CODE OF PRACTICE FOR THE SAFE OPERATION OF THERMAL OIL HEATERS

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

Occupational Safety and Health Branch
Labour Department

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Occupational Safety and Health Branch
Labour Department

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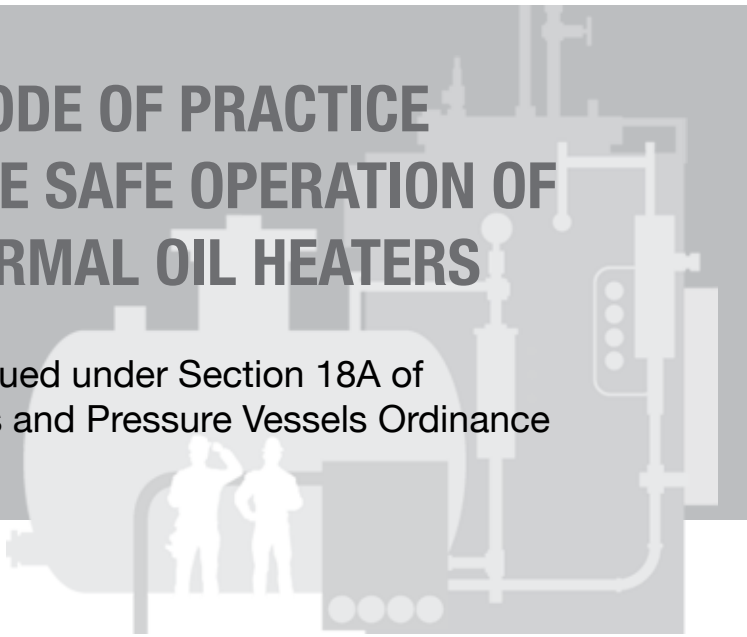

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INTRODUCTION

The Boilers and Pressure Vessels Ordinance, Chapter 56, sets out the provisions relating to the control in the use and operation of boilers and pressure vessels in Hong Kong. Boiler includes a vessel in which oil is heated at a pressure greater than atmospheric pressure and therefore covers thermal oil heaters.

This Code of Practice is issued by the Boilers and Pressure Vessels Authority under section 18A of the Ordinance for the purpose of providing guidance in order to ensure safe operation of thermal oil heaters.

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 thermal oil heaters 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 thermal oil heaters is by rigorous compliance of all manufacturer's instructions, relevant codes and standards for regulating design, fabrication and inspection of the thermal oil heaters and their auxiliary equipment.

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

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

The Commissioner for Labour has been appointed as the Boilers and Pressure Vessels Authority. The Authority has authorized the Principal Surveyor to perform and exercise some of the functions, duties or powers under the Ordinance.

Enquiry

If you wish to enquire about this Code of Practice or require advice on the regulation of boilers and pressure vessels, please contact the Boilers and Pressure Vessels Division of the Labour Department through:

Telephone : 3107 3458
Fax : 2517 6853
E-mail : enquiry@labour.gov.hk

Information on the services offered by the Labour Department and on major labour legislation is also available on our website at http://www.labour.gov.hk.

For details on the services offered by the Occupational Safety and Health Council, please call 2739 9000.

Complaints

If you have any complaint about unsafe workplaces and work practice, please call the Labour Department's occupational safety and health complaint hotline at 2542 2172. All complaints will be treated in the strictest confidence.

LIST OF APPLICABLE ORDINANCE AND REGULATIONS

(a) Boilers and Pressure Vessels Ordinance, Cap. 56

(b) Boilers and Pressure Vessels Regulations

(c) Boilers and Pressure Vessels (Forms) Order

(d) Boilers and Pressure Vessels (Exemption) (Consolidation) Order

CHAPTER 1

1. GENERAL

1.1 Purpose and Scope

The purpose of this Code of Practice is to promote the safe operation of thermal oil heaters.

This Code may also offer practical guidance for those responsible for the safety and direct supervision of thermal oil heaters.

The scope of the Code is limited to such basic information as is necessary for the safe operation of thermal oil heaters.

1.2 Interpretation

For the purpose 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 atmospheric pressure;

"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 the Boilers and Pressures 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.

CHAPTER 2

2. ESSENTIALS OF THERMAL OIL HEATER

2.1 General

Thermal oil heater is normally operated below the boiling point of thermal oil. The operating pressure is the pump pressure to circulate the thermal oil through the heater with sufficient flow to prevent overheating of thermal oil.

Thermal oil is a flammable substance which can produce flammable mist to induce fire and explosion hazards at high temperature. Control of the working temperature of thermal oil is important for the safe operation of thermal oil heaters.

The furnace for the fired thermal oil heater is the high risk space in which an explosive gas may accumulate when thermal oil or fuel oil is leaked into the furnace.

Thermal oil heaters have been involved in serious accidents abroad. This equipment should be operated with great care. The personnel engaged in operation and maintenance of these heaters should be fully conversant with correct operating procedures and safety devices as given in the manufacturer's manual. The essential devices for operation and safety of this equipment are given below.

