

Code of practice for

Oil firing —

**Part 2: Installations of 45 kW and above
output capacity for space heating, hot
water and steam supply services —**

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

UDC 662.94:662.75:697.32*44kW+

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Cooperating organizations

The Refrigeration, Heating and Air Conditioning Standards Committee, under whose direction this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

Association of Consulting Engineers	Heating and Ventilating Contractors' Association
Association of Manufacturers of Domestic Electrical Appliances	Hevac Association*
Boiler and Radiator Manufacturers' Association Ltd.	Institute of Fuel*
British Combustion Equipment Manufacturers' Association*	Institute of Refrigeration
British Gas Corporation	Institution of Electrical Engineers
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Engineering Equipment Users' Association	Society of British Gas Industries
	Solid Fuel Advisory Committee
	Water-tube Boilermakers' Association*

The organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

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

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Contents

	Page
Cooperating organizations	Inside front cover
Foreword	iv
Section 1. General	
1 Scope	1
2 References	1
Section 2. Oil fuels	
3 Types of petroleum oil fuels	3
4 Typical characteristics of petroleum oil fuels	3
Section 3. Application of oil burners	
5 General	5
6 Choice of grade of oil fuel	5
7 Boilers	6
8 Warm air heaters	12
Section 4. Methods of combustion air supply and of draught production and control	
9 Combustion air supply	15
10 Induced draught and forced draught	15
11 Conversions from solid fuel to oil firing	15
Section 5. Selection of burners	
12 General	17
13 Types of burner	17
14 Types of burner control	18
15 Choosing oil burner equipment: factors to consider	18
16 Application of burner types	19
Section 6. Oil tanks and equipment	
17 Construction	21
18 Capacity	21
19 Choice of number and type of tanks	21
20 Design and test conditions	22
21 Measurement of contents of oil storage tanks	22
22 Precautions against overfilling	22
23 Filling pipes and connections	23
24 Vent pipes	23
25 Drain valves	23
26 Multiple storage tanks with return line connections	23
27 Installation of oil storage tanks	24
28 Painting and cleaning	24
29 Heating for oil tanks containing classes E, F, G and H fuels	25
30 Service tanks	27
31 Rooftop tanks	27
32 Fire precautions	27
Section 7. Oil handling systems from storage tank to burner	
33 General	29
34 Distillate oil fuel systems (classes C2 and D fuels)	29
35 Heated oil fuel systems (classes E, F, G and H)	31

	Page
36 Rooftop systems	37
37 Size of oil pipelines	37
38 Materials and erection of oil pipelines	38
39 Testing	38
40 Painting and identification	38
Section 8. Design and construction of accommodation for oil-fired installations	
41 Introduction	39
42 Classification of buildings	39
43 Accommodation for boilers	39
44 Warm air heater installations	43
45 Accommodation for oil storage and service tanks	45
Section 9. Chimney and flue systems	
46 Definitions	51
47 Chimneys	51
48 Flue ducts	52
49 Dampers, draught control and combustion excess-pressure relief devices	52
50 Induced-draught fans	53
Section 10. Electrical equipment	
51 General	55
52 Wiring	55
53 Motors and motor control gear	55
Section 11. Instrumentation	
54 General	57
55 Essential instrumentation	57
56 Other instrumentation	57
Section 12. Commissioning: performance tests and handover	
57 Commissioning arrangements	59
58 Precommissioning procedure	59
59 Commissioning procedure	60
60 Performance tests	61
61 Handover	62
Section 13. Maintenance	
62 General	63
63 Supplier's and/or installer's responsibility	63
64 User's responsibility	63
Section 14. Safety provisions	
65 General	65
66 Oil handling system	65
67 Fire valve system	65
68 Housekeeping	65
69 Protection against combustion explosions	65
70 Fire prevention	66
Table 1 — Minimum tank, outflow and handling temperature for petroleum oil fuels	25
Table 2 — Fire resistance: recommended types of construction for boiler room enclosures, doors and windows in "large buildings" and places of public entertainment or assembly	41

	Page
Table 3 — Fire resistance: recommended types of construction for boiler room enclosures, doors and windows in all buildings other than “large buildings” and places of public entertainment or assembly	42
Table 4 — Examples of types of construction for the recommended standards of fire resistance given in Table 2 and Table 3	42
Table 5 — Fire resistance: recommended types of construction for tank chamber enclosures and the doors and openings therein in “large buildings” and places of public entertainment or assembly	49
Table 6 — Fire resistance: recommended types of construction for tank chamber enclosures and the doors and openings therein in all buildings other than “large buildings” and places of public entertainment or assembly	50
Publications referred to	67

Foreword

The application of oil firing to boiler plant and warm air heater plant requires many important decisions to be made at an early stage of planning.

It is desirable that there should be recommended requirements so that manufacturers, suppliers, installers and users of equipment 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 should be ascertained. In applying the recommendations in this code 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 this British Standard the committee considered it preferable to divide the code into Parts according to the type and purpose of the oil firing installations 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 rearrangement 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.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 67 and a back cover.

