

Code of Practice

for the Safe Operation of Electric Steam Boilers

Issued under Section 18A of
the Boilers and Pressure Vessels Ordinance



Occupational Safety and Health Branch
Labour Department

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INTRODUCTION

The Boilers and Pressure Vessels Ordinance, Cap.56, sets out the provisions relating to the control in the use and operation of boilers and pressure vessels in Hong Kong.

This Code of Practice is issued by the Boilers and Pressure Vessels Authority under Section 18A of the Ordinance for the purpose of providing practical guidance in order to ensure safe operation of electric steam boilers.

Under section 18A(2) of the Ordinance, any person who fails to observe the provisions of this Code shall not render himself liable to criminal proceedings of any kind, but any such failure may, in any proceedings whether civil or criminal and including proceedings for an offence under the Boilers and Pressure Vessels Ordinance, be relied upon by any party to the proceedings as tending to establish or to negative any liability which is in question in those proceedings.

These steam boilers must be operated safely and dependably and remain serviceable for years, with cleaning and maintenance for the most part being undertaken during pre-planned maintenance periods. The safety and dependability built into modern boilers is by rigorous compliance of all maker's instructions, relevant codes and standards for regulating design, fabrication and inspection of the boilers and their auxiliary equipment.

For the requirement on fire protection system, installations and equipment etc., please seek advice from the Fire Services Department.

For the requirement on the installation and maintenance of electrical supply to the boiler including the electrical parts, please seek advice from the Electrical and Mechanical Services Department.

The Boilers and Pressure Vessels Authority, currently the Commissioner for Labour, has delegated certain powers under the Ordinance to the Principal Surveyor of the Boilers and Pressure Vessels Division, Labour Department. Enquiries may, therefore, be directed to the Principal Surveyor or his staff at telephone number 3107 3458 or fax number 2517 6853.

Boilers and Pressure Vessels Authority

LIST OF APPLICABLE ORDINANCE AND REGULATIONS

1. Boilers and Pressure Vessels Ordinance, Cap. 56
2. Boilers and Pressure Vessels Regulations
3. Boilers and Pressure Vessels (Forms) Order
4. Boilers and Pressure Vessels (Exemption)
(Consolidation) Order

CHAPTER ONE

1.1 General

1.1.1 PURPOSE AND SCOPE

The purpose of this Code of Practice is to promote the safe operation of electric steam boilers.

This Code may also offer practical guidance for those responsible for the safety and direct supervision of electric steam boilers.

The scope of the Code is limited to such basic information as is necessary for the safe operation of electric steam boilers.

1.1.2 INTERPRETATION

For the purposes of this Code -

“Authority” means Boilers and Pressure Vessels Authority;

“boilers” means any closed vessel in which for any purpose steam is generated under pressure greater than atmospheric pressure and also means any economizer used to heat water being fed into any such vessel, any superheater used for heating steam and any fitting directly attached to such vessel that is wholly or partly under pressure when steam is shut off, and any vessel in which oil is heated at a pressure greater than atmosphere pressure; (Amended 87 of 1988 s.3)

“boiler inspector” means a person who has been appointed by the Authority to be a boiler inspector and whose appointment to be a boiler inspector has not been suspended;

“certificate of competency” means a certificate of competency issued by the Authority;

“certificate of fitness” means a certificate of fitness issued under section 33 of the Boilers and Pressure Vessels Ordinance;

“competent person” means a person whose name is for the time being entered in the register of competent persons kept pursuant to section 7(1)(e) of Boilers and Pressure Vessels Ordinance;

“Ordinance” means Boilers and Pressure Vessels Ordinance (BPVO);

“owner”, in relation to a boiler or pressure vessel, includes any person who is in possession of the boiler or pressure vessel under an agreement of hire purchase or under a contract between a supplier of boilers or pressure vessels, or the agent of any such supplier, and such person for the sale of the boiler or pressure vessel, notwithstanding that the property in the boiler or pressure vessel has not passed to such person, and, where the owner of a boiler or pressure vessel cannot be found or ascertained or is absent from Hong Kong or is under disability, also includes the agent of the owner;

“pressure vessel” means a steam receiver, an air receiver and a portable gas generator;

“recognized inspection body” means an independent inspection body recognized by the Boilers and Pressure Vessels Authority.

1.2 Statutory Requirement

1.2.1 THE AUTHORITY AND AUTHORIZED OFFICERS

The Authority may authorize any public officer to perform or exercise all or any of the functions, duties or powers which are imposed or conferred on the Authority or an authorized officer. In the discharge of the above legal responsibilities, the Authority and an authorized officer (under section 4 of BPVO) shall have the following powers: -

- (a) at any time, to enter any premises or place in which he knows or has reason to believe there is a boiler;
- (b) at any time, to examine and test any boiler and its auxiliary equipment; and
- (c) to require the production of any Certificate of Fitness concerned with the boiler and to make copies of the same.

Any person who willfully obstructs or delays the Authority or an authorized officer in the exercise of any power conferred on him by the Ordinance shall be guilty of an offence and shall be liable on summary conviction to a fine of \$10,000 and to imprisonment for 12 months.

The owner of a new boiler shall, in not less than 30 days before he intends to put the boiler into use, deliver to the Authority: -

- (a) one copy of the maker's certificate and one copy of the certificate of inspection during construction issued in respect of the electric boiler by a recognized inspection body; or
- (b) documentary evidence, to the satisfaction of the Authority, that the electric boiler complies with a recognized engineering standard or code in respect of:-
 - (i) the welders employed and welding procedures used in the construction and erection of and, if repairs have been carried out, in the repairs to, the electric boiler;
 - (ii) heat treatment before and after welding;
 - (iii) tests and inspections carried out on the electric boiler;
 - (iv) kind and grade of material used in the pressure parts of the electric boiler;
 - (v) any other relevant technical details that the Authority may, by notice in writing, specify; or
- (c) where the owner cannot deliver either the documents referred to in paragraph (a) nor the documents referred to in paragraph (b), details of the design and methods of construction, inspection and testing of the electric boiler and its auxiliary equipment.

1.2.3

CERTIFICATE OF FITNESS

Section 33 of the Ordinance prescribes the conditions for the issuance of Certificate of Fitness by a Boiler Inspector. If the Boiler Inspector is satisfied with the condition of the equipment, which he has examined, he should issue a Certificate of Fitness in a prescribed form and also deliver two copies of the certificate to the owner. The owner must then deliver the two copies of the certificate to the Authority within 7 days. The original Certificate of Fitness must be kept in the premises where the boiler is installed and displayed in a prominent place.

Section 49(1) of the Ordinance requires that equipment can only be operated when its Certificate of Fitness is still valid. The Certificate of Fitness is normally valid for 14 months.

The Competent Person who operates or supervises the operation of boilers must be in possession of a valid Certificate of Competency issued by the Authority.

