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Ministry of Labor and Skills

# Fruit And Vegetable Processing Level - II

## Based on June 2021, Version 3 Occupational Standard




## Module Title: - Operating a Boiler

## LG Code: IND FVP2 M04 1121 LO (1-4) LG (10-13)

## TTLM Code: IND FVP2 M04 TTLM 0423v1

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# Introduction to the Module

This unit covers the knowledge, skills and attitude required to set up, operate, adjust and shut down a boiler to produce steam to meet production requirements.

| LG #10 | LO #1- start boiler |
|---|---|

**Instruction sheet**

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Selecting personal protective clothing and equipment
- Conducting Pre-operational safety checks
- Identifying and reporting Hazards and potential hazards in work area
- Selecting control measures with the hierarchy of control
- Starting Boiler and brought on line
- Identifying and reporting maintenance requirements in with workplace

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Select personal protective clothing and equipment
- Conduct Pre-operational safety checks
- Identify and report Hazards and potential hazards in work area
- Select control measures with the hierarchy of control
- Start Boiler and brought on line
- Identify and report maintenance requirements in with workplace

**Learning Instructions:**

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

# Information Sheet 1

## 1.1 Selecting personal protective clothing and equipment

### 1.1.1 Introduction

The employer should become aware of the different types of PPE available and the levels of protection offered. It is definitely a good idea to select PPE that will provide a level of protection greater than the minimum required to protect employees from hazards. Then periodically reassess the workplace for any changes in conditions, equipment or operating procedures that could create occupational hazards. This periodic reassessment should also include a review of injury and illness records to spot any trends or areas of concern and taking appropriate corrective action. The suitability of existing PPE, including an evaluation of its condition and age, should be included in the reassessment

### 1.1.2 Selecting PPE

All PPE clothing and equipment must be of safe design and construction, and be maintained in a clean and reliable fashion. Employers shall take the fit and comfort of PPE into consideration when selecting appropriate items for their workplace. PPE that fits well and is comfortable to wear will encourage employee use. Most protective devices are available in multiple sizes and care should be taken to select the proper size for each employee. If several different types of PPE are worn together, make sure they are compatible. If PPE does not fit properly, it can make the difference between being safely covered or dangerously exposed. It may not provide the level of protection desired and may discourage employee use

**A. Eye and face protection**

Safety glasses, safety goggles, laser eyewear, face shields and helmets provide a level of protection as designated by the manufacturer. The hazard and the protection standards for each piece of eye and face protection PPE must be considered during selection.



**Figure 1.1 Eye and face protection**

B. **Hand Protection**

Gloves should be selected for each procedure to provide protection from the hazards. In some circumstances there may be several hazards and glove selection may involve different gloves for different steps of the procedure and/or several layers of gloves may be needed to address all hazards. For example leather glove Protect and comfort hands from moderate temperatures, sharp objects, damage by friction



Figure 1.2 Hand protection gloves

**C. Thermally insulated gloves**

Thermal proof gloves, such as heat resistant gloves and cold-resistant gloves, protect against extreme temperatures and are fabricated from a variety of materials, including:

Neoprene: Neoprene gloves are used for protection against frost and burn injuries, as in the case of fire fighting gloves. Besides its thermal resistant characteristics, this flexible and durable material is effective for various operations as it outlasts and outperforms even natural rubber when exposed to extreme temperatures. Some of the common applications for these gloves include petrochemical and wire manufacturing operations.

Aluminized Material: Aluminized material is capable of handling and withstanding extremely high temperatures (depending on the specific formula, up to and exceeding 2,000° F). Combined with the material's insulating and reflective properties, gloves made of this material are suitable for high-temperature operations such as welding, furnace and foundry, and some laboratory applications.




Figure 1.3 thermally insulated gloves

### D. Hard hat head protection

Head protection may be as simple as to protect the head from aerosols during boiler operations, or a hard hat to protect from overhead hazards. Electrical work may require arc flash protection of the head, face, hands and body.

Hard hats have an expiration date and should be replaced before they expire.

Hard hats are divided into three industrial classes:

- Class A hard hats provide impact and penetration resistance along with limited voltage protection (up to 2,200 volts).
- Class B hard hats provide the highest level of protection against electrical hazards, with high-voltage shock and burn protection (up to 20,000 volts). They also provide protection from impact and penetration hazards by flying/falling objects.
- Class C hard hats provide lightweight comfort and impact protection but offer no protection from electrical hazards.



Figure 1.4 Hard hat head protection

**E. Hearing protection**

The employer must provide ear protection when the noise level in the work area. Examples of hearing protection:

- Disposable foam plugs
- Molded ear plugs
- Noise-cancelling ear plugs
- Ear muffs



Figure 1.5 Ear muffs

**F. Respiratory protection**

- Elimination/substitution or Engineering controls
- Eliminate toxic material or substitute a less toxic material
- Enclose or confine operation
- General or local exhaust ventilation
- Only when engineering controls are not feasible, will respirators be used

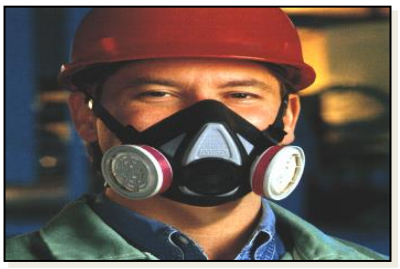


Figure 1.6 Respiratory protection mask

**Types of respirators**

**Air-Purifying (APR)** – remove contaminants from air

- Particulate respirators
- Chemical cartridge/ gas mask respirator
- Powered Air-Purifying Respirator (PAPR)

**Atmosphere-Supplying – provide clean, breathable air**

- Self-Contained Breathing Apparatus (SCBA)
- Supplied-Air Respirator (SAR)

**Eye and face protection**

Common causes of eye injuries

- Chemical splashes
- Blood or OPIM splashes or sprays
- Intense light
- Dust and other flying particles

## 1.2 Conducting pre-operational safety checks

### 1.2.1 Checks of feed water supply and system

- Boiler-feed water in power plants plays a crucial role in steam generation.
- Generally, water tubes are connected between the boiler drum at the top and the tube header at the bottom in the case of a water tube boiler
- This feed water circulates within the tube, boiler drum, and header.
- The rate of steam generation is in proportion to the water circulation rate.
- The circulation rate must be adequate to remove the heat from tube surfaces.
- A slow circulation of water may cause the formation of large bubbles and hence the possibility of tube burning.
- This feed water circulation must be unidirectional which means in one direction.
- There are two types of feed water circulation employed
- Natural circulation by the gravity force.
- Forced circulation by employing pumps. or
- A combination of both natural and force is generally employed.

A diagrammatic representation of the natural circulation of boiler feed water is shown below

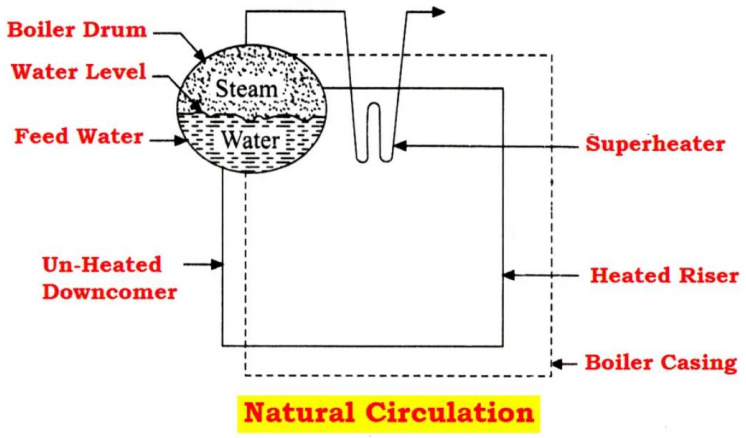



Figure 1.7 Natural circulation of feed water in boiler

### 1.2.2 Feed water supply

The feed water plays a crucial role in power plants for steam production. Initially, this feed water is first converted into saturated steam in the combustion chamber area and finally converted to superheated steam in the super heater. After utilizing heat energy in the steam turbine to rotate the turbo alternator, the steam is now condensed in the condenser vessel and recirculates again as feed water. The physical condition of the feed water such as pressure, temperature, and quantity is measured at various locations. The chemical condition of the feed water is determined by measuring conductivity, pH, dissolved oxygen, etc.

Based on the source, location, and application of feed water in the boiler operation are known as:

**Raw Water**

It is natural water along with impurities and minerals graced by the earth.

Raw water is available as 'Ground Water' or as 'Surface Water'.

**Ground Water**

The water is available from wells and springs with some hardness dissolved in it.

**Surface Water**

The water from river streams, ponds, and lakes have a dissolved hardness like groundwater and insoluble organic and inorganic matter.

- Since this surface water is turbid.
- Generally, natural water needs 'softening' for the removal of dissolved solids and 'clarification' for the removal of turbidity.

**Boiler feed water**

- The water is introduced into a boiler to replace the evaporation.
- This feed water must be pumped by the feed pump at higher pressure sufficiently above boiler drum pressure for correct flow into the boiler.

The feed water is made to pass through an economizer to pick up some heat coming from waste flue gasses to increase the efficiency of boiler operation.

**Condensate water**

- The steam generated from the boiler is used in the turbine for power generation.

- The exhaust steam coming from the steam turbine is condensed in the condenser vessel with the help of circulating cooling water and collected in the hot well.
- This condensate water collected in the hot well is reused as feed water and it does not require any treatment because of no impurities present in it.

Boiler Feed Water = Condensate Water + Makeup Water

- The condensate water is not sufficient as feed water because some portion of feed water is lost in the process as loss of water in the boiler system including blow down and loss of water in the steam turbine system due to evaporation, leakages, etc.
- To make up for that, raw water has to be treated and added to the condensate water.
- In a continuous boiler operation, the treatment is only required for make-up water known as boiler feed water.

**Make-up water**

- Make-up water is the water added to a boiler to compensate for losses. While recirculating condensed water and due to evaporation losses, the amount of dissolved minerals increases in the system. Therefore, water treatment is always required in the make-up water of a boiler. Make-up water treatment allows to optimize the boiler processes, reduce the blowdown rate and assume a high-quality stream. The energy consumption will decrease as well.

**Cooling water**

- A huge quantity of cooling water is required to condense the steam and reduce the steam pressure in the condenser.
- This required cooling water is taken from the river or pond, but this water is not considered boiler-feed water because this water is not treated.
- The heat absorbed by this water can be removed by sending this water to the cooling tower then the same water can be re-circulated.
- A typical boiler feed water supply consists of two parts, makeup water treated in the water treatment plant and condensate water. The feed water is heated and pumped by feed water pumps to the boiler.

- This boiler feed water is pumped to the deaerating heater inside the deaerator to get heated with a help of steam. While heating helps to improve boiler efficiency, de-aeration helps to remove dissolved gasses like oxygen and carbon dioxide.

### 1.2.3 Fuel supply/heat source system

Here, we are looking at different types of fuel system; there are coal or solid fuel system and liquid fuel managing system and gas fuel management. Because of fossil fuels that are burned in boilers can be used in solid, liquid/gaseous form. Each of these fuels requires specialised handling and treatment, and the control and instrumentation have to be appropriate to the fuel and the plant that processes it.

A fuel supply/heat source system boiler is a type of boiler that uses a single fuel source to heat water and provide central heating. The fuel source can be natural gas, oil, coal, biomass, or electricity. The system boiler consists of two main components: the boiler itself and a hot water cylinder. The boiler heats the water in the cylinder indirectly through a heat exchanger and also delivers heat to the radiators or underfloor heating. The hot water cylinder stores the hot water and supplies it to the taps and showers when needed. The system boiler is different from a combi boiler, which does not have a cylinder and provides instant hot water on demand. The system boiler is also different from a regular boiler, which requires a separate cold water tank and a feed and expansion tank.

**Some of the advantages of a system boiler are:**

- It can provide a constant supply of hot water to multiple taps and showers at the same time, without losing pressure or flow rate.
- It can work with a solar thermal system or a heat pump to reduce the carbon footprint and energy bills.
- It is easy to install and maintain, as most of the components are built into the boiler and there is no need for a cold water tank or a feed and expansion tank in the loft.
- It is compatible with a wide range of fuel sources and can be adapted to different heating requirements.

**Some of the disadvantages of a system boiler are**:

- It takes up more space than a combi boiler, as it requires a separate cylinder and a suitable location for it.

- It is less efficient than a combi boiler, as it loses some heat through the cylinder and the pipes.
- It can run out of hot water if the cylinder is not large enough or if the demand is too high.
- It can be more expensive to buy and install than a combi boiler, depending on the size and quality of the boiler and the cylinder.

**A. Coal firing (pulverised fuel)**

Coal is burned in solid form on grates, before feed into the combustion chamber the coal is broken into pieces it is usual. It depends on the coal used, some coal is fine to use directly. But some other coals are hard and in size can be jammed in the propeller. Coals are powdered and propelled to the burners by an air stream. Various types of the pulverised-fuel mill will be encountered, but two are most commonly used: the pressurised vertical-spindle ball mill and the horizontal-tube mill

**B.** Oil-firing systems

The oil-firing system is much simpler compared to the coal firing system what only required is a system to extract the oil from its storage tank and pump it to the burners. The important thing is the proper ignition of the oil into the burner. Proper ignition of oil depends on the fuel being broken into small droplets (atomised) and mixed with air. The atomisation may be achieved by expelling the oil through a small nozzle (a 'pressure jet'), or it may be achieved by the use of compressed air or steam. The injectors maintain the flow of fuel to the burner. Depending on the purposes the fuel can much viscous, there is clear chance of cooling fuel in the pipeline. To prevent cooling the fuel must be heated constantly. With the heavier grades of oil, prewarming is necessary, and to prevent it cooling and thickening the fuel is continually circulated to the burners via a recirculation system. The latter process is sometimes referred to as 'spill-back'. When a burner is not firing, the oil circulates through the pipework right up to the shut-off valve, which is mounted as close to the oil gun as possible.

### 1.2.4 Operating and position of boiler valves

Boiler safety valves are designed to prevent excess pressure, which is usually responsible for those devastating explosions. That said, to ensure that boiler safety valves are working properly and providing adequate protection they must meet regulatory specifications and require on-going maintenance and periodic testing. Without these precautions, malfunctioning safety valves may fail, resulting in potentially disastrous consequences.

Boiler safety valves are activated by upstream pressure. If the pressure exceeds a defined threshold, the valve activates and automatically releases pressure. Typically used for gas or vapor service, boiler safety valves pop fully open once a pressure threshold is reached and remain open until the boiler pressure reaches a pre-defined, safe lower pressure.

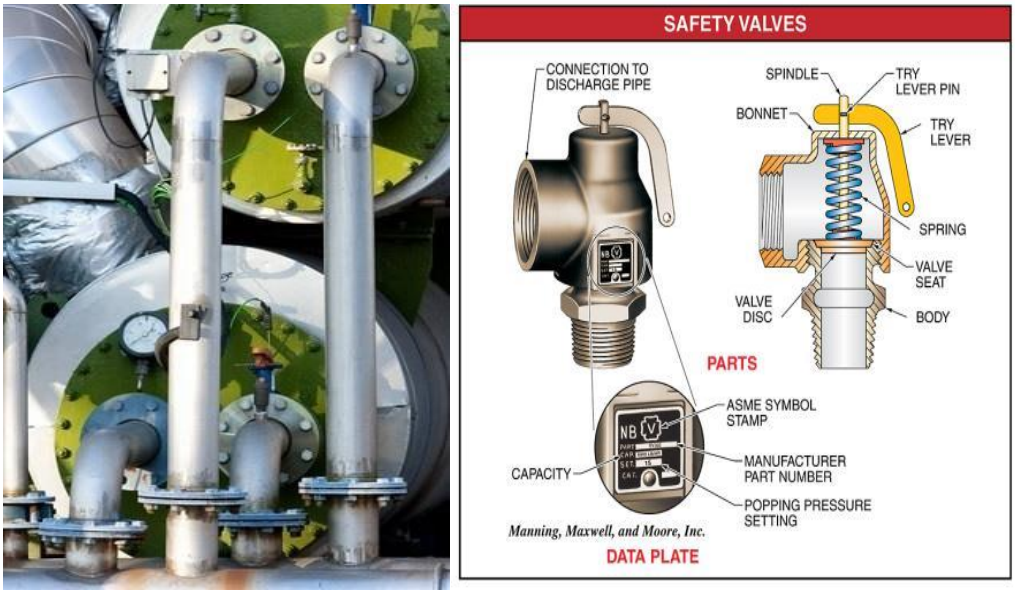



Figure 1.7 Boiler valves

Boiler relief valves serve the same purpose – automatically lowering boiler pressure – but they function a bit differently than safety valves. A relief valve doesn't open fully when pressure exceeds a defined threshold; instead, it opens gradually when the pressure threshold is exceeded and closes gradually until the lower, safe threshold is reached. Boiler relief valves are typically used for liquid service. There are also devices known as "safety relief valves" which have the characteristics of both types discussed above. Safety relief valves can be used for either liquid or gas or vapor service.

