if it is submerged and cooled.
29	Check that there are no abnormalities in the drain trap.
30	Check that there are no abnormalities in the differential pressure of the strainer.
	VALVEs, DAMPERs and DRIVES/ACTUATORS

No.	Item
31	Check the noise,vibration and non-smooth motion of the pneumatic drive, control and hydraulic drive valve and damper regularly.
32	Do not apply excessive force to the valve handle with a Wheel Key, etc. Check the structure of the valve and use it properly. ex) Use of partial opening of ball valve, excessive tightening of gate valve.
33	The valve should be tagged or colored so that the basic setting position, current open or closed state, etc. can be visually identified.
34	Refrain from continuous operation of high differential pressure valves such as continuous blow valves and emergency blow valves with an opening of 15% or less to prevent valve seat erosion.
35	Do not tighten with excessive force when ground leakage of the control valve happens. It may cause malfunction.
36	Check seat leak of the valve regularly. If the valve seat leaks, erosion may progress on the valve seat and the valve downstream side. If the poppet valve of the sootblower is leaked, erosion may occur in the furnace wall and tube near the spray outlet of the sootblower. When the furnace inspection is possible, check it together with the leak of the poppet valve.
37	The seat leak of the valve may be detected by the continuous release of white smoke from the blow tank. In addition, it is possible to identify the seat leak by the temperature rise etc. of the valve body in the closed state. Check regularly for seat leak of the valve.
38	Monitor regularly for loose grand packing of the valve and leak from ground packing.
39	Check that there are no seat leaks in the electric valve, manual valve, or safety valve.
	BOILER AUXIARIES (ROTATING MACHINARIES)
40	Regularly monitor in the vicinity of the equipment to be inspected for abnormal noise, vibration and odor.
41	Supply of lubricating oil and grease shall be carried out regularly in accordance with the indivisual manual of the equipment. The recommended time in the equipment manual indicates the maximum grace period and must be replaced within that period.
42	For equipment with spare equipment, operate the spare equipment regularly. Adjust the operating time so that the operating time of each device, including the spare unit, is as even as possible to prevent defect or deterioration due to not operating for a long time.

No.	Item
43	During operation, the pump and fan etc., other rotating machineries, should be kept under careful observation. The following measurement values should be checked with regular intervals. Suction pressure Suction temperature Discharge pressure Discharge temperature Bearing temperatures Vibration Stuffing box leakage (Pump) Check that the pump and fan etc., runs smoothly and quietly at all times. We recommend keeping a logbook on pump operation, to supervise the pump more closely. The luburicant and hydraulic oil, If applicable, oil level and oil quality should be checked regularly at least once a month.
	COAL BUNKER AND COAL FEEDING SYSTEM
44	When coal discharge from the bunker suspected of fire, there is a risk of explosion in the bunker.
45	If abnormal temperature rise (about over 50 degreeC as a guide) is observed in the bunker, please discharge coal without feeding the pulverizer. If CO occurs in the Bunker, be sure to consult with the equipment manager.
46	During boiler operation, switch the spare pulverizer so that coal is not placed for more than a week to prevent bunker fire.
47	Check that there is no burn discoloration, etc. of the paint every day. In addition, it is recommended that the paint re-tatch in the event of burn discoloration be carried out not only on the relevant part but also on the entire circumference to prevent confusion at next time the judgment.
48	Before the bunker coal feed, make sure that there is no odor (fire) that coal is smoldering inside the bunker. If there is odor, please continue pulverizer operation for at least 24 hours if the pulverizer in operation (do not stop absolutely, in case of stop there is a higher risk of pulverizer explosion with coal with odor inside of the pulverizer).
49	Put pulverizer in service after confirming that the pulverizer operating condition is normal and bunker temperature is enough low to start pulverizer operation.
	OTHERS
50	Regularly monitor Gas analyzer measurement whether the calibration gas pressure displayed on the gas analyzer is appropriate value. If the indicated value displayed on the gas analyzer is abnormal, investigate the cause.
51	The filter of the O2 meter for flue gas could be clogged with ash and it may not be able to measure correctly. Check the filter condition and take appropriate action.

5.4.2. Regular

While conducting daily and monthly inspections during in service on your boiler equipment will help, the operator shall also conduct more intensive inspections quarterly or every other month during the outage. A few of the most essential Regular Inspection Item List are to:

Table 5.4.2.1 Regular Inspection Item List (boiler)

■Furnace wall (inside)

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Tube	Erosion	VT, Palpation, Thickness measurement	Pay particular attention to tubes in the sootblower injection range and the wall sootblower injection range. Also, pay particular attention to the measurement seat, SB, WSB, and the opening of the observation door, the burner opening, and the OAP and SAP openings.
2	Tube	Crack	PT or MT	
3	Tube	Bulging	VT, Palpation, Thickness measurement, Replica inspection	
4	Tube	Fine wound	VT, Replica inspection	Fire crack
5	Tube	Corrosion	VT	Sulfurized corrosion etc.
6	Tube	Discoloration	VT	
7	Tube	—	Thickness Measurement at representative point fixed point	
8	Tube	Scale formation	Sample tube survey, scale thickness measurement	
9	Tube (Hopper part)	Dent, Sliding scratch	VT, Thickness measurement	
10	Tube (Ceiling penetration part)	Erosion	VT, Thickness measurement	
11	Tube, Furnace wall	Curvature	VT, Curvature (displacement) measurement	
12	Fin, seal attachment (furnace wall tube)	Crack	PT or MT	Including WSB, SB, observation door sleeves and integral fins

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
13	Fin, seal attachment (furnace wall tube)	Deformation	VT	Including WSB, SB, observation door sleeves and integral fins
14	Fin, seal attachment (ceiling penetration part)	Crack	PT or MT	Including integral fins
15	Fin, seal attachment (ceiling penetration part)	Deformation	VT	Including integral fins
16	Fin welding toe part of furnace wall tube (inlet at furnace)	Crack	PT or MT	
17	Refractory	Dropout, Missing	VT	
18	Clinker hopper seal plate	Deformation, Burnout	VT	
19	Boundary air port	Abnormality	VT	Abnormality=Clogged with ash
20	Furnace wall tubes near the sootblower	Erosion	VT	If the erosion of the furnace wall and pipe is progressing significantly near SB, check for clogging in the poppet valve leak of SB or drain valve/drain trap of SB system piping. There is a possibility of erosion due to drain.

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
21	Refractory	Erosion Repair	VT	Refractory may cause the crack and the small fraction fell apart as nature during the normal operation and need inspection and minor repair in regular basis during the regular maintenance shut-down. The refractory material at the burner throat shall not be enlarged more than the original design. The larger area of refractory than design would cause the severe slag formation around the burner starting from the refractory, may cause the damage of the burner due to redirection of the flame, or catch a fire of the burner. Re-ling of the refractory shall be consulted with the boiler OEM supplier.

■**Furnace wall (outside)**

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Fin, seal attachment (furnace wall tube)	Crack	PT or MT	
2	Fin, seal attachment (furnace wall tube)	Deformation	VT	
3	Welded portion of wall box	Crack	PT or MT	Burner, OAP, SAP, measuring seat, SB, WSB, observation door, boundary air port, CCTV
4	Backstay lock attachment	Abnormality	VT	Abnormality=Cracks, defects etc.
5	Welded portion of Backstay lock attachment	Crack	PT or MT	
6	Hanging plate piece	Crack	PT or MT	
7	Measuring seat plug	Gas leak	VT	Confirm that the stopper is closed
8	Backstay	Deformation	VT	
9	Sliding part of backstay	Abnormality	VT	

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
10	Backstay corner attachment	Abnormality	VT	Abnormality=Deformation, pin falling etc.
11	Welded portion of Backstay corner attachment	Crack	PT or MT	
12	Earthquake receiving attachment	Abnormality	VT	Abnormality=Cracks, defects etc.
13	Welded portion of Earthquake receiving attachment	Crack	PT or MT	
14	Bumper, its adjustment bolt	Abnormality	VT, Clearance measurement	Abnormality=Deformation, dropout, clearance abnormality

■HRA peripheral wall (inside)

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Tube	Erosion	VT, Palpation, Thickness measurement	In particular, be careful about pipes in the sootblower injection range. Also be careful about the measurement seat and sootblower opening.
2	Tube	Crack	PT or MT	
3	Tube	Bulging	VT, Palpation, Thickness measurement, Replica inspection	
4	Tube	Corrosion	VT	
5	Tube	Discoloration	VT	
6	Tube	—	Thickness Measurement at representative point fixed point	
7	Tube	Scale formation	Sample tube survey, scale thickness measurement	
8	Tube (Ceiling penetration part)	Erosion	VT, Thickness measurement	
9	Tube, Furnace wall	Curvature	VT, Curvature (displacement) measurement	
10	Fin, seal attachment (HRA peripheral wall)	Crack	PT or MT	Including SB sleeves and integral fins
11	Fin, seal attachment (HRA peripheral wall)	Deformation	VT	Including SB sleeves and integral fins
12	Fin, seal attachment (Ceiling penetration part)	Crack	PT or MT	Including Integral fin
13	Fin, seal attachment (Ceiling penetration part)	Deformation	VT	Including Integral fin
14	Fin end of HRA middle wall	Crack	PT or MT	
15	Refractory	Dropout, Missing	VT	

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
16	Baffle plate	Erosion Deformation Abnormality	VT	If gloss is seen on the lower tube surface of the baffle plate, install a erosion-proof plate or a deflection prevention plate. Depending on the nature and amount of ash, the progress of the erosion of the tube may be accelerated.

