

Code of practice for

Oil firing —

**Part 3: Installations for furnaces, kilns,
ovens and other industrial purposes —**

**(formerly part of CP 3002-1, CP 3002-2
and CP 3002-3)**

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Associated Offices Technical Committee	Greater London Council
Association of Shell Boilermakers	Health and Safety Executive
British Tar Industry Association	Home Office
Chief and Assistant Chief Fire Officers' Association	Industrial Warm Air Heater Manufacturers' Association
Domestic Oil Burning Equipment Testing Association	Institute of Fire Engineers
Engineering Industries Association	Oil Companies Materials Association
Fire Offices Committee	Process Plant Association
Fire Protection Association	Individual experts

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Foreword

The application of oil firing to furnaces, kilns, ovens and other similar plants requires many important decisions to be made at an early stage of planning.

It is desirable that there should be recommended minimum requirements so that equipment manufacturers, suppliers, installers and users may have a common basis on which to work.

While the code is intended to give guidance on current good practice, the requirements of Local Authorities, Fire Authorities and Insurance Companies must be ascertained. In applying the recommendations in this code it will become apparent that other authorities may need to be consulted.

The code was originally published as CP 3002 “Oil firing” in three Parts according to the types of fuel burnt as follows:

- *Part 1: 1961 Installations burning Class D fuel oil and C.T.F. 50;*
- *Part 2: 1964 Installations burning Class C and Class D fuel oils for vaporizing burners;*
- *Part 3: 1965 Installations burning pre-heated fuels. Class E, F and G fuel oils and C.T.F. 100 to 250.*

For the present revision the committee considered it preferable to divide the code into Parts according to the type and purpose of the oil firing installation as follows:

- *Part 1: Installations up to 44 kW output capacity for space heating and hot water supply purposes;*
- *Part 2: Installations of 44 kW and above output capacity for space heating, hot water and steam supply purposes;*
- *Part 3: Installations for furnaces, kilns, ovens and other industrial purposes.*

Because of this re-arrangement it is intended to defer the withdrawal of CP 3002-1, CP 3002-2 and CP 3002-3 until all three Parts of this revision have been published.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 44, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

1 Scope

This Part of BS 5410 deals with oil burning equipment for industrial installations such as furnaces, kilns and ovens. Recommendations are given for the selection, application and installation of burners, tanks, piping systems, accommodation, chimneys, electrical and control equipment. Recommendations are given also for commissioning, maintenance, change of fuel and essential safety requirements.

This code applies to the oil burning equipment forming part of a multifuel installation in which oil is not burnt simultaneously with any other fuel. This code does not apply to prime movers, multifuel burner installations, marine and mobile installations.

2 References

The titles of the publications referred to in this code are listed on the inside back cover.

3 Definitions

For the purpose of this Part of BS 5410 the following definitions relating to furnaces apply.

NOTE The term "furnaces" includes ovens, kilns, etc.

3.1

batch (or intermittent) furnace

a furnace in which the heating cycle is completed on one "batch" (or charge) of material, e.g. the material being raised to the required temperature and in some cases allowed to cool before removal from the furnace. Heat recovery is not necessarily adopted with this type of furnace

3.2

continuous furnace

a furnace in which the heating cycle is simultaneously maintained through the furnace, e.g. a continuous flow of material is heated and in some cases cooled whilst passing through the furnace. Heat recovery is usually integral with this type of furnace

3.3

moving fire furnace

a furnace in which the material is heated on a batch basis and the combustion zone is moved in a circular patch around the furnace. Heat recovery is integral with this type of furnace

3.4 direct fired furnace

One of the following two types (3.4.1 and 3.4.2).

3.4.1

open flame furnace

a furnace in which there is no barrier interposed between the burning fuel and the material being heated. The material is subject to direct heat transfer from the flame and from the products of combustion

3.4.2

semi-muffle furnace

a furnace in which the material being heated is not subjected to direct heat transfer from the flame

3.5

indirect fired furnace (muffle furnace or radiant tube furnace)

a furnace in which the material being heated is not subject to direct heat transfer from the flame and is also protected from contact with the products of combustion throughout the heating cycle

3.6

low temperature furnace

a furnace in which the fuel is burnt in surroundings which are below the spontaneous ignition temperature of the fuel/air mixture that is produced by the fuel firing equipment

3.7

high temperature furnace

a furnace in which the fuel is burnt in surroundings which are above the spontaneous ignition temperature of the fuel/air mixture that is produced by the fuel firing equipment

Section 2. Liquid fuels

4 Types of petroleum oil fuels

Liquid fuels are commercially available in the United Kingdom in various grades, comprising distillate fuels and residual grades, and blends thereof manufactured to comply with the specifications contained in BS 2869. The specifications which are relevant to this code of practice can be found in Table 2 of BS 2869:1970 and extracts are given here in Table 1.