2.2 Description of the Thermal Oil System

Thermal oil system is a heat carrier (thermal oil) heating plant comprised of thermal oil heater, circulating pump, heat consuming device, expansion tank, storage tank, de-aerator, piping and control panel.

Thermal oil heater is usually of the tube coil type, which can be vertical or horizontal. It can be heated electrically or fired by fuel to raise temperature of the thermal oil.

Thermal oil which circulates through the system is firstly raised to a temperature of about 300 degree C in the thermal oil heater. The heated oil then flows to the heat consuming devices to transfer heat energy for heating purposes. A temperature drop of approximately 40 degree C in the consuming devices is usually anticipated. After the heat has been absorbed, the thermal oil is returned to the thermal oil heater by means of a circulating pump.

An expansion tank is provided in the system to take up expansion of the thermal oil when it is heated. A de-aerator is sometimes installed for removing air in the system. A storage tank, having a capacity sufficient to contain all the oil in the system, is also installed. In case of any emergency or repairs, the entire contents in the system can be emptied into this storage tank.

2.3 Requirements of a Heat Carrier

The main requirements for an ideal heat carrier are:-

(a) high boiling point;
(b) low solidification temperature;
(c) good thermal stability;
(d) low viscosity;
(e) good heat transfer properties;
(f) low corrosion tendency; and
(g) non-toxic and odourless.

Commonly used thermal oils have the following significant advantages over water:-

(a) higher boiling point at atmospheric pressure;
(b) low tendency for corrosion or formation of scale;
(c) no need to carry out regular treatment; and
(d) no expansion during solidification.

The properties of a typical thermal oil are:-

Density at 200 ˚C	760 kg/m3
Specific Thermal Capacity	2.4 kJ/kgK
Flash Point	180 ˚C
Ignition Point	370 ˚C
Boiling Point	330 ˚C
Pour Point	-18 ˚C
Coefficient of Thermal Expansion	0.00076 / ˚C

2.4 Essential Fittings

2.4.1. Safety Valve

Its function is to prevent the thermal oil heater from operating at a pressure exceeding the maximum permissible working pressure. It should be connected directly to an independent oil outlet of the thermal oil heater and no valve should be placed in between. The safety valve should be vertically placed.

When an easing gear is fitted in order to lift the valve from its seat, it should be actuated once a day and the valve should be tested by oil pressure every week.

The discharge piping of a safety valve should be connected to the top of a closed vented expansion tank or storage tank. If a safety valve is installed on the circulation pump, then its discharge should connect to the suction of the pump.

2.4.2 High Thermal Oil Temperature Cutout Alarm

It is a temperature cutout switch which is used to safeguard the physical properties of the thermal oil and prevent the thermal oil heater from overheating. Overheating will lead to rapid deterioration of the thermal oil. If the temperature of the thermal oil has reached the setting value of the control thermostat, the fuel burner or electric heating element will be shut down automatically.

One method of testing the temperature cutout switch is to set the working temperature higher than the cutout temperature by changing the setting value of the control thermostat. The thermostat set value must be brought back to the normal value after the testing.

2.4.3 Thermal Oil Flow Limiter

It is in a form of differential pressure switch installed across the oil inlet and outlet of the thermal oil heater. If the flow of the oil is interrupted by any blockage found inside the oil pipe or by failure of the circulating pump, the fuel burner or electric heating element will be cut out.

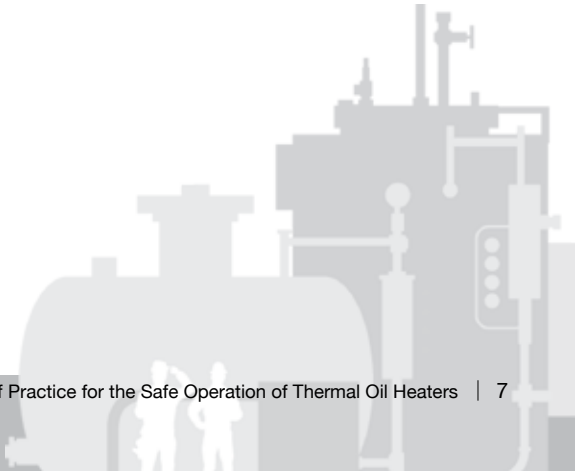
2.4.4 Low Oil Level Cutout in Expansion Tank

Any loss of thermal oil due to leakage can be indicated by this device which will shut off the fuel burner or electric heating element. The leakage is usually found on heater tubes, shaft seals of circulating pump, pipeline and flanges of the system. If the leakage from the fuel burner happens inside the furnace, explosion may occur.

2.4.5 Thermal Oil Heater Control

The main parameter controlling thermal oil heater is the working temperature. The role of the operating pressure, is not so prominent because any change of pressure will not affect the working temperature of the system. Furthermore the pressure in the system is basically the discharge pressure of the circulating pump only.

When the temperature of the oil inside the thermal oil heater has attained the upper temperature setting limit, the heat input will be stopped but the circulating pump would run continuously. When the temperature of the oil has attained the lower temperature setting limit, the fuel burner or electric heating element will again be actuated by the thermostat.