■HRA peripheral wall (outside)

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Fin, seal attachment (furnace wall tube)	Crack	PT or MT	
2	Fin, seal attachment (furnace wall tube)	Deformation	VT	
3	Welded portion of wall box	Crack	PT or MT	Burner, OAP, SAP, measuring seat, SB, WSB, observation door, boundary air port, CCTV
4	Backstay lock attachment	Abnormality	VT	Abnormality=Cracks, defects etc.
5	Welded portion of Backstay lock attachment	Crack	PT or MT	
6	Hanging plate piece	Crack	PT or MT	
7	Measuring seat plug	Gas leak	VT	Confirm that the stopper is closed
8	Backstay	Deformation	VT	
9	Sliding part of backstay	Abnormality	VT	
10	Backstay corner attachment	Abnormality	VT	Abnormality=Deformation, pin falling etc.
11	Welded portion of Backstay corner attachment	Crack	PT or MT	
12	Earthquake receiving attachment	Abnormality	VT	Abnormality=Cracks, defects etc.
13	Welded portion of Earthquake receiving attachment	Crack	PT or MT	
14	Bumper, its adjustment bolt	Abnormality	VT, Clearance measurement	Abnormality=Deformation, dropout, clearance abnormality

■Ceiling enclosure

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Support equipment (header or crown)	Abnormality	VT	Support equipment also includes the meaning of the hanging rod. Abnormality = deformation, loose
2	Support equipment (header or crown)	Erosion	VT, Palpation	Support equipment also includes the meaning of the hanging rod.
3	Support equipment protector (header or crown)	Erosion	VT, Palpation	
4	Penetration part fin	Deformation	VT	
5	Welded portion of penetration part attachment	Crack	PT or MT	Crown and sleeve, sleeve and tube
6	Skin casing	Break	VT	
7	Heat insulation material	Abnormality	VT	
8	Ash deposition	Gas leak	VT	Excessive ambient temperature rise in the ceiling enclosure → The possibility of damaging equipment in the ceiling enclosure is increased. Especially for the support equipment, it may cause fatal damage.

■Nose enclosure

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Support equipment (truss)	Abnormality	VT	
2	Fin end of through tube	Break	VT, PT or MT	
3	Skin casing	Deformation	VT	
4	Skin casing	Break	VT	
5	Ash deposition	Gas leak	VT	Excessive temperature rise of the ambient temperature in the nose enclosure rises the possibility of damaging equipment in the enclosure. Especially for hangers, it can cause fatal damage.

■**Header/manifold**

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Outside of container	Abnormality	VT	
2	Inside of vessel	Abnormality	VT	Inspection nipple open → Internal confirmation with fiberscope etc.
3	Inner surface of the vessel	Erosion	VT, Thickness measurement	
4	Welded portion of vessel and tube	Crack	VT, PT or MT	Welded portion of stub tube weldment
5	Welded portion of nozzle	Crack	PT, MT or UT	
6	Supporting attachment	Deformation	VT	Supporting attachment= Support equipment, stopper
7	Welded portion of supporting attachment	Crack	PT or MT	Supporting attachment= Support equipment, stopper
8	Hanging rod	Abnormality	VT	Abnormality= Deformation, erosion
9	Heat insulation material (heat cylinder, heat blanket)	Dropout, Missing	VT	There is the possibility to lead to excessive temperature rise of Hanging rod.

■**Primary superheater**

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Tube	Erosion	VT, Palpation, Thickness measurement	Pay particular attention to the sootblower injection point.
2	Tube	Crack	PT or MT	
3	Tube	Bulging	VT, Palpation, Thickness measurement, Replica inspection	
4	Tube	Corrosion	VT	
5	Tube	Discoloration	VT	
6	Tube	—	Thickness Measurement at representative point fixed point	
7	Tube	Scale formation	Sample tube survey, scale thickness measurement	
8	Tube row	Disorder	VT	
9	Tube (Furnace wall penetration part)	Burnout	VT	
10	Supporting attachment	Abnormality	VT	Supporting attachment＝Panel attachment, rug attachment Abnormality=Falling out, cracking, burning, erosion
11	Welded portion of supporting attachment	Crack	PT or MT	
12	Tube protector	Abnormality	VT	Abnormality＝Falling out, cracking, burning, erosion The tube protector erosions the protector instead of erosion the tube in order to prevent the erosion of the tube, and replaces it (and adds if necessary) at any time based on the results of regular inspections.
13	Alignment attachment	Abnormality	VT	Alignment attachment＝Tie rod, slide spacer, spacer cane tube
14	Welded portion of alignment attachment	Crack	PT or MT	
15	Vibration isolation plate	Abnormality	VT	Abnormality=Deformation, falling off, pin cracking

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
16	Erosion baffle	Abnormality	VT	Abnormality=Deformation, falling off, erosion, cracking
17	Other	Ash deposition	VT	

■Secondary superheater

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Tube	Erosion	VT, Palpation, Thickness measurement	Pay particular attention to the sootblower injection point and the fretting part of the bundle tube part.
2	Tube	Crack	PT or MT	
3	Tube	Bulging	VT, Palpation, Thickness measurement, Replica inspection	
4	Tube	Corrosion	VT	
5	Tube	Discoloration	VT	
6	Tube	—	Thickness Measurement at representative point fixed point	
7	Tube	Scale formation	Sample tube survey, scale thickness measurement	
8	Tube row	Disorder	VT	
9	Tube (Furnace wall penetration part)	Burnout	VT	
11	Alignment attachment	Abnormality	VT	Alignment attachment＝ Tie rod, slide spacer
12	Welded portion of alignment attachment	Crack	PT or MT	
13	Different material joint	Crack	PT or MT	

■**Final superheater**

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Tube	Erosion	VT, Palpation, Thickness measurement	Pay particular attention to the sootblower injection point and the plate spacer installation unit.
2	Tube	Crack	PT or MT	
3	Tube	Bulging	VT, Palpation, Thickness measurement, Replica inspection	
4	Tube	Corrosion	VT	
5	Tube	Discoloration	VT	
6	Tube	—	Thickness Measurement at representative point fixed point	
7	Tube	Scale formation	Sample tube survey, scale thickness measurement	
8	Tube row	Disorder	VT	
9	Tube (Furnace wall penetration part)	Burnout	VT	
11	Alignment attachment	Abnormality	VT	Alignment attachment＝Tie rod, slide spacer
12	Welded portion of alignment attachment	Crack	PT or MT	
13	Different material joint	Crack	PT or MT	

■Reheater

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Tube	Erosion	VT, Palpation, Thickness measurement	Pay particular attention to the sootblower injection point and the plate spacer installation unit.
2	Tube	Crack	PT or MT	
3	Tube	Bulging	VT, Palpation, Thickness measurement, Replica inspection	
4	Tube	Corrosion	VT	
5	Tube	Discoloration	VT	
6	Tube	—	Thickness Measurement at representative point fixed point	
7	Tube	Scale formation	Sample tube survey, scale thickness measurement	
8	Tube row	Disorder	VT	
9	Tube (Furnace wall penetration part)	Burnout	VT	
10	Supporting attachment	Abnormality	VT	Supporting attachment＝Panel attachment, rug attachment Abnormality=Falling out, cracking, burning, erosion
11	Welded portion of supporting attachment	Crack	PT or MT	
12	Tube protector	Abnormality	VT	Abnormality＝Falling out, cracking, burning, erosion The tube protector erosions the protector instead of erosion the tube in order to prevent the erosion of the tube, and replaces it (and adds if necessary) at any time based on the resultsof regular inspections.
13	Alignment attachment	Abnormality	VT	Alignment attachment＝Tie rod, slide spacer, spacer cane tube
14	Welded portion of Alignment attachment	Crack	PT or MT	
15	Vibration isolation plate	Abnormality	VT	Abnormality=Deformation, falling off, pin cracking