The Ordinance requires that a Competent Person must be present at all times to directly supervise the operation of a boiler.

Employer should employ sufficient Competent Persons to cater for leave, replacement so that no boilers would be left unattended during operation.

Section 6 of the Ordinance empowers the Authority to issue, upon payment of the prescribed fee, a Certificate of Competency to a person who:-

- (a) has produced satisfactory evidence as to his suitability and experience to operate any or all of the classes of boiler as specified in the Certificate of Competency; or
- (b) has passed the requisite examination.

1.2.5 CLOSURE ORDER

The Authority may issue a Closure Order to prohibit any further use of a boiler when it appears to him that -

- (a) the boiler or its fittings are not in safe working order;
- (b) the boiler or its fittings have not been examined in accordance with the Ordinance;
- (c) the boiler is operated at a pressure higher than its maximum permissible working pressure; or
- (d) the seal of the safety valve is broken or the setting of the safety valve has been tampered with by an unauthorized person.

1.2.6 SALE, HIRE OR REMOVAL OF BOILER

When a boiler is hired or sold, the owner must notify the Authority within 7 days of such a transaction and the name and address of the person to whom it has been hired or sold, and must report whether the sale or hire involves removal.

Any boiler which has been removed either to a new premises or to another part of the same premises must be examined by a Boiler Inspector and issued with a new Certificate of Fitness before it is put into use again.

The owner of a registered boiler should notify the Authority within 7 days if he changes his address.

1.2.7 PERIODIC EXAMINATION

Every electric boiler must be properly maintained in accordance with provisions laid down in the Ordinance and its Subsidiary Regulations and must be examined periodically by a Boiler Inspector. The maximum interval between examinations is 14 months. The record of periodic examination is required to be kept by the boiler user.

1.2.8 EXAMINATION AFTER EXTENSIVE REPAIRS

If extensive repairs have been carried out to a boiler or to its auxiliary equipment, fittings and attachments, the boiler must be examined by a Boiler Inspector and issued with a Certificate of Fitness before being put back into use. Extensive repairs mean alterations or welding repairs to the pressure parts of the boiler or its controls and safety devices.

1.2.9 ACCIDENTS

If an accident occurs to a boiler or to its auxiliary equipment or if the owner becomes aware of any defect that is likely to endanger life or property, he must at once take the equipment out of use and notify the Authority of the accident or defect within 24 hours. A copy of the latest Certificate of Fitness must be sent to the Authority at the same time together with detailed information about the equipment and the accident or defect.

1.2.10 OFFENCES AND PENALTIES

The Ordinance and the Regulations set forth penalties for various breaches as briefly summarized below:-

Section 15A

Failure to submit application for registration.

Maximum fine: - \$10,000 [Level 3 of Schedule 8 of Criminal Procedure (Amendment) (No. 2) Ordinance, 1994]

Section 22

Failure to ensure the proper maintenance of pressure vessel.

Maximum fine: - \$25,000 [Level 4 of Schedule 8 of Criminal Procedure (Amendment) (No. 2) Ordinance, 1994]

Section 49(1)

Operating boiler/pressure vessel not having been examined in accordance with the Ordinance.

Maximum fine: - \$50,000 [Level 5 of Schedule 8 of Criminal Procedure (Amendment) (No. 2) Ordinance, 1994]

Section 49(4)

Operating boiler/pressure vessel at a pressure greater than its maximum permissible working pressure.

Maximum fine: - \$50,000 [Level 5 of Schedule 8 of Criminal Procedure (Amendment) (No. 2) Ordinance, 1994]

Section 49(6)

Failure to comply with prohibition order issued by the Authority.

Maximum fine: - \$50,000 [Level 5 of Schedule 8 of Criminal Procedure (Amendment) (No. 2) Ordinance, 1994]

Section 49(7)

Operating boiler/steam receiver without the direct supervision of Competent Persons.

Maximum fine: - \$50,000 [Level 5 of Schedule 8 of Criminal Procedure (Amendment) (No. 2) Ordinance, 1994]

Section 55(1)(e)

Utters or makes use of any notice, form or document knowing the same to be forged or false.

Maximum fine: - \$10,000 and imprisonment for 12 months

Section 56

Corruptly solicits or receives any advantage whatsoever as an inducement for certification or forbearing to make any report or notification required to be made under the Ordinance.

Maximum fine: - \$50,000 and imprisonment for 5 years.

Regulation 4(1)(a)

Steam receiver not fitted with suitable steam reducing valve.

Maximum fine: - \$10,000 [Level 3 of Schedule 8 of Criminal Procedure (Amendment) (No. 2) Ordinance, 1994]

CHAPTER TWO

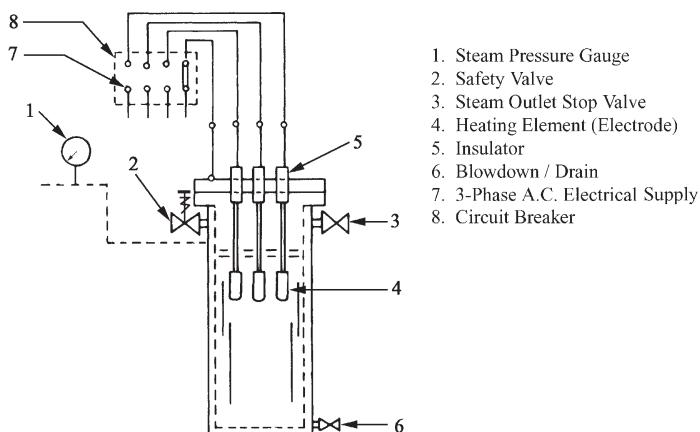
2.1 Types of Electric Steam Boilers

Electrical power is supplied to heat up the boiler water within the pressure vessel that is specifically designed to sustain high temperature and pressure. Basically there are two methods used for steam generation for electric steam boilers.

2.1.1 ELECTRODE TYPE ELECTRIC STEAM BOILER

Electrodes are immersed in the feed water in which the alternating current flows through. The principle applied is that the passage of current through any resistance causes a rise in temperature within the material of the resistance. In this case, the boiler water itself is a resistance and is heated up to generate steam instead of transmitting heat from an external source.

Operation is completely automatic. The controls regulate the load taken by the boiler to meet the steam demand and maintain a constant working pressure.