3. OPERATION AND MAINTENANCE

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

Modern thermal oil heaters are capable of operating for long periods of service. Successful operation requires adherence to basic operating principles, and it requires the thermal oil heater to be maintained in proper operating condition by performing the necessary in-service and preventive maintenance.

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

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

All record books or oil reports required by this Code should be kept by a responsible person for as long as practicable for reference, otherwise be kept for a continuous period of the recent 3 years or since registration and put to use.

3.1 Start Up

3.1.1 Preparation for Start Up

All preliminary operations for testing and cleaning of the thermal oil heater should be performed by experienced Competent Persons. They should have the knowledge and experience to ensure the safe operation of thermal oil heater by correct adjustment of controls, interlocks and cutouts.

Every new thermal oil heater or any thermal oil heater 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 thermal oil heater and its auxiliary equipment has two purposes. It verifies the conditions of the thermal oil heater so that appropriate remedial action can be done if required. It familiarizes the Competent Person with the equipment so that proper control on the operation of the thermal oil heater can be achieved.

3.1.3 Start Up from Cold

The following procedures are to be followed when starting a thermal oil heater from cold condition:-

(a) Read and be fully conversant with the detailed operating instruction for the thermal oil heater and its auxiliaries;

(b) Check the Certificate of Fitness for the thermal oil heater to ensure that it does not expire; be aware that the approved maximum permissible working pressure is indicated on the pressure gauge by a red line; and know the maximum permissible working temperature;

(c) Check the thermal oil heater and its associated equipment to ensure that they are in normal working condition;

(d) For fired thermal oil heater, check if the fuel system including fuel tank, pipeline and valves are in order, and clean all fuel filters;

(e) Clean all the thermal oil filters;

(f) Check if the thermal oil level at the expansion tank is normal and all the pipelines are securely connected with no visual loose connection or leakage;

(g) Check if the boiler room is clean and well ventilated;

(h) Check for the availability and condition of fire extinguishing equipment;

(i) Visually check that the electricity supply is securely connected and there are no visual loose connections or exposed electric wires;

(j) Switch on the main supply and ensure that the source light is lit;

(k) Start the circulating pump to get the thermal oil flowing through the thermal oil system;

(l) For electric thermal oil heater, switch on the electric heating element.

(m) For fired thermal oil heater, before the fuel discharged from the burner is ignited, the furnace must be thoroughly purged in order to expel any explosive mixture accumulated inside the furnace. The purging process must be repeated for each time the firing sequence is commenced;

(n) Adjust the set temperature from low to the desired value incrementally according to the manufacturer's recommendation.

3.2 Observation during Operation

The following observations should be made and monitored constantly when operating a thermal oil heater:-

(a) pressure, temperature and flow rate of the thermal oil;

(b) thermal oil level in the expansion tank;

(c) combustion condition inside the furnace (for fired thermal oil heater), and the proper operation of the electric heating element (for electric thermal oil heater);

(d) noise and water hammer found in the pipeline due to the presence of water in the thermal oil system;

(e) the temperature difference between outlet and inlet of the thermal oil heater;

(f) any leakage found at pipelines, level gauge, flanges and shaft seals of the circulating pump; and

(g) the running condition of the circulating pump.

3.3 Operation Data

The following readings should be recorded at regular intervals:-

(a) inlet and outlet oil temperature of thermal oil heater;

(b) thermal oil pressure of the circulating pump and the thermal oil heater;

(c) thermal oil flow rate;

(d) thermal oil level in expansion tank;

(e) thermal oil differential pressure between inlet and outlet of strainer;

(f) flue gas temperature (for fired thermal oil heater); and

(g) outlet coolant temperature of circulating pump.

3.4 General Precautions when Operating a Thermal Oil Heater

The operator should observe the following precautions when operating a thermal oil heater:-

(a) Do not break the safety valve seal or try to adjust the setting of the safety valve.

(b) Do not try to adjust the setting of the safety devices such as high temperature cutout, fluid low flow cutout, expansion tank low level cutout.

(c) Do not operate the thermal oil system on over-pressure or over-temperature.

(d) No modification shall be made to a thermal oil heater unless prior approval is sought from the manufacturer and the Authority.

(e) All automatic safety devices should be tested periodically as stipulated in the manufacturer's instruction to ensure that they are in good working condition at all times.

(f) Thermal oil heaters and their auxiliary equipment should be properly maintained at all times. Major overhauls should be carried out by a reputable engineering firm under the supervision of a Boiler Inspector.

3.5 Precautions to be observed on shutting down a Thermal Oil Heater

The operator should observe the following precautions when shutting down a thermal oil heater:-

(a) After switching off the fuel to the fuel burner or the electricity supply to the electric heating element, the circulating pump must be allowed to operate for a period of at least 15 minutes or the time recommended by the manufacturer in order to avoid the thermal oil from being overheated by the residual heat energy stored in the furnace or other heat source.

(b) The coolant supplied to the circulating pump, if any, should not be interrupted until the temperature of the pump has been lowered to the extent as stipulated by the manufacturer.

(c) It is also recommended to close the fuel valve, if any, and secure the electricity supply to the thermal oil heater if the thermal oil system is intended to be closed down for a long period.