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
16	Different material joint	Crack	PT or MT	

■Economizer

No	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Tube	Erosion	VT, Palpation, Thickness measurement	Pay particular attention to the sootblower injection point.
2	Tube	Crack	PT or MT	
3	Tube	Bulging	VT, Palpation, Thickness measurement, Replica inspection	
4	Tube	Corrosion	VT	
5	Tube	Discoloration	VT	
6	Tube	—	Thickness Measurement at representative point fixed point	
7	Tube	Scale formation	Sample tube survey, scale thickness measurement	
8	Tube row	Disorder	VT	
9	Tube (Furnace wall penetration part)	Burnout	VT	
10	Supporting attachment	Abnormality	VT	Supporting attachment＝Panel attachment, rug attachment Abnormality=Falling out, cracking, burning, erosion
11	Welded portion of supporting attachment	Crack	PT or MT	
12	Tube protector	Abnormality	VT	Abnormality＝Falling out, cracking, burning, erosion The tube protector erosions the protector instead of erosion the tube in order to prevent the erosion of the tube, and replaces it (adds if necessary) at any time based on the resultsof regular inspections.
13	Alignment attachment	Abnormality	VT	Alignment attachment＝Tie rod, slide spacer, spacer cane tube
14	Welded portion of Alignment attachment	Crack	PT or MT	

No	Inspection object	Symptom	Inspection method (recommended)	Remarks
15	Vibration isolation plate	Abnormality	VT	Abnormality=Deformation, falling off, pin cracking

■**Manhole**

No	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Bonnet	Damage	VT	
2	Grip Bar	Damage	VT	
3	Gasket/Packing	Damage	VT	
4	Refractory	Damage	VT	
5	Conecting Attachment for Casing	Damage	VT	

■**Main piping**

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Welded portion of piping (Longitudinal joint, circumferential joint)	Crack	MT, UT	
2	Welded portion of piping (Longitudinal joint, circumferential joint)	Metal structure deterioration	Replica inspection	
3	Outer surface of welded portion of small diameter pipe	Crack	VT, PT or MT	
4	Inner surface of welded portion of nozzle	Crack	VT, MT	In VT, cut (repair) the inspection nipple near the tube stand and use a fiberscope to check.
5	Outer surface of welded portion of nozzle	Crack	VT, MT	
6	Piping	Corrosion	VT	Especially, there is high possibility that the casing and the place where the heat insulation is damaged
7	Welded portion of piping attachment	Crack	PT or MT	Attachment with piping = rugs etc.
8	Welded portion of Release test nipple, release test plug etc.	Crack	PT or MT	Especially, planned inspection for high Cr materials is recommended.
9	Restraint	Abnormality	VT, PT or MT	
10	Heat insulation material	Dropout, Missing	VT	
11	Heat insulation cover	Abnormality	VT	Abnormality= Deformation, rust, defect
12	Valve outlet reducer part	Crack	VT, UT	

■**Pulverized coal piping**

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Piping inner surface	Erosion	VT, Thickness measurement	Pay particular attention to the bend part.
2	Joint part	Abnormality	VT	
3	Purge device	Abnormality	VT	

■Piping

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Piping	Deformation	VT	Especially for drain piping, check whether there is an abnormality in the drain slope. Especially for draft detection piping, check the connection between pipe and joint.
2	Swing stopper attachment	Abnormality	VT	
3	Pipe shoe	Abnormality	VT	Check if there is an abnormality in the sliding part, etc.

*Refer to the manufacturer's manual for the valve etc.

■Spray equipment

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Welded portion of spray nozzle (outside)	Crack	VT, PT, UT	
2	Inner cylinder spray water supply pipe	Abnormality	VT	Pull out and VT
3	spray nozzle	Abnormality	VT	Pull out and VT
4	Internal device of spray nozzle	Abnormality	VT	Internal device = liner, nozzle, venturi tube
5	Internal attachment	Abnormality	VT	Attachment = Locking plate, Guide attachment, Venturi holding bracket, Locking bracket, Pin Abnormality=Crack, deformation, missing etc. Use a fiberscope from the inspection nipple or water supply pipe.
6	Internal device	Abnormality	VT	Abnormality=Deviation

■STC damper

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Fan	Abnormality	VT	Abnormality=Erosion, deformation, gaps, etc.
2	Seal plate	Abnormality	VT	Abnormality=Such as erosion
3	Fan plate (= seat)	Abnormality	VT	Abnormality=Such as erosion
4	Axis	Abnormality	VT	Abnormality=Erosion, deformation, etc.
5	Bearing	Abnormality	VT	Abnormality=Such as erosion
6	Link device	Abnormality	VT	Abnormality=Deformation, malfunction etc.
7	Damper frame	Abnormality	VT	Abnormality=Erosion, deformation, etc.
8	Casing	Abnormality	VT	Abnormality=Erosion, deformation, cracking etc.

*Refer to the manufacturer's manual for the control drive etc.

■Duct

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Inside of duct	Abnormality	VT	Abnormality=rust, Erosion, deformation, etc.
2	Duct internal support	Abnormality	VT	Abnormality=Erosion, deformation, etc.
3	Duct internal strut protector	Abnormality	VT	Abnormality=Such as erosion
4	Duct detection seat	Abnormality	VT	Abnormality= Foreign matter such as ash clogged
5	Inside the duct	Ash deposition	VT	

■**Separator, Separator drain tank**

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Welded portion of Welded portion of container	Crack	VT, PT or MT	
2	The inner surface of the container	Erosion	VT, Thickness measurement	
3	Attachment inside the container	Abnormality	VT	
4	Welded part of attachment inside Welded portion of container	Crack	VT, PT or MT	

■**Damper**

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Fan	Abnormality	VT	Abnormality=Erosion, deformation, gaps, etc.
2	Fan plate (= seat)	Abnormality	VT	Abnormality=Such as erosion
3	Axis	Abnormality	VT	Abnormality=Erosion, deformation, etc.
4	Link device	Abnormality	VT	Abnormality=Deformation, malfunction etc.

*Refer to the manufacturer's manual for the control drive etc.

■**Expansion Joints**

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Bellows	Damage	VT	
2	Bellows other components	Damage	VT	Especially share bars, protectors (protective plates)
3	Expansion joint connection	Damage	VT	

■**Outer casing**

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	General	Damage	VT	Damage = rust, burnout etc. Especially the penetration part.
2	Presser foot	Damage	VT	

■Boiler House

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Floor	Abnormality	VT	
2	Stairs	Abnormality	VT	
3	Steel Frames	Abnormality	VT	
4	Roofs/Walls	Abnormality	VT	

Table 5.4.2.2 Regular Inspection Item List (Boiler Auxiliary Equipment)

No.	Item
1	Make sure that there is no other works such as high temperature, high heat, fire, grinder, etc. nearby. In order to prevent the spread of damage in the case of spilling lubricating oil and oil, cover the surroundings with a vinyl sheet etc. in advance. If spilled, wipe off immediately.
2	Carry out the overhaul with dismantling/re-assembling in every a few years interval in accordance with the instruction of the indivisual. Carry out the overall visual inspection after dismantling the equipment whether abnormal/excessive erosion, clearance, bending and deformation of the equipment is found.
3	Check the bearing condition and replace in accordance with the lifetime in the indivisual maintenance manual, or if the excessive erosion is found.
4	Chcek the mechanical seals condition and replace in accordance with the lifetime in the indivisual maintenance manual, if the excessive erosion is found.
5	Chcek the blade/impeller condition and conduct the reapir work, if necessary.
6	Check the casing erosion condition and conduct the reapir work, if necessary.
7	Avoid the foreign material entering the equipment during the inspection and maintenance work.
8	Make sure the re-alignment after dismantling and re-assembling of the equipment. It is recommended to leave such as eye marks on each disassembly parts when disassembly of equipment carry out during of periodic inspection.
9	Tighten the bolt according to the torque control value specified by each manufacturer. It is the same when there is a specification such as double nut etc. Also in hot bolting which is carried out by the temperature rising etc. when resteat of plant operation, carry out with the torque management value of each equipment regulation.
10	Discovery of white turbidity and abnormalities of lubricating oil and fats oil. We recommend recording and inspection because there is the possibility of something abnormal.
11	O2 densitometer inserted into the ECO outlet gas duct should be set to power ON. In that case, even if the atmosphere temperature in the duct decreases, the O2 densitometer is held at a high temperature due to current, so do not touch it.