5 Typical petroleum oil fuel characteristics

The approximate design data for petroleum oil fuels available in the United Kingdom are given in Table 2.

Table 1 — Specification data for petroleum oil fuels as given in BS 2869:1970

(as amended by AMD 972, June 1972 and AMD 1532, August 1974, AMD 2253, March 1977, AMD 2478, February 1978, AMD 3230, April 1980 and AMD 3549, November 1980)

Property		BS 2869 class					
		C2	D	E	F	G	H
Kinematic viscosity at 37.8 °C, cSt	min.	1.0	1.6				
	max.	2.0	6.0	—	—	—	—
Kinematic viscosity at 80 °C, cSt	max.	—	—	13.5	35.0	85.0	130
Carbon residue Ramsbottom, % by mass on 10 % residue	max	—	0.2	—	—	—	—
Flash point (Abel), °C	min.	38	—	—	—	—	—
Flash point (Pensky-Martens), °C	min.	—	55	66	66	66	66
Water content, % vol.	max.	Free from visible water	0.05	0.5	0.75	1.0	1.0
Sediment, % mass	max.	Free from visible sediment	0.01	0.15	0.25	0.25	0.25
Ash, % mass	max.	—	0.01	0.1	0.15	0.2	0.2
Sulphur, % mass	max.	0.2	0.5	3.5	4.0	4.5	5.0

Table 2 — Typical characteristics of petroleum oil fuels available in the United Kingdom

Property	BS 2869 class					
	C2	D	E	F	G	H
Specific gravity (relative density) 15 °/15 °C	0.79	0.83	0.94	0.95	0.97	0.98
Gross calorific value, MJ/kg	46.6	45.5	43.1	42.7	42.2	41.8
Mean specific heat kJ/(kg K)	2.09	2.05	1.92	1.90	1.88	1.87
NOTE For other characteristics including kinematic viscosity, users are advised to obtain from their fuel suppliers typical values for the grades of fuel currently available.						

Table 3 — Minimum storage, outflow and handling temperatures

	BS 2869 class					
	C	D	E	F	G	H
Minimum temperature in tank, °C	Atmospheric	Atmospheric	10	25	40	45
Minimum temperature for outflow from tank and for handling, °C	Atmospheric	Atmospheric	10	30	50	55

6 Storage and handling temperatures for petroleum oil fuels

Fuels of classes E to H require storage and handling plant equipped with heating facilities. The minimum recommended temperatures which may be expected to give satisfactory results with all fuels of the given class are given in Table 3.

7 Types of coal tar fuels

Coal tar fuels are available in the United Kingdom, comprising distillate fuels and residual grades, manufactured to comply with the specifications contained in BS 1469. The specifications which are relevant to this code of practice can be found in Tables 1 and 2 of BS 1469:1962 and extracts converted to SI units are given in Table 4.

Table 4 — Specification data for coal tar fuels

Property	BS 1469 class			
	C.T.F. 50	C.T.F. 100	C.T.F. 200	C.T.F. 250
Kinematic viscosity, cSt, at temperatures shown	13 at 37.8 °C	24 at 37.8 °C	24 at 93 °C	24 at 121 °C
Liquidity	Completely liquid at 0 °C	Completely liquid at 32 °C	—	—
Flash point (Pensky-Martens closed cup), °C min.	65	65	65	65
Gross calorific value, MJ/kg	38.5	38.5	37.6	37.2
Ash content, % by mass, max.	0.05	0.05	0.25	0.3
Sulphur content, % by mass	1 approx.	1 approx.	1 approx.	1 max.

Table 5 — Typical characteristics for coal tar fuels available in the United Kingdom

Property	BS 1469 class			
	C.T.F. 50	C.T.F. 100	C.T.F. 200	C.T.F. 250
Specific gravity (relative density) at 15 °C	1.016	1.047	1.145	1.178
Gross calorific value, MJ/kg	39.6	39.2	38.5	38.3
Mean specific heat, kJ/(kg K)	1.68	1.68	1.68	1.68
Sulphur content, % by mass	0.5	0.5	0.65	0.65

8 Typical coal tar fuel characteristics

The typical characteristics for coal tar fuel available in the United Kingdom are given in Table 5.