Proper sizing and correct installation are the primary concerns for boiler safety valves. Some general guidelines to ensure proper sizing include:

- The differential between operating and set steam pressure should be at least 20%.
- Safety valves should never be oversized; oversized valves can lead to issues such as leaks, chattering, and premature failure.

- Total steam capacity of a safety valve located downstream from a pressure control valve must exceed the control valve's maximum steam flow capacity.
- High steam capacity requirements, physical or economic constraints may make the use of a single safety valve impossible. In these cases, using multiple safety valves on the same system is considered an acceptable practice, provided that proper sizing and installation requirements are met – including an appropriately sized vent pipe that accounts for the total steam venting capacity of all valves when open at the same time.
- The lowest rating (MAWP or maximum allowable working pressure) should always be used among all safety devices within a system, including boilers, pressure vessels, and equipment piping systems, to determine the safety valve set pressure

### 1.2.5 Boiler water level

The process of converting water into steam is quite simple: heat up the water until it boils. Anyone who has ever boiled a pot of water for cooking knows how this process works. Making steam continuously, however, is a little more complicated. An important variable to measure and control in a continuous boiler is the level of water in the "steam drum" (the upper vessel in a water-tube boiler). In order to safely and efficiently produce a continuous flow of steam, we must ensure the steam drum never runs too low on water, or too high. If there is not enough water in the drum, the water tubes may run dry and burn through from the heat of the fire. If there is too much water in the drum, liquid water may be carried along with the flow of steam, causing problems downstream.

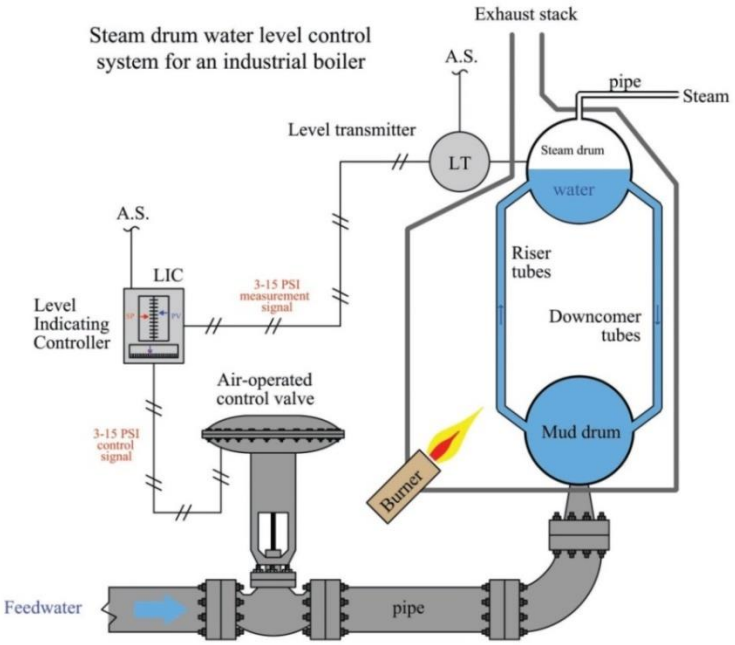



Figure 1.8 Boiler water controls

### 1.2.6 Combustion air supply system

A combustion air supply system in a boiler is a system that provides the air needed for the combustion of the fuel in the boiler. The combustion air supply system consists of two main components:

- a forced draft fan forced takes air from the atmosphere and blows it into the furnace through air ducts
- an air heater heats the air before it enters the furnace by using the heat of the hot flue gases that leave the boiler. The heated air improves the efficiency and performance of the combustion process. The combustion air supply system also needs to consider the ventilation and cooling requirements of the boiler room, as well as the effect of the venting system on the air flow and pressure. The amount of air required for the combustion process depends on the type and amount of fuel being burned, the design and size of the burner, and the altitude of the boiler room. A general rule of

thumb is to provide 4 - 6 square inches of unrestricted air flow for every boiler horsepower. As an example, if you have a 60 HP boiler, you can estimate 240 – 360 square inches of area are needed for optimal operation. What if you want to look at a more precise way of calculating combustion air required? If you have a gas or oil fuelled package fire tube boiler, the following formulas help determine boiler needs:

**Total Air Required (CFM) / Allowable velocity at opening (FPM) = Net Free Open Area of Opening**

CFM = cubic feet per minute (cu ft/min)

FPM = feet per minute (ft/min)

BHP = Boiler horsepower (including the total maximum boiler horsepower in the boiler room)

TOTAL AIR REQUIRED (CFM)

| | |
|---|---|
| **Air for Combustion =** | BHP x 8 CFM |
| **Air for Ventilation =** | BHP x 2 CFM |
| **Total Air Required (Combustion + Ventilation) =** | BHP x 10 CFM |

ALLOWABLE VELOCITY AT OPENING (FPM)

| | |
|---|---|
| **0-7 Feet Above The Floor =** | 250 FPM |
| **More Than 7 Feet Above The Floor =** | 500 FPM |
| **Duct From Air Supply To Boiler =** | 1,000 FPM |

Note: These calculations are standard for boiler room operations up to 1,000 fasl (feet above sea level). Due to thinner air, it's important to add 3% air for each 1,000 fasl for accurate estimates.

Furthermore, it is recommended that two louvers are installed for the operation of a single boiler for optimal airflow. If there is more than one boiler installed, it's important to have at least one louver per boiler.



Figure 1.9 the best types and locations of boiler room

Once you've determined the square footage you will need for boiler, it's important to take into consideration the location of fresh air inlets.

As a general rule, there should be at least two permanent air supply openings in the boiler room walls. If possible, these openings should be on opposite sides of the boiler room and should be no higher than 7 feet off the floor. This setup is optimal because it:

- Promotes mixing of fresh and warm air already in the boiler room
- Ensures proper cooling of the boilers
- Tempers the cooler air prior to entering the burner for adequate combustion

It's also important to ensure that the air inlets themselves offer unobstructed air flow with protection from the weather, pests, and debris. Some boiler rooms choose a fine mesh-wire screen for airflow. These types of screens are prone to clogging due to dust, paper, dirt, and pest infiltration.

**A simple test for boiler room air supply**

One of the easiest ways to test if boiler room has an air supply issue is to open an exterior door (if available). If when you open the door you feel air rushing in and upon releasing the door it slams, then you have a problem. This means boiler room is under negative pressure.

This can create combustion issues and cause fans to work harder than necessary.

**Troubleshooting centralized boilers**

Not every facility has the most optimal setup for air supply directly from the outside. If the boiler room does not have access to outside walls, there are generally two possible solutions. You can duct a source of fresh air into the boiler room, or duct a source of fresh air directly into the boiler.

**Ducting a source of fresh air into the boiler room**

For this method, the size of the wall opening in the boiler room can be used to determine the size of the ducting. Additionally, the pressure drop through the duct work must never exceed 0.05″ inches of water column ( w.c.}

### 1.2.7 Ducting a source of fresh air directly into the boiler

This method of air supply offers some advantages and disadvantages. The ducting actually becomes a part of the boiler system. This can affect the stability of combustion (via wind direction/velocity, humidity, temperature, inclement weather conditions).

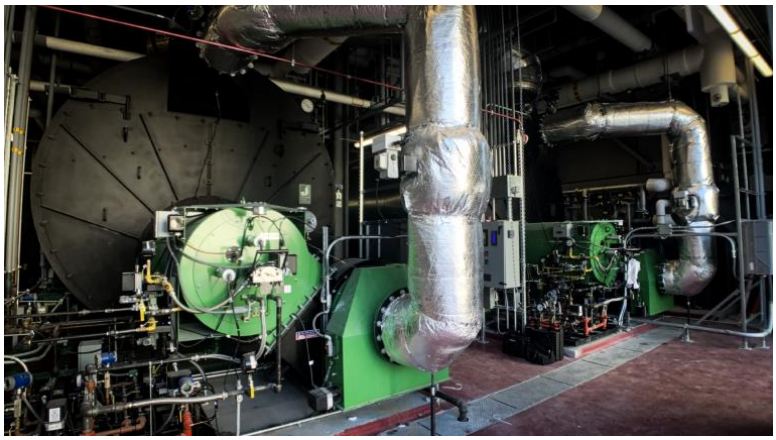


Figure 1.10 Ducting example

Consequently, subtle or drastic fluctuations in outdoor temperature can lead to changes in fuel and air mixture, potentially causing a substantial increase in CO production, soot formation, and other unsafe combustion outcomes. However, ducting a combustion air blower to the outside can alleviate issues with negative room pressures, freezing pipes near open air inlets in the winter, or interlocked makeup air heaters.

**The following factors should be adhered to for direct ducting:**

- Every boiler should have its own fresh air ducting and exhaust stack (minimizes combustion problems)
- Boilers that are directly connected to fresh air ducts must be regularly checked. Generally every 3 months or sooner by a certified boiler specialist. (Including proper combustion adjustment). Advanced controls may allow for a longer interval here.
- Ductwork for fresh air supply should be sized for a maximum pressure drop of 0.05″ w.c. during maximum flow. That is unless the fan design is adjusted to accommodate the additional losses.
- Fresh air should be tempered by a steam, or glycol heater to at least 50ºF to prevent condensation or mixing issues.

Understanding and optimizing boiler room air supply are vital for achieving efficient combustion and preventing operational challenges. By ensuring a consistent and sufficient supply of air, the pressure inside and outside the boiler room can equalize. This promotes proper combustion and minimizing issues such as process outages, soot accumulation, and carbon monoxide risks.

### 1.2.8 Combustion equipment

The combustion equipment is a component of the steam generator. Since the source of heat is the combustion of a fuel, a working unit must have, whatever, equipment is necessary to receive the fuel and air, proportioned to each other and to the boiler steam demand, mix, ignite, and perform and other special combustion duties, such as distillation of volatile from coal prior to ignition.

- Fluid fuels are handled by burners; solid lump fuels by stokers.
- In boiler plants hand firing on grates is practically unheard of nowadays in new plants, although there are many small industrial plants still in service with hand firing
- The fuels are mainly bituminous coal, fuel oil and natural gas mentioned in order of importance. All are composed of hydrocarbons, and coal has, as well, much fixed carbon and little sulphur.

To burn these fuels to the desired end products, $CO_2$ and $H_2O$, requires:

- Air in sufficient proportions,
- A good mixing of the fuel and air

- A turbulence or relative motion between fuel and air. The combustion equipment must fulfil these requirements and in addition, be capable of close regulation of rate of firing the fuel, for boilers which ordinarily operate on variable load. Coal-firing equipment must also have means for holding and discharging the ash residue.

Requirements of Combustion Equipment of Steam Boilers:

- Thorough mixing of fuel and air.
- Optimum fuel-air ratios, leading to most complete combustion possible, maintained over full load range.
- Ready and accurate response of rate of fuel feed to load demand (usually as reflected in boiler steam pressure).
- Continuous and reliable ignition of fuel.
- Practical distillation of volatile components of coal.
- Adequate control over point of formation and accumulation of ash, when coal is the fuel.

**Classification of combustion equipment of steam boilers:**

Depending on the type of combustion equipment, boilers may be classified as follows:

- Solid Fuels Fired:
  - Hand fired
  - Stoker fired:
    - Overfeed stokers
    - Underfeed stokers.
  - Pulverised Fuel Fired:
    - Unit system
    - Central system
    - Combination of (i) and (ii).
- Liquid fuel fired:
  - Injection system
  - Evaporation system
  - Combination of (a) and (b).

- Gaseous fuel Fired:
  - Atmospheric pressure system
  - High pressure system.

### 1.2.9 Fire fighting equipment

An accident on such objects occurs in the explosion or ignition of the boiler, which happens due to equipment failure or breach on the part of personnel safety. This may be a boiler kindling flammable liquids (gasoline, kerosene), lack of control over serviceability of electrical wiring, untimely cleaning of combustible dust. In case of emergency duly fire fighting boiler allows you to quickly evacuate the personnel and minimize property damage.

Fire extinguishing means in the boiler room should be chosen depending on the type of object. Modern boilers are classified:

- Fuel & ash; gas, solid fuel, liquid fuel;
- On coolant &ash; water, steam, mixed;
- To place & ash; built-in, self-contained, roof, modular, and others.

Depending on the type of boiler have different categories of fire and explosion, ie extinguishing gas boiler will have their features in comparison with other kinds of objects.

Firefighting safety equipment is essential for firefighters to protect themselves from the hazards of their job. Some of the most important equipment includes:

- **Protective clothing**: Firefighters wear protective clothing, including helmets, gloves, boots, and turnout gear, to protect themselves from heat, flames, and other hazards.
- **Self-contained breathing apparatus (SCBA)**: SCBA provides firefighters with a supply of clean air to breathe in smoky or toxic environments.
- **Fire extinguishers**: Firefighters use fire extinguishers to put out small fires or to control flames while they work.
- **Hoses and nozzles**: Hoses and nozzles are used to direct water or other fire suppressants onto flames.
- **Thermal imaging cameras**: These cameras help firefighters locate people and hot spots inside burning buildings.
- **Ladders**: Firefighters use ladders to gain access to upper floors of buildings and to rescue people from high places.

- **Hydrants**: Hydrants provide firefighters with a source of water to fight fires.
- **Fire trucks**: Fire trucks are equipped with hoses, ladders, and other equipment to help firefighters do their job.



**Figure 1.11 fire fighting safety equipment**

### 1.2.10 Inspection and location of explosion doors

During the ignition or operation of oil fired boiler or gas fuel boiler, the furnace and trailing smoke tubes would explode because of improper operation, such as incompletely cleaning the furnace before ignition, leakage in the nozzle, or insufficient combustion, not promptly cut off the burning flame, etc.. Besides, the secondary burning is damage to the furnace walls, chimneys and other components of boilers. The explosion-proof doors are used for unusual gas emissions to relief pressure and prevent explosion accident, which is one of the safety accessories for oil gas fired boilers.

**Explosion-proof doors types**

There are two general explosion-proof doors, overturn type explosion-proof door and blasting membrane type explosion-proof door. The overturn type explosion-proof door, also called swing proof doors, is generally installed on the furnace wall. According to the installation position, it includes is inclined and vertical types. It is composed of a door frame and door cover that made with iron and made into a round or square. The door cover is coated with a refractory concrete, its thickness according to the limit pressure value, to determine by calculation or test. When the gas explosion chamber or the flue, the door cover is automatically opened to release the pressure around the shaft, then shut itself down when the pressure is lower than designed value. The blasting membrane type

explosion-proof door is generally made of asbestos, aluminium and stainless steel sheet. When the explosion occurred in the furnace or flue gas generated, the shock wave pressure and the blasting membrane will be damaged to release pressure. The blasting film type explosion-proof door can only work one time, and it will not automatically reset. We must open the clamping device to reset the blasting membrane to carry on the operation of boiler.