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Section 1. General

1 Scope

This Part of BS 5410 deals with the provision of new, or modernizing of existing, oil burning systems for petroleum oil fuel to BS 2869 as applied to boiler and warm air heater plants for space heating, hot water and steam supply purposes, having a total rated output of 45 kW or more; it also deals with oil tanks of any capacity associated with such systems.

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 oil fired systems for marine installations or flueless heaters. Relevant sections apply to thermal fluid heaters and to plants of a portable nature (e.g. as used for emergency or temporary heat supplies).

NOTE The use of coal tar fuels is not included in Part 2 of the code and reference may be made to Part 3 for information regarding their use.

2 References

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

Section 2. Oil fuels

3 Types of petroleum oil fuels

Oil fuels are commercially available in the United Kingdom in various grades, comprising distillate and residual grades, manufactured to comply with the specifications contained in BS 2869. The specifications that are relevant to this code of practice can be found in Table 1, Table 2 and Table 3 of BS 2869:1998.

4 Typical characteristics of petroleum oil fuels

Users are advised to obtain from their fuel suppliers typical values for the grades of fuel currently available.

Section 3. Application of oil burners

5 General

It is desirable that there should be an agreed specification covering the performance of the oil burning equipment in terms of heat output and efficiency in addition to all other operating and safety criteria.

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

6 Choice of grade of oil fuel

6.1 General. The selection of a particular grade of fuel cannot be determined on the sole basis of fuel price which, in general, decreases from class D to class H as viscosity increases.

The final selection is influenced by various practical, environmental and cost factors that have to be taken into account before a rational choice can be made.

The six main factors to be assessed are described in **6.2**, **6.3**, **6.4**, **6.5**, **6.6** and **6.7** and from a considered assessment of these interrelated factors the most economical scheme for a particular application can be selected.

6.2 Size of plant. There is a minimum limit (e.g. of individual boiler rating) below which it is not practicable to burn residual fuel oils. These, for various classes of oil, are, as a general guide, as follows:

class E	140 kW
class F	250 kW
class G	400 kW
class H	special applications

It may be necessary to arrange for a small summer-load boiler in a boiler plant consisting of larger units to be fired by say class D oil in order to achieve satisfactory conditions.

6.3 Environment. In addition to general statutory requirements, in certain areas of high population density the local authority may already possess, or subsequently take, powers whereby acceptable fuels in that area are restricted to low-sulphur-bearing varieties (e.g. class D) in order to limit the sulphur dioxide emissions. In other cases where there is doubt about the effects of high concentrations of sulphur dioxide emissions on, for example, buildings, exposed plant, etc., the advisability of using fuels of lower sulphur content should be considered.

6.4 Steam/water temperature conditions. Where boiler heating surfaces can fall below the acid dewpoint, the corrosion effect is magnified considerably. This can occur with low-temperature hot water boilers and in such cases the use of a distillate fuel of lower sulphur content will reduce the corrosion rate and increase useful boiler life.

6.5 Plant operational schedule. The operating schedule of the plant can affect the grade of fuel to be selected and the control system required; for example, where plant requirements are such that fully automatic, virtually unattended performance is required, with night and weekend shutdown and minimal maintenance requirements, a distillate fuel may be necessary. A similar plant operating on continuous load with more expert supervision/maintenance could utilize a residual fuel oil. The purchaser should assess his requirements so as to compare savings in labour for supervision and maintenance with the higher cost of distillate fuel and control equipment.

6.6 Capital cost of equipment and plant. The extra cost of providing the following equipment and plant when burning residual oil fuels (classes E, F, G and H) has to be taken into account:

- pumping and heating equipment;
- burner equipment;
- chimney cost (extra height requirement).

6.7 Operating cost

6.7.1 Attendance. The labour cost of boiler plant attendants that will apply for various alternative schemes should be considered. This cost will be affected by the degree of automation provided.

6.7.2 Fuel. In addition to variations in fuel prices, any differences in the cost of oil heating and handling and in the efficiency of use, etc. should be assessed.

6.7.3 Maintenance. The cost of maintaining burners, oil pumping and heating equipment, and control equipment and of cleaning the flueways of boilers and air heaters, flue ducts and chimneys, and oil tanks should be estimated for the various fuel grades under consideration.

7 Boilers

7.1 Preamble. Reliable and efficient operation of a boiler installation depends upon satisfactory coordination of the designs of the boiler and the oil burning equipment. New boilers are frequently supplied as package units in which the boiler, burner and certain ancillary equipment are supplied to site preassembled. This practice, which may be applied to all but very large units, facilitates prematching and pretesting the boiler-burner assembly as a standardized design.

When specifying oil burners, whether for use with new appliances or with existing boilers that have previously been fired by other fuels or other oil burners, it is necessary to consider the suitability of the proposed burner for the conditions and intended duty.