3.6 Routine Maintenance

Improper maintenance of a thermal oil heater could result in fire or explosion hazards. In order to maintain the proper functioning of a thermal oil heater, the following points are to be observed:-

3.6.1 Thermal oil samples should be taken from the system preferably in the presence of a Boiler Inspector, and be sent for laboratory analysis to confirm its serviceability during initial and each periodic examination. The thermal oil specification and analysis reports should be kept in a secure file for ready reference. Periodic examination will develop a degradation trend of the thermal oil through which it will assist to determine the replacement schedule of thermal oil. Thermal oil degradation is one of the main safety issues with thermal oil heaters as it causes the following problems:

(a) Formation of a carbon layer on the internal surface of the thermal oil heating coil which will reduce the heat transfer rate and cause overheating of coil;

(b) Reducing the flashpoint of the thermal oil which may form the flammable vapour under the normal working temperature;

(c) Damage to the circulation pumps by the hard carbon particles generate by the degradation of thermal oil; and

(d) Clogging of filters which reducing flow and impairing heat transfer efficiency.

3.6.2 A thermal oil record book should be properly maintained by a responsible person indicating the record of any transfers of oil with date.

3.6.3 Thorough examination should be made of the thermal oil heater and its auxiliary equipment and its associated safety devices at regular intervals.

3.6.4 The following safety devices should be tested in the presence of a Boiler Inspector prior to the renewal of Certificate of Fitness:-

(a) safety valve setting;

(b) thermal oil low flow cutout/alarm;

(c) maximum permissible temperature cutout/alarm;

(d) circulating pump and fuel burner/electric heating element interlocks;

(e) thermal oil expansion tank low level cutout/alarm;

(f) flame failure cutout/alarm; and

(g) flue gas high temperature cutout/alarm.

3.6.5 All maintenance and general repairs carried out on a thermal oil heater should be recorded. These record books should be kept by a responsible person for as long as practicable for reference, otherwise be kept for a continuous period of the recent 3 years or since registration and put to use.

3.6.6 All modifications, extensive repairs and repairs involved with pressure parts, other than those involved with parts replacement, carried out on a thermal oil heater should be recorded and reported. These record books and reports should be kept by a responsible person for as long as practicable since the equipment was registered and put to use.

3.7 Common Faults in Operating Thermal Oil Heater

3.7.1 Overpressure

Causes:-

(a) blockage in pipeline;

(b) accidental shut off of circuit valves; and

(c) mal-function of circulating pump relief valve.

Remedies:-

(a) check the pipeline and valves; and

(b) check the relief valve.

3.7.2 Low Thermal Oil Flow Rate

Causes:-

(a) dirty filters;

(b) deterioration of pump performance; and

(c) accidental shut off of circuit valves.

Remedies:-

(a) clean filters;

(b) check the pump speed, motor current and pump coolant; and

(c) check the circuit valves.

3.7.3 High Thermal Oil Temperature

Causes:-

(a) lmalfunction of temperature controller;

(b) low flow rate of thermal oil; and

(c) wrong calibration of temperature controller.

Remedies:-

(a) check temperature controller and calibrate it with an accurate thermometer; and

(b) check the circulating pump.

3.7.4 Low Oil Level in Expansion Tank

Causes:-

(a) malfunction of level controller; and

(b) leakage in the thermal oil system.

Remedies:-

(a) check the level controller; and

(b) check for any leakage of the whole thermal oil system.

3.7.5 Abnormal Differential Thermal Oil Temperature

Causes:-

(a) It is mainly due to low thermal oil flow rate.

Remedies:-

(a) Refer to Section 3.7.2 of this Chapter on 'Low thermal oil flow rate'.

3.7.6 Abnormal Noise and Vibration

Causes:-

(a) gas or air found in the thermal oil system;
(b) deteriorated thermal oil; and
(c) water found in the thermal oil system.

Remedies:-

(a) check the de-aerator and drain water in the expansion tank;
(b) check the air vent; and
(c) check the shaft seal of the circulating pump.

3.7.7 Further Points to be Noted

(a) When the thermal oil heater has been shut down whether due to abnormal condition or not, the circulating pump must be kept running for a period of at least 15 minutes or the time recommended by the manufacturer, whichever is longer. All the defects must be rectified before attempting to re-start the thermal oil heater.

(b) Before commencing any major repair work on the pressure parts of the thermal oil heater, advice must be sought from a Boiler Inspector or from the Authority.

(c) It is emphasized that the system must not be emptied while the temperature of the heat carrier is still at a high level because flammable atmosphere may build up within the cavities and pipeline. Any subsequent hot work may lead to a hazardous situation – risk of explosion.

(d) When the temperature of the thermal oil has been lowered, a particular section of the system can be isolated and drained entirely and then thoroughly rinsed in order to prevent formation of flammable mixtures. Inert gas may also be filled into the concerned section during the whole course of hot work.

4. SAFETY REQUIREMENTS IN OPERATION AND MAINTENANCE

(a) Thermal oil heaters must be fitted with an expansion tank of sufficient capacity. The expansion tank should be provided with appropriate level indicator so that its level can easily be read and monitored.