Figure 1.12 explosion doors of boiler

Requirements when use explosion-proof doors

- Oil or gas fired steam boilers must be installed explosion-proof doors. Explosion-proof doors generally be arranged in the side of the furnace wall or top of flue outlet tube.
- Installation and use of explosion-proof door should not endanger the safety of person.
- Regular maintenance to prevent being rusted is needed.
- Inflammable and explosive materials should not be placed near explosion-proof doors.
- The number and area of explosion-proof doors should be set by calculating reasonably.
- Real-ability of explosion-proof doors should be guaranteed.

## 1.3 Identifying and reporting potential hazards in work area

### 1.3.1 Chemical hazards

- Irritation of eyes, respiratory tract and skin as a result of exposure to hydrazine and its derivatives, used as additives to boiler water.
- Irritation of the upper respiratory tract and coughing, as a result of inhalation of sulphur dioxide, particularly if burning high-sulphur fuels.
- Pneumoconiosis from exposure to vanadium-containing dust, and to asbestos from the insulation, particularly during maintenance and repair work, and from exposure to respirable fly ash.
- Dermatoses from exposure to fuels and to corrosion inhibitors (various organic or metal organic compounds) and other water additives.
- Asbestos may cause cancer; smoking strongly increases the risk.

### 1.3.2 Thermal hazards

Operates automatically fired boilers to generate steam that supplies heat processes: Lights gas- or oil-fed burners using torch. Starts pulveriser and stoker to grind and feed coal into furnace of boiler. Boilers work at a high heat adjacent to pressurized vessels which put their operators at a risk of burns and explosions. Burning of fuel used in boilers may lead to fires, carbon monoxide poisoning, etc. Boiler operators come into contact with various substances used in boilers (fuel, water additives, etc.) which may lead to eye and skin disorders. Boiler operators work in a noisy, hot and humid environment that may cause tiredness and general ill-feeling. Observes boiler and auxiliary units to detect malfunctions and makes repairs, such as changing burners and tightening pipes and fittings. May test and treat boiler feed water, using specified chemicals.

### 1.3.3 Boiler low water condition

Low or no water in the boiler can lead to severe damage. When the water level drops below the minimum level, the boiler’s high temperature affects metallurgy’s strength. If temperature soars to a high enough value, it can even melt the steel.

### 1.3.4 Leakage of steam plant

The following common place where you may find leaks on a hot water heating system boiler or its components is arranged alphabetically. Some of these leaks, such as at temperature and pressure relief (TPR) valves, are dangerous and require urgent attention or even system shut-down.

- Air bleeder vent valve leaks -Leaks can occur at automatic air bleeder valves or air vents wherever these vents are installed on hot water heating systems including at baseboards, expansion tanks, air scoops, or radiators.
- Boiler control valve leaks, boiler drains, zone service valves, zone drain valves, & radiator control valves
- Bolt opening leaks - suspect hidden damage - can occur at any bolt connection that connects boiler components.
- Boiler section leaks between cast iron boiler sections of a cast iron boiler, possibly occurring where the push nipples or seals join the water passages of individual cast iron boiler sections together. A photo showing cast iron boiler sections is just above
- Boiler crack or split leaks in a cast iron boiler section, also leaks at a crack, split, or rust perforation of a steel boiler.
- Circulating pump mounting flange leaks -
- Expansion tank / compression tank leaks due to water-logged expansion tanks - occur when the expansion tank has lost its air charge.
- Freeze protection for boilers:
- Piping leaks at poorly-soldered copper pipe fittings on finned copper baseboard heating systems -
- Piping leaks due to frozen and burst piping or in extreme cases, frozen and burst heating boilers themselves.
- Temperature / pressure relief valve TPR valve leaks:

  Leaks at the boiler temperature/pressure relief valve. This leak may be very dangerous as corrosion from water passing through the valve may prevent its safe operation in an emergency.

  The boiler pressure/temperature relief valve may be leaking because the system pressure or temperature is too high - it's working properly; or the relief valve may be leaking because its

internal gasket has failed or because it has become jammed partly open by corrosion and mineral debris build-up.

Prompt expert inspection and repair are needed. Watch for leaks below the valve's mouth or discharge pipe (a pipe should extend from the relief valve to a few inches from the floor) or watch for corrosion at the tip of the discharge pipe. Gently feel inside the tip of this pipe to see if it's wet.

### 1.3.5 Leakage of fuel

Gas leaks are a home emergency, no matter where they're coming from. If you notice signs of a gas leak, you should act as soon as possible.

### 1.3.6 Signs of a boiler gas leak

If you're suspicious about a gas leak, look for the following signs:

- Black stains on or around boiler. On the boiler, or maybe on the ceiling above it, black stains mean that a leak is coming from flue.
- A faint smell. Carbon monoxide is odourless, but manufacturers mix it with other gases, so people can smell a leak and be warned.
- Condensation in the boiler room. Carbon monoxide doesn't cause condensation, but if boiler doesn't vent properly, it will mist the windows. Exhaust gases won't leave house, and this will result in carbon monoxide to be unleashed.

### 1.3.7 Causes for a boiler gas leak

The main cause for a boiler gas leak at home is usually a poorly fitted, or a badly maintained gas hose that leads into boiler or from around the seal. The best way to avoid such a situation is to make sure that you get boiler installed by a registered Gas Safe engineer in the first place. Another cause for the issue can be faulty boiler parts with damages from general wear and tear and hard water deposits. There's nothing you can do about those, but it will help if you have boiler regularly serviced by a Gas Safe engineer. You can also consider the idea of investing in a boiler and central heating cover plan.

### 1.3.8 Odour of gas

The most obvious sign that boiler is leaking is the smell. The gas itself is odourless, but when it escapes through an appliance like a boiler, then it can be detected by nose. This will often come in the form of an unpleasant rotten eggs smell. You might also notice black stains around the area the boiler is situated in, which could be an indicator there is a leak. A large volume of condensation, which can be seen by misty windows or wet surfaces, is another thing to look out for.

## 1.4 Selecting control measures with the hierarchy of control

### 1.4.1 Hazards in boiler operation

- **Physical**
  - ✓ Excessive continuous noise levels - as high as 94 dBA
  - ✓ Heat stress caused by prolonged work at high temperatures and relative humidifies
  - ✓ Potential exposure to radon
- **Chemical**
  - ✓ Irritation of eyes, respiratory tract and skin as a result of exposure to hydrazine and its derivatives, used as additives to boiler water.
  - ✓ irritation of the upper respiratory tract and coughing, as a result of inhalation of sulphur dioxide, particularly if burning high-sulphur fuels
  - ✓ Pneumoconiosis from exposure to vanadium-containing dust, and to asbestos from the insulation, particularly during
  - ✓ maintenance and repair work, and from exposure to respirable fly ash
  - ✓ Dermatoses from exposure to fuels and to corrosion inhibitors (various organic or metal organic compounds) and other water additives
  - ✓ Asbestos may cause cancer; smoking strongly increases the risk
- **Biological**
  - ✓ Development of fungi and growth of bacteria in the boiler room, due to the elevated temperature and humidity
  - ✓ Presence of rodents and insects may result in bites and infectious diseases
- **Accidental**
  - ✓ Falls from ladders, stairs and elevated platforms
  - ✓ Slips and falls on the level, particularly on floors made slippery by water, fuel, oils, etc.
  - ✓ Struck by falling objects
  - ✓ Mechanical accidents when operating pulveriser and stoker in coal-fired boilers
  - ✓ Burns from hot surfaces, hot water and escaping steam
  - ✓ Electrocution or electric shocks

- **Leakage of steam plant**

Leakage of steam plant is a serious problem that can cause energy losses, safety hazards, environmental issues, and reliability failures in the steam and condensate system. According to the web search results, some of the common causes of steam and condensate leaks are:

- Threaded pipe connections that fail due to expansion and contraction of the steam and condensate during system start up, operation, and shutdown
- Standard packing on steam isolation valves that fail and leak steam during operation without a proactive maintenance program
- Carbonic acid corrosion that attacks the components of the steam and condensate system, especially at the thinnest part of the pipe, which is the threaded connection
- Water hammer that can damage the pipes, valves, and fittings in the steam and condensate system
- Flange leakage that can occur due to improper installation, gasket failure, or thermal expansion

**Some of the possible solutions to prevent or correct steam and condensate leaks are:**

- Use other connection methods in the steam and condensate system, such as welded connections or tube-type connections, that are more resistant to thermal stress and corrosion
- Use other types of valves that have corrected the sealing problems encountered in steam and condensate, such as ball valves and butterfly valves (in some applications)
- Use materials that are resistant to corrosion, microorganisms, and impact, and are non-toxic for the guards, pipes, valves, and fittings in the steam and condensate system
- Implement a proactive maintenance program that includes regular inspection, testing, and replacement of the components in the steam and condensate system
- Use condensing boilers that are more efficient than non-condensing boilers, as they capture some of the heat that would otherwise escape from the flue and reuse it

## 1.4 Selecting control measures with the hierarchy of control

Boilers are equipped with a safety system to prevent damage in case of any malfunctions. If the problem in a boiler is not addressed in a timely manner, the results can be devastating because a boiler replicates a pressurized vessel's structure. The complete mechanical, electrical, and electronics structures are tailored to handle pressure from different fluids.

Boilers are an essential part of many industries, and how different sectors utilize boilers in their production are many. Making boilers useable is so much more than a simple conversion of water into steam. It involves complex systems made up of many components, including the safety system in the boiler.

### 1.4.1 Importance of boiler safety control

The boiler can be dangerous on a considerable scale. Unlike other machinery that only causes danger to products or humans on a relatively small scale, boilers can lead to large-scale destruction.

### 1.4.2 Property damage

The boiler's unsafe operation can damage the building or the infrastructure of installation. If this occurs, a simple repair is not the solution. At the least, the building will need basic infrastructure repairs or at the worst, a complete rebuild from the foundation.

### 1.4.3 Loss of life

Unsafe boiler use or conditions also affect human life due to the boiler's enormous temperature. The mechanical structure is sturdy, built to withstand high pressure created inside the boiler. In the case of an explosion, the high temperatures and the possibility of shrapnel pose a hazardous situation for anyone on the premises.

### 1.4.4 Production Loss

Steam is an essential source of heating requirements and it is used in many industries. If there is a problem with the boiler and it completely breaks down, restarting normal operation could take many days or even weeks. Without a functioning boiler, production comes to a standstill.

### 1.4.5 Safety Systems for boilers

Modern-day boiler systems come with a safety system that triggers an alarm, stops the operation or even shuts the system down depending on the issue. These safety systems help avoid dangerous conditions to man, production material, and equipment.

The following types of safety systems are commonly installed in a boiler system:

a. Safety valves or TPR
b. Low water level controls
c. Flame safeguard systems

#### a. Safety valves

Safety valves are the major safety component installed on a boiler. Their basic function is to release the pressure built inside the boiler when it exceeds the boiler's maximum pressure value. This abnormal pressure occurs when other safety functions do not work due to failure.



Figure 1.13 safety valve

The safety valves' design is according to the pressure that the valve can withstand, often called rated pressure. If the boiler's pressure becomes greater than the rated value, the safety valve opens, releasing the pressure until it falls back to the safety valve's rated pressure.

The safety valve requires calibration at regular intervals to test and verify proper operation. This calibration also ensures it is satisfactorily working if an emergency is not necessarily related to the boiler system itself, such as a natural disaster.

**b. Low water level controls**

A control system continuously monitors the water level to avoid problems associated with low water levels. When the system detects low levels, it triggers the safety system, effectively shutting down the boiler. The boiler's restart condition depends upon the user requirement. Some may opt for an automatic restart, while others may require a manual restart after ensuring the appropriate water level is inside the boiler.

**c. Flame safeguard system**

The flame safeguard system's purpose is to detect the presence of flame continuously. If a flame is not detected, it shuts off the fuel supply.



Figure1.14 Flame safeguards system

If no flame is present, a large quantity of fuel collects in the burner. In large enough quantities, this accumulated fuel could cause the furnace to explode. If the flame reignites after a prolonged period, the boiler could explode due to the large amount of deposited fuel.

**ISO standards for boiler system safety**

The industrial sector benefits from set standards in many ways. Standards provide valuable guidelines to help avoid and overcome dangerous situations for operators and structures.

In all cases, boiler safety systems are tested and verified. Implementing the standard set forth allows the relevant industry to take advantage of the standardized body's research and expertise. Additionally, customers have more confidence when buying products that meet or exceed standards.

Different reputable standardization bodies have developed standards for boiler safety systems, but we will look at the International Organization for Standardization or ISO standards.

The ISO standard for boiler safety is ISO 16528-1:2007, Boiler and Pressure Vessels – Part 1: Performance requirements. This standard covers the following points:

- Welding connections in the boiler
- Threaded joints, flange connections, fittings connection, and safety accessories
- Feed water inlet and steam outlet
- Different interconnecting tubing
- Safety accessories and connection to the boiler

## 1.5 Start boiler and brought on line

Before the boiler is restarted after a long shutdown, several items and procedures must be checked. Start by reviewing the logbook for any previous problems or areas of concern. Before proceeding further, making sure that any noted maintenance returned the equipment to a satisfactory operating condition is needed. The need to heat the boiler slowly will be explained throughout this procedure and it can take many hours for a large cold boiler to be heated correctly to operating temperature and pressure. Timing will also depend on how much treated water is available to fill the boiler.

An operator must pay special attention to the fact that:

- Under no circumstances should the boiler be left unattended until all of the following steps have been completed and the boiler is up to pressure and temperature and back on-line if appropriate.
- Also taking care when handling chemicals or working on live steam etc.; always ensuring that PPE appropriate to the task is worn.
- Also remembering that most accidents in boiler houses are falling from height; equipment. Also note working at height can include pits and trenches as a "working at height hazard"

How to start boiler line https://youtu.be/IRv5GJG6k4M access date December20/23

## 1.6 Identifying and reporting maintenance requirements in with workplace

### 1.6.1 Leaking steam pipe

A leaking boiler pipe is never a good thing. The severity of the leak will depend on individual circumstances but what every boiler leak has in common is that the sooner you can fix it, the better. If you leave a leaking boiler pipe and ignore it, you can cause more damage and affect central heating, boiler pressure, and even hot water supply. Thankfully, a leaking boiler pipe is usually not dangerous, but that doesn't mean it shouldn't be repaired as soon as possible.

In emergencies, calling a plumber to fix the leaking boiler pipe may not be a viable option.



Figure 1.15 steam pipe Leaking

### 1.6.2 Causes of a leaking boiler pipe

One of the most common reasons a boiler pipe leaks is because of pressure issues. When there's too much pressure in the boiler, it will need to discharge excess water to help relieve some of the pressure. This can lead to a water leak that needs fixing.

Loose joints and general wear and tear are possible causes of a leaking boiler pipe. As boilers age, the repeated cooling and heating of the water can lead to erosion and cracks. Hopefully, you won't need an entirely new boiler. Most of the time, leaks like this can be repaired with a trusty water leak sealant such as Miracle Seal.

Another major cause of leaks in boiler pipes is damaged boiler seals. Here at C-Tec, we're sealant experts and the creators of the world's best sealant, CT1, and it's new brother, BT1. Using our expertise on sealants, we came up with a new water sealant that's specifically designed to seal leaks in boiler pipes, cooling systems, heating systems, radiators, and so on.

When there's a leak in a boiler that's caused by damaged or eroded boiler seals, it should be repaired immediately. Leaks like this occur when the seal is damaged and stops doing its initial job, which is to protect the boiler's structure from cracking. So, you need a sealant that can expand along with the heat while withstanding the boiler pressure at the same time. A leaking combi boiler is one of the most well-known causes of a boiler not working. A leak can spring up anywhere in the system and drop the boiler pressure significantly - if it's after the boiler pressure gauge, it might not even get picked up by the readings.

Following are the important objectives to be fulfilled by a boiler:

- It should be safe,
- It should operate to its capacity with efficiency and
- It should have long economical life.