For use in oil burners, the following grades of petroleum fuels and coal tar fuels respectively may be regarded as approximately equivalent.

Petroleum fuels	Coal tar fuels
Class D	C.T.F. 50
Class E	C.T.F. 100
Class F	C.T.F. 200
Class G	C.T.F. 250

In general, where petroleum fuels are referred to in this code, the text applies also to the equivalent coal tar fuel as indicated above. It should be noted that petroleum fuels have to be regarded as being incompatible. In making any change from one to the other, advice should be sought from the fuel supplier and the manufacturer of the burner.

Section 3. Selection and application of oil burners

9 General

The overall supervision of the application of oil burning equipment should be effected by a competent combustion engineer who has obtained a detailed knowledge of the process.

10 Choice of grade of fuel

10.1 General. This clause 10 is intended to provide guidance on the technical factors that should be taken into account when considering the grade of oil fuel or C.T.F. that may be used.

10.2 Minimum heat input rate. The minimum rate at which complete combustion can be achieved increases as the viscosity of the fuel increases.

The actual minimum rate is dependent upon the amount of heat lost from the flame particularly at the flame root and therefore the hotter the environment in which the fuel is burnt, the lower can be the firing rate.

As a guide in this respect, the usual minimum heat input rate for grades heavier than class D or C.T.F. 50 in a cool environment, such as a low temperature furnace, is about 70 kW per burner.

Where the temperature of the environment will gradually be increased, such as occurs with a batch type furnace, the minimum heat input may be about 35 kW per burner for grades heavier than class D or C.T.F. 50.

It is usually not practicable to achieve heat input rates of less than 10 kW with an atomizing burner.

10.3 Heat release rates. When the volume of the combustion zone is such that the maximum heat release rate exceeds 5 000 kW/m³, oil fuels heavier than class D or C.T.F. 50 will require very special combustion equipment.

Class D or C.T.F. 50 fuels will be more suitable where very low heat release rates are required in order to minimize the effects of loss of heat from the flame before combustion is completed (flame chilling).

10.4 Configuration of combustion chamber.

The configuration of the space available as the combustion zone may influence the choice of oil or C.T.F. grade. This is particularly relevant in respect of flame length.

Generally classes C and D fuels, being more readily vaporized and burnt, give a shorter flame than do the classes E, F and G fuels under equivalent conditions. In this respect, the choice of burner type is generally of major significance.

In many types of high temperature furnace the nominal combustion chamber is in fact a preliminary combustion chamber as combustion of the oil fuel is completed beyond the confines of the nominal combustion chamber.

In those cases where it is proposed to use classes E, F or G fuels, great care is necessary to match the configuration of the preliminary combustion chamber with the flame shape produced by the chosen burner type.

With classes C and D fuels, a little more tolerance is permissible but here again it is essential that gross flame impingement on the surroundings of the preliminary combustion chamber is avoided.

10.5 Environmental considerations. There are several environmental factors to be considered which may have a bearing on the choice of grade of fuel, mainly in respect of sulphur content, some of which are noted below.

- a) Location of furnace within factory.
- b) General ventilation
- c) Furnace pressure where process inevitably causes combustion gases to pass into working area.
- d) Furnace atmosphere required for process.

There may well be other factors applying to individual situations that have to be investigated, including external environmental considerations.

10.6 Waste gas handling system. The method by which the products of combustion are handled may influence the choice of fuel. To minimize possible corrosion, caused by acidic condensate, consideration should be given to the acid dew point of the waste gases. The acid dew point is influenced by the sulphur content of the fuel. With excess air values between 5 % and 50 % and sulphur content in excess of 1 %, acid dew point temperatures of about 150 °C can be expected.

Draught available at burner positions will sometimes affect the choice of fuel as well as the choice of burner. A high draught, thus enabling a well designed air register to be used, may permit in turn the use of a heavier grade of fuel.

10.7 Heat input variation (turn-down ratio).

The most suitable grade of oil may be dictated by the variation of heat input (and thus of burner turn-down ratio) required by the process. If, for example, a process requires a single burner to operate high/low/off where the ratio of high/low heat inputs is say 2 to 1 and the high rate is 100 litres/h, then a fuel of class E, F or G may well be suitable. On the other hand, if the ratio has to be in excess of say 6 to 1, then it may well be better to use a class D fuel (for the same high rate of 100 litres/h).