(b) Thermal oil heaters and their auxiliary equipment are usually to be located in a boiler room.

(c) Drip trays must be installed under the components of the installation where leakage is likely to occur, i.e. pump unit, valves, filters etc. These drip trays should be emptied to a sludge tank at regular intervals.

(d) The inlet and outlet valves of the thermal oil heaters should be controllable from outside of the compartment where they are situated.

(e) Flanges are not permitted to be covered by insulation materials.

(f) Details of physical and chemical properties of the thermal oil should be provided by the oil manufacturer.

(g) The highest working temperature must not be exceeded during operation.

(h) Air vents to fuel or thermal oil tanks should be fitted with flame arresters of fine mesh. They must be kept clear, especially from paint, to ensure effective venting.

(i) Caution tallies, in Chinese and in English, should be displayed in conspicuous locations near the thermal oil heater, reminding the operator to “PURGE COMBUSTION SPACE PRIOR TO LIGHTING UP A BURNER” for fired thermal oil heaters, and “IF ANY THERMAL OIL LOSS IS OBSERVED FROM THE EXPANSION TANK OR THE SYSTEM, THE THERMAL OIL HEATER SHOULD BE SHUT DOWN IMMEDIATELY FOR A THOROUGH LEAKAGE CHECK”.

(j) Thermal oil heaters must be used strictly in accordance with the manufacturer’s operational guide in order to avoid deterioration of the thermal oil.

(k) Used thermal oil should be properly disposed for the sake of environmental protection. Owners should consult the Environmental Protection Department for proper disposal of used thermal oil.

5. FIRE PRECAUTIONS, FIRE FIGHTING AND EQUIPMENT

5.1 Fire Hazard

(a) Liquid fuels evaporate at rates varying with the temperature. The more volatile fuels are those which give off vapour more readily at lower temperatures. With appropriate quantities of air, these vapours can form mixtures which will flash or explode if ignited. If ignition takes place inside a compartment, there will be an explosion with destructive results. The destructive ability of vapour mixtures can exceed that of many solid explosives; a cupful of gasoline has the potential explosive power of 2.26 kg (5 lb) of dynamite.

(b) Fire hazards are more likely in thermal oil heaters than that in other kinds of boiler since thermal oil is also flammable. When the thermal oil is in contact with fire, it fuels the fire.

(c) Fire causes the thermal oil to undergo 'thermal cracking' where molecular chains of the thermal oil break off forming toxic bituminous and gaseous substances. Its flash point lowers as a result of the cracking.

(d) The working temperature of the thermal oil usually exceeds its flash point and is only marginally below its auto-ignition temperature. Despite the assurance given by the oil suppliers that it is normal for the oil's working temperature to be higher than its flash point and auto-ignition point, the potential hazard in this type of heater should never be ignored.

(e) When thermal oil leaks out from the system to the atmosphere due to failure of flange joints or tube-coil, the possibility of auto-ignition exists. In the extreme case, an explosion can occur if thermal oil leaks into the combustion chamber of the thermal oil heater or into a poorly ventilated boiler room.

(f) There are many factors which contribute to the failure of tube-coils in fired thermal oil heaters, e.g. severe scale deposit formed by the combustion gas surrounding the external parts of the coils and poor design giving uneven distribution of heat to the coils. In addition, inherent manufacturing defects and high thermal stress due to a rapid cold start may also cause the tube failure.

5.2 Precautions

5.2.1 Precautions relating to the storage of liquid fuel generally aim at achieving:-

(a) The elimination of either liquid or vapour accumulations outside the oil fuel tank or pipe system in use.

(b) The exclusion of all sources of ignition from the neighbourhood of any position where vapour-air mixtures may exist.

5.2.2 Air vent pipes to oil fuel tanks should be fitted with flame arresters consisting of double wire gauze of fine mesh. They must be kept clean, especially from paint, to allow them to fulfil their purpose.

5.2.3 In the boiler room, no oil should be allowed to accumulate in the air boxes, furnace bottoms, or on the boiler room floor. If leakage from the oil fuel system to the boiler room occurs at any time, the oil supply to that part of the system should be shut off immediately. Drip trays should be placed under all fittings from which liquid fuel may spill when the fitting is opened. “Save-alls” should be frequently examined for the presence of oil.

5.2.4 A box filled with sand should be kept in a readily accessible place in the boiler room to facilitate the extinguishing of any fire.

5.2.5 Oily waste can ignite without any external application of heat (such as from a flame or spark), this is called spontaneous ignition. Oil waste should therefore be kept in a metal receptacle partially filled with water to prevent spontaneous ignition. The waste should be disposed of, as soon as possible.

5.2.6 In general, the best safeguard against fire is a proper attitude towards cleanliness, the disposal of flammable refuse in all its forms, and an intelligent regard for possible danger. Many explosions have occurred when operating thermal oil heaters merely because of lack of care and knowledge of potential danger.