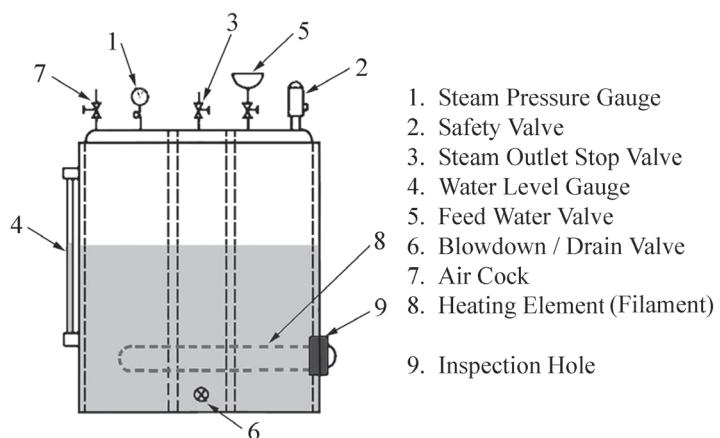
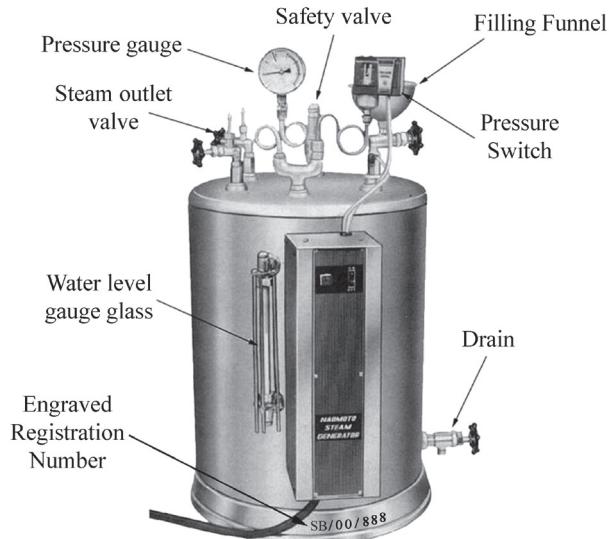


Electrode Type Electric Steam Boiler

2.1.2

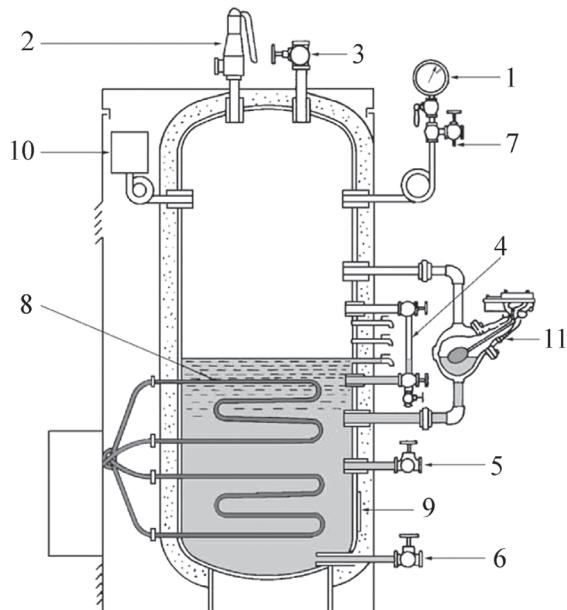
FILAMENT TYPE ELECTRIC STEAM BOILER

Heating element is used in which electrical energy is converted to heat energy so that steam is generated by heating of boiler water. Both manually and automatically controlled heating element types are widely used in factories of Hong Kong.



Manually Controlled Filament Type Electric Steam Boiler

1. Pressure Gauge
2. Safety Valve
3. Stop Valve
4. Water Gauge
5. Feed Water Valve
6. Drain Valve
7. Bleed Air Valve
8. Heating Coil
9. Mud Hole / Cover
10. Pressure Control Switch
11. Water Level Controller

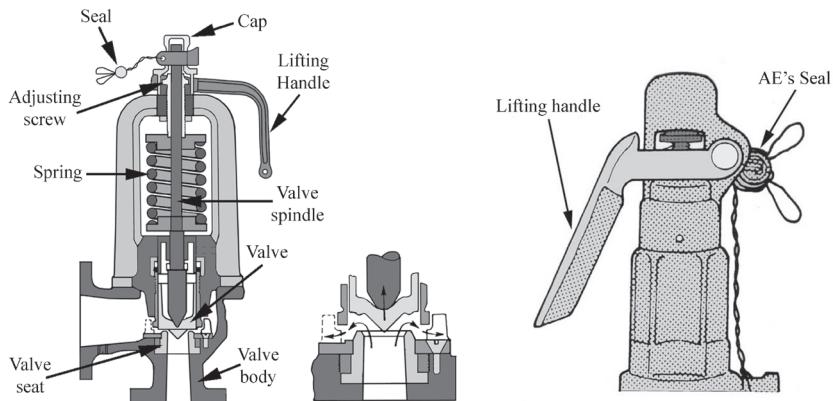


Automatically Controlled Filament Type
Electric Steam Boiler

2.2 Essential Fittings

2.2.1 SAFETY VALVE

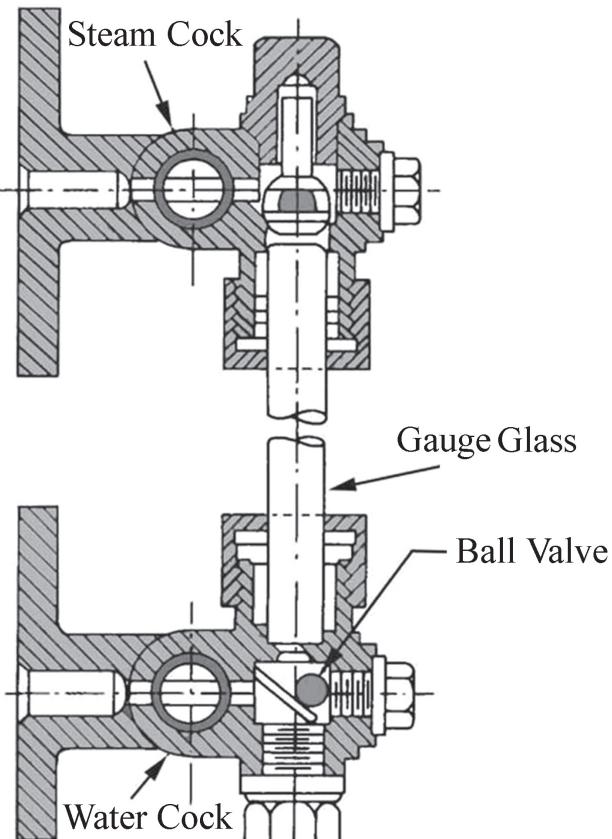
Every electric steam boiler must have a suitable spring-loaded safety valve, separate from any stop valve and capable of being sealed, which should be attached directly to the boiler. It automatically opens to reduce steam pressure so prevents the boiler from being operated in excess of its maximum permissible working pressure. The capacity of the safety valve must be capable of discharging maximum boiler output with the stop valves shut and without causing any increase in steam pressure. Safety valve blows out the steam from the boiler to keep the pressure within the maximum permissible working pressure. When the safety valve blows out continuously or several times, it would be a safe procedure to shut down the boiler to examine the pressure switch and the control circuit. Permanent provision is made for the hot effluent from the safety valve to be discharged safely when it blows.



