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INVESTIGATION ON SAFE OPERATION OF A
RADIANT PORTABLE LPG HEATER

by

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FIRE RESEARCH STATION

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SUMMARY

A portable butane-fired radiant heater of high heat output was tested in accordance with BS 2773 and BS 1945. The heater failed to comply with a number of clauses, but was not in fact stated to comply. However, recent trends in domestic heating comfort requirements indicate that a re-appraisal of current limitations of heat output could be justified.

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INTRODUCTION

There are two types of liquefied petroleum-fired domestic heating appliances: one, the catalytic heater, oxidizes the fuel gas on a catalytic bed. With this type there are no flames once the heater has ignited and reached its normal operating conditions. There is at present, no British Standard for such appliances. The second type, a radiant heater, burns the fuel as gas within perforated ceramic burners. BS 1945¹ and BS 2773² appear to be the British Standards giving constructional and performance specifications appropriate to these latter appliances.

In recent years a number of imported radiant heaters have appeared on the UK market, but these are not stated to comply with the relevant British Standards. Two models of such heaters have previously been examined³ by the Fire Research Station, for compliance with BS 1945 : 1971 Fireguards for heating appliances and BS 2773 : 1965 Domestic single-room space heating appliances for use with liquefied petroleum gas. The results of an examination of a third heater are reported in this Note which is of general interest in the field of domestic heating appliances. As this report is being made openly available the heater cannot therefore be identified by name.

APPARATUS AND MATERIALS

Heater

The heater was bought by mail order. It was supplied with a regulator and tube for connecting to the gas cylinder. There were no operating instructions attached to the heater but a general information leaflet was supplied. The heater had a single row of gas jets under a heavy mesh gauze; this was backed by a curved reflector plate. The heat output could be varied from 0.6 - 3.0 kWh (2,000 - 10,000 Btu/h). There was a thermocouple flame failure device which isolated the fuel supply when the pilot jet and heating jets were extinguished.

This device was also claimed to shut down the fuel supply when the CO₂ concentration in the ambient atmosphere reached a certain unspecified value. To start the heater the gas container valve was opened, and the fuel to the burner and pilot jet admitted by pressing a button. The fuel was ignited by a match. Once the thermocouple was hot the EMF generated held open a valve admitting fuel to the burner and the button could be released. The 32 lb fuel container was held within the heater body behind a metal plate protecting the curved reflector plate.

Measurement of temperatures

Surface temperatures at points specified in the standard were measured with a commercial surface thermometer calibrated against T₁ and T₂ alloy thermocouples.

Measurement in draught

An air flow was produced by a 60 cm (24 in) diameter fan. The heater could be tested in a range of wind speeds obtained by placing the heater at different distances from the fan. Values of the air flow given in the text are the extremes measured over the whole area of the heater at given distances from the fan.

Gas sampling

Combustion products were collected in a hood over the heater terminating in a flue. The flow profile within the flue was modified with gauze and honeycomb inserts until a non-helical and symmetrical flow profile was obtained and the gas flowing through the flue had a homogeneous composition in accordance with BS 3300⁴ (Fig 1). Gas samples were taken through probes in the flue

Gas analysis

The carbon monoxide and carbon dioxide concentrations were determined using infra-red gas analysers. The maximum resolution of these analysers for both CO and CO₂ was given as 0.001 per cent by volume.

Apparatus for measurement of floor and wall temperature

The apparatus and the procedure specified in BS 3300 were used. A sketch of the apparatus is shown in Fig 2.

Flannelette test

This test was carried out in accordance with BS 1945 using the specified cotton flannelette.

RESULTS

The heater was tested in accordance with relevant clauses of BS 2773 with the following results.

Stability - Clause 20:

The heater complied with this Clause. It did not fall when tilted 15° forward or 10° backward.

Flame failure device - Clause 30:

The heater complied with this Clause. The flame failure device opened and shut within 90 seconds.

Portable free-standing heater - Clause 33:

The heater failed to comply with this Clause as its output exceeded the limiting value of 1.76 kWh (6000 Btu/h). (see discussion).

Resistance to draught - Clause 41:

The heater was subjected to draughts onto its front face within the range of 0.3 - 1.05 m/sec (1 - 3.5 ft/sec). At the maximum heat output setting a draught of 0.45 - 0.76 m/sec (1.5 - 2.5 ft/sec) was sufficient to blow out only the pilot light for a fraction of a second but the main burners re-ignited it. A draught of 0.76 - 1.05 m/sec (2.5 - 3.5 ft/sec) blew out the pilot light within 1 min, for a time sufficient to shut down the gas supply to the burners.

At the minimum heat output setting the pilot light was blown out and the gas supply shut down by a draught of 0.3 - 0.6 m/sec (1-2 ft/sec) within 10 seconds.