The classification of boilers used in this code has been adopted to serve as a basis for consideration of factors relating to oil burning equipment and is not intended to be a general or exhaustive classification of all boiler types.

NOTE 1 Boiler burner units should conform to BS EN 303-1, BS EN 303-2 and BS EN 303-4 as appropriate.

NOTE 2 Attention is drawn to the Boiler (Efficiency) Regulations 1993 amended by the Boiler (Efficiency) (Amendment) Regulations 1994 [1].

7.2 Boiler sizes for load requirements. It is important that boiler sizes are selected to match the actual load requirements. Where boilers are oversized in relation to the load, the oil burners are subjected to frequent on/off operation and long off periods that produce the following undesirable effects:

- a) a reduction in overall “seasonal” efficiency of boiler plant;
- b) increased fouling of boiler gas-side heating surfaces;
- c) increased danger of corrosion of boiler heating surfaces, flue ducts and chimneys;
- d) increased wear and tear on control gear, contractors, motors, etc.;
- e) fluctuations in steam pressure or in temperature of water flow from the boiler plant;
- f) difficulties with feed-water treatment and continuous blow-down control of steam boilers.

A curve showing winter and summer load should be produced and the boiler sizes selected so that under normal load conditions the oil burners are working within the high/low or modulating range. On/off boilers are normally only used for boilers with output below 300 kW.

Practical considerations usually favour selection of a boiler having an output range (in conjunction with the turn-down ratio of the burner, i.e. the ratio between high and low levels of output) as follows:

<i>Type of boiler</i>	<i>Maximum turn-down ratio</i>
Cast iron sectional boilers	2 to 1
Small shell and other steel boilers (up to 2 000 kW)	2 to 1
Large hot water shell and other steel boilers (over 2 000 kW)	3 to 1
Large steam shell boilers (over 2 000 kW)	4 to 1

With large water-tube boilers fitted with multiple oil burners the turn-down ratio can be correspondingly extended beyond the above ranges depending upon the particular boiler and system design under consideration, but risk of acidic corrosion at low output should be considered.

The precise size(s) and the number of boilers to be provided can only be assessed by a study of the anticipated annual load characteristics, relating this to the above desirable principles of load matching. The most effective scheme of boiler control to adopt, e.g. automatic sequencing of the plant, will also be evident from these considerations.

Special attention should be given to the summer load, which may be much less than winter demand where no process heat is required, and to schemes with a phased development, where the ultimate load may not be available for a period of years.

The question of standby plant should be considered to determine whether this is to be provided by means of a separate standby boiler or by extra capacity built into certain boiler units where this can be done without upsetting the load-matching principles outlined.

7.3 Quality of boiler water

7.3.1 Requirements for steam boilers. When converting existing steam-raising equipment from solid fuel to oil firing or when replacing older types of steam-raising plant with modern compact oil fired equipment, it is essential to review the method of treating boiler water to ensure its suitability for protection of the boiler; normally boiler makers will specify the limiting conditions for boiler water.

When the user does not employ a person competent in the chemistry of water treatment, the quality of the boiler water should be controlled by following the recommendations of a specialized treatment company that will furnish the services of an area engineer with knowledge of local raw water conditions. He will be able to advise on and subsequently to supervise treatment.

It cannot be overemphasized, however, that treatment will only be successful if the recommendations of the boiler maker and of the water treatment specialist are followed conscientiously and continuously.

7.3.2 Requirements for hot water boilers. Although hot water systems are regarded essentially as “closed circuits”, make-up water is necessary, the quantity depending upon the amount of leakage from such items as pump glands and from draining down for maintenance purposes, etc. Unless adequate water treatment is provided, the boiler water is likely to become deposit-forming and corrosive.

Depending upon the requirements of the boiler maker for protection of the boiler and taking into account the operating temperatures, the raw water (for initial fill and make-up) will usually need treatment varying from simple chemical dosing to full demineralization with the application of oxygen scavenging and pH corrective chemicals.

The provision of specialized water treatment facilities with frequent checks on internal water conditions as recommended in **7.3.1** is also essential for hot water boilers.

7.4 Cast iron sectional boilers

7.4.1 General. This clause covers boilers of cast iron construction in which the rating of the boiler can be selected within limits by the number of assembled sections. The usual configuration covers a horizontal combustion space, but subsequent travel of the flue gas may be via a multiplicity of passes in series and/or parallel and arranged horizontally or vertically.

With all boilers, the associated system should be designed to maintain the water return temperature at a value to minimize condensation and sulphur corrosion.

Noise from oil firing equipment and combustion should not exceed any specified limits.