5.3 Fire Fighting

5.3.1 In case of a fire, the Competent Person should:-

(a) Raise the alarm;

(b) Switch off the main power supply;

(c) Shut off the fuel supply to the fuel burner (for fired thermal oil heater);

(d) Call the Fire Services Department if necessary;

(e) Restrict the air supply to the boiler room by closing windows and doors;

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

5.3.2 Oil fire – If water is used in fighting an oil fire, it should be sprayed on the oil using a special spray nozzle. Water has the effect of lowering the temperature of the oil below its fire point, and the fire will therefore go out. However, care should be taken not to allow too much water to accumulate, as oil being lighter than water will float on top of the water, and may cause what started as a small local fire to expand a large general one. Foam is a better fire extinguishing agent to use in the case of oil fires and is normally provided in each boiler room. Foam floats on the surface of the oil and acts as a blanket thereby starving the fire of the oxygen necessary for combustion. Dry sand may be used as a means of confining the oil fire to a small area, thus preventing the oil fire from spreading. The oil fuel supply to the burners should be shut off, and for this purpose, a master shut-off valve is usually fitted in the oil fuel supply line and located outside the boiler room.

5.3.3 Electrical fire – In the case of electrical fire or fire 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 (CO_2) 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.

5.4 Fire Fighting Equipment

Some common types of portable fire extinguishers used in combating oil and electrical fire are described in the following paragraphs.

5.4.1 Foam Fire Extinguisher

A chemical foam extinguisher consists of a main body, which contains sodium bicarbonate solution, and a sealed inner body within which contains aluminium sulphate solution.

After a plunger is rotated to release the sealing cap of inner body, the fire extinguisher is turned upside down to mix the two solutions. Chemical reaction produces carbon dioxide to push out foam.

A mechanical foam extinguisher consists of a main body which contains water, a middle body within which contains foam solution, and an inner body which contains pressurized carbon dioxide. After a plunger is pressed to release the carbon dioxide, the foam solution mixes with water and is forced out of the fire extinguisher.

Foam is emitted to a distance from 6 m (20 ft) to 9.1 m (30 ft). Once started the discharging, the extinguisher will be empty. The foam should be directed to fall upon the fire or by deflecting it from another surface.

Foam extinguishers are suitable for oil fires. They should not be used in fires involving electrical equipment as electric shock, which can result in death, might be experienced.

5.4.2 Dry Powder Fire Extinguisher

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. The expellant gas is stored in a cartridge (the gas is usually carbon dioxide). The nozzle is attached to the body of the fire extinguisher and is fitted with a shut-off control valve. Dry powder extinguishers have an effective range of 3.3 m to 7 m and discharge times from 8 seconds to 30 seconds, according to the size of the fire extinguishers.

To operate the fire extinguisher, pull out the safety clip and strike the knob on top of the fire extinguisher. This causes a stainless steel piercer to puncture the carbon dioxide bottle seal. Then, carbon dioxide blows out the powder charge in the shape of a cloud.

5.4.3 Carbon Dioxide Fire Extinguisher

This type of fire extinguisher consists of a steel cylinder, filled with liquidified carbon dioxide to approximately two-third of its capacity, and fitted with a sealing disc and a piercing device or a valve. A special discharge horn is also fitted, which, on smaller models, is rigidly connected to the outlet 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 carbon dioxide gas on the fire. Carbon dioxide is a colourless, odourlessand non-combustible gas that can cause suffocation when the gas is inhaled in a large quantity.

Portable models are available in various sizes, having capacities 1 kg to 6 kg of liquefied gas, and have an effective range of 1.3 m to 3.3 m depending on their capacities. The operation of carbon dioxide fire extinguisher is similar to dry powder fire extinguisher.

5.5 Fire Drill

The Competent Person together with other staff should conduct fire drill at least once every 3 months

A record book 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 fighting the fire should be posted outside the entrance to the boiler room or other pertinent area as appropriate.

6. ACCIDENTS AND DEFECTS

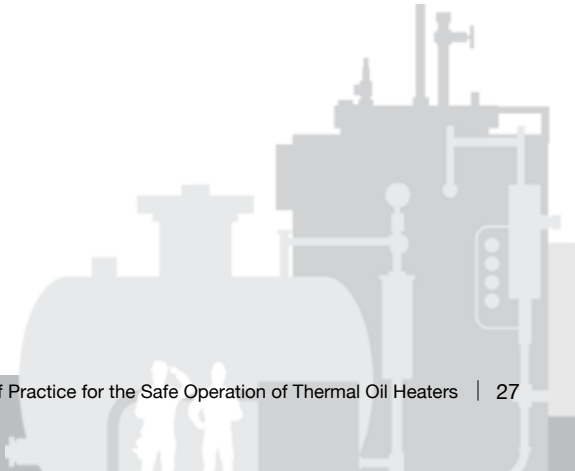
It is obligatory on the owner of a thermal oil heater to report to the Authority when:-

(a) an accident occurs in or to the thermal oil heater or its auxiliary equipment; or

(b) the owner is aware of any defect in the thermal oil heater or in its auxiliary equipment that is likely to cause danger to life or damage to property.

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

The owner must forthwith stop the use and operation of the thermal oil heater 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 thermal oil heater.