In order to ensure that the above objectives are achieved, it is necessary not only to operate the Boiler in a proper manner but to also maintain it in a condition so that the above objectives are achievable. If due emphasis is not given to the proper and scientific maintenance of a boiler, it would suffer from frequent unplanned shut downs and breakdowns resulting in production loss and high cost of putting it back into operation after each such unplanned shut down or breakdown. Further, such frequent unplanned stoppages of steam generation shall result in consequential losses in the process where steam is put to use. Also, if a boiler is not maintained properly, its condition can be unsafe and result in accidents causing loss of life and property apart from losses of revenue. Therefore, modern techniques of maintenance are used for ensuring that the above-enumerated three objectives are achieved. These techniques are the following:

**Routine maintenance** - covering such activities as are recommended by manufacturers of various machinery or components of a boiler. For example - topping up lubricant of bearings of fans and fan

motors and pumps and pump motors, blowing cocks of level gauges, maintaining cleanliness in and around boiler house, etc.

**Preventive maintenance:**

Preventive maintenance is the most widely used means of minimizing common problems in boilers. Statistics indicate about two-thirds of all boiler failures and nearly all unscheduled shutdowns are caused by poor maintenance and operation. Boiler inspection and maintenance are critical. A typical inspection schedule covers four basic areas: boiler, burner, controls, and system. Regardless of boiler design, application, or size, the basic maintenance criteria remain the same.

**Maintaining the burner:**

Although burners vary by design, application, fuel, regulations, and insurance requirements, the same basic maintenance criteria must be addressed. Burner maintenance generally focuses on safety, efficiency, and reliability. Only a trained service technician using the proper instrumentation and tools should make adjustments.

### 1.6.3 Fuel and air linkage:

Changes in fuel and air linkage affect the combustion fuel-to-air ratio. Flame failure or a hazardous fuel rich condition may result. Proper linkage settings should be physically marked or pinned together. Linkage should be checked for positioning, tightness, and binding. Any noticeable changes should be remedied immediately.

**Oil pressure and temperature:**

Pressure and temperature directly affect the ability of oil to properly atomize and burn completely and efficiently. Changes promote flame failure, fuel-rich combustion, soot blowing, oil build-up in the furnace, and visible stack emissions. Causes include a dirty strainer, worn pump, faulty relief valve, or movement in linkage or pressure regulating valve set point. Oil temperature changes typically are caused by a dirty heat exchanger or a misadjusted or defective temperature control

**Gas pressure**

Gas pressure is critical to proper burner operation and efficient combustion. Irregular pressure leads to flame failure or high amounts of carbon monoxide. It may even cause over or under firing, affecting the boiler's ability to carry the load. Gas pressure should be constant at steady loads, and should not oscillate during firing rate changes. Usually, pressure varies between low and high fire. Therefore, readings should be compared to those taken at equivalent firing rates to determine if adjustments are

needed or a problem exists. Gas pressure irregularities are typically caused by fluctuations in supply pressure to the boiler regulator or a dirty or defective boiler gas pressure regulator.

**Atomizing media pressure:**

When oil is burned, an atomizing medium, either air or steam, is needed for proper, efficient combustion. Changes in atomizing media pressure cause soot blowing, oil buildup in the furnace, or flame failure. Changes result from a regulator or air compressor problem or a dirty oil nozzle. **Fuel valve closing:**

If a fuel valve leaks, after burn may occur when the burner is turned off or raw fuel could leak into a hot boiler and cause an explosion. When the burner is turned off, the flame should extinguish immediately. Prolonged burning is a hazard and demands immediate action.

### 1.6.4 Leaking feed pump gland

In boiler feed pumps, mechanical seals, packing and labyrinths are the seals of choice today. Feed water is sealed with mechanical seals and packing. Bearing housings are sealed labyrinth or magnetic seals except in the case of older pumps that aren't upgraded from lip seals. The single cartridge seal is the most popular and is still being improved with more aggressive pumping rings to circulate fluids for better cooling around the seal faces, which is where the most problems occur.

### 1.6.5 Lockout tags

All authorized employees are required to comply with the restrictions and limitations imposed during the use of lockout. This process establishes the minimum requirements for the lockout of energy isolating devices whenever servicing or maintenance is done on boilers.

It shall be used for the following reasons:

- To ensure that the boiler is stopped and isolated from the power source that enables it to operate.
- To assure a safe condition before employees perform servicing or maintenance on the equipment.
- Compliance with this program

| | Self-check | Written test |
|---|---|---|

Name…… ID…… Date…….

**Directions:** Answer all the questions listed below.

**Test I: Choose the best answer**

1. Which one of the following is common place where you may find leaks on a hot water heating system boiler
   A. Air bleeder vent valve leaks
   B. Boiler control valve leaks
   C. Boiler section leaks between cast iron boiler
   D. Bolt opening leaks
2. The following types of safety systems are commonly installed in a boiler system:
   A. Safety valves
   B. Low water level controls
   C. Flame safeguard systems
   D. All
3. Which one of the following is not Solid Fuels Fired
   A. Stoker Fired
   B. Hand fired
   C. Injection system
4. Falling from ladder is _____ type of hazard.
   A. Biological hazard
   B. Chemical hazard
   C. Accidental hazard
   D. None of the above
   E. All
5. Dermatoses from exposure to fuels can be _____ hazard

A. Biological hazard
B. Physical hazard
C. Chemical
D. Thermal

**Test II: Short Answer Questions**

1. Write kinds of PPE used in boiler operation
2. Write Causes of a leaking boiler pipe

## Operation Sheet -1

### 1.1 Methods of Preventive measures for boiler

**A. Tools and equipment**

**I. PPE**

**B. Procedures**

I. Wear safety shoes with non-skid soles Periodically check and adjust burners operation to prevent carbon monoxide generation

II. Install effective exhaust ventilation to prevent air contamination;

III. add local exhaust ventilation if necessary Wear long-sleeve shirts and protect hands with chemical-resistant gloves;

IV. if impractical, use a barrier cream Wear appropriate eye protection; Consult a safety supervisor or a supplier

V. Arrange periodic inspection of boilers, to detect failure of components, metal cracking, etc.

VI. Wear hearing protection appropriate for the noise levels and type of noise - consult the supplier or an expert

VII. Replace hydrazine with less-hazardous substitutes

VIII. Wear respiratory protection during maintenance or other work in which dust may be released into the atmosphere

IX. Learn and use safe lifting and moving techniques for heavy or awkward loads;

X. use mechanical aids to assist in lifting Specialized information

**1.2 Lock out Procedure**

I. Notify the following that the boiler requires servicing/maintenance and will be shut down and locked out.

II. Identify the location, type and magnitude of the power source; understand the hazards associated with its use and the methods to control it.

III. Locate the on/off switch (may be a toggle switch) on the boiler and turn to the "off" position.

IV. locate the breaker that provides power to the boiler primary pump (if so equipped).

V. Move the breaker handle to the "off" position and apply lock, tag and lockout device (if more than one person will be working on the boiler).

VI. Turn valve for the boiler gas line to the "off" position.

VII. In the room where the electrical panels are located, identify the electrical breaker that supplies power to control panel on the boiler. Turn breaker to the "off" position and apply lock, tag and lockout device (if more than one person will be working on the boiler)

VIII. Verify there is no power by testing the main power source on the terminal block (located on the control panel) with a volt meter.

IX. If the result is zero, then equipment is considered locked out and safe to work on. Complete servicing and maintenance as needed

| 2 LAP TEST-1 | Performance Test |
|---|---|

Name……. ID……..

Date…….

Time started: _____ Time finished: _____

**Instructions:** Given necessary templates, tools and materials you are required to perform the following tasks within **5** hour. The project is expected from each student to do it.

**Task-1 Perform preventive measure of boiler**

**Task-2 Perform lockout procedure**

# LG #11 LO #2- Operate monitor boiler

## Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content cover

- Diagnosing operating status
- Maintained operating log
- Statutory requirements, manufacturer's recommendations and workplace procedures
- Monitoring Boiler
- Conducting water quality tests and adjusting with workplace criteria
- Storing and handling boiler house chemicals
- Responding boiler emergency

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon c learning guide, you will be able to:

- Diagnose operating status
- Maintain operating log
- Statutory requirements, manufacturer's recommendations and workplace procedures
- Monitor Boiler
- Conduct water quality tests and adjust with workplace criteria
- Store and handle boiler house chemicals
- Respond boiler emergency

**Learning Instructions:**

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the "LAP test"

# Information Sheet 2

## 2.1 Diagnosing operating status

A boiler operates on a straightforward mechanism, it can encounter problems in the system or pressure vessel. Every entry or mid-level technician interested in learning to fix and maintain boilers must know these issues and how to run a diagnostic check.

### .1.1 Six Common boiler problems

Common problems with commercial and industrial boilers can range from missing insulation to blockage. Some issues may display visible signs, whereas others will need close investigation and diagnostics to pinpoint.

**A. Scale build-ups or blockages**

Poor water quality severely damages a boiler. Calcium and other minerals from the water can accumulate as scale deposits within the boiler's pressure vessel and pipes. Such deposits can interrupt the water pathway or even block it in extreme cases.

These deposits also cost money, as they increase the amount of fuel needed for the system to operate. A water treatment system for a boiler can prevent this issue. Remember, scale deposits are the biggest contributors to reduced efficiency and premature metal fatigue (costly repairs) in a commercial or industrial boiler.

**B. Water leakage**

A water leak is common and can occur anywhere in the system. You must thoroughly inspect the pressure vessel and its pipes. However, the leak may have occurred somewhere else in the system away from the pressure vessel. It makes identifying the source difficult. Using a water meter can help you identify water leakage in a closed system, even if it is from a concealed hole. If you do not find this gauge on a system, you can recommend having one installed.

A water leak will eventually result in water levels dropping low enough to shut down the whole system. If the system continues to leak without any drop in water levels, that means atmospheric pressure is getting into the system. This untreated water can damage pressure vessel by causing

premature wear. In an open-loop system, increased water delivery to the pressure vessel also indicates excessive water loss. Remember that leaks mean untreated water, which when introduced into the boiler, brings in the potential of air (resulting in holes) and hardness, which can cause overheating of the boiler metals.

Water leakage in a boiler https://www.youtube.com/watch?v=2uuGKZ9BUMU accessed date November 12/2/2023

**C. Slow pressure or loss of pressure**

Weak pressure generally indicates leakage in the system. A leakage in the steam pipe will prevent the build-up of necessary internal force. As an industrial boiler technician, you will need to conduct an inspection of the boiler for leaks. You can start the examination by thoroughly checking all the valves. These valves are most likely to be affected by a miniature hole that can go unseen, affecting the pressure. The pressure vessel's exterior may also experience leaks, preventing the boiler from maintaining adequate pressure. In open system boilers using freshwater inside the pressure vessel, the water can cause holes in a cast iron jacket by boiling away at the waterline. If you are unable to see any visible holes, the next step will be to shut down the system and fill the pressure vessel up to the piping.

Another common pressure-related issue occurs in boilers with an on-off water feeding system. Although the new water that enters the boiler is hot, its temperature is still lower than the water in the boiler. This difference in temperature reduces steam production until the newly added water reaches the desired temperature. Low steam production can reduce pressure. However, an uninterrupted water feeding system can help alleviate this pressure issue.

An inadequate heating element can also cause pressure issues. Obviously, an undersized heat source will not be able to boil the water to the desired temperature. Be sure to check and see if any parts were recently replaced in the boiler.

**D. Safety and water probes break**

Just like pipes, water probes can get encrusted due to staying submerged in water. It prevents these probes from effectively gauging the water pressure and temperature, and the boiler automatically shuts down.

Faulty safety sensors and controls may also fail to shut off the boiler in dangerous instances, such as excessive pressure build up. These sensors and controls are immensely critical for the safety of the boiler and the safety of the ones working around it. Therefore, you must inspect them regularly.




**E.** Figure 2.1 Safety and water probes break

**F. Random system shutdowns**

You may run into situations where the heating component automatically switches itself off. It may happen as the safety system detects an issue. If the system shuts off due to a safety concern, do not turn it on before running a full inspection.

**G. Irregular maintenance**

Although not directly a boiler's fault, irregular or inappropriate maintenance is one of the major problems with boilers. An unnoticed or ignored minor issue may end up resulting in more serious damage. It can also pose a safety threat to people working in the vicinity. Therefore, be a responsible technician and run regular maintenance checks on boilers. Remember that most catastrophic boiler failures are caused by low water condition and lack of maintenance (together, these lead to almost 80% of catastrophic failures).

### 2.1.1 How to troubleshoot boiler problems

As a boiler technician, you must know the basics of troubleshooting a commercial or industrial boiler. Here are some details to get you started.

**Check water treatment daily**

Attention should be paid to checking boiler water daily. This can be done by the operator in very short order. This can help to avoid premature pressure vessel damage and leaks that might otherwise occur at the boiler itself.

**Check the pressure**

Some issues have a simple solution, such as making minor adjustments to pressure and temperature. However, if the pressure is too high, it can cause a bigger problem. The right settings depend on the usage and system the boiler operates on. Check the requirements and verify them before making adjustments to the pressure.

**Check the gauge**

A faulty gauge is a culprit at times. If boiler is heating fine and the building is getting the heat as usual, then it may be time to replace that gauge. However, you must get the right gauge for the boiler and system running in the building.

**Safety first**

An unchecked, malfunctioning boiler may result in a catastrophe such as a boiler explosion. Regular inspection routines can help you identify many minute problems in early stages, saving the equipment, employees from any unfortunate incidents.

Boiler systems provide heating requirements. However, there are also manufacturing activities dependent on what the boiler produces steam and heat for safe production of food and fruit processing industries. In the event of a problem with the boiler, production stops and the process break down. To avoid a boiler system breakdown and to keep the boiler working with full parameters, companies must plan maintenance activities to keep the boiler running at an optimum level. Planning ahead for boiler system maintenance allows for the time the boiler takes to cool down to be able to start the maintenance activities. Similarly, after completing maintenance, the boiler takes time to heat up and output steam again. Because of this time commitment, maintenance activities are not executed frequently, making them even more important. It’s better to have boiler maintenance at regular intervals to avoid sudden breakdowns.

### 2.1.2 Regular boiler system maintenance

Advancement in the instrumentation and control components of boiler systems has helped in taking more accurate and complex measurements. The more detailed measurements, the more productive maintenance operators can perform.

Some solutions used in boiler system maintenance measurements include:

- Drum level measurements
- Combustion control systems
- Steam flow measurements
- Gas exhaust analysis

### A. Drum level measurements

The drum is the boiler's fundamental section where conversion from water to steam takes place. Drum measurements include measuring for the correct levels of steam and water.

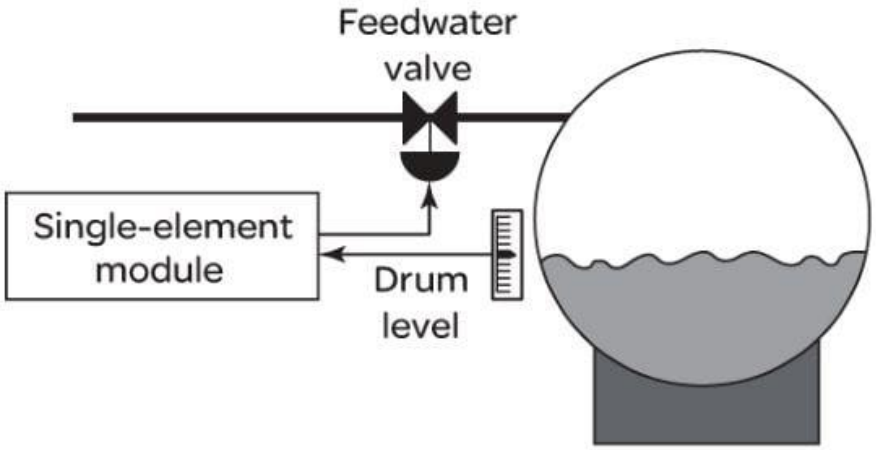



Figure 2.1 Drum level measurements

Level measurement is essential because the drum's performance and longevity are affected by the uneven portion of the steam and water levels. If the water level is too low, then heat (high temperature) damages the internal structure of the boiler. If the water level is higher than the normal range, the excess water flows through the output, again damaging the respective parts.