7.4.2 Heating boilers of solid-fuel type

7.4.2.1 As some designs of boilers have been developed from appliances designed to burn solid fuel, the pressure loss in the gas passes is low and in addition a pressure below atmospheric is required in the smoke box to produce a draught in the combustion space. When oil firing this type of boiler, either on a converted boiler (or oil burner replacement) or on a new boiler, attention should be paid to:

- a) the correct negative pressure in the combustion space;
- b) sealing between the sections and between the sections and the base;
- c) thermal protection of the floor of the boiler room (if the boiler is not fitted with a complete waterway base);
- d) tightness of the section clamping;

- e) the recommendations of the manufacturers of the boiler and of the burner regarding the arrangement of refractory in the combustion space, including the covering of waterway fire bars (when incorporated);
- f) correct closure of flueway doors and sealing of all joints in the flue system;
- g) the removal or locking in the open position of flue dampers; alternatively the damper should be interlocked with the oil burner to ensure that it is open before burner operation is initiated;
- h) avoiding impingement of flames upon metal surfaces [see e) above];
- i) adequate water circulation.

7.4.2.2 Some boilers can be fitted with baffles in the flue passes to increase the heat transfer and this improves the efficiency. When converting to oil firing, the correct baffles should be obtained from the boiler manufacturer and the fitting instructions carefully followed. As these baffles increase the pressure and heat transfer in the combustion space, particular attention should be given to items b) and i) above. Burner adjustments will need to be carried out after fitting the baffles.

7.4.2.3 When converting sectional boilers from solid fuel to oil firing, it is necessary to remove loose fire bars (where fitted), also the fire, clinker, ash-pit doors and frames. A front plate suitably designed to accommodate the burner in the correct position and insulated as necessary should be fitted.

The front plate should be obtained from the boiler maker or burner supplier.

7.4.2.4 In certain cases a front section of boiler may have to be replaced by a purpose-designed section for correct burner application.

7.4.2.5 If a satisfactory performance is not obtained after conversion, the boiler manufacturer should be consulted.

7.4.3 Purpose-made boilers

7.4.3.1 Boilers of modern design are increasingly using combustion spaces at a positive pressure and attention to inter-section sealing is thus of increased importance.

These boilers are less sensitive to flue conditions, but the boiler maker's recommendations in this respect should be observed. In these boilers, it is essential that all flueway doors and observation windows are gastight and that any excess-pressure relief door should be suitably loaded to withstand the normal operating pressure without leakage.

7.4.3.2 Due to the higher rates of heat release on purpose-made boilers, correct circulation of the water is very important and pumps and associated equipment should be of sizes that ensure an adequate circulation of all items.

7.5 Shell boilers

7.5.1 General. The term "shell boilers" is applied to a group of boilers in which the flue gases usually traverse the boiler horizontally between the burner and the off-take. One or more furnace tubes, usually of circular cross-section, are fitted and these may be arranged for through or reversed flow of the combustion gases. After leaving the furnace tube the products of combustion pass through one or more longitudinal externally water-cooled return passages before reaching the chimney gas off-take. The gas passes may consist of nests of externally water-cooled tubes or of annular spaces. In older types the gas passes may consist of brick-set passages external to the boiler shell. This group includes:

- Lancashire and Cornish boilers;
- economic boilers, in which the rear chambers (known as "combustion chambers") may be refractory lined (dry-back) or water-cooled (wet-back);
- reverse flame furnace tube boilers;
- boilers in which the return gas passages are annular.

Noise from oil firing equipment and combustion should not exceed any specified limits.

7.5.2 Installation design: relevant factors

7.5.2.1 Chimney and flue gas ducts should be designed to comply with the anti-pollution regulations and to hold the pressure at the boiler exit within limits suitable for the particular boiler-burner combination.

7.5.2.2 When selecting on/off burners or those having a turn-down ratio, consideration should be given to the following points if acidic corrosion is to be kept to a minimum and smutting avoided:

- a) water temperature or steam pressure;
- b) boiler efficiency;
- c) length, type and material of flue ducting, including lagging;
- d) height and type of chimney, and its insulation;
- e) chimney efflux velocity;
- f) type and analysis of fuel.

7.5.2.3 With modern oil firing equipment and modern compact boilers, the heat transfer rate through heating surfaces is likely to be higher than with older designs. It is therefore essential to give special attention to the pretreatment of feed water to ensure absence of scale on the heating surfaces (see 7.3).

7.5.3 Conversion to oil firing or replacement of oil burning

7.5.3.1 Arrangements for conversion should always include provision for the removal of old stoker equipment, fire bars, ash, etc., which should on no account be bricked over.

7.5.3.2 In the older types of shell boilers the gas passages were so proportioned that the pressure drop experienced by the gases in passing from furnace to chimney was small (usually less than 60 mm water gauge). Such boilers were intended for operation under zero or negative draught pressure, and the design of smoke boxes, excess-pressure relief devices, access doors and other fittings is unlikely to be suitable for use with modern forced-draught oil burners without detail modification. See also Appendix A of BS 799-4:1991.

7.5.3.3 When converting these older types of boiler, special consideration should be given, particularly in the case of dry-back boilers, to those of the following points that may be relevant:

- a) tightness of gas joints between front and rear smoke boxes and the boiler shell;
- b) sealing between brickwork or insulation and shell of smoke boxes;
- c) seals of access doors;
- d) suitability of excess-pressure relief devices for resisting gas leakage under forced-draught conditions including those on start-up of burners;
- e) suitability of existing refractory linings covering non-water-cooled surfaces for increased surface temperature likely with oil firing.