10.8 Supervision and maintenance. The extent of supervision and maintenance whether this be minimal or otherwise can influence the choice of fuel grade since it is generally recognized that systems using the lighter grades of fuel require less supervision and maintenance than those using the heavier grades of fuel.

10.9 Fuel characteristics. Some industrial processes, where products of combustion are in direct contact with the material being heated, may require a fuel free of certain constituents, sulphur and ash being usually the most significant.

Local legislation relating to chimney emissions and permissible chimney heights may also influence the choice of fuel.

11 Selection and application of burner types

11.1 General. Having decided upon the most suitable grade of fuel to be used, the choice of burner type can be made from the groups of burners generally available. A description of each of these groups is given in BS 799-2 to BS 799-4. A well judged compromise has to be made from the factors given in 11.2 to 11.10 together with other factors such as first cost, rate of energy consumption, physical size of equipment and maintenance requirements.

11.2 Maximum and minimum heat input requirements. A very careful assessment should be made of the maximum and minimum heat input requirements to determine the "turn-down" capability required of the combustion equipment.

Where the turn-down required is very great, and beyond the capacity of a single burner, the use of multiburners should be considered.

The minimum firing rate required of a single burner may be the deciding factor in the choice of burner type, e.g. for firing rates less than 30 kW, the medium pressure air atomizing burner is generally preferable.

11.3 Heat release rates (heat release rate per unit volume). The volume of the space in which combustion is to be effected is an important factor. Heat release rates less than 300 kW/m^3 , i.e. small flames in large spaces, and heat release rates in excess of $3\,500 \text{ kW/m}^3$, both require special attention. The rate of heat release depends on the energy used for the combustion system; the larger the heat release rate the larger has to be the pressure energy supplied by the combustion air.

11.4 Type and shape of flame. The design of the burner results in flames of widely differing character, and, in considering the application, the most suitable flame is of crucial importance. For example, a slow burning, long, luminous flame may be desirable, or at least acceptable; the burner could then be relatively simple, cheap and use little air energy. At the other extreme, a very short, small flame, or indeed no visible flame, may be required, in which case the burner will be more complex, more costly and use more air energy.

It should not be overlooked that oil burning equipment can be obtained that will produce special flames such as flat, fish-tail or saucer shaped; these flames may be more suitable in certain circumstances.

The process may require a non-luminous flame or one having a high velocity. These flames may be needed under conditions where either oxidizing or reducing conditions are a process requirement.

A burner designed to produce particular flame characteristics at full firing rate may not be capable of continuing to maintain these conditions at the low firing rate.

If preheated combustion air is used, the combustion temperature will be higher than with cold air. The nearer to the stoichiometric rate at which the burner operates, the higher will be the combustion temperature.

Generally, and within reasonable limits, the more excess air that is supplied, the shorter will be the flame. Care is necessary regarding the method of introducing such excess air into the combustion zone when the amount is greater than 50 % of the stoichiometric quantity. In such cases, the excess air should not be introduced through the burner assembly but at a point away from the burner assembly.

11.5 Configuration of the combustion zone.

The size and proportions of the combustion zone relative to the firing rate and the combustion conditions will largely determine the number of burners to be used and the flame characteristics they should produce.

The provision of deep quarls to support combustion at low rates, or baffle walls to help reduce length, are expedients that may be considered in cases where the configuration of the combustion zone requires it.

11.6 Process considerations. In some processes it may be considered that a simple robust plant requiring little maintenance is preferable. Other processes requiring close control may need sophisticated equipment. Careful examination of the process requirements is important in order that the correct type of burner should be chosen.

11.7 Combustion air source. Combustion air may be introduced into the combustion zone by any of the following methods:

- a) induction by the natural draught of the chimney;
- b) induction by an induced draught fan;
- c) induction by draught created by a venturi system;
- d) blown in by a forced draught fan;
- e) various combinations of a), b), c) or d).

According to the individual arrangements, all or some of the combustion air may be passed through the burner(s).

The size of the flues and waste gas passages has to be large enough to enable the burners to work efficiently at their maximum rating, with due allowance being made for the accumulation of dirt and other obstructions. The forced or induced draught system has to be capable of providing all the combustion air needed to burn the oil fuel at the maximum rating of the burner(s) together with any excess air or dilution air necessary for the process.