Common methods of measuring include utilizing a differential pressure transmitter. Some manufacturers also use guided wave radar technology for better performance.

**B. Combustion Control System**

During a routine day, there are times when there is a higher or lower demand for steam. These changing load requirements affect the fuel combustion ability of a boiler. The fuel does not combust fully and wastes uselessly. To avoid poor fuel combustion, control mechanisms are applied. They assist the boiler in burning the fuel in an optimized way, considering the varying load requirements throughout the boiler operation.

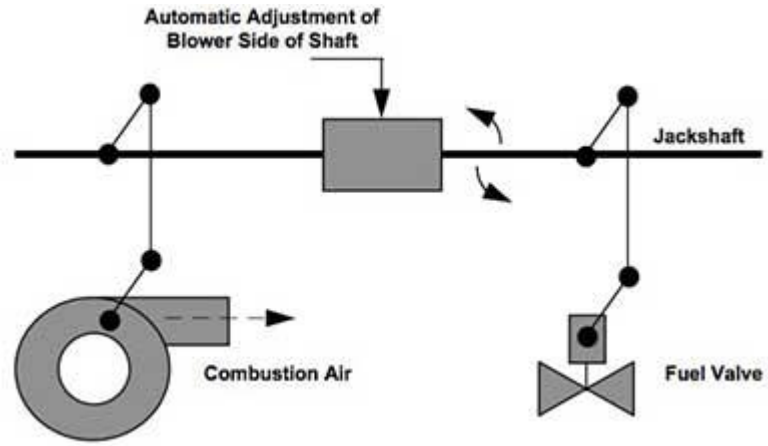



Figure 2.2 Combustion Control System

There are two methods of implementing a combustion control system: single point positioning and parallel positioning. Single point positioning, also called the jackshaft control method, and includes mechanical linkage to control the fuel control valve and airflow damper to the burner. Parallel positioning uses a master pressure controller to control the fuel control valve and airflow damper.

**A. Steam flow measurements**

During normal factory operations, there can be many levels of requirements put on the boiler system. Feedback of these peaks and troughs should be accurately relayed back to the boiler system, allowing for adjustments in different boiler operations such as combustion control depending on other requirements to ensure safe operation and efficiency.

There are three types of flowmeters commonly used in boilers: differential pressure meters, vortex flow meters, and Coriolis flowmeters. Differential pressure measures the change in the pressure as the steam flows through a cross-sectional element such as a nozzle. Vortex flowmeters measure the frequencies created by the vortex as it indicates the steam's flow. Coriolis flowmeters measure the twist of tubes placed in the path of the steam. The twist indicates the flow of the steam.

Steam flow measurement https://www.youtube.com/watch?v=HWiBK5xKVXk accessed date November 12/2/2023

**B. Gas exhaust analysis**

The exhaust gases from the boiler are an adequate source of feedback for the boiler's performance. By examining the exhaust and studying its contents, we get an understanding of what is going on in the boiler. It also enables us to control emissions — one of the many compliance requirements of regulatory bodies in all parts of the world. Some common gases analysed in the exhaust include carbon dioxide, carbon monoxide, and nitrogen oxide. By continuously monitoring these gases, we can optimally adjust the fuel combustion so that the emissions of these gases are at the minimum level. In addition to environmental factors, poor exhaust quality also has an impact on the health of the boiler.

### 2.1.4 Benefits of boiler system maintenance

Taking shut-down time for boiler system maintenance is not always an easy choice, as it takes time away from production. However, boiler maintenance is an essential job like all other production activities, and cannot be neglected. Let's look at some of the benefits of proper maintenance.

**A. Increased lifespan**

Maintaining the boiler in working conditions increases the life of the boiler because it finds and removes wear and tear of parts. If a part is faulty, replacing it prevents damage to other parts that are still functioning correctly.

**B. Reduced energy costs**

Whenever there is a problem with any system or component, the output degrades in terms of quality and capacity. It means more energy is input while the output lags behind. Maintenance keeps things balanced and under control. Any part or system that has undergone maintenance contributes to an enhanced output, avoiding wastage and loss.

**C. Reduced emissions**

Any fault in the boiler system causes reduced output and increased emissions, some of which are dangerous gases for the environment and humans. These emissions are an indicator that the fuel is not fully converting into the desired output.

Moreover, the Environmental Protection Agency obliges industrial units to keep their emissions within a set limit to avoid harm to the environment. Neglecting these set units leads to fines and even longer shutdown periods while the boiler system is brought up to code.

**D. Ensured safety**

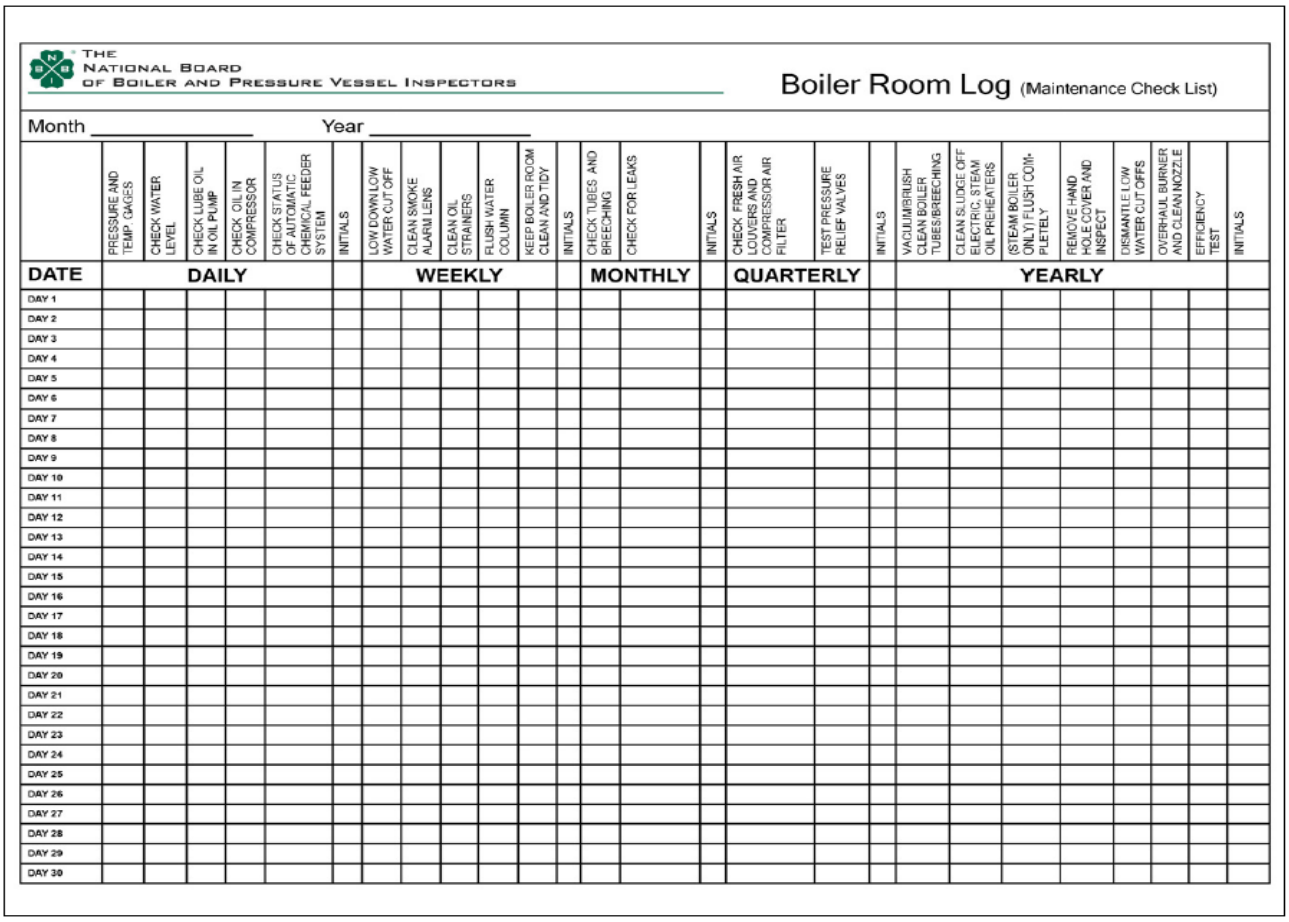
A boiler can be deadly if it is not properly handled because it contains and produces steam and this steam is under immense pressure. Pressurized steam is capable of exploding. Correct maintenance of the boiler helps keep it in a safe condition. Any leak, blockage in the piping or the physical structure, or malfunctioning of components or systems is avoidable by maintaining the boiler regularly.

## 2.2 Maintained operating log

A Boiler Log is a checklist for the boiler operators. It helps to track the operating parameters over a period. For any Boiler Preventive Maintenance the Boiler log is a key factor. Separate log sheets are required for each Boiler in the plant. One option is having a log sheet that is valid for one month (31 days), and has provision for two sets of readings per day for low and medium pressure boiler and three sets of reading per for high pressure boilers. It is recommended that completed logs should be properly preserves for future analysis. The need for a boiler log: It helps to avoid an emergency shutdown. Over a period of time, by following operating trends from the boiler log, one can properly diagnose the problems and fix up a suitable system maintenance schedule. For example, a steady rise in stack temperature, at the same boiler load, indicates dirty boiler firesides or waterside scale build-up. In either case preventive measure can be taken before it is necessary to shut the unit down for cleaning. The majority of the Boiler accidents occur mainly due to two reasons, control failure and human operational / maintenance mistakes.

When the boiler is new or recently over hauled, such a comparison reveals significance deviation, technician may need to inspect and repair components. Check list to be covered in a boiler log: Log sheets are available from boiler insurance companies. Maintenance log should include those items recommended in the boiler and burner manufacture's operating instructions. It is always advisable to prepare customised log form. These logs can be easily customised for the particular installation and its unique requirements. Suggested items that might be included in maintenance log are shown below. But items may be added or deleted as needed for the specific installation. It is advisable to maintain two Log Sheets to fill up by the control room and field operators separately.

Proper keeping and analysis of boiler logs help operators to avoid operational/maintenance error and therefore reduce boiler accidents. Data in the log should be compared with data recorded



THE NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS

Boiler Room Log (Maintenance Check List)

Month _____ Year _____

| DATE | DAILY | | | | | | WEEKLY | | | | | | MONTHLY | | QUARTERLY | | YEARLY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PRESSURE AND TEMP. GAGES | CHECK WATER LEVEL | CHECK LUBE OIL IN OIL PUMP | CHECK OIL IN COMPRESSOR | CHECK STATUS OF AUTOMATIC CHEMICAL FEEDER SYSTEM | INITIALS | LOW DOWN LOW WATER CUT OFF | CLEAN SMOKE ALARM LENS | CLEAN OIL STRAINERS | FLUSH WATER COLUMN | KEEP BOILER ROOM CLEAN AND TIDY | INITIALS | CHECK TUBES AND BREECHING | CHECK FOR LEAKS | CHECK FRESH AIR LOUVERS AND COMPRESSOR AIR FILTER | TEST PRESSURE RELIEF VALVES | VACUUM/BRUSH CLEAN BOILER TUBES/BREECHING | CLEAN SLUDGE OFF ELECTRIC, STEAM OIL PREHEATERS | (STEAM BOILER ONLY) FLUSH COMPLETELY | REMOVE HAND HOLE COVER AND INSPECT | DISMANTLE LOW WATER CUT OFFS | OVERHAUL BURNER AND CLEAN NOZZLE | EFFICIENCY TEST | INITIALS |
| DAY 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 2 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 3 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 4 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 5 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 6 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 7 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 8 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 9 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 10 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 11 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 12 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 13 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 14 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 15 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 16 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 17 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 18 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 19 | | | | | | | | | | | | | | | | | | | | | | | | |
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| DAY 21 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 22 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 23 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 24 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 25 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 26 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 27 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 28 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 29 | | | | | | | | | | | | | | | | | | | | | | | | |
| DAY 30 | | | | | | | | | | | | | | | | | | | | | | | | |

Figure 2.3 example of operating log

## 2.3 Statutory requirements, manufacturer's recommendations and workplace procedures

### 2.3.1 Good practices for normal operation of boilers

Proper records of all operations and inspections should be maintained. The records for boiler performance must show

- The time,
- Boiler pressure,
- Steam temperature at the inlet and outlet of super heater,
- Rate of evaporation,
- Rate of feed flow, feed water inlet and outlet temperatures,
- Undue leakages from pump glands,
- Draught readings at boiler economiser and air heater exit,
- Air and gas temperature at entry and exit of air heater, gas temperature at entry and exit of economiser,
- Water temperature at entry and exit of economiser,
- Current reading of forced secondary and induced draught fans, speed of the fan if variable type, quantity of raw water used, bearing temperature of fans, rate of consumption of fuel, co2 and o2 readings,
- Occurrence of water shortage in boiler, frequency of soot blowing, condition of feed water, chemical dozing, concentration of solids in water,
- Frequency of blow down period, testing of alarms, and safety devices, leakages from valves and frequency of ash removal and name of persons responsible for boiler operation.

The boiler house records hourly or per shift must be examined every day by the plant engineer and any departure from routine or significant event recorded like flue gas explosion or shortage of water in a boiler must be investigated and set right. If inaccuracy of the instrument is suspected they must be inspected and calibrated.

To derate a boiler and to work it at turn down ratio the burner nozzle size is required to be reduced and an air blower of a smaller capacity provided to prevent excess air to ensure complete combustion, and

which will prevent frequent on and off operation of a boiler which would create thermal shocks due to which the tube ends in the hot zone may leak.

The burner assembly must be cleaned periodically and a consistent flame configuration maintained. The target must be 13 to 14% CO2 and no O2.

Excess air is the cause of all ills and reduces efficiency. It is detectable by reduces CO2 level.

If the burner is oversized the flame may be carried away from the confines of the furnace overheating the tube ends in the reversing chamber of a smoke tube boiler. Calorific value of CO is 2430 kcal/kg and that of C is 8084 kcal/kg. It means that incomplete combustion of Carbon resulting in formation of CO results in loss of 2430 kcal/kg out of available 8084 kcal/kg (meaning thereby that around 30% of available Calorific Value goes waste. Thus maintaining high CO2 level at the chimney base cannot be overemphasized.

### 2.3.2 Practical hints for successful boiler operation

High capacity boiler may operate very uneconomically at low loads. Hence large boilers should not be operated at very low loads, in general.

- after a boiler is in regular use exposed flanges should be lagged, instruments should be checked for accuracy against standard apparatus, feed water regulators, remote water level indicators and low water alarms inspected and adjusted and dowelling of all motors and bearings of fans, pumps and other auxiliaries attended to.
- The principal aim of a boiler operator is to operate a boiler safely as nearly as possible under design parameters as regards evaporation, steam pressure, final temperature and produce steam of required quantity and quality at lowest practical cost.
- Continuous supervision of boilers by the boiler house personnel is necessary and the personnel to attend a boiler are not allowed to leave the post for more than a few minutes at a time. Therefore for his personal comforts facilities must be provided in the boiler house.
- An operator must observe the water level in the gauge glass, blow down water column on each boiler after operating all the cocks and observe that the water smartly returns back in the glass. He should check the pressure in the gauge if it is within the operating limits. He should peruse the remarks column of the logbook if any abnormal condition had occurred in the last shift.
- Some of ideal conditions are under the control of boiler operators and other fall within the jurisdiction of steam users and other authorities.

- The steam demand depends upon nature of plant using steam. In power stations and large industrial complex, the load could be fairly constant for several hours and the fluctuations could be anticipated with regular frequency and approximate time of incidence. In case of rolling mills, steel plants electric traction etc. load is subjected to violent fluctuations depending upon the particular period of the day.

The boiler operator must get acquainted with the periodic variations of load and anticipate intermittent fluctuations and get ready to combat the load variations. Peak efficiency could be obtained in the range of 60 to 90percent of rating. If the load is below 30 to 40 per cent of rating 5 per cent decrease in efficiency may be expected.