*1: The above description is general descritption and refer to each indivisual maintenance manual of the original equipment supplier for the precise interval and procedure etc.

Table 5.4.2.3 Regular Inspection Item List (handling of storage material)

No.	Item
1	Before carry-in equipment, materials and parts to the installation site, make sure that the loading path can withstand the weight of the equipment.
2	Regarding the carry of equipment, materials and parts to the installation site, make sure in advance that there is no interference with other already installed equipment when pulling in. If space is not available, confirm with the factory personnel beforehand and move or temporarily remove a part of the device. If removal is not possible, notify the operator to ensure safety.
3	As it is common to use forklifts when unloading equipment, materials and parts, and horizontal holding often, check the claw insertion position of the forklift in advance.
4	The craw insertion position is to be marked, but be careful because it may not be visible due to wrapping or packing.
5	In order to avoid condensation, do not move to a place where temperature changes rapidly.
6	Do not unpack the double wrap until the equipment, materials and parts are transported to the designated place for unpacking.
7	Do not give impact to equipment, materials and parts. Floor damage, Damage due to touch with other equipment, Occurrence of defect due to condensation, Damage to equipment due to impact may happen.
8	Do not put your body and body part under the lifted equipment, materials and parts. The body pinched when unloading and/or moving equipment, materials, parts.
9	Store in a weatherproof and dry place under appropriate conditions (temperature and humidity).
10	Do not unpack at the following places. Unstable place. Place where rain, fog, etc. get in directly. Place with rapid temperature change. Place with strong vibration Dusty place.
11	Discontinue unpacking if an abnormality such as abnormal noise or odor is found in the package at the time of unpacking.
12	Check the load capacity of the floor by checking the height, length, weight, and number of equipment, materials, and parts to be carried in.
13	For the passage of heavy objects, carry out curing such as laying an iron plate on the passage surface.
14	If the carry-in passage is narrow, protect cushions, etc., in addition to protecting equipment, materials and parts, and protecting the walls of the passage.
15	Transport under appropriate conditions (temperature and humidity).
16	Make sure that the center of gravity of each unit does not tilt more than 10 degrees to the vertical of the floor when the system is being transported or not fixed to the floor.
17	Products using stainless steel are prone to stress corrosion cracking caused by chlorine ions (Cl-) contained in seawater and rock salt especially in the weld zone, so measures should be taken to prevent stress corrosion cracking during storage.

No.	Item
18	Do not place stainless steel products directly on the floor, but place them on mambos, steel frames (requires anti-corrosion measures), etc.
19	However, when putting on a mambo or a steel frame, sandwich an Ethafoam® or nylon sheet (chlorine free material) and do not keep the contact area between the product and mambo moist.
20	As a rule, stainless steel products should be stored indoors to avoid long-term accumulation of chloride ions by sea breeze and dust.
21	The following is necessary if you are forced to store outdoors. Good drainage and places where seawater does not directly affect the product. No possibility place of submersion or seawater inflow. Measures that do not receive sea breeze and sand dust directly.
22	If the storage of spare parts is for a long-term, check the status regularly.
23	The spare part shall be stored in the controlled atmosphere and check the stored conditions regularly.
24	For instruments and equipment, according to the short, medium, and long term, the instruments energized and store it, the lubricant replace with a rustproof oil and store it. Follow the instruction manual of each equipment for storage procedures of equipment.

Table 5.4.2.4 Regular Inspection Item List (disposal of the waste)

No.	Item
1	For the disposal of equipment, materials and parts, understand the contents of the hazard and handled properly.
2	When disposing of equipment, materials and parts, they may be subject to the regulations of laws and regulations set by the government or local government, etc., so dispose of them according to the waste according to the laws and regulations.
3	Since boiler plant use chemical substances that are harmful to the human body, when disposing of chemical substances generated during maintenance work, properly treat them as hazardous waste.
4	Treat waste liquid and waste according to various laws and regulations.

5.4.3. Irregular (Boiler Tube Leak)

This section describes the inspection when tube leak is suspected as an irregular inspection.

If you suspect a boiler tube leak during plant operation, you need to stop the operation, identify the leak location, repair it, and restart it. If the tube leak is left for a long time, the damage will spread, so we recommend that you do it promptly to minimize the secondary damage from boiler tube leaks.

In addition, before stopping operation, opening a manhole (in some cases setting a foothold) and finding a leak point, it is recommended to move to the discovery process with an idea of where it is.

The following is a list of inspection items for estimating the boiler tube leak locations.

However, depending on the structure, the location of the leak, and the degree of steam leakage, it may not always possible to estimate even if it is carried out before shut-down. In addition, as a result of stopping and inspection, boiler tube leaks have not been reached, and there may be other problems that are not boiler tube leaks. Please make a comprehensive judgment and estimate whether it is a boiler tube leak.

- Check for leak noise and other unusual noises around the boiler pressure part.
  (Detect the noise inexhaustibly after stopping the sootblower)
- Infer based on operation data and previous boiler inspection results.

The following is a list of items that should be checked after finding a boiler tube leak.

- Confirmation of secondary damage caused by water vapor leaked from the first punctured part. Furthermore, confirmation of the presence or absence of further damage due to water vapor leaked from the secondary punctured hole.
- Confirmation that the upstream and downstream pipes in the flow of the punctured part are not damaged.

After repairing the tube leak, confirm the integrity of the repair site by NDT, water pressure, etc.

Identify the cause of tube leak and check and confirm that similar trouble has not occurred at other parts. By the same factor, similar trouble can occur at different parts.

Even if inspected, the damaged part may not be identified. In that case, it is one of the options to find it by sealing the water in the pressure-proof part.

In addition, the degree of damage may be significant, even if it is not completely damaged or even punctured. After considering the cause of the damage, we recommend checking the area where the same damage can be expected to occur.

Pay attention to the the following items during the tube repair works;

- Work with a fully skilled welder using appropriate materials, thicknesses, and welding rods, using appropriate welding methods.
- Active use of water soluble paper is not recommended. When using, it is recommended to keep the sample and to record the place and amount of use. When using water soluble paper, it is necessary to sufficiently raise and hold the temperature of the boiler water so that it melts firmly.
- Tube repair work with great care not to leave foreign matter inside the pipe.

5.4.4. Irregular (Earthquake)

This section describes the inspection when the earthquake occurs as an irregular inspection.
Depending on the degree of shaking of the earthquake, parts that are difficult to assume may be damaged. Perform inspection after confirming safety enough.

Table 5.4.4 Inspection Item List for earthquake happens

■Common

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Are there any leaks such as tube leaks and gas leaks?	—	VT	
2	Are the header, furnace and main piping in the correct position?	—	VT	
3	Is there no space between pressure parts?	—	VT	
4	Are there any places that constrain thermal expansion?	—	VT	
5	Is there any damage to the furnace, piping, and the swinging attachment of the duct?	—	VT	
6	Are there any problems with the lifting device and the support equipment?	—	VT	
7	Is there any abnormality in the welds of small diameter piping connected to the header, main piping, and connecting pipe?	—	VT	

■Header, main piping, communication pipe

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Earthquake receiving goods	Abnormality	VT, PT or MT	Abnormality = deformation, damage
2	Welded portion of header stub	Damage	PT or MT	Especially the end of the portion.
3	Suspension device	Abnormality	VT	Abnormality = Damage, abnormality in travel position
4	Hanging rod	Abnormality	VT	Abnormality = deformation or damage
5	Anti-vibration device	Abnormality	VT	

■**Separator**

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Suspension device	Abnormality	VT	Abnormality=Damage, abnormality in travel position
2	Support equipment	Abnormality	VT	Abnormality=Damage