7.5.3.4 The quality of the refractory brick should be such as to withstand a temperature of not less than 1 100 °C, but where the brick surfaces cannot reradiate heat to any nearby water-cooled surfaces it would be preferable to use a quality of refractory capable of operating at temperatures up to 1 400 °C.

7.5.3.5 The use of hot-face insulating bricks for the construction of the combustion space is sometimes desirable and the boiler manufacturer should be consulted. Where the burner design makes use of a brick quarl to ensure flame stability, care should be taken to follow exactly the quarl shape specified. The burner maker's advice should be sought on the design of the burner quarl. If necessary, refractory material should be fitted to exclude heat from the burner plate, and from those parts of the furnace tube not water-cooled, particularly the weld between furnace tube and head plate.

7.5.3.6 The suitability of tube attachment at the entry end of the first tube pass to withstand the changed conditions should be considered. It is recommended that the ends of welded stay tubes and of seal-welded plain tubes should be dressed flush with the weld, and plain tubes that are not welded should be no more than 1.5 mm proud of the tube plate.

7.5.3.7 The suitability of water-side circulation in tubed hot water boilers to sustain the higher rates of heat transfer in the region of the first tube pass entry when changing from solid fuel to oil firing should also be examined.

7.5.3.8 Combustion at the maximum required output should be completed within the available length of furnace tube so that the flame does not make contact with the water-cooled surface of the furnace tube (or with Galloway tubes where fitted in Lancashire boilers). The fuel should burn efficiently within the volume available.

7.5.3.9 Special problems may arise when converting boilers of riveted construction since the changed heat distribution within the boiler may possibly cause old riveted joints to work loose and leak. If the boiler is old, difficulty may be experienced in overcoming such a tendency towards leakage.

7.5.4 *New equipment.* If the boiler is supplied separately from the firing equipment the recommendations of **7.5.3** can apply. When a matched boiler-burner unit is supplied, the various points listed above will have been considered by the manufacturer of the unit, who will also state requirements in respect of temperature and pressure of fuel supply. Draught requirements at the boiler outlet will also be stated. Such recommendations by the manufacturer should always be followed.

7.5.5 *Maintenance of equipment.* The equipment manufacturer's instructions for maintenance should be followed conscientiously at all times, particular attention being given to the periodic testing of automatic safety devices.

7.6 Water-tube boilers

7.6.1 *General.* Oil firing of water-tube boilers requires special consideration by the boiler and burner makers in respect of furnace volume, rate of heat release, the number of burners and their location, their proximity to the combustion space boundaries and the length of flame. Attention is drawn to the necessity for a low rate of firing when starting the boiler from cold. This point is particularly important when superheaters are fitted.

When the bottom of the combustion space is not water-cooled, arrangements should be made to limit the heat flow into the boiler room floor. This can be achieved by the provision of an air gap below the hearth, which should be adequately cooled by natural convection or by induced or forced ventilation.

Noise from oil firing equipment and from the combustion process should not exceed any specified limits.

7.6.2 *Conversions to oil firing or replacement of oil burners.* It should be appreciated that, when converting boilers to oil firing, thermal conditions in the boilers may be different from the original design conditions.

It is considered essential that joint discussions between the boiler maker and the burner supplier are arranged to agree upon technical aspects of the oil firing equipment. Attention should be given to relevant recommendations in **7.6.2.1**, **7.6.2.2**, **7.6.2.3**, **7.6.2.4**, **7.6.2.5**, **7.6.2.6**, **7.6.2.7**, **7.6.2.8**, **7.6.2.9**, **7.6.2.10**, **7.6.2.11** and **7.6.2.12**.

7.6.2.1 When a water-tube boiler fitted with mechanical stokers is to be converted, removal of the stoker or grate is essential if efficient performance with oil firing is to be achieved. The covering of chain grates, etc., by refractory material can be accepted only on the grounds of expediency. This practice is usually detrimental to overall performance with oil burning. A suitable combustion space should be reconstructed in such a manner as to restrict downward and other unnecessary heat losses to a minimum.

7.6.2.2 Consideration should be given to the higher flame temperature in the combustion chamber usually resulting from the conversion to oil firing; all refractories in the high temperature zone should be capable of withstanding the higher temperatures involved. (See also **7.5.3**.)

7.6.2.3 The water circulation rates in the tubes of the boiler should be adequate to meet the new conditions of heat transfer. Where boilers have been in service for long periods before conversion, it is recommended that tubes be examined for internal scaling.