The oil supply should be shut off if the combustion air supply fails. Any fault condition that results in inadequate air supply should cause an alarm to be activated and/or the oil supply to be shut off (see clause 50).

Where the air is drawn direct from the atmosphere, or where the air has been preheated to a temperature not exceeding 150°C , it may be passed through the body of the burner, e.g. as with low air pressure atomizing type burners. Where combustion air is preheated to temperatures in excess of 150°C , it should be introduced in such a way that overheating of the oil fuel will not occur as it passes through the atomizer.

Care is necessary in designing the combustion air flow regulation system to take into account any specific volume variation that can occur with varying air preheat temperature particularly for cold starting conditions.

In siting forced draught combustion air fans, care should be exercised to ensure that as far as possible the air intakes will draw clean fresh air. Provision should be made to ensure that

- a) flash steam from steam traps or drains;
- b) waste gases or vented combustible gases from plant;
- c) fuel gas control systems;
- d) entrained combustibles, e.g. paint spray, timber dust

should not be entrained into combustion air fan intakes. In dusty environments consideration may be given to the fitting of fan air intake filters. Account should be taken of the restriction to air flow which will progressively increase with use. Where air filters are fitted, it is essential that the air flow is monitored.

If the combustion air could possibly be dust laden, as may occur for example with stone dryers or calciners, then a type of burner should be selected that is not vulnerable to internal dust deposition.

Where some of the combustion air is supplied from a compressor, i.e. for atomizing with medium or high pressure air type atomizers, it should be reasonably free from lubricating oil and water. Adequate facilities should be provided in the air supply system for this purpose, which should be regularly maintained. (See also clause 78.)

11.8 Pressure in the combustion zone. To ensure efficient combustion of the oil fuel, the pressure within the combustion zone should be considered.

The pressure to be chosen is influenced by:

- a) the design of the combustion zone;
- b) the process requirements;
- c) the method used for the disposal of the waste gases.

When the combustion zone will be under a positive pressure, the design of the combustion air system should take this into account.

Local overheating of the burner and the burner quarl due to the discharge of products of combustion at the burner can be caused by the positive pressure in the combustion zone. If a positive pressure persists after the burner has been shut down, means should be provided to protect the burner assembly against overheating.

Operation of combustion chambers with relatively high positive pressures in excess of 250 mbar¹⁾ will accelerate the mixing rate of the oil fuel and the combustion air compared with that at atmospheric pressure. Consideration should therefore be given to the effect of the increase in the intensity of combustion under these conditions.

Where the combustion zone will be under a negative pressure the possible effects on burner performance and on the design of the combustion system should be considered.

11.9 Positioning of burners. The location of the burner is governed by the combustion requirements and flame shape needed within the combustion zone. Account should be taken where the burners are to be mounted to fire vertically upwards, vertically downwards, horizontally or in intermediate positions. When the firing position has been decided, it is then necessary to ensure that each burner is accessible externally for control and maintenance. In positioning several burners to fire into one combustion zone, care should be taken to avoid mutual interference of their flames unless this is required for heat transfer reasons.

The burner should be capable of being securely mounted in its correct firing position with provision for easy removal for cleaning, maintenance and replacement. Connections for oil and air should be simple to disconnect and reconnect when using the appropriate tool.

Ideally, for easy control and maintenance, the burner should be located so that it is accessible from floor level. If this is impracticable, then either working platforms should be provided at the proper height or the burner should be capable of being withdrawn to a space where maintenance can be more readily performed.

Where working platforms are provided above normal floor level, their construction should take account of, and provide protection against, any hazard that may arise for persons on the platform or underneath it, e.g. danger from hot gases discharged from furnace doors or openings rising through open mesh platform floors, from spillage of oil or from dropping of tools or other items or materials through open mesh floors.

11.10 Noise level. It is generally desirable to assess the likely noise level that will result from the proposed burner assembly, including any associated fans, compressors, oil pumps, etc.

¹⁾ 1 mbar = 10² N/m² = 100 Pa.

The noise resulting from the combustion process is not readily predictable; generally the greater the energy imparted to the air and the oil, the greater will be the noise produced by the combustion process.

To achieve a low noise level, the following procedures should be considered.