Every such notice shall include the following particulars:-

(a) the address or place at which the thermal oil heater is installed;

(b) a general description of the thermal oil heater;

(c) the purpose for which the thermal oil heater is or was used;

(d) where applicable, the name of the Boiler Inspector who issued the latest Certificate of Fitness in respect of the thermal oil heater;

(e) in the case of an accident in or to a thermal oil heater:-

- the number of persons killed or injured, if any;
- details of the part thereof that failed and the extent of failure generally, if known;
- the pressure and the thermal oil temperature at which the same was being operated at the time of the accident; and
- in the case of a defect in a thermal oil heater, 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.

7. BASIC KNOWLEDGE OF ELECTRICITY

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 breaker trip 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 thermal oil heater's 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.

8. FIRED THERMAL OIL HEATER

The construction and operation of fired thermal oil heater is similar to electric thermal oil heater except the means of heating. Fired thermal oil heater burns fuel to produce heat for raising the temperature of thermal oil. Electric thermal oil heater utilizes electric heating element for the same purpose. Fired thermal oil heater has some specific fittings, operating faults, fire hazard due to its combustion process.

8.1 Essential Fittings

In addition to all the essential fittings listed in Section 2.4, the following fittings are also applicable for the fired thermal oil heaters:

8.1.1 Flue Gas Temperature Limiter

It is installed to safeguard against thermal overload of the thermal oil heater that utilize liquid or gaseous fuel as the heating medium. It also indicates leakage of thermal fluid into the combustion chamber, if any, since the burning of thermal oil will form soot which will foul the heating surface thus producing higher flue gas temperatures. In the event of high flue gas temperature, flue gas temperature limiter will shut off the fuel supply to stop the operation of the thermal oil heater.

8.1.2 Flame Detector

When flame failure occurs in a fired thermal oil heater, a flame detector will sense the loss of fire and actuate the cutout device to shut off the fuel supply to the burner in order to avoid any accumulation of flammable gas inside the furnace.

Functional tests of the flame detector should be carried out daily and recorded. By withdrawing the sensor from the socket and covering it to simulate a flame failure, fuel supply should be shut off automatically and immediately.

8.2 Common Faults in Operating Fired Thermal Oil Heater

In addition to all the common faults listed in Section 3.7, the following faults are also applicable for the fired thermal oil heaters.

8.2.1 Fuel Burner Misfire

Causes:-

(a) blocked filters and/or water in fuel;
(b) defective fuel pump;
(c) malfunction of fuel burner; and
(d) defective flame detector.

Remedies:-

(a) clean all filters and drain all the water from the fuel system; and
(b) check the fuel system and flame detector.

8.2.2 High Flue Gas Temperature

Causes:-

(a) leakage of thermal oil into the fuel system;
(b) fouling of combustion chamber and uptake;
(c) incorrect air/fuel ratio; and
(d) blockage of air filter.

Remedies:-

(a) clean the furnace and uptake;
(b) adjust the air/fuel ratio;
(c) clean the air filter; and
(d) check for any damage on the coil tube.

8.3 Uptake Fire

Soot and unburnt carbon can deposit on the walls of the thermal oil heater uptake (chimney). They form, in effect, another fuel and can catch fire in the uptake. Although uptake fires do not often occur, they can be very difficult to extinguish and the hazard builds up quietly and usually undetected. The fire is caused by smouldering of the deposits accumulated in the uptake. It usually occurs during thermal oil heater shutdown or under light load condition. There is evidence that under normal loads the flue gas "cools" the soot and the carbon deposits so that a smouldering fire does not occur. In the absence of flue gas or if the flue gas flow is insufficient to cool the deposits, they can catch fire.

When an uptake fire occurs, it results in very high exhaust temperatures and excessive thick black smoke, mixed with sparks, coming out of the uptake. The fuel burner must be shut down immediately and the blower switched off or the damper closed to stop any air supply to the uptake. The Fire Services Department must be called. If the uptake is common for several thermal oil heaters, all the heaters must be shut down. The key point is to stop the fuel burner air supply. No attempt should be made to extinguish the fire by water unless the water supply is plentiful. The fire should be allowed to die out. The fire must be contained by restricting and removing any combustibles in the near vicinity.

To prevent an uptake fire, the operator must clean the uptake periodically to eliminate accumulation of soot and unburnt carbon. He should also exercise care in the daily operation of the fuel burner and maintains the correct air/fuel ratio to ensure complete combustion of fuel and minimizes production of soot or unburnt carbon.

8.4 Basic Knowledge of Combustion

Liquid fuel (e.g. diesel oil) and gaseous fuel are hydrocarbon fuels containing molecules made up of carbon and hydrogen atoms. Hydrocarbon molecules can be written as CmHn where m and n are integer variables indicating the number of carbon atoms and hydrogen atoms building up the molecule respectively. Both carbon atoms and hydrogen atoms can react with oxygen chemically under high temperature. This chemical process is more commonly known as burning or combustion. Some impurities exist in the fuel and also undergo chemical changes during combustion. Harmful products may be produced depending on the type of impurities e.g. sulphur can form acidic oxide. However, impurities usually occupy a very minor part in the fuel. Careful operation can minimize or even eliminate the effect of harmful impurity products.