2.2.2

WATER LEVEL GAUGE

Every electric steam boiler must be fitted with at least one water level gauge of transparent material, or such type as approved by the Authority. It allows constant visual observation of the water level in the boiler. In the case of glass tubular types, an efficient guard, for protection of persons from injury by a burst glass gauge, shall be provided.

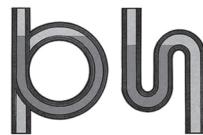
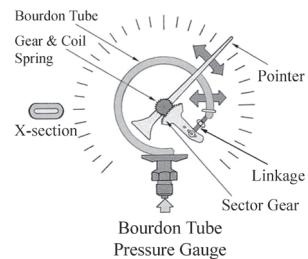
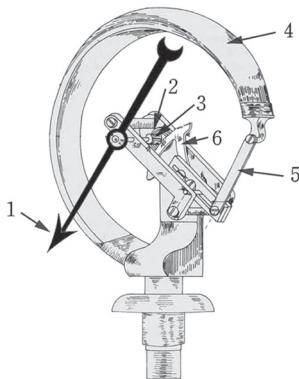


2.2.3

STEAM PRESSURE GAUGE

Every electric steam boiler must be fitted with a suitable ranged and calibrated pressure gauge, connected to the boiler and easily visible by the Competent Person. A red line should be marked on it to indicate the maximum permissible working pressure of the boiler. The pressure gauge shall indicate the true steam pressure in the boiler.

1. Pointer
2. Coil spring
3. Gear
4. Bourdon tube
5. Linkage
6. Sector gear

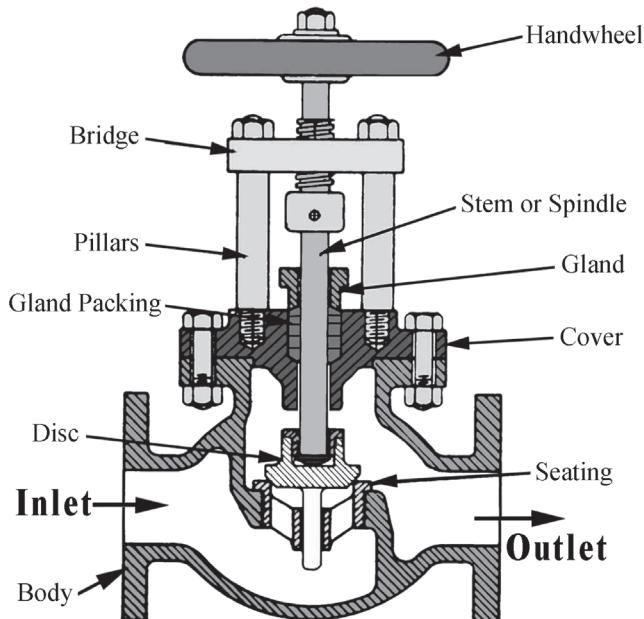


The Competent Person is required to observe the pressure shown on the pressure gauge. Therefore, the gauge must be accurate. To ensure the accuracy, the pressure gauge must be calibrated as necessary and at least at the time of periodic survey.

2.2.4

STOP VALVE

Every electric steam boiler must be fitted with a suitable stop valve connecting the boiler to the system.



Globe Stop Valve

2.2.5

AIR VENT

An air vent should be fitted at the highest point of the boiler to release air trapped inside the boiler during flash up or to prevent creation of vacuum during shut down. Some typical automatic electric steam boiler also equips with vacuum breaker that consists of a spring-loaded disc and associated piping.

2.2.6

BLOWDOWN DRAIN VALVE

A blowdown drain valve should be fitted for removing precipitates or to empty the boiler for lay-up or maintenance work to be carried out. Hot effluent from the blowdown should be discharged safely.

Automatic blowdown system may be installed optionally in electric steam boilers. This system starts and drains boiler on a periodic basis utilizing a motorized ball valve, control timer and relay. This system facilitates cleaning the boiler and prolongs the life of the heating elements and bottom shell.

2.3 Instruments and Control Systems

Instruments and automatic controls serve to assure safe, economic and reliable operation of a boiler. Instruments and methods for measuring pressure of steam and water level of drum are essential in the operation of a boiler. They range from the simplest manual devices to more complex measuring devices used to actuate the automatic control of boilers and their auxiliaries.

A Competent Person maintains a constant watch in the operation of an electric steam boiler for the occurrence of any disturbance. Since time is required for the boiler to respond to a correction, over-correction is possible for further disturbance to the boiler if the Competent Person is not aware of this time lag.

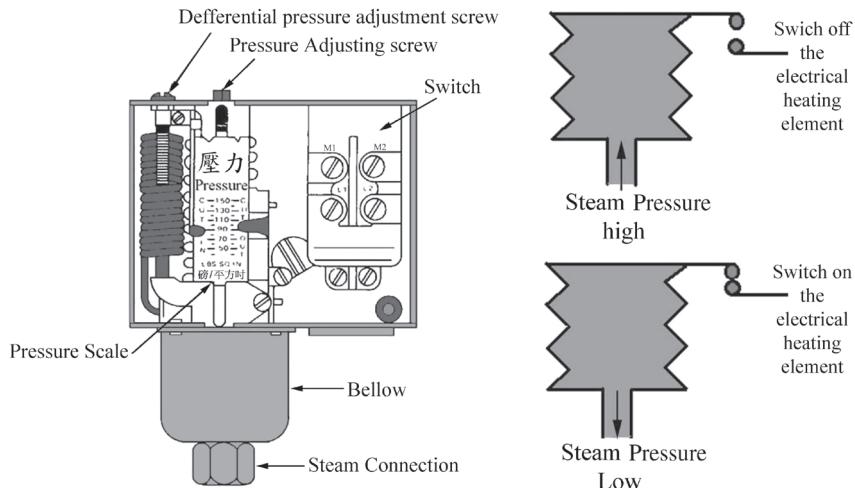
Boiler control regulates the boiler outlet conditions of steam flow, pressure, and temperature to the desired values. Electric steam boiler has two main control systems.

They are :-

- (a) steam pressure control; and
- (b) water level control.

2.3.1 STEAM PRESSURE CONTROL SYSTEM

This system maintains the steam pressure of the electric boiler within the desired boiler operating pressure. By energizing the heating elements, the steam pressure will build up until the upper-limit operational pressure is reached, and then electric power supply to the heating elements will be cut out or reduced. When the steam pressure drops below the lower limit, the heating elements will be re-energized to ensure the pressure works within the pre-determined limits. The pressure switch is a vital device to control the generation of the steam. It should also be calibrated at the time of periodic survey.