■**Furnace wall, HRA wall**

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Fin, seal attachment	Abnormality	VT, PT or MT	Abnormality=crack, crack, shift. In particular, fins at the connection between panels and seal attachment.
2	Refractory	Dropout Missing	VT	Burner, OAP, SAP, SB, header penetration.
3	Clinker hopper seal plate	Damage	VT	
4	Welded portion of wall box	Break	VT, PT or MT	Especially the burner wind box part.
5	Back stay lock attachment	Abnormality	VT, PT or MT	Abnormality=Cracks, defects etc.
6	Welded portion of Welded portion of earthquake receiving attachment	Abnormality	VT, PT or MT	
7	Bellows of expansion joint	Damage	VT	Header penetration
8	Outer casing, Skin casing	Damage	VT	
9	Backstay	Damage	VT	
10	Back stay lock attachment	Damage	VT	
11	SB support	Damage	VT	

■**Ceiling wall**

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Skin casing	Abnormality	VT	Especially the corner part.
2	Crown part, crown sleeve part	Abnormality	VT, PT or MT	
3	Earthquake receiver	Abnormality	VT, PT or MT	
4	Ceiling wall penetration	Abnormality	VT	
5	Ceiling wall back stay	Abnormality	VT	

■Ceiling enclosure

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Ceiling enclosure top beam	Abnormality	VT	An earthquake receiver located in the center of the boiler, in particular.
2	Heat insulation material	Abnormality	VT	Head included Heat insulation material.
3	Small diameter tube support	Abnormality	VT	
4	Casing	Abnormality	VT	Especially the bottom of the corner.
5	Entrance part of ceiling wall tube and connection part of furnace front wall and side wall	Abnormality	VT	Abnormality = Damage, contact marks, Such as erosion.

■Nose enclosure

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Skin casing	Break	VT	
2	Backstay	Abnormality	VT	
3	Back stay lock metal (including wind ties)	Abnormality	VT, PT or MT	

■Superheater, Reheater, Economizer

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Supporting attachment	Abnormality	VT	Supporting attachment= Panel attachment, rug attachment Abnormality=Dropout, loss, damage
2	Welded portion of supporting attachment	Crack	VT, PT or MT	
3	Alignment attachment	Damage	VT	Alignment attachment= Tie rod, slide spacer, spacer cane tube
4	Vibration isolation plate	Abnormality	VT	Abnormality=Deformation, falling off, pin cracking
5	Furnace wall penetration	Deformation	VT	
6	Ceiling penetration	Deformation	VT	
7	Tube and SB lance tube interference	Abnormality	VT	Especially if some SBs operated at the moment of earthquake.

■Duct

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Duct	Abnormality	VT	
2	Duct internal support	Abnormality	VT	
3	Duct internal strut protector	Abnormality	VT	
4	Duct shoe	Abnormality	VT	Abnormality=damage, slide part abnormality
5	Duct Support equipment	Abnormality	VT	
6	Duct stop metal	Abnormality	VT	
7	Link system for ducted dampers	Abnormality	VT	
8	Expansion joints	Abnormality	VT	Especially the bellows.

■Boiler house

No.	Inspection object	Symptom	Inspection method (recommended)	Remarks
1	Floor	Abnormality	VT	
2	Stairs	Abnormality	VT	
3	Steel Frames	Abnormality	VT	
4	Roofs/Walls	Abnormality	VT	

5.4.5. Irregular (Restart after Lay-up)

The condition for resuming operation after a long operation stop may not be the same as the operation stop condition. For example, it is possible that damage due to corrosion such as rusting or deterioration over time has occurred and progressed. Please check that the equipment is not damaged and restart operation.

It is recommended to inspect the same items listed in the Regular Inspection Item List in Section 5.3.2.
Refer to section 5.5.3 for recommended inspection items as a boiler plant.

5.5. Boiler Repair and Chemical Cleaning

This section describes boiler repair and chemical cleaning.

5.5.1. Boiler Repair

It is recommended to repair the boiler regardless of the degree of damage.

Basically, please repair as original.As for the method of repair, determine the appropriate method and carry out according to the object, its condition and the situation at that time.

The followings are the major tasks that may be required before and/or after repair.

Depending on the content of the repair, other tasks may also be required.

Check that you understand the contents of Chapter 0 and Section 5.2 and have taken the safety measures necessary for the work.

- Cooling of boiler pressure part.
- Opening and closing of a manhole to accelerate the inside of the boiler etc.
- Ensuring oxygen concentration (ventilation with boiler inside and outside air), oxygen concentration measurement.
- Installation and dismantling of scaffolding and/or gondola.
- Cleaning (vacuum, blast).
- Lighting.
- Temporary removal and restoration of heat insulation.
- Temporary removal and restoration of outer casing.
- Temporary removal and restoration of objects that interfere with work.

5.5.2. Scaling Control

Scaling control of furnace is mandatory for the reliable operation of once-through Boiler unit. Scaling control shall be conducted in two (2) phase activities of scale measurement and chemical cleaning. The clause describes scaling measurement.

Scaling measurement is conducted in accordance with following procedure. And chemical cleaning shall be conducted if the thickness of scale exceeds the criteria.

The Sampling Procedure

1) Section of tubes shall be sampled for the scaling measurement according to following criteria and procedures:

<Furnace lower wall>

Length of a sample tube	: Approx. 800 mm
Required number	: One from each furnace wall (front, rear, right and left)
Location	: Approx. 1,000mm to 3,000mm above upper burner level (see **Fig. 5.4.2**)
Sampling interval	: Once per year*

<Furnace upper wall>

Length of a sample tube	: Approx. 800mm
Required number	: One from each front & rear wall
Location	: Approx. 1,000mm above welding point of scissors elbow/center of furnace wall (see **Fig. 5.4.2**)
Sampling interval	: Once per year*

* The interval can be extended by the scaling condition of first sampling, but it shall not be longer than two (2) year.

2) Insulations and claddings around the sampling areas shall be removed.

3) Sample tubes shall be cut with a portable sawing tool.

4) The pieces of new tubes shall be put in the slots in the place of sampled tube and welded to the existing tubes.

5) Welded joints between new tubes and existing tubes shall be radio-graphically tested.

6) Insulations and claddings around the tube sampling areas shall be replaced.

Scale Measurement Procedure

7) The external surface of the sample tubes shall be completely cleaned by grinding machine.

8) Cut off a piece (called segment (A) herein after) as shown in **Fig. 5.4.2** from each sampled tube.

9) The exposed metal surfaces of the segment (A) shall be coated with a plastic film.

10) The segment (A) shall be weighed, and the weight shall be recorded.

11) The internal surface area of segment (A) shall be measured and recorded.

12) Internal scale on the segment (A) shall be dissolved in an acid bath.

13) The segment (A) shall be weighed again, and the weight shall be recorded.

14) The weight of the internal scale shall be calculated by the difference between the weight of the segment (A) before and after internal scale removing by the acid bath.

Scaling thickness evaluation

When the weight of scale unit area in segment (A) exceeds the following criteria, the water circulation system shall be chemically cleaned.