Hydrocarbon molecules combine with oxygen at high temperature to form carbon dioxide and water. At the same time a large amount of heat is generated. Part of this heat energy is in turn used to maintain the high temperature favourable for the combustion (chemical process) of the fuel, while most of this heat is extracted for use. In our subject of discussion on fired thermal oil heaters, bulk of the heat generated is used to raise temperature of the thermal oil. Chemical equation:-

$$C_m H_n + (m+n/4)O_2 = mCO_2 + (n/2)H_2O + HEAT$$

Air contains about 20 % by volume of oxygen. It is a cheap and convenient source of oxygen for combustion. From the chemical equation, it can be seen that a certain minimum amount of oxygen, or air, is required for a particular hydrocarbon fuel to burn completely. Insufficient air supply causes poor combustion producing sooty smoke, less heat, carbon monoxide, etc. Taking into consideration air/fuel mixing efficiency and to ensure complete combustion, excess air is required. For most fired thermal oil heaters, 20 - 50 % excess air is usually arranged.

Excessive air will, however, lower the efficiency of the fuel burner, cause flame instability and create undesirably high flue gas temperatures. The correct amount of air depends on the fuel as m and n vary with the type or supply of fuel. The operator should consult the fuel supplier and the fuel burner appliance manufacturer for the optimal air/fuel ratio. The operator should adjust the air blower damper mechanism as necessary to establish an optimal flame. An optimal flame is a stable flame (i.e. the shape of the flame is stable) with a near colourless exhaust.

The fuel burner injects gas or atomizes oil fuel which mixes with the air from the blower. Turbulence produced by the air draught thoroughly mixes the fuel particles and air producing plenty of reacting contact surfaces between the hydrocarbon molecules and oxygen molecules. If a flame exists, the heat will cause the chemical process described above to occur and sustains the flame. If there is no flame but an ignition spark is produced, the high temperature spark (2000 ˚C or above) starts the combustion process and creates a flame. The combustion process is self-sustaining and the flame continues as long as there is fuel and sufficient air being supplied and mixed at the correct ratio.

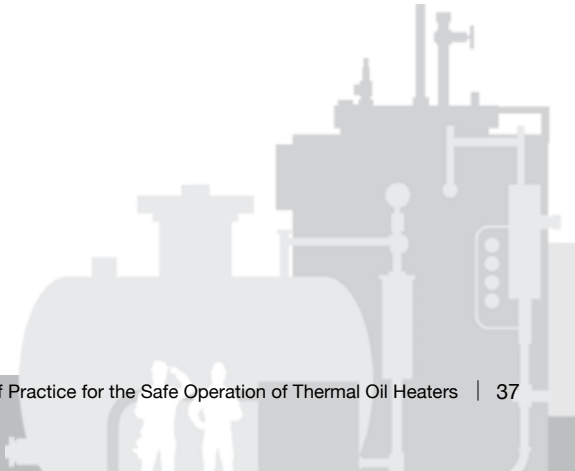
Diesel oil vaporizes even at room temperature. The vapour is similar, in its effect, to gaseous fuel and is combustible. After a flame has been extinguished or a fired thermal oil heater has been shut down, residual diesel oil, if any, would then vaporize and enters into the furnace and mixes with the air inside. This mixture is flammable and extremely dangerous. If any hot source/spot is present it may set off a very rapid combustion with a large amount of heat released in an extremely short time or, more exactly, an explosion can occur.

A spark for ignition purpose would be hot enough to cause such an explosion. This can happen if the operator tries to ignite a flame inside the furnace to start the thermal oil heater without knowing that there is an explosive mixture present. The spark can ignite the explosive mixture before igniting the fuel/air mixture to make the flame. A similar phenomenon applies in the case of gaseous fuel.

The operator must take every precaution to eliminate accumulation of the explosive mixture. The rule is to purge the furnace every time before attempting to ignite a flame and to purge the furnace after extinguishing a flame. Never try to ignite a flame using the heat of the furnace. Under such circumstance, a large amount of fuel is injected into the furnace giving a very good opportunity for an explosive mixture to build up and to explode subsequently.

During ignition, the jet of fine fuel particles as atomized by the fuel burner at high pressure or injected through gas nozzle mixes with air. This is a flammable mixture but got ignited and burnt before accumulating to large. However, if it fails to ignite a flame after several sparking, a considerable volume of flammable mixture, which is explosive, may have created. The operator should not insist on attempting to ignite a flame. He should shut off the fuel supply and purge the furnace thoroughly to remove any explosive mixture which might have been created. He should check and eliminate any fault in the burning system. Most automatic combustion control fitted for automatic fired thermal oil heaters will carry out the above practice, except examining the system, automatically. Nevertheless, the operator should make himself aware of the consequence and should never be complacent. In case of failure of automatic device, the system shall be changed over to manual control where the operator has to exercise the above practice.

PURGING THE FURNACE BEFORE IGNITION!



Labour Department
Occupational Safety and Health Branch

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