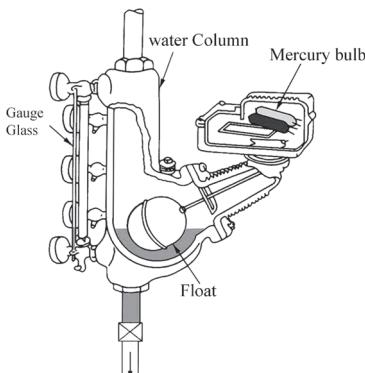


Pressure Switch for Steam Pressure Control

2.3.2

WATER LEVEL CONTROL SYSTEM

Most water level control of electric steam boilers is ON/OFF control which operate boiler feed pump for supplying water to the boiler. It maintains the level of water in the boiler between certain pre-determined limits. Normally the water level should be approximately half way up the sight glass. It starts to operate when the water level is below the lower limit and stops when the water level is above the upper limit.



CHAPTER THREE

3 OPERATION AND MAINTENANCE

The safety and reliability of boilers require proper attention not only while they are being designed, manufactured and erected, but also, while they are in service.

Modern electric steam boilers are capable of operating for long periods of service. Successful operation requires adherence to basic operating principles, and it requires that the boiler be maintained in proper operating condition by performance of necessary in-service and preventive maintenance.

Operation and maintenance manuals and instructions provided by the boiler manufacturer should be understood and strictly followed by all personnel involved.

Proper and adequate training including electrical safety, should be provided for the Competent Person, in particular for those medium to large size electrical steam boilers.

3.1 Start Up

3.1.1 PREPARATION FOR START UP

All preliminary operations for testing, cleaning and blowing steam lines of the boiler should be performed by experienced Competent Persons, working under the supervision of a Boiler Inspector or person authorized by the Authority. They should have the knowledge and experience to ensure the safe operation of boiler by correct adjustment of controls, interlocks and cutouts.

Every new boiler or any boiler that has undergone major repairs or alterations must be prepared for putting back into service through various steps, such as inspection, hydrostatic testing and safety valve setting and testing.

3.1.2 INSPECTION

An inspection of boiler and its auxiliary equipment has two purposes. It verifies the conditions of the boiler so that appropriate remedial action can be done if required. It familiarizes the Competent Person with equipment so that proper control on the operation of the boiler can be achieved.

3.1.3 START UP FROM COLD

The following procedures should be followed when starting an electric steam boiler from cold condition: -

- (a) Read and be fully conversant with the detailed operating instructions for the boiler and its auxiliaries;
- (b) Check the Certificate of Fitness for the boiler to ensure that it has not expired and that the approved maximum permissible working pressure is indicated on the pressure gauge by a red line;
- (c) Shut the steam outlet stop valve and the blowdown/drain valve;
- (d) Open the air vent;
- (e) Set the water level gauge valve/cock to the normal operating positions;
- (f) Feed water into the boiler as appropriate until the water level is just below the half-gauge level;

- (g) Visually check that the electricity supply is securely connected and there are no visual loose connections or exposed electric wires;
- (h) Switch on the main power supply and see that the source light on the boiler is lit;
- (i) Switch on heating element at low heating rate and see that the heating light is lit;
- (j) Heat the boiler to raise steam at a low rate. The Competent Person may choose to use a continuous heating method or an intermittent heating method depending on the design and the past operating experience of the boiler. Intermittent heating is safer but it takes a longer time to raise steam;
- (k) The boiler should be heated gradually to raise steam. After steam has been coming out from the air vent for 3-5 minutes, shut the air vent. This waiting period is to ensure that all air trapped inside the boiler has been driven out;
- (l) The boiler may be switched to high heating rate to bring the steam pressure up to the working pressure that must not exceed the maximum permissible working pressure;
- (m) Test the water level gauge to ensure that the gauge is in proper working order;
- (n) When the steam pressure has reached the working pressure, open the steam outlet stop valve gradually and cautiously. If hammering or any abnormal noise is heard along the steam pipeline, do not open the stop valve any further. Instead, the stop valve should be closed at ‘cracked open’ position (about 1/2 turn open) to warm the pipeline. If possible, the pipeline should be drained during this procedure. After warming the pipeline for a few minutes, the stop valve can be

- opened gradually and cautiously again until it is fully opened;
- (o) The steam outlet stop valve should be fully opened at all times during operation. Do not throttle the stop valve.

3.2 Over Maximum Permissible Working Pressure

Boiler steam pressure must never exceed the approved maximum permissible working pressure. If such a situation occurs, switch off the heating immediately. If the safety valve has failed to blow automatically, lift the safety valve by means of the easing gear, if fitted, to release the pressure inside the boiler. Shut off the steam outlet stop valve to prevent damage to the system by the excessive pressure.

In the situation where the safety valve fails to function automatically, the boiler shall not be brought back to service again unless: -

- (a) the defect causing excessive pressure in the boiler is identified and rectified;
- (b) the boiler shows no signs of leakage, structural damage or distortion;
- (c) the system has been thoroughly checked and found in satisfactory condition; and
- (d) the safety valve has been tested and reset correctly by a Boiler Inspector and a new Certificate of Fitness issued.

The safety valve is designed to prevent the boiler from operating above the approved maximum permissible working pressure. However the Competent Person must not rely solely on the safety valve but must observe the steam pressure continuously and take corrective action as necessary.

3.3 Low And Extra-Low Water Level

Whenever low water level or extra-low water level is observed, switch off the power supply to the boiler immediately. Shut the steam outlet stop valve and allow the boiler to cool. **DO NOT** immediately feed water into the boiler to restore water level. The cold water fed in may cause damage to the hot boiler or even an explosion. Never rely solely on the low water level alarm or the extra-low water level trip. Blow the water level gauge to confirm the water level. If the level observed was faulty and the true level is normal, bring the boiler back to operation carefully after rectification of false water level indication. Otherwise, the Competent Person shall shut down the boiler and inspect the boiler internally for any damage. Check the feed water system and repair as appropriate. Start up the boiler only after a satisfactory thorough examination of the boiler. If in doubt, seek professional advice from a Boiler Inspector and/or re-examine the boiler as necessary.

3.4 Power Failure

In case the power supply to an individual boiler fails, or electrical fault is suspected, the boiler must be shut down by switching off the electric power supply at main switch and locked off properly. A notice should be attached to the switch for warning others not to turn on the boiler.

A registered electrical worker should be called to trace the fault and repair the circuit. The Competent Person shall not, unless he is also a registered electrical worker, attempt to repair the electric circuit.

The physical danger from electric equipment would be an electric shock, electrocution, electrical flashover or electrical fire. These conditions could arise through carelessness, defective or worn out insulation, or excessively damp conditions.