- a) The furnace should be mounted on a solid foundation. Any oil firing equipment, such as fans, which can cause vibration should be mounted to avoid the transmission of noise and vibration.
- b) Furnaces with metal casings should have a non-combustible insulating lining in the space between the casing and the inner furnace.
- c) All flue connections on the furnace and the chimney should be correctly jointed and carefully sealed.
- d) To prevent transmission of vibrations between the furnace and the oil burning equipment, direct contact should be avoided. Where equipment has to pass into the furnace, heat-resistant packing should be fitted to provide an adequate seal. Unit burners directly mounted on the furnace should have suitable heat-resistant gaskets fitted between the burner plate and the furnace casing, and the mounting bolts should be properly insulated against vibration.
- e) To achieve very low noise levels in the vicinity of the furnace it may be necessary to provide sound-absorbent casings around burners and other noise sources such as fans.
- f) Burner equipment incorporating electromagnetic features should be prevented from creating magnetic hum.

12 Control of burners

12.1 Burner firing rate control. The control of the quantity of oil fuel throughput to air blast atomizing, steam atomizing and rotary cup burners is effected by purpose designed metering valves in which the controlling orifice is of a form not easily blocked.

Oil fuel throughputs to pressure jet atomizing burners are controlled by the size of atomizer fitted and the oil fuel pressure; the turn-down ratio with this arrangement is limited to about 2 to 1, but regulation may be effected by means of spill return systems (see 11.1 of BS 799-4:1972) which will increase the turn-down capability.

Regulation of metering valves may be by hand or by automatic actuator (see section 8) signalled by a process sensing device. Movement of automatically operating metering valves may be effected by modulating control between the upper and lower operating capacities of the burner or by two-position high/low control over a similar range.

It is essential that automatic on/off control is not effected by metering valve movement but by separate automatic shut-off valve.

Where multiple burners are used they may be jointly regulated by manual or automatic control of oil ring main pressure. Each burner, unless of the pressure jet type, should be provided with a metering valve or metering orifice in order to give the facility to balance individual burner outputs.

With any form of automatic or manual control system, regardless of the type of burner, it is essential to provide the oil fuel at a steady pressure and, if preheated, at a uniform temperature.

Steady oil pressures are achieved by correct sizing of pressure regulating valves and ring main pipework (see 11.2). Pressure regulating valves should be located as close as is practicable, after the last burner take-off on multiburner installations. Pumping units should be sized to circulate between one and a half to three times the maximum burning rate to be drawn from the ring main. It is desirable that each ring main has its own pump.

For fuels requiring heating, uniform oil fuel ring main temperatures are achieved by means of a correctly sized line heater or outflow heater fitted with control and limit thermostats. Oil temperatures in the ring main are maintained by thermal insulation and by correctly rated and installed independently controlled pipe tracing to compensate for the heat losses. Correct pump sizing (as described above) is also a factor in achieving uniform oil fuel ring main temperatures.

It is desirable and in some cases it is essential that the combustion air supply to the burner is regulated with the oil flow. In the smaller units, the oil fuel and air regulating valves may be operated by linkage from a single actuator.

Where separate actuators are employed for fuel and air, care has to be taken to ensure that fuel-rich conditions cannot occur as a result of varying opening or closing rates of the fuel and air regulators.

12.2 Starting up, shutting down and flame monitoring control.

(See also clause 2 of BS 799-3:1970 and clauses 3, 4 and 5 of BS 799-4:1972.) The starting up and shutting down of an oil burner may be under hand control, partly automatic control or fully automatic control. With hand control and partly automatic control the flame may or may not be monitored. When flame monitoring is employed with hand or partly automatic systems, it may be effected after the flame has been established. Alternatively, it may be arranged to additionally monitor the flame during the ignition period thereby enabling control of the time in which unburnt fuel is emitted from the burner if ignition is not achieved. Fully automatic systems, by definition, always provide flame monitoring of both ignition and running periods.

The method of control used for starting up and shutting down the burner, and the need for flame monitoring control are determined by the type of process as defined in clause 3. For example, low temperature and batch processes should generally be provided with fully automatic controls. Where a large number of burners is involved and adequate supervision is available, manual control with flame monitoring of the ignition and running periods is acceptable. Where flame monitoring is not practicable, continuous supervision during the ignition and running periods is essential and a high standard of maintainance of the combustion equipment is required.

For high temperature continuous processes, such as tunnel kilns and continuous metallurgical furnaces where burners fire into permanently high temperature zones and continuous supervision is provided, a hand controlled system, without flame monitoring, is normally acceptable.

When starting up this type of furnace, it is desirable to monitor the flame(s) until a safe temperature (normally about 750 °C) is achieved, when the flame monitoring device may be withdrawn.