7.6.2.4 Adequate standards for water treatment should be determined to meet the new conditions. (See **7.3**.)

7.6.2.5 Air leaks into the combustion chamber, gas passes and flue ducts should be reduced to a minimum.

7.6.2.6 When it is intended to use the existing fans, the suitability of their performance should be checked.

7.6.2.7 Where superheaters are fitted to the boilers, it should be borne in mind that the difference in flame characteristics of solid and liquid fuels is likely to result in a change of superheated steam temperature, which can be corrected by modification of the boiler plant.

7.6.2.8 The sulphur content of fuel oils fired in boilers may cause low-temperature acidic corrosion problems and steps should be taken to reduce the resulting effects. In the case of boilers fitted with economizers, corrosion can be reduced by the following methods:

- removal of sections of the economizer;
- recirculating feed water through the economizers;
- increasing the feed-water inlet temperature of the economizer by external means;
- selection of burners suitable for operation near stoichiometric conditions over the required turn-down range.

7.6.2.9 Where air heaters are fitted, it is desirable that the metal temperatures of the air heaters and associated flue ducting do not fall below the acid dew point of the flue gases for prolonged periods. Solutions to this problem include:

- air recirculation through the air heaters;
- air bypass of the air heaters;
- installation of steam-to-air or hot-water-to-air heaters in the forced-draught fan ducting;
- selection of burners suitable for operation near stoichiometric conditions over the required turn-down range;
- operation with high flue gas temperature (this has a detrimental effect on efficiency).

7.6.2.10 Flue gas ducts should be adequately insulated to prevent low metal temperatures.

7.6.2.11 Consideration may be given to the use of corrosion control additives under carefully monitored conditions.

7.6.2.12 Where the combustion chamber reconstruction incorporates large quantities of refractory material, it is essential to impress on boiler operators that the plant should be brought slowly up to maximum working load.

7.6.3 New equipment

7.6.3.1 When the boiler plant is supplied by the manufacturer complete with the oil firing equipment, he will need to consider relevant recommendations in **7.6.2**.

7.6.3.2 The boiler user may decide to purchase the oil firing equipment separately from the boiler. In these cases it is desirable that agreement is reached between the boiler maker and the burner supplier as to the suitability of the firing equipment.

7.6.3.3 In addition to the points referred to in **7.6.3.1** and **7.6.3.2**, special consideration should be given to oil firing equipment fitted with water-tube boilers designed to operate with positive gas pressure in the combustion chamber. Absolute tightness of casings, access and excess-pressure relief doors, flame-viewing ports, etc., is essential. When a number of burners are fitted to such a boiler, the design of the firing equipment should incorporate devices to enable atomizers and igniters to be removed for maintenance without danger to the personnel involved.

7.7 Instantaneous steam and hot water generators. Instantaneous steam generators may be defined as a group of appliances characterized by pressure parts consisting of a continuous coil of pipe that provides the convected heat transfer zone and may also completely or partly surround the combustion space. Water is fed to the coil under pressure and is largely or entirely converted into steam before reaching the other end of the coil. Instantaneous hot water generators are similar but designed so that the water is heated during passage through the coil to the required outlet temperature.

Units of this type are usually supplied as fully packaged appliances. This type of equipment necessitates a degree of interlock between the water pumping rate and the firing rate; the combustion chambers are often of compact size and shape. For these reasons the appliances should be fired only by the burner supplied by the appliance manufacturer.

In certain cases it is possible to convert the appliance to use a fuel different from that for which it was originally designed but in view of the considerations outlined above such a conversion should be carried out only by the original equipment manufacturer.

The manufacturers' requirements in respect of chimney and fuel supply conditions should be precisely followed.

Noise from oil firing equipment and combustion should not exceed any specified limits.

7.8 Other types of steel boilers. The general principles of application for both conversions and new installations given in preceding clauses will apply to other types of steel boilers, as may be appropriate to the type of boiler concerned. For detailed information, it will be necessary to consult the makers of the boiler.

8 Warm air heaters

8.1 General. For the purposes of this code of practice, a warm air heater is defined as a self-contained appliance for supplying warm air for heating commercial and industrial premises.

NOTE The requirements for warm air heaters are specified in prEN 13842:2001.

The appliance is generally an enclosed unit containing a burner and a heat exchanger system. The air to be heated is circulated by a fan across the heat exchanger and the warm air is then discharged directly or via ductwork to the space to be heated.

The heat exchanger consists generally of a metal-walled combustion chamber where the combustion of the fuel is completed and a secondary section in which further heat is transferred from the products of combustion prior to their discharge into the flue system.

Warm air heaters are designed with the heat exchanger system operating under either a negative or positive pressure. To enable the correct condition to be achieved the chimney and flue duct should be of such size as to provide the draught specified by the manufacturer, which may involve the fitting of an induced-draught exhaust fan. This fan may be built into the heater unit or supplied as an additional item of equipment, but in either case interlocking with the burner control is required to ensure that the burner cannot operate unless the fan is running.

Noise from oil firing equipment and combustion should not exceed any specified limits.