3.5 Water Treatment

The Competent Person must use the recommended sampling system and test the boiler water quality according to the maker's instructions. The correct dosage of water treatment chemicals should be used as recommended by the boiler manufacturer or the supplier of the chemicals for the boiler water treatment.

The limits generally recommended for low-pressure boilers at the pressure range of 0 - 15 bar are: -

Alkalinity to Phenolphthalein (ppm CaCO ₃)	50-300
Chloride max. (ppm CaCO ₃)	300
Phosphate (ppm CaCO ₃)	30-70
Dissolved solids (ppm)	1,500

The person responsible for the boiler chemical treatment must exercise extreme care when handling chemicals for boiler water treatment since most of them are corrosive and/or toxic.

3.6 Shutdown

The following procedures should be followed in a normal shutdown operation: -

- (a) Switch off the heater and the main power supply;
- (b) Shut the steam outlet stop-valve;
- (c) Stop the feed water supply and shut off the feed water valves;
- (d) Let the boiler cool down slowly. The Competent Person should not drain all the hot water from inside the boiler or feed in cold water in order to accelerate cooling as undue thermal stress can be created;
- (e) When the boiler pressure has dropped down to about 20 kPa as indicated by the pressure gauge on cooling, take all safety precautions first, then open the air vent carefully. It will prevent vacuum being created when steam inside the boiler condenses;
- (f) The water remaining in the boiler may then be drained particularly if the boiler is to be laid up for a considerable long time, say one week or more. Care must be taken to discharge the hot water safely.

3.7 Preventive Maintenance

The maintenance of equipment in a condition to assure the capability of boiler to operate safely and remain in service in accordance with plans is known as “preventive maintenance”. Preventive maintenance includes a policy of operating a boiler within its designed range, maintaining it in a clean condition and performing the necessary repairs.

3.8 In-service Maintenance

The first emphasis is on safe operation, the avoidance of conditions that could result in electric hazard and the protection of pressure parts to prevent excessive thermal stresses or overheating, resulting in failure.

3.8.1 HEATING ELEMENT

Heating element must be cleaned and electrically secured to ensure efficiency and safety. The Competent Person should examine and clean the deposit on the heating element according to the maker's instruction. With the main power off, he should make sure that all wiring terminations are tightened to avoid arcing or overheating. Since any substitution of components or modification of wiring system may lead to dangerous operating conditions. Boiler manufacturer should be consulted prior to commencement of these works.

3.8.2 SAFETY VALVE

Safety valves are normally tested both for relieving and closing pressure. This requires the boiler pressure be raised until the valve opens and relieves sufficient pressure for the valve to close.

Safety valve seats are susceptible to damage caused by wet steam or grit. Cleaning of the boiler and steam lines before testing safety valves is necessary.

Testing of safety valves always requires special precaution. Safety valve exhaust piping and vent piping should not exert any excessive forces on the safety valve.

When a Boiler Inspector is carrying out an examination of a boiler, he must, by sealing the safety valve, ensure that the safety valve is so adjusted as to prevent the boiler from being operated at a pressure greater than the maximum permissible working pressure. The maximum permissible working pressure can be obtained from the Certificate of Fitness.

The seal attached to the safety valve should be maintained intact and the setting of the safety valve should not be altered by a person who is not a Boiler Inspector.

3.8.3 SCALE

Water contains different kinds of dissolved salts. Some salts form hard scale, which is in general due to the combined effects of heat, pressure and concentration of dissolved salts in boiler water. Hard scale formed on the boiler interior surfaces and the heating element surface will not only reduce the thermal efficiency but may also cause overheating of the heating element and choking of small diameter pipes/valves.

The Competent Person should cause the boiler to be shut down periodically for cleaning of the scale. The period should be in accordance with the boiler manufacturer's recommendation or after six months operation.

Scale formation can be minimized by adding chemicals into the feed water to turn the hard scale salt into non-adhering sludge. The sludge is subsequently blown out. However, chemical method may not be proved to be cost effective in small capacity electric steam boilers. The Competent Person must exercise extreme care when chemicals are handled since most of them are either corrosive or toxic. The instructions by the chemical manufacturer must be strictly followed and the safety requirements in the Factories and Industrial Undertakings (Dangerous Substances) Regulations in relation to the use and handling of chemicals in industrial undertakings must be complied with. The Competent Person should use appropriate types of chemical, in accordance with the boiler manufacturer's instruction.

3.8.4 CORROSION

Corrosion includes, for the purpose of this Code, rusting, localized pitting and erosion of metal parts of the boiler. Corrosion causes wastage of metal, which will weaken structural parts of the boiler rendering it liable to structural failure.

Removing scale is a good means to minimize corrosion. The Competent Person should take the opportunity of shutdown to inspect the boiler for any serious corrosion, especially localized corrosion, during scale removal.

The Competent Person should guard against leaky valves/pipes that drip water onto the boiler and cause corrosion. Leaky handhole is especially dangerous as it corrodes the shell rapidly. Handhole cover should be kept clean and tight.

When serious corrosion is observed, the Competent Person or the owner shall cause the boiler be inspected by a Boiler Inspector and seek professional advice for proper repairing method.

3.8.5 ACID CLEANING

Since all scales are soluble in acid, they can be removed by acid cleaning. As strong concentrations of acid solution could be proved extremely harmful to the boiler, acid cleaning should be done only under the direct supervision of a skilled consultant in the field. Industrial organizations specializing in boiler water treatment usually provide information and service for acid cleaning of boilers. Draining of the used acid shall be in accordance with the environmental rules as applicable.

However, the use of chemical cleaning is not allowed in some electric steam boiler. It may damage the sheath heating elements and electronic control devices. Therefore boiler manufacturer's instruction/manual should be referred to before the commencement of chemical cleaning process.

3.9 Periodic Examination

Every electric steam boiler must be opened for statutory periodic examination before expiry of the Certificate of Fitness. The boiler should be cleaned, defects should be rectified, steam pressure gauge should be re-calibrated. All valves should be stripped for inspection and overhauled. Safety valves, water level gauges, low water level alarm and other automatic control devices shall be tested in a test run in the presence of the Boiler Inspector prior to the issue of Certificate of Fitness. The Competent Person or the owner should organize the overhaul of the boiler for examination by the Boiler Inspector. The record of periodic examination is required to be kept by the boiler user.