The response to load variations depends upon method of firing fuel. In oil gas and pulverized coal firing, immediate control could be established within the range of operation of the supply source burner regulation.

In automatic stoker firing, certain degree of flexibility is provided to control within the limits the rate of combustion by additional supply of fuel and air. When increased steam demand is expected, large bank of fire is built up and preparation could be made in advance for increase or decrease in load. Where load is likely to fluctuate, the design of the boiler must be such that it is capable of adjusting itself certain sporadic changes in load.

## 2.4 Monitoring Boiler

### 2.4.1 Boiler monitoring

Boiler plants which incorporate systems which significantly exceed the minimum requirements of the law and include the highest level of automation and monitoring May in certain circumstances still need to be fully manned, and this may be for reasons of steam security to process or other considerations. There are different methods to monitor boiler operation system those are:

- Local control and alarms
- Fail safe and alarm
- Automatic shut down on limiters with alarms
- Remotely continuously monitored on limiters
- Remotely monitored fail safe with alarms

**A. Local control and alarms**

Where the risk assessment determines that the boilers cannot be left alone, a competent boiler operator shall be in the immediate vicinity of the boilers at all times whilst the boilers are operating. They shall be within earshot and sight of alarms at all times, and able to attend the boilers immediately.

This type of supervision is required when the boiler controls are extremely basic or the boiler is in a vulnerable state, e.g. on start-up or after an unexpected alarm. It is also commonly used when firing solid fuels or unusual liquid fuels, or if there is an unacceptably high risk with the

**B. Fail safe and alarm**

If the boilers can, and actually do, automatically shut down safely as a result of any malfunction or incident, a competent boiler operator shall be on site at all times whilst the boilers are operating; they shall be able to attend the boiler house within 5 minutes.

The operator shall be able to hear or see if the boiler is in alarm at all times. Electronic call devices may be used if accepted by risk assessment.

The boiler operator may have other duties at the site, but they will be present for warming through, starting and stopping the boiler, and shall have specific boiler operational duties such as testing alarms and water quality tests. The boilers shall be their first priority.

**C. Automatic shut down on limiters with alarms**

Where the boilers automatically shut down safely as a result of any limiting device activating (low water for instance), or a malfunction or an incident, a competent boiler operator shall attend the boilers at least on a daily basis – they might not be based on site. Speed of response to alarms might be a critical part of the risk assessment. Auto TDS and bottom blowdown shall be installed on any boiler left unattended for 24hrs. location of the boilers.

**D. Remotely monitored fail safe with alarms**

If the boilers are monitored from a remote monitoring location all the time they are operating then a competent boiler operator shall attend the boilers at least on a daily basis or once in every 24 hours; they might not be based on site. Also, a suitably trained and instructed person at the remote monitoring location shall have the ability to respond to an alarm and summon a competent boiler operator.

**E. Remotely continuously monitored on limiters**

Where automation on the boilers is such that the boilers self-monitor all operational parameters and have the proven ability to shut themselves down safely in the event of any limiting device activating or a malfunction or an incident, a competent boiler operator shall attend the boilers at least every 72 hours - they might not be based on site. Speed of response to alarms might be a critical part of the risk assessment.

Monitoring boiler stack temperature

- Checks of steam reticulation line pressure
- Usage of and supply of steam
- Quality of steam
- Combustion/heat source system
- Feed water system

- Fuel system
- Combustion air supply
- Water level
- Steam pressure
- Operation of control/safety devices

### 2.4.2 Safety precautions of boiler operation

- Always study every conceivable emergency and know exactly what action to take.
- Always proceed to proper valves or switches rapidly but without confusion in time of boiler emergency. You can think better walking than running.
- Always check the water level in the gauge glass with the gauge cocks at least dailyalso at any other time you doubt the accuracy of the glass indication.
- Always accompany orders for important operations with a written memorandum. Use a logbook to record every important fact or unusual event.
- Always have at least one gauge of water before lighting off. The gauge cocks should heck the level.
- Always be sure the blowdown valves are closed, and proper vents, water-column valves, and pressure-gauge cocks are open.
- Always use the bypass if one is provided. Crack the valve from its seat slightly andawait pressure equalization. Then open it slowly.
- Always watch the steam gauge closely and be prepared to cut the boiler in, opening the stop valve only when the pressures are nearly equal.
- Always lift the valve from its seat by the hand lever when the pressure reaches about three quarters of popping pressure.
- Always consult the officer in charge of the plant, your CPO, or other proper superior and accept his/her recommendations before increasing the safety-valve setting.
- Never fail to anticipate emergencies. Do not wait until something happens before you start thinking.

- Never start work on a new job without tracing every pipeline in the plant and learning the location and purpose of each and every valve regardless of size. Know your job!
- Never leave an open blow down valve unattended when a boiler is under pressure or has a fire in it. Play safe--your memory can fail.
- Never give verbal orders for important operations or report such operations verbally with no record. Have something to back you up when needed.
- Never light a fire under a boiler without checking all valves. Why take a chance?
- Never open a valve under pressure quickly. The sudden change in pressure, or resulting water hammer, may cause piping failure.
- Never cut a boiler in on the line unless its pressure is within a few pounds of header pressure. Sudden stressing of a boiler under pressure is dangerous.
- Never bring a boiler up to pressure without trying the safety valve. A boiler with its safety valve stuck is the same as playing with dynamite.
- Never increase the setting of a safety valve without authority. Serious accidents have occurred from failure to observe this rule.

## 2.5 Conducting water quality tests and adjusting with workplace criteria

### 2.5.1 Water in boiler operation

Water quality sampling and test procedures including the purpose of test and safe use, care and storage of relevant test equipment, interpretation and recording of results. Water quality monitoring is commonly defined as the sampling and analysis of water (lake, stream, river, estuary, or ocean) and conditions of the water body.

All natural waters contain acid materials and scale-forming compounds of calcium and magnesium that attack ferrous metals. Some water sources contain more scale-forming compounds than others; therefore, some waters are more corrosive than others. Subsurface or well waters are generally more scale-forming, while surface waters are usually more corrosive. To prevent scale formation on the internal water-contacted surfaces of a boiler and to prevent destruction of the boiler metal by corrosion, chemically treat feed water and boiler water. This chemical treatment prolongs the useful life of the boiler and results in appreciable savings in fuel, since maximum heat transfer is possible with no scale deposits.

### 2.5.2 Boiler water testing

As we have just seen, boiler water must be treated with chemicals to prevent the formation of scale on the internal surface of the boiler and to prevent deterioration of the boiler metal by corrosion. Boiler water must be tested to determine the sufficiency of chemical residuals to maintain clean boiler surfaces. As a UT, you should be able to make various boiler water tests. The procedures for a few types of tests that you may have to make are given here-tests for hardness, phosphate, tannin, caustic alkalinity (with and without tannin), sodium sulfite, and PH. A test kit is provided for the different tests. Each test kit contains the equipment and materials for the specified test.

**A. Test for hardness**

Boilers operating at pressures of 15 psi and less are normally used for space heating and hot-water generation. Practically all the condensate is returned to the plant. Only a small amount of makeup is required, and secondary feed water treatment usually is sufficient. When appreciable quantities of steam are used in process work and not returned as condensate to the plant, the problem of scaling and

corrosion arises, and more complete treatment of feed water must be considered. The ideal water for boilers does not form scale or deposits, does not pit feed water systems and boiler surfaces, and does not generate appreciable CO2 in steam.

**B. Test for phosphate**

The calorimetric test for phosphate uses a decolorizing carbon to remove tannin. Carbon absorbs the tannin, and the carbon and tannin are then filtered out. When tannin is not present, carbon improves the test for residual phosphate by making the tricalcium phosphate sludge more filterable.

**C. Test for Tannin**

The purpose of the tannin test is to determine the amount of tannin in the boiler water. Tannin holds sludge in suspension. In treating boiler water with tannin, control the dosage by the depth of brown formed in the boiler water by the tannin. To estimate the depth of the color, which is necessary in adjusting tannin dosages, compare a sample of the boiler water with a series of brown color standards of successively increased depths of color.

**D. Test for Sodium Sulfite**

The sample for this test should be cooled to 70°F, or below, and exposed to the air as little as possible, because oxygen in the air combines with sodium sulfite in the sample and causes low readings. Collect a separate sample, using the boiler water sample cooler, with the line reading to the bottom of the sampling bottle. Allow the boiler water to run until a few bottlefuls overflow to waste.

**E. Test for pH**

The value of pH indicates the degree of acidity or alkalinity of a sample. A pH of 7.0 represents the neutral point; the lesser values denote acidity; the greater values denote alkalinity. The test is made as soon as possible after you take the sample. Avoid exposure to the air as much as possible to reduce absorption of CO2.

**F. Test for total dissolved solids**

The solu-bridge method is a simple and rapid way to determine the total dissolved solids (TDS) content. Ionizable solids in water make the solution conduct electricity. Pure water, free from ionizable solids, has low conductance and thus high resistance.

The solu-bridge instrument measures the total ionic concentration of a water sample, the value of which is then converted to parts per million. The solu-bridge test equipment and reagent are furnished by the supplier in a kit. The model of the solu-bridge given below is not suitable for measuring solids

in condensed steam samples or an effluent of the de-mineralizing process. A low conductivity meter is necessary because of the extremely low solids content of condensed steam and de-mineralized water.

Water boiler testing https://youtube.com/watch?v=fX6yDfJqehg Access date December 2023

## 2.6 Storing and handling boiler house chemicals

### 2.6.1 Chemicals used in boilers

Chemicals are divided into two categories for Boilers to choose from. Boilers are divided into two chemical groups: steam boilers and hot water boilers.

- Steam Boiler Chemicals - Oxygen Scavengers, Amines, Phosphates, Polymers, and Alkalinity Builders are some of the chemicals used in steam boilers.
- Oxygen Scavengers - The most prevalent variety is a 38 percent oxygen scavenger with a pH of 4 or less. Other solutions include a cobalt catalyst as well as alkalinity boosters. These blends are typically 50 percent dilutions with pH levels of 7 and 10. These blends eliminate the need for an alkalinity source (i.e. eliminates using a separate alkalinity drum).
- Boiler Alkalinity Builders - The most popular boiler alkaline products are potassium or sodium hydroxide. Sold mostly in 25 percent and 50 percent solutions.
- Neutralizing amines are referred to as neutralizing compounds. Diethylaminoethanol, Cyclohexylamine, and Morpholine, these compounds are available as single components or multi-blends in a variety of dilution ratios.
- Phosphates and polymers in a blend to prevent scale
- Hot Water Boilers - A mixture of Sodium Nitrite is the most cost-effective chemical to employ.

Boiler house chemicals include:

- Extinguishing agent’s carbon dioxide
- Water
- Soda acid
- Organic foam and dry powder
- Oxygen scavenger
- Feed water additives

- Other chemicals
  - Amines
  - Condensate chemicals

The storage of all above chemicals to be done in dry place and out of sunlight because they affected by bad storing activities

## 2.7 Responding boiler emergency

### 2.7.1 Boiler emergencies

The following situations are rare occurrences if the boiler has been receiving proper routine operation and care. Nevertheless, when upset conditions do occur, they can develop rapidly into serious situations. The operator must be prepared to act calmly but efficiently, and this requires a prior knowledge of emergency procedures. The following list is again only general in nature, every operator must become completely familiar, and at ease, with the specific procedures in his or her plant. Typical emergency situations encountered with the operation of boilers are

- Low water,
- High water,
- Serious tube failure,
- Flarebacks,
- Minor tube failure, and
- Broken gauge glass.

**A. Low water,**

A rapidly falling water level in the boiler may be caused by a faulty feed water level controller, feed water or condensate pump failure, and interruption of the water supply to the pump, or leakage from the boiler due to ruptured tubes or open blow-off valves. Normally, when the level drops to the low-water cut off point, the boiler will shut down automatically. However, should the cutoff fail to shut the boiler down, the water level may drop to a dangerous level. If the operator finds the boiler in operation while unable to see the water level in the gage glass, it may be that the glass is either completely full or empty. This should be checked quickly by opening the drain on the glass. If the level is found to be below the gage glass, the boiler should be shut down immediately.

**B. High water level**

Should the water in the gage glass of a boiler show higher than normal or even climb out of sight, the level should be brought back to normal to prevent carry-over of the water with the steam. This can be done either by shutting off the feed water or condensate pump or, more quickly, by draining the excess water through the blow-off valves.

Neither of these methods should be used to maintain normal water level while continuing boiler operation. The first method requires the boiler operator to manually control the operation of the feed water pump while the second method is wasting too much water. The cause of the trouble, usually a defective level control system, should be repaired as soon as possible. It may be necessary to put the level control system in the manual mode while the fault is being found and repaired.

### C. Flame failure

Some of the reasons why the flame may fail during operation are:

- Insufficient fuel oil supply due to plugged filter
- Water in the fuel
- Excessive air supply
- Insufficient gas pressure

When flame failure occurs, the flow of the fuel to the burner must be stopped immediately to prevent the furnace from filling with unburned fuel which could cause an explosion. Most boilers are now equipped with flame detection devices which will shut off the fuel supply within a few seconds after the flame fails. Regular testing of the operation of these devices is a must.

| | |
|---|---|
| • -**Self-Check – 2** | **Written test** |

Name…… ID…… Date…….

**Directions:** Answer all the questions listed below.

**Test I: Multiple choice**

1. Which one of the following is a typical emergency situation encountered with the operation of boilers
   A. High water,
   B. Serious tube failure
   C. Flarebacks
   D. All of the above
2. Which one of the following is a not reason why the flame may fail during operation
   A. Excessive air supply
   B. Insufficient fuel oil supply due to plugged filter
   C. Water in the fuel
   D. None
3. One of the following boiler emergencies caused due to excessive air supply is _____
   A. Low water
   B. Flame failure
   C. High water level
   D. All
4. One of the following test is not needed in water quality for boiler operation
   A. . Test for Hardness
   B. Test for Phosphate
   C. Test for Tannin
   D. None

**Test II: Short Answer Questions**

1. Write Six Common Boiler Problems
2. What is operating log of boiler?

## Operation Sheet -2

### 2.1 Methods of Test for Hardness of boiler water

**A. Tools and equipment**

- 50 ml of water sample
- Conical flask 250 ml
- Ammonia buffer solution: Dissolve 67.5 gm. of ammonium chloride in 570 ml of ammonium hydroxide and dilute to one liter with deionised water.
- Eriochrome Black -T indicator: Dissolve 0.5 gm. of EBT in 10 ml Methanol & makeup to 100 ml
- 0.02 N EDTA Solutions: Take 3.723 gm of EDTA in the 1 lit. volumetric flask. Add DM water to 1000 ml mark in the flask.
- Inhibitor for Heavy metals: Dissolve 5.0 g sodium sulfide (Na2S.9H2O) in 100 ml Distilled water.

**B. Procedure**

1. Take 50 ml Sample in a 250 ml conical flask.
2. Add 2 – 4 ml Ammonia Buffer and mix by stirring.
3. Add 3-4 drop EBT indicator.
4. Titrate against 0.02 N EDTA solution.
5. Check for the end point – Wine red to blue color.

Steps of water hardness testing **https://youtu.be/Sa0WfA9UGG0 access date December 2023**

Steps of water hardness testing **https://www.youtube.com/watch?v=fX6yDfJqehg&t=1s December 2023**

| | | |
|---|---|---|
| | • **LAP TEST-2** | **Performance Test** |

Name……. ID……..

Date…….

Time started: _____ Time finished: _____

**Instructions:** Given necessary templates, tools and materials you are required to perform the following tasks within **1** hour. The project is expected from each student to do it.