Table 5.4.2 Criteria to conduct chemical cleaning

		Furnace upper wall	Furnace upper wall
Weight of scale	mg/cm2	30	35

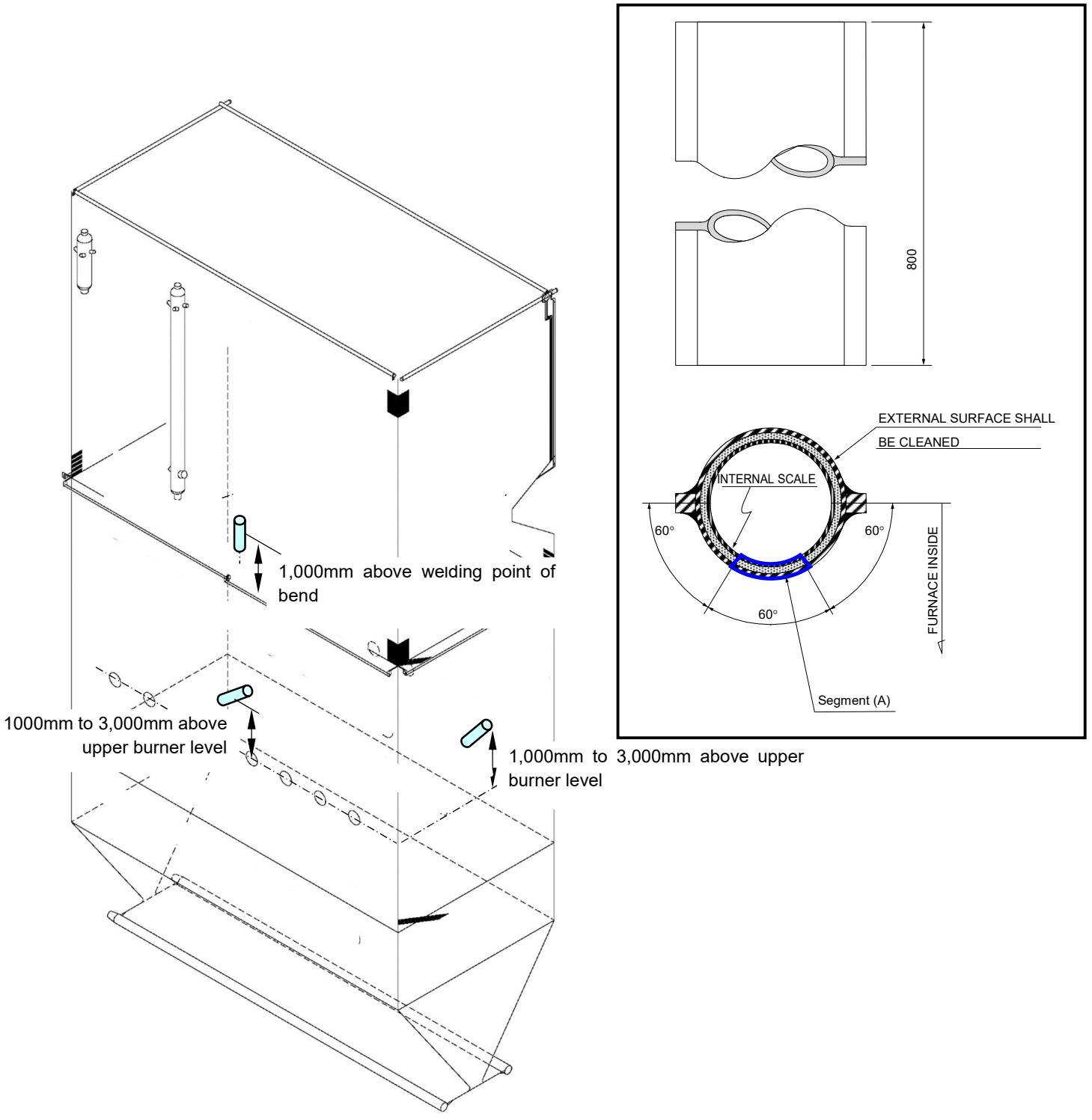


Fig. 5.4.2 Location of Sample Tubes

5.5.3. Boiler Chemical Cleaning

If the scale adheres to the tube and the scale thickness increases, the following problems may occur.

- The scale in the pipe adheres and accumulates, and the peeled scale scatters to the outside of the boiler system as it flows into the steam flow, causing damage to the turbine blades.
- Tube leak due to flow inhibition by scale in the tube.
- (Pressure increase due to excessive rise of metal temperature, furnace path, HRA path, superheater path, reheater path, etc.)
- Damage in the pressure resistant part due to the thermal expansion difference generated by the imbalance of metal temperature.

Measure the thickness of the scale in the pipe regularly, consider the timing of chemical cleaning, and carry out the chemical cleaning by an appropriate method.

5.6. Boiler Plant Lay-up

This section describes boiler preservation and boiler plant preservation.

Although some references are made to individual facilities and equipment, the descriptions in this section are basically basic, and the manual for the individual facilities and equipment is also confirmed and appropriate measures taken.

NOTICE

- **As for the instruments and equipment, store the instruments by energizing the instruments and replacing the lubricating oil with rustproofing oil according to the short, medium, and long-term periods.**
- **Follow the instruction manual of each device for the storage procedure of the devices.**

5.6.1. Boiler Lay-up

Regarding Boiler Lay-up, refer to “4.7.4 Boiler Preservation Procedure”.

5.6.2. Boiler Plant Lay-up

This section explains how to store equipment and devices other than boiler proper.

NOTICE

■Type of Lay-up method

- **Full water Lay-up: Lay-up filled with hydrazine water at an appropriate concentration and remove dissolved oxygen in the water.**
- **Nitrogen gas filled Lay-up: Lay-up that prevents oxidation by nitrogen gas filled.**
- **Natural drying Lay-up: Drying preservation by opening to the atmosphere.**
- **Drying Lay-up: Lay-up by air conditioning moisture removal or dehumidified air inclusion.**
- **Evaporative rust Lay-up: Seals and encloses a corrosion inhibitor that turns into a gas at normal temperature, and the sublimation gas Lay-up the metal to prevent rust.**
- **Dust-proof Lay-up: Lay-up that prevented rainwater infiltration and dust adhesion by using vinyl sheet etc.**
- **Dustproof vaporization rust Lay-up: Lay-up combined dustproof + vaporization rust Lay-up.**
- **Anti-corrosion oil Lay-up: Entrapped Lay-up by volatile anti-corrosion oil.**
- **Lay-up application such as rust Lay-up agent: Lay-up to apply rust Lay-up grease or water soluble resin to metal surface and prevent rust.**
- **Antifreeze with antirust agent Lay-up: Lay-up filled with antifreeze solution containing antirust agent to prevent freezing.**

Also store equipment and equipment other than the boiler proper using an appropriate method. After the storage procedure has been performed, confirmation of the storage condition (such as confirmation of the rust prevention condition) or operation check to confirm that the storage procedure has been properly performed or to restart upon storage, Measure the insulation resistance, etc.The frequency of these confirmations varies greatly depending on the weather conditions at the plant installation site.It is recommended to conduct inspections at least once a month at the beginning of storage and to gradually extend the inspection period.By dealing with the damage before it spreads, it is possible to store it better.

5.6.3. Restart after Lay-up

When start-up operation after outage, check that all the equipment and equipment are in good condition, take appropriate measures, and shift to the process of start-up operation.
If it is the same as the state before start-up operation, it may not be in the damaged state.

The general measures are shown below.

- Cleaning
- External inspection
- Removal of rust preventive agent and dustproof material filled in storage
- Disassembly inspection of valves, pumps, fans, bearings, reduction gears, etc.
- Water washing
- Replacement of lubricating oil
- Operation check
- Air leak test
- Measurement of insulation resistance

etc.

5.7. Spare Parts

For spare parts, refer to below drawings.
“VP1-C-L1-G-H-30041 (K095-451) Contract Spare Parts List (IHI Portion)”
“VP1-C-L1-G-H-30042 (K095-453) Strategic Spare Parts List (IHI Portion)”

NOTICE

- **If spare parts are stored for a long time, check the status regularly.**

5.8. Special Tools

For special tools, etc., refer to “VP1-C-L1-G-H-30043 (K095-455) Special Tool List (IHI Portion)”.