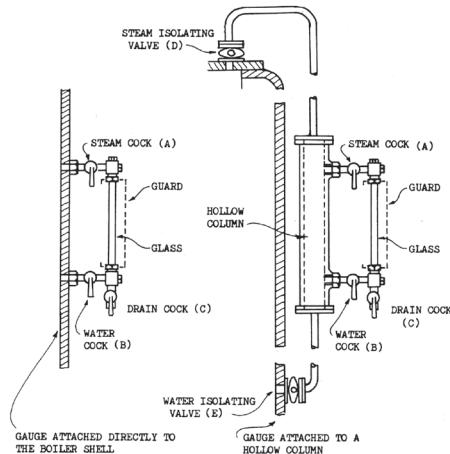
CHAPTER FOUR

4.1 Duties of The Competent Person

Boiler steam pressure must be maintained within close limits of the working pressure. For a manual boiler, the Competent Person switches on and off the heating elements at the high and low setting pressures. For an automatic boiler, the Competent Person should see that the heating is automatically switched ON or OFF at the prescribed pressures. In no case shall the maximum permissible working pressure be exceeded.

Boiler water level must be properly maintained. For a manual boiler, water is fed into the boiler from time to time to maintain the level at about half-gauge. Too high or too low a water level must be avoided. For an automatic boiler, the Competent Person shall see that water is being fed into the boiler automatically at prescribed levels. And he should ensure that a reliable water supply is maintained. The boiler must be shutdown in case of interruption in water supply.

Continuous observation of the water level gauge must be carried out whenever the boiler is in operation. It should be tested at least once in a watch.



4.2 Procedure of Testing a Water Level Gauge:

It is a very common design to have all the three cock handles pointing downwards while the water gauge is in operation.

- (a) close A and B.
- (b) open C, if the column of water inside the gauge drains out easily, C is not clogged.
- (c) open B slowly, if a blast of hot water is seen coming out from the drain pipe, B is not clogged. Close B.
- (d) open A slowly, if a blast of steam is seen, A is not clogged. Close A.

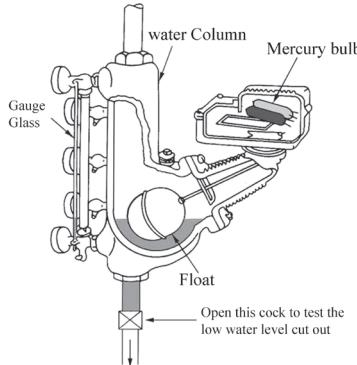
When any of the cocks is found to be clogged, shutdown the boiler and overhaul the water level gauge.

After confirming that all the cocks are not clogged, the water level gauge is brought back into service as follows:-

- (i) Close C and open B slowly, a full column of water should be seen otherwise the actual water level inside the boiler is below the level at B. If water cannot be seen, take action for a low water level emergency.
- (ii) With a full column of water in the gauge, open A slowly. An interface of steam and water should be seen coming down from the gauge top and settling down. This level of the interface is the actual water level inside the boiler. If the column remains full of water with A opened, the actual water level is above that at A. Check the feed water system, adjust the feed and carry out blow-down to bring the water level to about half gauge.

When a low water level alarm or, low water level cut-off is fitted, the Competent Person must never rely solely on these devices. It may be too late if the Competent Person takes action only when such alarm devices are activated. These devices should be tested periodically to ensure that they are functioning properly. This test can be done, while the boiler is operating and before it takes up the normal load, as follows:

- (a) switch off the feed water supply;
- (b) isolate the water level float chamber and open its drain to lower the water level inside it;
- (c) the alarm should operate the cut-off device to switch off the heating element;
- (d) if the devices do not work at the prescribed water level, the boiler must be shutdown;
- (e) the defective devices must be repaired, adjusted and tested before the boiler resumes service. In case of doubt, the manufacturer of boiler should be consulted;
- (f) if the devices work properly, the test is completed. Bring the float chamber to normal, switch on the feed water supply and reset the boiler to resume normal operation.



CHAPTER FIVE

5 FIRE PREVENTION AND FIRE FIGHTING EQUIPMENT

Electric steam boilers are susceptible to fire caused by electrical faults. The Competent Person and the owner of an electric steam boiler shall maintain electric parts of the boiler properly to avoid short-circuiting and overloading of electric circuits, which may result in a fire.

5.1 Fire Prevention

The old maxim ‘GOOD HOUSEKEEPING IS GOOD FIRE PREVENTION’ is always true. The rule of preventing fires lies in proper maintenance of boilers and its accessories and good house-keeping. To achieve these aims, the daily routine work of Competent Person must include the inspection of boiler, the rectification of defects and the removal of the common sources of fire. For electric steam boiler, the fire hazard may be due to accumulation of waste materials, and defective or faulty electrical devices.

5.2 Fire Fighting

In case of fire, the Competent Person should: -

- (a) Raise the alarm;
- (b) Switch off the main power supply to the electric boilers;
- (c) Call the Fire Services Department if necessary;
- (d) Restrict the air supply to the boiler room by closing windows and doors;

- (e) If situation permits, smother the fire using suitable fire extinguishers.

In the case of electrical fire or fire is in the close vicinity of electrical appliances, a fire extinguishing medium which is a non-conductor of electricity should be used, otherwise, the fire fighter may experience electric shock. Dry powder extinguishers and carbon dioxide (CO₂) extinguishers are suitable for combating electrical fire. All fuses, switches, etc. that can isolate the affected section from the source of electrical supply should be withdrawn or opened.

5.3 Fire Fighting Equipment

Two common types of portable fire extinguishers used in combating electrical fire are:

- (a) dry powder extinguishers; and
- (b) carbon dioxide extinguishers.

5.3.1 DRY POWDER FIRE EXTINGUISHERS

This type, sometimes called dry chemical, consists of a cylindrical container filled to a certain level with a free-flowing, non-toxic, non-conductive dry powder. The main constituent in general use is sodium bicarbonate (see Fig. 1). The expellant gas is stored in a cartridge (the gas is usually carbon dioxide). The nozzle is attached to the body of the extinguisher and is fitted with a shut-off control valve. Dry powder extinguishers have an effective range of 3.3m to 7m and discharge times from 8 to 30 seconds, according to the size of the extinguishers.

To operate the extinguisher, pull out the safety clip and strike the knob on top of the extinguisher. This cause a stainless steel piercer to puncture the CO₂ bottle seal, CO₂ then blows out the powder charge in the shape of a cloud.

5.3.2

CARBON DIOXIDE FIRE EXTINGUISHERS

This type of extinguisher (see Fig. 2) consists of a steel cylinder, filled with liquid carbon dioxide to approximately two-thirds of its capacity, and fitted with a sealing disc and piercing device or a valve. A special discharge horn is also fitted, which, on smaller models, is rigidly connected to the valve mechanism, and on larger sizes is connected by a flexible high-pressure hose. The horn is a distinctive feature and provides a means of directing the gas on the fire. CO₂, which is a colourless, odourless gas, is a non-supporter of combustion, and when inhaled in a large quantity leads to suffocation.

Portable models are available in various sizes, having capacities of 1 to 6 Kg of liquefied gas, and have an effective range of 1.3m to 3.3m depending on their capacities.

The operation of CO₂ fire extinguisher is similar to dry powder extinguisher.