Task-1 perform water hardness test for steam boiler

| LG #12 | LO #3- Shut down and store boiler |
|---|---|

**Instruction sheet**

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Shutting down Boiler
- Cleaning internal and external of boiler
- Removing boiler valves and fittings with statutory requirements, manufacturer's recommendations and workplace procedures.
- Identifying appropriate mode of storage with statutory requirements, manufacturer 'recommendations and workplace procedures.
- Storing Boiler with statutory requirements, manufacturer's recommendations and workplace procedures

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Shut down boiler
- Clean internal and external of boiler
- Remove boiler valves and fittings with statutory requirements, manufacturer's recommendations and workplace procedures.
- Identify,appropriate mode of storage with statutory requirements, manufacturer 'recommendations and workplace procedures.
- Store Boiler with statutory requirements, manufacturer's recommendations and workplace procedures

**Learning Instructions:**

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the "LAP test"

## Information Sheet 3

### 3.1 Shutting down Boiler

When shutting down a boiler, the firing rate and draught conditions should be reduced as recommended by the manufacturers simultaneously with the steam flow. After the lower limit of the control range is reached, manual operated should be adopted. Economiser recirculation valves where provided should be opened soon after the boiler is shut down or before changing over form continuous to intermittent feeding. Pulverisers should be taken out after running them empty, which must be progressively down, the last to be taken out of service being nearer the boiler entry. At the prescribed minimum lead, oil support and igniters should be used. As the pulverisers empty out it would be necessary to have its igniters in operation to prevent flame instability.

In stoker-fired boilers the stoker hopper should be run empty and fuel permitted to burn out before the boiler is taken out of service. The expansion movement of the boiler should be checked at regular intervals as the load is reduced. If the boiler is connected to a common steam range, the stem of the non-return valve should be run down and then the range side valves closed. Where two stop valves re provided, the range side valve should be closed after the boiler side valve is shut off. The shut off valves may be cheeked for tightness by opening the drain valve between them.

The furnace must be cooled steadily and the forced draught fan continued in service to purge the boiler for about thirty minutes after the fire is killed. Where refractory work is extensive, the boiler must be cooled sufficiently, before airflow is increased for rapid cooling. After the fire is killed, the boiler may be fed with water to three quarters in the gauge glass and then feeding stopped. The feed pump should be kept running in case of controlled circulation boilers.

When drum pressure drops to\1.75 kg/cm2 (25 psi), drum vents should be opened to prevent formation of vacuum to prevent leakages at the gasket joints. After the boiler has sufficiently cooled, soot blowing or dusting may be carried out keeping the airflow as high as possible. Soot blowing when the furnace is hot may cause flue gas explosion.

### 3.2 Cleaning internal and external of boiler

#### 3.2.1 Importance of cleaning for boiler

Before commencing the work for boiler cleaning etc., all feed and steam valves must be shut tight and locked. Pulveriser and fan breakers should be de-energised. Oil and atomizing steam supply valves should be closed and oil gun removed from burner housing. Gas supply valves, where provided, must be closed. It is advisable to blank the supply line and thoroughly purge the gas line towards the boiler beyond the blank with inert gas or steam, before may lead to serious or fatal accidents.

The treatment and conditioning of boiler feed water must satisfy three main objectives:

- Continuous heat exchange
- Corrosion protection
- Production of high quality steam

#### 3.2.2 Internal cleaning

For internal inspection or cleaning, manhole covers of mud drums must be opened last after the cover of the top drum is knocked in first. If the process of opening the covers is reversed, there is a likelihood of injury to personnel due to escaping steam or hot air caused by suction action.

The cleaning of internal surface of high pressure boiler can be grouped into two main methods, one pre-commissioning and the other post commissioning cleaning. Pre-commissioning cleaning

Internal treatment can constitute the unique treatment when boilers operate at low or moderate pressure, when large amounts of condensed steam are used for feed water, or when good quality raw water is available. The purpose of an internal treatment is to

- React with any feed-water hardness and prevent it from precipitating on the boiler metal as scale;
- Condition any suspended matter such as hardness sludge or iron oxide in the boiler and make it non-adherent to the boiler metal;
- Provide anti-foam protection to allow a reasonable concentration of dissolved and suspended solids in the boiler water without foam carry-over;
- Eliminate oxygen from the water and provide enough alkalinity to prevent boiler corrosion.

In addition, as supplementary measures an internal treatment should prevent corrosion and scaling of the feed-water system and protect against corrosion in the steam condensate systems.

During the conditioning process, which is an essential complement to the water treatment program, specific doses of conditioning products are added to the water. The commonly used products include:

- Phosphates-dispersants, polyphosphates-dispersants (softening chemicals): reacting with the alkalinity of boiler water, these products neutralize the hardness of water by forming tricalcium phosphate, and insoluble compound that can be disposed and blow down on a continuous basis or periodically through the bottom of the boiler.
- Natural and synthetic dispersants (Anti-scaling agents): increase the dispersive properties of the conditioning products. They can be:
- Natural polymers: lignosulphonates, tannins
- Synthetic polymers: polyacrilates, maleic acrylate copolymer, maleic styrene copolymer, polystyrene sulphonates etc.
- Sequestering agents: such as inorganic phosphates, which act as inhibitors and implement a threshold effect
- Oxygen scavengers: sodium sulphite, tannis, hydrazine, hydroquinone/progallol-based derivatives, hydroxylamine derivatives, hydroxylamine derivatives, ascorbic acid derivatives, etc. These scavengers, catalyzed or not, reduce the oxides and dissolved oxygen. Most also passivate metal surfaces. The choice of product and the dose required will depend on whether a deaerating heater is used.
- Anti-foaming or anti-priming agents: mixture of surface-active agents that modify the surface tension of a liquid, remove foam and prevent the carry-over of fine water particles in the steam.

During manufacturing of seamless steel tubes, a quantity of mill scales are bound to be formed, and some of these can remain inside. During fabrication and erection of the pressure parts, some amount of oil and grease can also get into the tube surface apart from the weld slag and other materials. Taking all of these into consideration, the pre-commissioning cleaning has three major steps.

- Alkali boils out - which is for removing the oil and grease from the internal surface.
- Acid cleaning - for removing the mill scales in the internal surface. Both acid cleaning and alkali boil-out are done for all water-touched surfaces.

- Steam blowing - In the case of super heaters, reheaters, and steam pipes, they are cleaned by steam blowing.

**Alkali boil-out**

This operation in boilers is taken up after hydraulic testing of the boiler is completed and the oil burners are commissioned. Alkaline flushing is carried out before the boiler is taken for alkali boil out. It is a practice to mechanically remove the oil and grease wherever possible. The drum internals are installed before start of alkali boil out. Normally sodium carbonate and sodium phosphate in equal quantity along with a detergent to about 0.05 to 0.1% by volume are used for alkali boil out. After the boil out solution is added, the drum level is checked though a gauge glass and confirmed before firing the boiler. The boiler is brought to 20 kg/cm square in about 8 hours' time keeping in mind the rate of pressure raise and temperature raise allowed for cold start up. The drum level is maintained at normal level during this operation. After about four hours at pressure, the fire is shut down and the boiler is allowed to cool. This ensures the sludge settle down and the boiler blow down is carried out using the bottom drain. Care should be taken to maintain the drum water level with in the visible range of gauge glass. This operation is done for four times to a total of about 16 hours. Solution samples are taken at regular intervals, and if the original concentration drops to half or below, chemicals are added to bring back the concentration. The boiler is then drained after the drum metal temperature is below 90 degree C. The boiler is then rinsed with clear rinse water and flushed.

**Acid cleaning**

Many methods are used by different boiler makers to clean the mill scale and rust inside the tube surface. It is very important that this operation is carried out by an experienced and reliable agency. The methods used are circulating acid method and soaking method. In the case of the circulating method, external acid cleaning pumps are used to keep the acid in circulation. However in the case of soaking method the acid is kept stationary for a specified time. Many combinations of acids are used for this purpose. The most popular acid is 5% hydrochloric acid with inhibitors that are used to inhibit the action of acid on the cleaned surface of the tube. The super heater tubes should be plugged and water filled and maintained under positive pressure so that the acid vapors do not enter the tube surface

### 3.2.3 External cleaning

If external surfaces are to be washed by steam or water, this should be carried out just before the boiler is put back in service, so that the water, which accumulates in pockets, crevices, porous refractory, or other such places, may cause corrosion, if permitted to remain. After water washing, if the boiler cannot be put in service, the boiler must be fired to dry out the moisture. Specially in oil fired boilers, water must not be permitted to remain after water washing, as the oil deposits may absorb moisture and cause corrosion, and hence the boiler must be fired for a short period to dry out the tubes and setting.

External treatment is the reduction or removal of impurities from water outside the boiler. In general, external treatment is used when the amount of one or more of the feed water impurities is too high to be tolerated by the boiler system in question. There are many types of external treatment (softening, evaporation, deaeration, membrane contractors etc.) which can be used to tailor make feed-water for a particular system. Internal treatment is the conditioning of impurities within the boiler system. The reactions occur either in the feed lines or in the boiler proper. Internal treatment may be used alone or in conjunction with external treatment. Its purpose is to properly react with feed water hardness, condition sludge, scavenge oxygen and prevent boiler water foaming.

### 3.3 Removing boiler valves and fittings with statutory requirements, manufacturer's recommendations and workplace procedures.

**Fittings**

All steam boilers are fitted with at least one water level indicator, but those with a rating of 100 kW or more should be fitted with two indicators. The indicators are usually referred to as gauge glasses

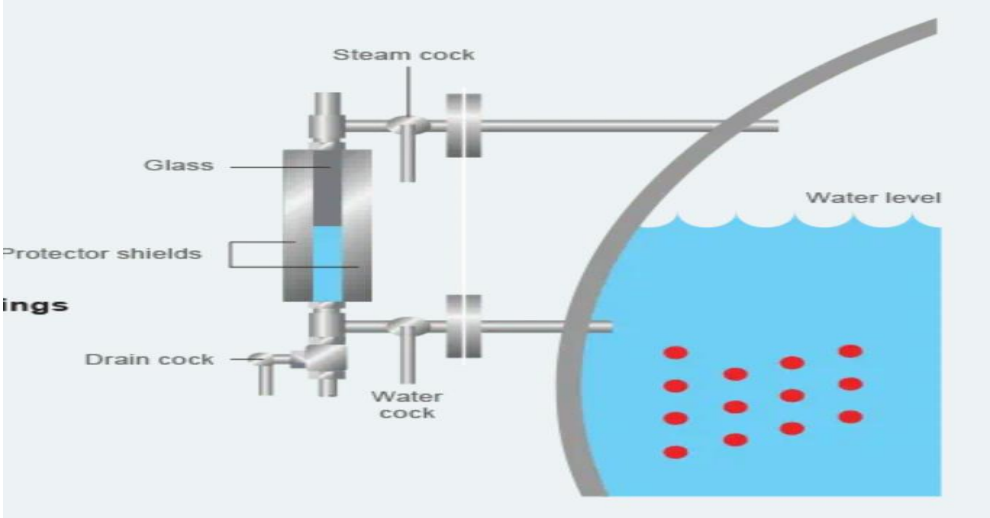



Figure 3.1 glass gauge fitting

A gauge glass shows the current level of water in the boiler, regardless of the boiler's operating conditions. Gauge glasses should be installed so that their lowest reading will show the water level at 50 mm above the point where overheating will occur. They should also be fitted with a protector around them, but this should not hinder visibility of the water level. Figure shows a typical gauge glass.

Gauge glasses are prone to damage from a number of sources, such as corrosion from the chemicals in boiler water, and erosion during blowdown, particularly at the steam end. Any sign of corrosion or erosion indicates that a new glass is required.

When testing the gauge glass steam connection, the water cock should be closed. When testing the gauge glass water connections, the steam cock pipe should be closed.




Figure 3.2 example of the whole fitting

**Type of Fittings**

- Collar
- Elbow
- Gasket
- Union
- Reducer
- Tee
- Nipple
- Trap

**Valves**

Valve is a device that opens or closes to let things through or to control passage. Control Valves are used to control the flow of boiler steam. The actuator is the device that applies the force to open or close the Valve.

The controller compares the process condition with the set value and sends a corrective signal to the actuator, which adjusts the Valve setting.

- A variety of control types exist:
- Pneumatically actuated valves - Compressed air is applied to a diaphragm in the
- Actuator to open or close the Valve.
- Electrically actuated valves - An electric motor actuates the Valve.
- Self-acting - There is no controller as such - the sensor has a liquid fill which expands and contracts in response to a change in process temperature. This action applies force to open or close the Valve.

Fitting and removing valve of boiler https://youtu.be/Wfz5HduBCDE access date November 12/2/2023

### 3.4 Identifying appropriate mode of storage with statutory requirements, manufacturer ‘recommendations and workplace procedures.

Steam Boilers when not in use are liable to deterioration from corrosion. Unless well cared for and made rust proof, they may depreciate more rapidly than when in use. There are two modes to store boiler. Those modes are:

- Wet storage
- Dry storage

#### A. Wet storage

If the boilers are required to be kept out of service, but are likely to be required as standby units, the wet method is a practical one, by which a unit could be made ready for service. In the wet method, the boiler is filled through the economiser with deaerated treated water to give the required alkalinity, and the boiler is fired with low sulphur fuel, and steamed in service so that the boiler water will be circulated to secure uniform concentration throughout the unit, and the oxygen eliminated from the water. The boiler load should then be reduced slowly and the water level raised as high in the gauge glass as its consistent with safe operation, while delivery some steam a concentration of 100 ppm of hydrazine should be maintained for preventing oxygen corrosion. When air cocks reveal no pressure in the boiler, and before a vacuum can be produced, the boiler should be filled in by deaerated water, until water spills over and fills the super heater using a high point air vent, such as pressure gauge connection as an indicator. The drum air cock should be connected to a surge tank located above the steam drum to ensure positive pressure and prevent ingress of air to the boiler, thus compensating for volumetric changes due to temperature.

After firing the boiler, the setting should be closed and maintained in a closed condition. Periodical inspections may be carried out to observe if condensation has occurred on external surfaces, and if this happens, heating devices may be placed at convenient points to keep metal surfaces above dew point. In wet storage, the boiler must be protected from frost. If the ambient temperature is likely to be dropped to freezing point, this type of storage must be avoided.

Boiler connections should be checked for leakages and water samples analyzed. If hydrazine concentration has dropped below 50 ppm, chemicals should be injected to bring the concentration to normal after lowering the level. The boiler should then be steamed sufficiently to circulate the water added with chemical and the procedure followed as stated above. In any case, if the boiler is to be stored for unduly long periods, it should be emptied and inspected for corrosion defects.

**B. Dry storage**

For dry storage the boiler must be cleaned properly and dried thoroughly, since the moisture may cause corrosion of metal surfaces. Precaution must be taken to prevent entry of moisture in any form, from steam, feed and air lines. For this intent moisture assimilating material such as quick lime at the rate of 0.9 kg (2 lb) or silica gel at the rate of 4.5 kg (10 lb) for 4546 litres (1,000 gallons) capacity, should be placed on trays inside the boiler shells or drums to absorb moisture from the air. The manholes should then be closed and all connections on boilers tightly banked. The serviceability of the materials for such purposes and their replacement may be judged through regular internal boiler.

## 3.5 Storing Boiler with statutory requirements, manufacturer's recommendations and workplace procedures

Once the boiler is installed in an appropriate room, it needs to be properly managed to ensure that it remains safe and doesn't become hazardous or pose a danger to staff or members of the public. The following advice will help:

The boiler room must remain a room that is for the boiler only. It should not be used as a storage room for other items, or used in any other way. The burners in a boiler need proper air circulation so that they don't start producing carbon monoxide, which can be impeded by having other items in the room. There is also the risk of accidentally placing something flammable in the room. One of the best things you can do for boiler safety is to ensure that nothing is in there that shouldn't be in there.

**Complete regular inspections and maintenance**

Adhering to a strict routine of inspections and maintenance will help to foresee any future problems and act on them before they become an issue. Regular testing of boiler controls, limiting devices and feed water quality is essential to ensure the boiler continues to be safe, reliable and efficient.

| | |
|---|---|
| • **Self-Check – 3** | **Written test** |

Name…… ID…… Date…….