8.2 Conversion of warm air heaters fired by solid fuel to oil firing. Present-day manufacture of warm air heaters is confined mainly to either gas or oil firing but solid fuel units have been produced in the past. It is unlikely that conversion to oil firing will be an economic proposition, but on this point the heater manufacturer should be consulted. Conversion may involve a new combustion chamber and in such circumstances the heater may have to be returned to the manufacturer's works for modification.

8.3 Conversion of gas fired heaters to oil firing. It is recommended that when conversion of gas fired equipment to oil firing is required, the manufacturer of the heater should be consulted. It is possible that the heater was originally designed for either of these fuels and a simple substitution of burner and controls may be adequate to bring about the conversion.

8.3.1 Many manufacturers of warm air heaters use packaged gas burners supplied by independent burner manufacturers. In these cases the burner manufacturer can usually supply a suitable oil burner. If not, a suitable burner should be easily obtainable from an independent burner supplier.

8.3.2 When a substitute oil burner is not available from the heater manufacturer, consideration should be given to the gas firing characteristics so that a suitable type of oil burner may be selected.

Where the gas burner has been incorporated as a special part of the heater design, physical difficulties can arise when attempting to fit an alternative oil burner. It is then advisable to consult the manufacturers of both the heater and the oil burner. It is unlikely that heaters fitted with atmospheric gas burners can be converted to oil firing.

8.4 General recommendations for conversion to oil firing or replacement of oil burners
(additional to recommendations in 8.2 and 8.3)

8.4.1 The correct selection of the oil burner input rating can normally be determined from the heater output (shown on the data plate or obtained from the manufacturer's information) and from the expected thermal efficiency.

8.4.2 Determine the conditions available in the combustion chamber so that the correct oil-burner fan characteristics can be provided. These should take into account the combined resistance of the heater and flue system and also whether or not an exhaust fan is fitted.

8.4.3 The flame shape requires to be closely matched to the size of the combustion space to avoid any impingement that could give rise to local hot spots, or incorrect flow of combustion gases that would lead to a reduction in overall efficiency.

8.4.4 The turn-down ratio of high/low/off burners is usually not more than 1.5 to 1. Higher turn-down ratios (up to 3 to 1) can be used provided that they do not result in excessively low exhaust gas temperatures and a corresponding increase in the risk of corrosion in the secondary section and the flue duct.

8.4.5 A check should be made on the heater to ensure that there is sufficient airflow across the heat exchanger to limit the air temperature rise to that recommended by the heater manufacturer.

8.4.6 All joints in the combustion system should be properly sealed to avoid any leakage between the combustion gases and the warm air flow or the heater surroundings. This also applies to the correct fitting of excess-pressure relief devices.

8.4.7 The heat exchange system should be checked. Particular attention should be paid to the combustion chamber for any cracking or broken welds due to excessive thermal stressing, and the secondary section for leakage caused by corrosion. Faulty parts should be repaired or, if necessary, replaced.

8.5 New equipment

8.5.1 In new equipment the recommendations already given on size and on application of burner will have been taken into account by the manufacturer. The user should assure himself that the size or number of heaters installed is sufficient to meet the maximum load of the space to be heated. Oversizing of heaters will mean frequent shut-down and long periods of inactivity resulting in inefficient operation.

8.5.2 Where high/low/off heaters are proposed, they should be selected so that the maximum designed heating load falls between the high and low flame outputs.

8.6 Installation design

8.6.1 Warm air heaters should be sited to ensure that air inlets are not restricted in any way and that there is sufficient clearance for maintenance of burner, controls, heater, and exhaust flue. Heaters should be isolated from any combustible materials or flammable vapours (see also clause 44).

8.6.2 Flue-gas ducts and chimneys should be designed to satisfy the draught requirements specified by the heater manufacturer and to ensure that the products of combustion cannot be recirculated to the air inlets.

8.7 Maintenance of equipment. The heater manufacturer's instructions for periodic and annual maintenance should be carried out regularly and conscientiously to ensure the correct and safe operation and safety of the equipment.

Section 4. Methods of combustion air supply and of draught production and control

9 Combustion air supply

9.1 Induced draught. The necessary combustion air is induced by natural chimney draught or mechanically by an induced-draught fan or by a combination of both. Most modern burners are, however, of the forced-draught type.

9.2 Forced draught. Combustion air is supplied to the burner at a positive pressure by means of a fan (or fans), which may be integral with the oil burner or separate from it, supplying air to one or more burners. The choice of fan is dependent on the conditions in the combustion space. It is essential to verify that the fan is capable of supplying the required quantity of air at a pressure high enough to overcome the pressure loss through the burner together with the maximum back pressure that will occur in the combustion space. In addition an adequate margin on the duty of the forced-draught fan should be specified to take into account fouling of the boiler or heater gas passages after prolonged periods of operation.

9.3 Balanced draught. Under all conditions of load, the combustion space is maintained at a slightly subatmospheric pressure, normally by means of an induced-draught fan fitted with a control device, and the necessary combustion air is supplied to the burners as described in 9.2.