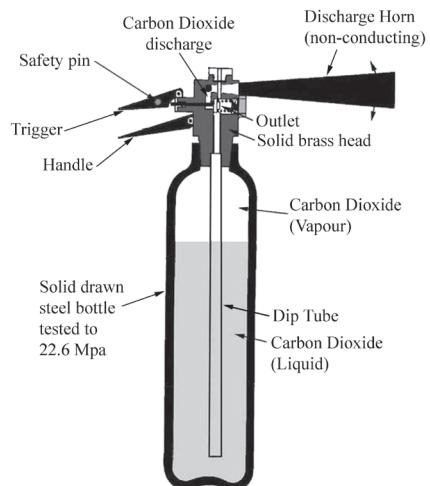
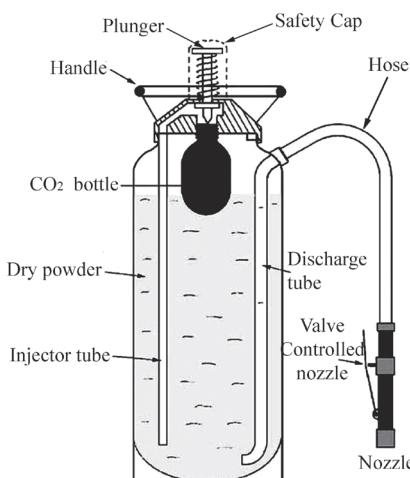


Fig.1 Dry Powder Fire Extinguisher

Fig.2 CO₂ Fire Extinguisher

5.4 Fire Drill

The Competent Person together with other staffs should conduct fire drills at least once every 3 months.

A record of fire drills with the dates, names and signatures of persons participating in the fire drill should be kept in the boiler room for inspection.

Written procedures for use in case of fire should be posted outside the entrance to the boiler room or other pertinent area as appropriate.

CHAPTER SIX

6 ACCIDENTS AND DEFECTS

It is obligatory on owner of a boiler to report to the Authority when: -

- (a) an accident occurs in or to the boiler or its auxiliary equipment; or
- (b) he is aware of any defect in the boiler or in its auxiliary equipment that is likely to cause danger to life or damage to property.

Accident means an explosion of a boiler or any damage or occurrence to or in a boiler that weakens the boiler and renders it liable to explode or collapse.

The owner must forthwith stop the use and operation of the boiler and shall, as soon as practicable and in any event within 24 hours, notify the Authority of the accident or defect, as the case may be, and, where applicable, shall, at the same time, send to the Authority the latest Certificate of Fitness issued in respect of the boiler.

Every such notice shall include the following particulars: -

- (a) the address or place at which the boiler is installed;
- (b) a general description of the boiler;
- (c) the purpose for which the boiler is or was used;

- (d) where applicable, the name and address of the Boiler Inspector who issued the latest Certificate of Fitness in respect of the boiler;
- (e) in the case of an accident in or to a boiler:-
 - (i) the number of persons killed or injured, if any;
 - (ii) details of the part thereof that failed and the extent of failure generally, if known; and
 - (iii) the pressure at which the same was being operated at the time of the accident; and
- (f) in the case of a defect in a boiler, details of the nature of the defect.

A safety valve with its seal broken, whatever is the cause, is considered a defect. Although such a defect does not create immediate danger, the owner must immediately arrange a Boiler Inspector to examine and re-seal the safety valve.

CHAPTER SEVEN

7 ELECTRICAL PRACTICE

7.1 Basic Knowledge

All matter is made up of minute particles called atoms. Atoms consist of various combinations of even smaller particles called protons, electrons and neutrons. Atoms of different substances differ only in the number and grouping of their particles.

Under the action of a force and with movement restricted path, such as along a wire, electrons will flow in a stream. The force which sets the electrons in motion outside the confines of their atoms is called the Electromotive Force (E.M.F.). This force causes a flow of electricity in a circuit. A difference of E.M.F. is called Potential Difference (P.D.). As long as a potential difference exists in a circuit, a current will flow through it. The current flows from high to low potential.

7.2 Basic Terms of Electricity

Electric Circuit:

A network of insulated conductors designed for the passage of electric current to perform a specified function.

Circuit Breaker:

Circuit Breaker is one form of device that provides ON/OFF function and automatic tripping of the electric circuit in the event of short circuit or circuit overload. The point at which the breaker trips depends on the rating of the circuit. The breaker can normally be reset to operate again after the fault has been cleared.

Fuse:

A conductor, usually in the form of a wire or a cartridge, of low melting point material placed in the electrical supply circuit and forms part of the circuit. It serves to protect the electric circuit from short-circuiting or overloading. It melts to interrupt the electricity supply because the excess current produces a large amount of heat. Unlike the circuit breaker, it must be replaced with a new unit after blowing.

Earth Line:

A conductor or wire that electrically connects the boiler metal casing with the earth terminal provided by the electricity supply company. This line plays a very vital role in the prevention of electric shock.

Electric Shock:

This is a phenomenon whereby the human body has become a path for electric current. The human body may suffer burns and heart difficulties, which can result in death.

7.3 Safety Precaution:

Never try to repair any faulty electric circuit. The repair should be carried out by a registered electrical worker only.

CHAPTER EIGHT

8 BASIC KNOWLEDGE OF HEAT TRANSFER

Heat transfer is the science which predicts the energy exchange that may take place between material bodies as a result of a temperature difference.

Apart from the change of form of heat energy, heat can be transferred from one substance to another by three basic methods. They are conduction, convection and radiation.

8.1 Conduction

In a solid body, one surface may be hot, while the other surface is cooler. The quantity of heat conducted through the body in a given time is directly increased by an increase in the difference of temperature between the hot and cooler surfaces. The heat exchange rate is proportionally reduced by an increase in the thickness of the solid, and also depends on the nature of the material involved.

8.2 Convection

In liquids and gases, if the moving particles differ in temperature or come into contact with a hot solid surface, then they transmit heat to each other by contact. This transmission of heat by the motion of the fluid or gas against a solid is known as convection heat transfer. When the motion is maintained by natural buoyancy arising from heating, it is described as natural or free convection. When the motion is produced by mechanical devices, such as pumps or fans it is known as forced convection.

8.3 Radiation

Heat energy can be exchanged without direct contact of particles. A hot body emits radiation over a wide range of wavelengths. The capacity of a body to absorb radiation is referred to as ‘black body’, a perfect black body having an emissivity of 1. A good absorber is also a good radiator.

In the electric boiler, electrical power is supplied to the heating element through which heat energy is conducted through a layer of boiler scale to the water. The temperature of water increases and subsequently steam is generated. Convection takes place within the water part.

Harmful scale accumulated around the heating element not only reduces the conducting surface, lowers the efficiency of the boiler but also overheats the element resulting failure of the boiler.



Occupational Safety and Health Branch
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