6. Reference List

Owner's Document No.	Contractor's Document No.	Document Title
0 General Documents		
VP1-C-L1-G-GEN-00502	K090055	Fuel Specification for Boiler and Auxiliary Design
VP1-C-L1-M-H-05003	K200145	Boiler Construction (for Owner)
VP1-C-L1-G-H-30041	K095451	Contract Spare Parts List (IHI Portion)
VP1-C-L1-G-H-30042	K095453	Strategic Spare Parts List (IHI Portion)
VP1-C-L1-G-H-30043	K095455	Special Tool List (IHI Portion)
VP1-C-L1-M-H-15014	K093151	Boiler Hazardous Area Classification
1 Layout Drawings		
VP1-0-L1-M-H-15000	K093101	Boiler Elevated Layout (Each Floor)
VP1-0-L1-M-H-15001	K093111	Boiler Elevated Layout (Side & Front View)
2 System Descriptions		
VP1-C-L1-P-H-25000	K3003A1	System Description for Air and Flue Gas System
VP1-C-L1-P-L-25001	K6003A1	System Description for Steam and Feedwater System
VP1-C-L1-P-LBG-25002	K6003A2	System Description for Auxiliary Steam System
VP1-C-L1-P-HJF-25003	K6003A3	System Description for Fuel Oil System
VP1-C-L1-P-H-25072	K6003A5	System Description for Pulverizer System
VP1-C-L1-P-H-25004	K6003A6	System Description for Waste Water System
VP1-C-L1-P-H-25005	K6003B2	System Description for Sootblowing Steam System
VP1-C-L1-P-HCC-30070	F411BC1	System Description and Operation Philosophy for Water Sootblower
VP1-C-L1-P-ETA-30011	KF10001	System Description for Bottom Ash Handling System (IHI Portion)
3 P&ID		
VP1-C-L1-P-H-25057	K600301	Legend for P&ID
VP1-C-L1-P-H-25006	K300311	P&ID for Air and Flue Gas System
VP1-C-L1-P-L-25007	K600311	P&ID for Steam and Feedwater System
VP1-C-L1-P-LBG-25008	K600312	P&ID for Auxiliary Steam System
VP1-C-L1-P-HJF-25009	K600313	P&ID for Fuel Oil System
VP1-C-L1-P-PG-25010	K600314	P&ID for Closed Cycle Cooling Water System
VP1-C-L1-P-GAF-25011	K600315	P&ID for Service Water Supply System
VP1-C-L1-P-H-25012	K600316	P&ID for Waste Water System
VP1-C-L1-P-H-25013	K600319	P&ID for Cooling and Sealing Air System
VP1-C-L1-P-QE-25014	K600320	P&ID for Instrument Air Supply System
VP1-C-L1-P-QE-25015	K600321	P&ID for Station Air Supply System
VP1-C-L1-P-HCB-25016	K600322	P&ID for Sootblowing Steam System
VP1-C-L1-P-H-25017	K600323	P&ID for Blowdown Drain System
VP1-C-L1-P-L-25018	K600324	P&ID for Blowing Out System
VP1-C-L1-P-H-25019	K600325	P&ID for Air Vent and Nitrogen Gas System
VP1-C-L1-P-HN-25020	K600327	P&ID for Safety Valve Exhaust System
VP1-C-L1-P-HFC-25021	K600329	P&ID for Pulverizer System
VP1-C-L1-P-HLD-30056	K414A61	P&ID for Air Heater
VP1-C-L1-P-HCC-30063	K411B61	P&ID for Water Sootblower
VP1-C-L1-P-HLB-30064	K421B61	P&ID for FDF Lubrication Oil System
VP1-C-L1-P-HFV-50008	K440811	P&ID of Lubrication Oil for Pulverizer
VP1-C-L1-P-HFE-30065	K446B61	P&ID for PAF Lubrication Oil System
VP1-C-L1-I-CFB-40067	K739A53	P&ID for Local Instrument Rack
VP1-C-L1-P-ETA-30012	KF10061	P&ID for Bottom Ash Handling System
VP1-C-L1-P-SG-30110	K533161	P&ID of Water Spray System - Boiler Area and CO2 System (IHI Portion)

4 Controls and Operations		
VP1-C-L1-M-GEN-00500	K09005A	Boiler Operation Philosophy for Boiler
VP1-C-L1-M-HAY-00506	K090059	Boiler Feedwater Quality Requirement
VP1-C-L1-I-CJF-40053	K7005A3	Boiler Start-up and Shut-down Operation Diagram
VP1-C-L1-I-CA-30014	K710404	Function of boiler Protection System
VP1-C-L1-I-CA-30015	K710421	Boiler Protection System Logic Diagram (IHI Portion)
VP1-C-L1-I-GEN-30055	K710-411	Set Point List (IHI Portion)
5 Operation and Maintenance Manual		
VP1-C-L1-M-SG-30034	F5331M1	Operation and Maintenance Manual for Water Fire Fighting System (IHI Portion)
VP1-C-L1-M-H-00515	K096001	Operation and Maintenance Manual for Boiler General
VP1-C-L1-I-HCB-30058	K710402	Operation Philosophy for Sootblowing System
VP1-C-L1-M-HCB-30026	F411AM1	Operation and Maintenance Manual for Sootblower
VP1-C-L1-M-HCC-30027	F411BM1	Operation and Maintenance Manual for Water Sootblower
VP1-C-L1-M-HLD-30028	F414AM1	Operation and Maintenance Manual for Air Heater
VP1-C-L1-M-HLB-30029	F421AM1	Operation and Maintenance Manual for Forced Draft Fan
VP1-C-L1-M-HFE-30033	F446AM1	Operation and Maintenance Manual for Primary Air Fan
VP1-C-L1-M-HHQ-30030	F425AM1	Operation and Maintenance Manual for Flame Detecor Cooling Fan
VP1-C-L1-M-HLA-10010	F358D02	Operation and Maintenance Manual for Damper
VP1-C-L1-M-HFB-55022	K096895	Operation and Maintenance Manual of Coal Feeder
VP1-C-L1-M-HFC-50016	K096802	Operation and Maintenance Manual of Pulverizer
VP1-C-L1-M-HHA-55015	K096854	Operation and Maintenance Manual of Pulverized Fuel Buner
VP1-C-L1-M-HFC-50017	K096811	Operation and Maintenance Manual of Speed Reducer for Pulverizer
VP1-C-L1-M-HFC-50022	K096857	Operation and Maintenance Manual of Pulverizer Pyrite Box
VP1-C-L1-M-HFV-50018	K096812	Operation and Maintenance Manual of Lubrication Oil Unit for Pulverizer
VP1-C-L1-M-HFC-50019	K096813	Operation and Maintenance Manual of Turning Equipment for Pulverizer
VP1-C-L1-I-HFE-50021	K096841	Operation and Maintenance Manual of Air Cylinder for Pulverizer Cut Damper
VP1-C-L1-I-HFE-50023	K096861	Operation and Maintenance Manual of Air Cylinder for Pulverizer Primary Air Shut Off Damper
VP1-C-L1-M-HJA-55014	K096852	Operation and Maintenance Manual of Ignitor
VP1-C-L1-M-HJF-55016	K096871	Operation and Maintenance Manual of Burner Valve Rack
VP1-C-L1-I-HHL-55019	K096885	Operation and Maintenance Manual of Burner Air Register Actuator
VP1-C-L1-I-HJA-55021	K096893	Operation and Maintenance Manual of Ignition Exciter and Spark Rod
VP1-C-L1-I-HFC-50020	K096826	Operation and Maintenance Manual of Pulverizer Classifier Vane Actuator
VP1-C-L1-I-HHY-55020	K096887	Operation and Maintenance Manual of Flame Detector
VP1-C-L1-I-HJA-55017	K096875	Operation and Maintenance Manual of Air Cylinder for Burner
VP1-C-L1-M-HJ-30032	F437AM1	Operation and Maintenance Manual for Light Fuel Oil Accumulator
VP1-C-L1-I-HFE-50024	K096862	Operation and Maintenance Manual of Limit Switch for Pulverizer Damper
VP1-C-L1-I-HJA-55018	K096876	Operation and Maintenance Manual of Limit Switch for Burner
VP1-C-L1-I-CJF-40034	F721AM1	Operation and Maintenance Manual for Control Valve (IHI Portion)
VP1-C-L1-I-CJF-40035	F721AM2	Operation and Maintenance Manual for Separator Drain Tank Level Control Valve
VP1-C-L1-I-CDC-40036	F721CM1	Operation and Maintenance Manual for HP Turbine Bypass Valve
VP1-C-L1-I-CJF-40037	F722AM1	Operation and Maintenance Manual for Control Drive (IHI Portion)
VP1-C-L1-I-CJF-40038	F723AM1	Operation and Maintenance Manual for Pneumatic Control Cylinder (IHI Portion)