10 Induced draught and forced draught

The characteristics of induced-draught fans should be carefully examined in the light of the total resistance of the boiler or heater flue and chimney systems at all rates of firing, and allowances made for excess air. In addition, allowance is needed for added resistance due to fouling of gas passages and for loss of fan performance due to build-up on the impeller during periods between cleaning. The fan manufacturer should be informed of the flue gas temperature at which the fan will operate.

The output of forced-draught and induced-draught fans can be controlled by:

- a) fan speed control;
- b) flue damper control;
- c) inlet damper or vane control.

All these methods can be accomplished by manual or automatic means. Electrical interlocking of the fan(s) with the burner is essential for reasons of safety (see 49.1) and where both forced-draught and induced-draught fans are installed on a unit the forced-draught fan should not be allowed to continue running unless the associated induced-draught fan is operating correctly. A device should be incorporated (e.g. an air flow switch) to prevent burner operation in the event of failure of the induced-draught fan; this is particularly important where belt-driven fans are employed.

11 Conversions from solid fuel to oil firing

When existing boilers fired with solid fuel are converted to oil firing, consideration should be given to the matching of existing fans to their required new duties. In order to obtain effective induced-draught control with the lower gas volumes usually resulting when firing oil, it is sometimes necessary to reduce the total fan head available from the induced-draught fan where one is fitted. This may be obtained by fitting a different impeller and, when the unit is belt driven, by changing pulley sizes. The forced-draught requirements for the oil burners may also necessitate the replacement or modification of the existing forced-draught fans and this matter should be checked with the burner manufacturer.

Section 5. Selection of burners

12 General

The selection of the type of oil burner to be used and the mode of control of the burner depends on the following factors:

- a) type of plant unit (e.g. shell boiler, water-tube boiler, warm air heater, etc.);
- b) class of oil (BS 2869) to be used (see section 2);
- c) utilization pattern of plant (e.g. constant output, variable output such as heating load);
- d) ability to satisfy environmental regulations for the particular application;
- e) capital and running cost of burner and associated equipment.

13 Types of burner

The types of burner are listed in BS 799-4 and BS EN 267, the differentiation of type being designated by the methods of atomization used. The characteristics of these types are as described in 13.1 and 13.2.

13.1 Pressure-jet burners

13.1.1 General. In this type of burner oil is supplied, under pressure and at a suitable viscosity, to a nozzle in which some of the pressure is used to impart rotation (swirl) to the oil before it is discharged through the final orifice. On issuing from the final orifice, a film is produced which breaks up into oil droplets.

13.1.2 Simplex pressure-jet. In this type of atomizer the droplet size increases with reduction of oil pressure. Consequently the range of turndown is limited.

NOTE Variations of the simplex pressure-jet atomizer have been devised to overcome this limitation.

13.1.3 Spill return pressure-jet. This type of atomizer has flow and return oil passages. Turndown is effected by returning oil from the atomizer to the tank or other parts of the system.

13.1.4 Duplex pressure-jet. This type of atomizer has two flow passages designated pilot and main. It has two sets of swirl passages, a common swirl chamber and final orifice. At low flow, oil is only supplied to the pilot passages, and at high flow, the oil is supplied to both pilot and main.

13.1.5 Duple pressure-jet. This type of atomizer has two flow passages, pilot and main. It has two sets of swirl passages, two swirl chambers and two final orifices that are concentric. At low flow, oil is only supplied to the pilot passage and jet, and at high flow, the oil is supplied to both pilot and main.

13.2 Two-fluid type

13.2.1 General. In this type of burner oil droplets are produced by promoting high rates of shear in the oil by the use of an additional fluid such as air or steam.

13.2.2 High pressure air (or steam) type. Oil is fed at a controlled rate to the nozzle where a stream of air (or steam) under a gauge pressure generally of over 1 bar meets the oil and atomizes it by impact.

13.2.3 Medium pressure air type. Oil is fed at a controlled rate to the nozzle where a stream of air under pressure meets the oil and atomizes it by impact. Burners of this class generally use air at gauge pressures from 70 mbar to 1000 mbar.

13.2.4 Low pressure air type. Oil is atomized by the impact of air supplied by a fan at gauge pressures generally from 30 mbar to 100 mbar.

13.2.5 Spinning cup or rotary type. Oil is supplied at a controlled rate to the interior of a hollow conical cup, rotated by means of an electric motor or by a turbine driven by air or steam. Oil leaves the outer lip of the cup as a thin film under the influence of the centrifugal force. Atomization is carried out by the impact of a stream of air supplied through an annular nozzle surrounding the rotating cup.

13.2.6 Emulsifying type. Oil atomization is substantially effected by the nozzle, normally using air as the atomizing medium. Oil at a suitable viscosity is metered and mixed with a controlled proportion of air at the inlet to a compressor from which the mixture emerges as an emulsion, and is conveyed to the nozzle. In some burners, oil saturated air and emulsified oil are separated from the compressor in a stabilizing chamber before remixing at the nozzle.