Where flame monitors are to be used, great care should be exercised in the selection of the type of unit and in the siting and location of the flame detector on the furnace. It should be noted that air cooling of the flame detector head may be required under high temperature conditions. Burner and control manufacturers should always be consulted.

When shutting down low temperature furnaces, it is advisable to provide a purge period to ensure adequate ventilation and removal of unburnt fuel.

When shutting down furnaces that are at high temperatures, care should be exercised to prevent excessive air infiltration to avoid spalling refractory brick work. Nevertheless, sufficient air should be allowed to pass through the furnace to ensure complete combustion of any fuel that may be introduced after shut-down.

The effects of back radiation from hot refractory brick and charge should be taken into account and, if necessary, provision made for withdrawing the burners and plugging the burner openings.

Manual isolating fuel valves (see clause 77) have to be provided and kept shut when the furnace is not in use; similarly, individual burners have to be manually isolated when not in use. This requirement also applies to pilot gas and electric supplies.

12.3 Temperature and pressure control. The process sensing devices used to provide the signal for automatic control of firing rate will in many cases require the combined knowledge of the furnace designer, the instrument engineer and the oil burner manufacturer to produce a suitable system which will take into account the following factors.

- a) The scale range of the instrument.
- b) The type of sensing element, e.g. bimetal stem, vapour pressure bulb, mercury-in-steel bulb, thermocouple, diaphragm, Bourdon tube, etc.
- c) Location of sensing element.
- d) Length of sensitive portion and inactive portion of stems or bulbs.
- e) Length of capillary between bulb and controller for filled systems.
- f) Material of sensing device to suit temperature, pressure and furnace atmosphere.
- g) The requirements of pockets or sheaths in respect of resistance to damage, e.g. from furnace atmospheres, charge material and temperature conditions.
- h) Type of controller most suited to the process, such as high/low, on/off or modulating.
- i) Type of signal required, e.g. electrical or pneumatic to suit the valve actuator to be used.
- j) Requirement for temperature indicating and/or recording devices to be included in the system.
- k) Requirement for manual override.

13 Refractory lining and insulation of combustion chamber

The combustion chamber is usually an enclosure that maintains an environment suitable for the combustion of fuel. It may be formed from or lined with refractory material. Alternatively, it may be an air, gas or liquid cooled metal enclosure. Whatever its type, it is essential that account is taken of items a) to h).

- a) Excessive heat transfer from the burning fuel to the enclosure arising from, for example, maloperation of the oil burning equipment.
- b) Possibility of flame impingement caused by maloperation of the oil burning equipment.
- c) Sulphur or ash content of the fuel. In some cases, it is necessary to take account of the possible dust entrainment in the combustion air.
- d) Thermal shock that can occur through sudden chilling where large quantities of cold air or cold material are introduced into a hot combustion chamber.
- e) Corrosive vapours or liquids arising from the material being heated.
- f) Required direction of the products of combustion.
- g) The "cold face" temperature requirements. Where the cold face is the outer casing of the furnace, the overall conductivity of the materials should ensure that the external surface temperature is limited so as to:
 - 1) minimize heat loss;
 - 2) avoid danger and discomfort to personnel;
 - 3) avoid damage to ancillary equipment.
- h) The method used for applying the lining should take account of the intended pressure conditions in the combustion zone.

The burner manufacturer's advice should be sought on the design and correct installation of the burner quarl. The function of the quarl is to stabilize the flame, assist in shaping the flame and assist in promoting the mixing of the air with the fuel.

14 Combustion and safety controls

14.1 General. To ensure its safe working, oil burning equipment is fitted with protective devices, described below, which should be in accordance with the requirements of BS 799-3 and BS 799-4.

14.2 Flame monitoring. The most suitable form of flame monitoring is generally by some type of photoelectric system. Such systems can be obtained to operate on the visible light band, at the ultraviolet end or at the infra-red end of the spectrum. Flame sensors should be so positioned as to be sensitive only to the main oil burner flame and insensitive to any other condition.

As photoelectric devices are temperature-sensitive, if overheating is possible, air or water cooling has to be provided.

Spurious signals have to be prevented. These can be electrically induced or promoted by vibration.

In some instances, as an alternative to monitoring the main oil flame, the pilot flame may be monitored.