VP1-C-L1-I-H-30095	F728AM1	Operation and Maintenance Manual for Motor Operated Damper Actuator
VP1-C-L1-I-CFB-40043	F741AM1	Operation and Maintenance Manual for Flue Gas Oxygen Analyzer
VP1-C-L1-P-H-25073	F63GG51	Operation and Maintenance Manual for Boiler Safety Valve
VP1-C-L1-M-LBY-30037	F6AGCM1	Operation and Maintenance Manual for Power Actuated Pressure Relife Valve
VP1-C-L1-M-H-30038	F6AGBM1	Operation and Maintenance Manual for Motor Operated Valve (HP)
VP1-C-L1-M-H-30092	F6AGBM2	Operation and Maintenance Manual for Motor Operated Valve (LP)
VP1-C-L1-P-H-25053	F63GA51	Operation and Maintenance Manual for Manual Valve (Samshin)
VP1-C-L1-P-H-25074	F63GO51	Operation and Maintenance Manual for Manual Valve (Okano)
VP1-C-L1-P-H-25075	F63GB51	Operation and Maintenance Manual for Manual Valve (KSB)
VP1-C-L1-P-H-25076	F63GA52	Operation and Maintenance Manual for Manual Valve (KITZ)
VP1-C-L1-P-H-25077	F63GA53	Operation and Maintenance Manual for Butterfly Valve (OKM)
VP1-C-L1-P-H-25078	F63GN51	Operation and Maintenance Manual for Ball Valve (NDV)
VP1-C-L1-P-H-25079	F63GA54	Operation and Maintenance Manual for Coal Burner Inlet Valve (Stock)
VP1-C-L1-M-H-30039	F62GCM1	Operation and Maintenance Manual for Pneumatic Operated Valve
VP1-C-L1-M-H-30093	F63GDM1	Operation and Maintenance Manual for Pneumatic Operated Valve (Ball)
VP1-C-L1-M-H-30094	F65GFM1	Operation and Maintenance Manual for Pneumatic Operated Valve (Butterfly)
VP1-C-L1-P-H-25052	F62GJM1	Operation and Maintenance Manual for Trap
VP1-C-L1-M-SM-30035	F5440M1	Operation and Maintenance Manual for Electrical Hoist
VP1-C-L1-M-SMH-30126	F5440M2	Operation and Maintenance Manual for Furnace Inspection Gondola
VP1-C-L1-M-SNA-30036	F5511M1	Operation and Maintenance Manual for Boiler Elevator
VP1-C-L1-M-HBB-30091	F426AM1	Operation and Maintenance Manual for Tripper Conveyor Room Ventilation Fan
VP1-C-L1-E-BJK-40088	F5351M1	Operation and Maintenance Manual for Aviation Obstacle Light for Boiler Building
VP1-C-L1-P-L-15026	K096101	Operation and Maintenance Manual for Hanger
VP1-C-L1-E-HLB-30031	F421EM1	Operation and Maintenance Manual for Medium Voltage Motor
VP1-C-L1-I-ETA-30103	FF10C01	Operation Philosophy for Bottom Ash Handling System
VP1-C-L1-M-ETA-30040	FF10051	Operation and Maintenance Manual for Bottom Ash Handling System
VP1-C-L1-I-CJF-40042	F731AM1	Operation and Maintenance Manual for Transmitter (IHI Portion)
VP1-C-L1-I-CJF-40039	F732HM1	Operation and Maintenance Manual for Coriolis Type Flow Meter (IHI Portion)
VP1-C-L1-I-CJF-40040	F733AM1	Operation and Maintenance Manual for Level Transmitter for Coal Bunker
VP1-C-L1-I-CJF-40041	F735CM1	Operation and Maintenance Manual for Thermocouple with Transmitter (IHI Portion)
VP1-C-L1-I-CJF-40083	F735DM1	Operation and Maintenance Manual for Temperature Transmitter (IHI Portion)
VP1-C-L1-I-HLB-30096	F745CM1	Operation and Maintenance Manual for Vibration Monitoring System (IHI Portion)
VP1-C-L1-I-CYP-40044	F746AM1	Operation and Maintenance Manual for CCTV System (Boiler Monitoring)
VP1-C-L1-I-CJF-40045	F753AM1	Operation and Maintenance Manual for Local Pressure Gauge

6. Reference List

VP1-C-L1-I-CJF-40046	F753BM1	Operation and Maintenance Manual for Local Temperature Gauge
VP1-C-L1-I-CJF-40047	F757CM1	Operation and Maintenance Manual for Coal Bunker Level Switch
VP1-C-L1-I-CJF-40070	F757CM2	Operation and Maintenance Manual for CRP Drain Pod Level Switch
VP1-C-L1-M-SG-30034	F5331M1	Operation and Maintenance Manual for Water Fire Fighting System (IHI Portion)
VP1-C-L1-M-H-00515	K096001	Operation and Maintenance Manual for Boiler General
VP1-C-L1-I-HCB-30058	K710402	Operation Philosophy for Sootblowing System
VP1-C-L1-M-HCB-30026	F411AM1	Operation and Maintenance Manual for Sootblower
VP1-C-L1-M-HCC-30027	F411BM1	Operation and Maintenance Manual for Water Sootblower
VP1-C-L1-M-HLD-30028	F414AM1	Operation and Maintenance Manual for Air Heater
VP1-C-L1-M-HLB-30029	F421AM1	Operation and Maintenance Manual for Forced Draft Fan
VP1-C-L1-M-HFE-30033	F446AM1	Operation and Maintenance Manual for Primary Air Fan
VP1-C-L1-M-HHQ-30030	F425AM1	Operation and Maintenance Manual for Flame Detecor Cooling Fan
VP1-C-L1-M-HLA-10010	F358D02	Operation and Maintenance Manual for Damper
VP1-C-L1-M-HFB-55022	K096895	Operation and Maintenance Manual of Coal Feeder
VP1-C-L1-M-HFC-50016	K096802	Operation and Maintenance Manual of Pulverizer
VP1-C-L1-M-HHA-55015	K096854	Operation and Maintenance Manual of Pulverized Fuel Buner
VP1-C-L1-M-HFC-50017	K096811	Operation and Maintenance Manual of Speed Reducer for Pulverizer
VP1-C-L1-M-HFC-50022	K096857	Operation and Maintenance Manual of Pulverizer Pyrite Box
VP1-C-L1-M-HFV-50018	K096812	Operation and Maintenance Manual of Lubrication Oil Unit for Pulverizer
VP1-C-L1-M-HFC-50019	K096813	Operation and Maintenance Manual of Turning Equipment for Pulverizer
VP1-C-L1-I-HFE-50021	K096841	Operation and Maintenance Manual of Air Cylinder for Pulverizer Cut Damper
VP1-C-L1-I-HFE-50023	K096861	Operation and Maintenance Manual of Air Cylinder for Pulverizer Primary Air Shut Off Damper
VP1-C-L1-M-HJA-55014	K096852	Operation and Maintenance Manual of Ignitor
VP1-C-L1-M-HJF-55016	K096871	Operation and Maintenance Manual of Burner Valve Rack
VP1-C-L1-I-HHL-55019	K096885	Operation and Maintenance Manual of Burner Air Register Actuator
VP1-C-L1-I-HJA-55021	K096893	Operation and Maintenance Manual of Ignition Exciter and Spark Rod
VP1-C-L1-I-HFC-50020	K096826	Operation and Maintenance Manual of Pulverizer Classifier Vane Actuator
VP1-C-L1-I-HHY-55020	K096887	Operation and Maintenance Manual of Flame Detector
VP1-C-L1-I-HJA-55017	K096875	Operation and Maintenance Manual of Air Cylinder for Burner
VP1-C-L1-M-HJ-30032	F437AM1	Operation and Maintenance Manual for Light Fuel Oil Accumulator
VP1-C-L1-I-HFE-50024	K096862	Operation and Maintenance Manual of Limit Switch for Pulverizer Damper
VP1-C-L1-I-HJA-55018	K096876	Operation and Maintenance Manual of Limit Switch for Burner
VP1-C-L1-I-CJF-40034	F721AM1	Operation and Maintenance Manual for Control Valve (IHI Portion)
VP1-C-L1-I-CJF-40035	F721AM2	Operation and Maintenance Manual for Separator Drain Tank Level Control Valve
VP1-C-L1-I-CDC-40036	F721CM1	Operation and Maintenance Manual for HP Turbine Bypass Valve
VP1-C-L1-I-CJF-40037	F722AM1	Operation and Maintenance Manual for Control Drive (IHI Portion)
VP1-C-L1-I-CJF-40038	F723AM1	Operation and Maintenance Manual for Pneumatic Control Cylinder (IHI Portion)
VP1-C-L1-I-H-30095	F728AM1	Operation and Maintenance Manual for Motor Operated Damper Actuator

VP1-C-L1-I-CFB-40043	F741AM1	Operation and Maintenance Manual for Flue Gas Oxygen Analyzer
VP1-C-L1-P-H-25073	F63GG51	Operation and Maintenance Manual for Boiler Safety Valve
VP1-C-L1-M-LBY-30037	F6AGCM1	Operation and Maintenance Manual for Power Actuated Pressure Relife Valve
VP1-C-L1-M-H-30038	F6AGBM1	Operation and Maintenance Manual for Motor Operated Valve (HP)
VP1-C-L1-M-H-30092	F6AGBM2	Operation and Maintenance Manual for Motor Operated Valve (LP)
VP1-C-L1-P-H-25053	F63GA51	Operation and Maintenance Manual for Manual Valve (Samshin)
VP1-C-L1-P-H-25074	F63GO51	Operation and Maintenance Manual for Manual Valve (Okano)
VP1-C-L1-P-H-25075	F63GB51	Operation and Maintenance Manual for Manual Valve (KSB)
VP1-C-L1-P-H-25076	F63GA52	Operation and Maintenance Manual for Manual Valve (KITZ)