**Directions:** Answer all the questions listed below.

**Test I: Short Answer Questions**

1. Explain detail about cleaning of boiler
2. What is the two common methods of boiler storage

**Operation Sheet -3**

3.1 Operation external cleaning of boiler

A. Safety Precautions:

- Ensure that the boiler is shut down and isolated from the power source.
- Allow the boiler to cool down before starting the cleaning process.
- Wear appropriate personal protective equipment (PPE) such as gloves, safety goggles, and protective clothing.
- Follow all applicable safety guidelines and procedures.

B. Gather Required Equipment and Materials:

- High-pressure steam cleaner or pressure washer.
- Clean water source.
- Soft-bristle brushes or scrubbing pads.
- Cleaning agents suitable for boiler surfaces (if necessary).
- Ladders or scaffolding (if required for accessing higher areas).

C. Inspection:

- Visually inspect the external surfaces of the boiler for dirt, debris, and deposits.
- Identify areas that require special attention, such as crevices, seams, and porous refractory.

D. Preparing the Cleaning Solution (if applicable):

- If using a cleaning agent, prepare the solution according to the manufacturer's instructions.
- Ensure that the cleaning agent is suitable for the type of boiler and its external surfaces.

E. Cleaning Process:

- Start by removing loose debris and dirt from the surfaces using soft-bristle brushes or scrubbing pads.
- If using a cleaning agent, apply it to the dirty areas and allow it to penetrate for the recommended time.
- Use the high-pressure steam cleaner or pressure washer to wash the external surfaces, focusing on areas with stubborn deposits.

- Pay close attention to crevices, seams, and other hard-to-reach areas, using brushes or scrubbing pads if necessary.
- Rinse the surfaces thoroughly with clean water to remove any residual cleaning agent or loosened dirt.
- Repeat the cleaning process if needed to ensure all surfaces are clean.

F. Drying:

- After completing the cleaning process, allow the boiler surfaces to dry completely.
- If there are pockets or areas where water may accumulate, use compressed air or fans to facilitate drying.
- Ensure that all moisture is removed, especially in oil-fired boilers, to prevent corrosion

G. Post-Cleaning Inspection:

- Inspect the surfaces again to ensure that they are clean and free from debris.
- Check for any signs of corrosion or damage that may require further attention.
- Make note of any maintenance or repair needs discovered during the inspection.

H. Documentation:

- Record the cleaning process, including the date, cleaning methods used, cleaning agents (if applicable), and any maintenance or repair needs identified.
- Maintain a cleaning log for future reference and to track the condition of the boiler's external surfaces over time.

| | LAP TEST-3 | Performance Test |
|---|---|---|

Name……. ID……..

Date…….

Time started: _____ Time finished: _____

**Instructions:** Given necessary templates, tools and materials you are required to perform the following tasks within **3** hour. The project is expected from each student to do it.

Task-1 Perform external cleaning of boiler

3. Operation Sheet: External Cleaning of Boiler
4. 
5. Safety Precautions:
6. 
7. Ensure that the boiler is shut down and isolated from the power source.
8. Allow the boiler to cool down before starting the cleaning process.
9. Wear appropriate personal protective equipment (PPE) such as gloves, safety goggles, and protective clothing.
10. Follow all applicable safety guidelines and procedures.
11. Gather Required Equipment and Materials:
12. 
13. High-pressure steam cleaner or pressure washer.
14. Clean water source.
15. Soft-bristle brushes or scrubbing pads.
16. Cleaning agents suitable for boiler surfaces (if necessary).
17. Ladders or scaffolding (if required for accessing higher areas).
18. Inspection:
19. 
20. Visually inspect the external surfaces of the boiler for dirt, debris, and deposits.
21. Identify areas that require special attention, such as crevices, seams, and porous refractory.
22. Preparing the Cleaning Solution (if applicable):
23. 
24. If using a cleaning agent, prepare the solution according to the manufacturer's instructions.
25. Ensure that the cleaning agent is suitable for the type of boiler and its external surfaces.
26. Cleaning Process:
27. 
28. Start by removing loose debris and dirt from the surfaces using soft-bristle brushes or scrubbing pads.

29. If using a cleaning agent, apply it to the dirty areas and allow it to penetrate for the recommended time.
30. Use the high-pressure steam cleaner or pressure washer to wash the external surfaces, focusing on areas with stubborn deposits.
31. Pay close attention to crevices, seams, and other hard-to-reach areas, using brushes or scrubbing pads if necessary.
32. Rinse the surfaces thoroughly with clean water to remove any residual cleaning agent or loosened dirt.
33. Repeat the cleaning process if needed to ensure all surfaces are clean.
34. Drying:

35. After completing the cleaning process, allow the boiler surfaces to dry completely.
36. If there are pockets or areas where water may accumulate, use compressed air or fans to facilitate drying.
37. Ensure that all moisture is removed, especially in oil-fired boilers, to prevent corrosion.
38. Post-Cleaning Inspection:
39.
40. Inspect the surfaces again to ensure that they are clean and free from debris.
41. Check for any signs of corrosion or damage that may require further attention.
42. Make note of any maintenance or repair needs discovered during the inspection.
43. Documentation:
44.
45. Record the cleaning process, including the date, cleaning methods used, cleaning agents (if applicable), and any maintenance or repair needs identified.
46. Maintain a cleaning log for future reference and to track the condition of the boiler's external surfaces over time.

| LG #13 | LO #4- Record information |
|---|---|
| **Instruction sheet** | |

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Conduct work with workplace information and environmental guidelines
- Maintaining workplace records with workplace recording requirements
- Recording workplace information in appropriate format
- Signing all records
- Communicating record information to supervisor
- keeping workplace information records in appropriate place

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Conduct work with workplace information and environmental guidelines
- Maintain workplace records with workplace recording requirements
- Record workplace information in appropriate format
- Sign all records
- Communicate record information to supervisor
- keep workplace information records in appropriate place

**Learning Instructions:**

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

## Information Sheet 4

### 4.1 Conduct work with workplace information and environmental guidelines

All combustion plant has an impact on the environment through a combination of emissions to air, land and water. Individual combustion plants with a nett rated thermal input of between 1MW and 50MW will eventually all be covered by a permit issued under the Medium Combustion Plant Directive. This permit will detail the boiler's effect on the environment and list the permit conditions applied to the operator. It is illegal to operate the plant without a permit and outside these conditions, and all new medium combustion plants first fired after 19/12/2018 require a permit.

A safe, healthy workplace environment is important for the physical safety, mental well-being and productivity of modern-day employees. Bad air quality and ventilation, as well as asbestos-riddled structures, can lead to sick building syndrome, which can compromise the health and comfort of workers. Not only can poorly managed work settings reduce productivity, but research has shown they may be linked to causing asthma, lung cancer and other medical problems.

Employers need to ensure the health and welfare of their workers. Proactivity can ensure health management savings, low absenteeism and contained insurance premiums. To make sure your business is complying with the law, you should consult the United States Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA) guidelines and follow directives. If necessary, contact an environmental consultant to determine cost-effective ways to handle workplace environment issues.

Taking into account recommendations from the manufacturer, checklists should be created for all procedures related to the boiler and any other equipment located within the boiler room and followed very strictly. This should include starting up the boiler, shutting down the boiler, running tests, performing maintenance and everything in between. The HSE recommends the following records should also be created and retained:

The report of the last examination of the boiler:

- Details of repairs or modifications to the system.

- Any previous reports containing information relating to the safe operation of the system.
- Routine testing records for the past two years.
- Technical documentation provided by the manufacturer and installer.

### 4.2 Maintaining workplace records with workplace recording requirements

**Recording Information**

**Maintaining Workplace records**

- Work place information related to maintaining food quality may include
- Standard Operating Procedures (SOPs),
- Manufacturer's specifications
- Specifications and production
- Quality specification
- Log sheets
- Basic data
- Standard forms
- Written and verbal instruction'

**General requirements**

- Good documentation constitutes an essential part of the quality assurance system.
- Documents must be designed, prepared, reviewed, and distributed with care.
- Documents must be approved, signed, and dated by the appropriate competent and authorized persons.
- Documents must have unambiguous contents. The title, nature, and purpose should be clearly stated. Reproduced documents must be clear and legible.
- Documents must be regularly reviewed and kept up-to-date.
- Documents must not be handwritten;

**Documentation system.**

- Arrangements for the preparation, revision, and distribution of documents
- Necessary documentation for the manufacture

- Any other documentation related to product quality that is not mentioned elsewhere (e.g. regarding microbiological controls and product quality includes
  - Specifications
  - Sampling procedures
  - Testing procedures and records (including analytical worksheets and/or
  - Laboratory notebooks)
  - Analytical reports and/or certificates
  - Data from environmental monitoring, where required
  - Validation records of test methods, where applicable
  - Procedures for and records of the calibration of instruments and maintenance.

**4.3 Recording workplace information in appropriate format**

Clear, written instructions describing how and when to carry out routine tests must be kept on-site and be followed by suitably trained and competent boiler operators. Where the boiler controls may be operated off-site, must also be available at the point of control and operated by a person competent to do so.

A record of such tests shall be maintained to keep an audit trail of the boiler operation.

Examples of the type of records and documents that shall be kept and made available for scrutiny include:

- Risk assessment;
- Boiler log book;
- Water treatment test records;
- Combustion analysis records;
- Manufacturer's records and instructions;
- Standard Operating Procedures;
- Emergency Procedures;
- Written Scheme of Examination (WSE);
- Examination reports;
- Record of periodic tests (e.g. Non Destructive Testing (NDT), Hydraulic test);

- Certificates of thorough examination;
- Records of servicing & modifications;
- Maintenance of controls;
- Training records for boiler operators, supervisors and managers;
- Audit reports for boiler operators.

The use of loose-leaf log books is not recommended. Paper logs shall be securely bound, while electronic logs must comply with the requirements of BS 10008:2014: Evidential weight and legal admissibility of electronic information. Specification.

Careful consideration of where logbooks are stored is required. While it is useful for information flow between operators to keep the current logbook in the boiler house, there is a risk that the log itself could be lost in the event of a catastrophic incident. For that reason, only the current log should be stored near the boiler. Verified copies and older logbooks should be stored away from the boiler house. Routine testing of controls, limiters and water quality is essential to ensure continued safe, reliable and efficient operation. It can help prevent the following dangers:

- Low water level which can expose the furnace or fire tubes and lead to metal overheating & catastrophic boiler failure;
- High water level which can lead to priming of the boiler or carry-over of water, causing water-hammer, damage to valves and pipework as well as sudden steam leaks;
- Scale, excessive sludge deposits and dissolved solids which can quickly build up in a boiler through inadequate blowdown or water treatment regimes. These can cause boiler overheating or water carry-over which can ultimately cause boiler or system failure;
- Faulty combustion controls which can allow the uncontrolled presence of fuel, air and an ignition source, which can result in fires or explosions.

The tests and their frequency shall be based upon:

- Risk assessment of the plant and boiler system;
- Manufacturers’ or modifiers’ instructions; and
- The controls and manning levels.

**4.4 Signing all records**

The record of all activities done in above section to be approved by:

- Supervisor
- Operator
- Manager
- Shift leader
- Quality manager

In the Work Order Tracking and Quick Reporting applications, you can sign off one or more operations by using the Sign off action. The person who signs off the operation must have the relevant qualifications to perform the operation

Depending on the security options for your organization, you might have permission to specify another user in the Sign-Off By field. In the Security Groups application, the Sign Off for Others signature option defines whether the logged in user can specify another user as the person who signs off the operation. When you save the work order record, the selected operations are signed off, and your electronic signature is applied to the record.

Some operations must be countersigned by a witness or an inspector before the work order that is associated with the operation can be closed or completed. The following table provides a description of the types of inspection that can be associated with an operation:



Figure 4.1 example of signing record

## 4.5 Communicating record information to supervisor

### 4.5.1 Communication in workplace

Effective communication with supervisor is fundamental to building a successful professional relationship. It plays a vital role in promoting understanding, collaboration, and productivity within the workplace. Let's explore the importance of effective communication with supervisor, highlighting the benefits and emphasising its significance in fostering a positive and productive work environment.

### 4.5.2 Benefit of communication

**A. Building Trust and Rapport**

One of the primary reasons for effective communication with supervisor is to establish trust and rapport. By maintaining open lines of communication, you can build a positive working relationship based on mutual respect and understanding.

**B. Clear Expectations and Goal Alignment**

Clear communication with supervisor helps establish and clarify expectations and goals. By openly discussing job responsibilities, performance expectations, and project objectives, you can ensure that you are on the same page.

**C. Effective Information Exchange**

Communication is the foundation for effective information exchange within the workplace. Regularly updating supervisor on progress, sharing challenges you may be facing, and seeking guidance or clarification ensures that everyone remains informed and can make well-informed decisions.

### 1.2.2 Feedback and Performance Improvement

Effective communication with supervisor provides an opportunity for feedback and professional growth. Regular check-ins and constructive feedback sessions allow you to understand strengths, areas for improvement, and progress towards goals.

### 1.2.3 Conflict Resolution and Problem-Solving

In any workplace, conflicts and problems may arise. Effective communication with supervisor enables timely resolution of conflicts and effective problem-solving. You can maintain a positive work environment and foster collaboration among team members by addressing issues promptly and professionally.

### 1.2.4 Support and Advocacy

Communicating effectively with supervisor can also provide access to support and advocacy. supervisor can act as a mentor and advocate for professional growth, helping you navigate career path effectively.

## 4.6 keeping workplace information records in appropriate place

### 4.6.1 Introduction

Having good quality of information means that you keep records to a high standard so that they accurate, secure, and reliable. Good record management can only be achieved by making sure your records are up to scratch in the first place if you're managing badly kept documents, it takes away the whole point of looking after them in the first place.

Every organisation needs its information to be reliable in order to plan, allocate and prioritise resources and deliver their services effectively. As an employee, you have a responsibility to ensure that the quality of records you create will support this. The importance of good documentation shouldn't be underestimated.

### 4.6.2 Information Quality Criteria

A. **Accuracy**

Records must be accurate, meaning that all the details are correct and exact. To ensure that the information in a record is accurate, it should be captured as soon as possible after the event has taken place.

**B. Validity**

Information in records must be valid. This means that it has a sound basis working alongside logic and fact. It also means that where national rules apply they need to be followed. For example, the government requirements require that financial records need to contain certain information in order to be classed as valid for businesses in the public sector both. Pushing for validity also means that the information you are producing is consistent over time too.

**C. Reliable:**

Information in records should always be collected in the same way to ensure reliability. This means that anyone using the records can be confident that variations are due to real changes, rather than differences caused by a changing collection method.

**D. Timely bounded**

Information in records must be used in a timely manner, this doesn't mean rushing, but you can't be slow when it comes to record management. This is because they can quickly become out-of-date, something that means they lose their value.

**E. Relevancy**

Information in records should be relevant to its purpose. If the requirements for the records change, then you need to review the information to make sure that it meets the new requirements, maintaining its relevance as a result.

### 4.6.3 Information Security at Work

Having a file plan is the perfect way to keep **control** of your records to increase efficiency and organisation of the business information. A file plan is a structure for the organisation to control their documents, whether that's paper-based or electronic records. File plans should be based on the activities and functions of the company rather than organisational structures as these are more likely to change. A good file plan in place means that:

- It's easier and quicker to find records
- Information sharing is improved

- Duplication is reduced
- Retention and disposal are more manageable
- Records are accessible when someone leaves

| • **Self-Check – 4** | **Written test** |
|---|---|

Name…… ID…… Date…….

**Directions:** Answer all the questions listed below.

**Test I: Short Answer Questions**

1. What A good file plan in place mean?
2. What is the role of communication in boiler operation
3. Who make sigh in boiler operation record?
4. what does validity mean in the context of information?
5. Why is validity important for information?
6. How does validity relate to national rules and regulations?
7. What role does validity play in financial records?
8. Why is consistency over time important for validity?

## Reference Materials

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**Web addresses**

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Line https://youtu.be/IRv5GJG6k4M**https://youtu.be/Sa0WfA9UGG0 access date December 2023**

Steps of water hardness testing **https://youtu.be/Sa0WfA9UGG0 access date December 2023**

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