The pilot flame may be provided by gas in which case flame safeguard devices should be fitted to gas pilots where the release of unignited gas could cause unsafe conditions. Slow acting flame safeguard devices i.e. thermoelectric, or fast acting devices, i.e. electronic, may be used. Where a permanent pilot is used (either gas or oil) it alone may be monitored on the assumption that its continued presence assures the ignition of the main oil flame. In some industrial installations it may not be necessary or indeed desirable to have flame failure protection. For instance in the case of a high temperature process operating continuously there will always be sufficient temperature to ensure the re-ignition of fuel in the event of a momentary stoppage of fuel.

Careful consideration should be paid to the conditions relevant to any particular installation before deciding what, if any, flame failure system to employ.

14.3 Failure of ignition

14.3.1 Automatic light-up. With an installation involving a fully automatic burner it is essential that a starting sequence is monitored by a control device which will comply with BS 799-3 and BS 799-4. Failure to light has to be followed by an automatic purge as defined in section 5 of BS 799-4:1972.

The burner should not be reset from lock-out more than two or three times before the reason for failure to ignite is investigated.

14.3.2 Manual light-up. For installations arranged for hand lighting, instructions on start-up and shut-down should be displayed adjacent to the oil firing equipment. These instructions should emphasize that oil is not to be allowed to accumulate in the combustion zone. If a burner does not successfully light within the specified time, then its fuel valve is to be closed and time allowed for unburnt gases to disperse naturally.

14.3.3 Oil or vapour present. With all installations, if liquid oil has accumulated in the combustion zone, it should be removed before a light-up is attempted. With a hot furnace, no source of ignition should be introduced until it is definitely established that the complete furnace is vapour-free or has been allowed to cool to a temperature below the vaporization temperature of the oil.

14.4 Failure of electricity supply and voltage variations. With all systems, including fully automatic systems (see 5.4 of BS 799-4:1972), provision should be made to ensure that, in the event of any electricity supply failure or of excessive voltage drop which will interfere with the safe operation of the plant, the fuel supply will be shut off. The conditions under which the burner may then restart should receive careful consideration at the design stage.

14.5 Plant breakdown. The overall plant control system should include interlocks which will ensure a "fail safe" condition in the event of any breakdown.

14.6 Excess temperature. In the event that a normal temperature control can fail to function and a process temperature continue to rise, provision should be made for a limiting temperature control, set at a higher temperature, to shut off the burner. The limiting temperature control should be of the hand-reset type and if necessary the shut off should be coupled to an alarm.

In special cases, the limiting temperature control may be arranged to reduce the heat input to a safe limit until the normal temperature control is restored.

14.7 Change from selected oil pressure conditions. Most oil burning systems will be sensitive to a change in oil pressure either above or below the selected values.

Pressure gauges should be provided having the selected values marked. With automatic control systems, it may be desirable that suitable pressure switches should be provided linked into the burner control system.

14.8 High or low oil temperature change. In installations using fuels requiring preheating it is most important that the selected temperature remains as constant as possible to avoid changes in the viscosity of the fuel. The preheating device should always be under the control of a suitable thermostat. A further limiting thermostat with manual reset should also be installed to guard against excess oil temperature. A minimum temperature thermostat to prevent the burner starting until the oil is raised to the required temperature is recommended. The position of such a thermostat will depend on the type of oil burner system used but in cases of packaged burners the thermostat will probably be part of the burner and be fitted by the manufacturer.

14.9 Fan failure. Provision has to be made to guard against fan failure. It is essential that if any fans fail, including any recirculation fans if fitted, then the fuel supply to the burner is shut off immediately. It is usual to design control circuits so that the fans are electrically linked in sequence. In addition it is advisable to add further protection to the system by fitting air pressure or air flow switches inserted into a proving circuit. Such precautions have the added advantage that an installation cannot be started up except in the correct sequence.

14.10 Fire at appliance. Where the installation is not under the supervision of an operator, automatic means such as heat-sensitive devices should be provided to operate the shut-off valve and stop the supply of oil to the burners in the event of an external fire. (See clause 15 of BS 799-5:1975.)

14.11 Remote alarms. Where oil burners are automatically controlled or remotely supervised a remote warning signal, either audible or visual, should be provided (see clause 58).

Section 4. Oil tanks and equipment

15 Construction

Storage tanks may be of the following construction:

- a) mild steel welded (see BS 799-5 and BS 2654);
- b) mild steel sectional (see BS 799-5 and BS 1564);
- c) cast iron sectional (see BS 799-5 and BS 1563);
- d) concrete with impervious oil-proof lining.

Where it is not practicable to use factory or site welded tanks, sectional or concrete tanks may be used.