In no instance did the burner flames extend outside the guard.

The heater did not comply with this clause of the standard as it requires that the pilot light shall not be extinguished by a draught of 2.3 m/sec (7.5 ft/sec). However, as the fuel supply was shut down it would be safe in practice.

Combustion - Clause 43:

- (i) The heater was positioned beneath a sampling hood as specified in the Standard and measurements of CO and CO₂ concentration in the flue were taken when the appliance had reached thermal equilibrium. The test was carried out at the maximum and the minimum heat output settings. Although the resolution of the CO analyser is given as 0.001%, it was possible to read half this value on the scale of the instrument thus improving the accuracy of the ratios given in the table.

Results - CO/CO₂ ratio in
combustion products

Setting	CO %	CO ₂ %	CO/CO ₂ ratio
Max	0.0005	0.58	0.00086
Min	< 0.0005	0.17	< 0.003

The maximum allowable CO/CO₂ ratio is 0.02; therefore the heater was within this limit at both settings, as required by BS 2773.

Floor and wall temperatures - Clause 45:

The heater was positioned in the corner of the wooden apparatus shown in Fig 2 in the manner specified in BS 3300 and the temperature was measured at specified points on the floor, side wall and back wall of the apparatus. The standard requires that the temperature at these points shall not rise above 150°F.

The following table shows the maximum temperatures reached.

Position	Temp °F
Floor	75
Side wall	159
Back wall	70

The heater would fail the test in respect of side wall temperature but, as is suggested below, some modification of this part of the standard may be desirable.

Surface temperature of appliances - Clause 46:

Surface temperatures were measured of the specified parts of the heater, excluding working surfaces, ie refractories, guards, etc, when the heater had reached thermal equilibrium at the maximum setting. The table shows the temperatures measured against the maximum allowable temperature according to the standard. The heater complied with this requirement.

Surface	Measured temperature °F	Max. allowable temperature °F
Metal tap handles	95	135
Nozzle for flexible inlet	72	130
Regulator	63	120
Hose	70	120
Gas container	64	90

Guards - Clause 28:

The guard on the heater was tested according to the BS 1945 Standard for 'Fireguards for Heating Appliances'.

Guards for Gas Fires - Clause 212:

This section deals with openings in the guard. It specifies that no opening in the guard shall have a major dimension exceeding 150 mm, a minor dimension exceeding 35 mm or a diagonal measurement exceeding 154 mm.

The dimensions for the heater were: major - 10 mm, minor - 8 mm, diagonal - 13 mm. The heater complied with this Clause.

Clause 213:

The heater was allowed to burn for 30 min at the maximum setting and the guard was then tested for effectiveness against smouldering or ignition.

A piece of dry flannelette, 100 cm wide, was held in close contact with the centre of the guard and reaching from the top to the bottom of the guard. The Standard specifies that the flannelette shall not smoulder or ignite within 10 seconds of being so held. There was no smouldering or ignition although the material did become scorched. The heater therefore complied with this clause.

ADDITIONAL TEST

The function of the flame failure device said to shut down the fuel when the CO₂ concentration reached a certain unspecified value was tested by setting the heater to the maximum setting and placing it in a closed room of 11 m³ (400 cu ft). The room was fitted with a fan for stirring the atmosphere, a window for observation and a gas sampling line connected to a meter for continuous measurement of CO₂.

The flame failure device operated and cut off the fuel supply after 39 minutes when the CO₂ concentration in the room had reached 2.0 per cent.

DISCUSSION

The heater complied with the clauses of BS 1945, but failed to comply with BS 2773 in several respects. These were:

- Clause 33 Heat output
- Clause 41 Resistance to draughts
- Clause 45 Floor and wall temperatures

BS 2773 sets the maximum heat output at 1.76 kWh (6000 Btu/h), therefore the heater does not comply with this clause. It is however, questionable whether this upper limit is large enough. The maximum output of most modern heating appliances is about $2\frac{1}{2}$ kWh (8530 Btu/h). If however this value were to be adopted, heaters such as the one tested would need to be redesigned to reduce the radiant heat output to the side wall of the test structure (Fig 2) in order to pass the test for maximum allowable wall temperature.

BS 2773 gives an air speed of 2.25 m/sec (7.5 ft/sec) for the draught test and it has been suggested³ that this value should be raised to as high as 4.5 m/sec (15 ft/sec). In either case the heater would need redesigning to meet the requirement.

CONCLUSIONS

Standards for the performance and structure of new domestic butane-fired radiant heaters need to be brought up to date. If the existing BS 2773 is to be retained a reappraisal of the current limitations of heat output could be justified.

REFERENCES

1. British Standard 1945 : 1971 Fireguards for Heating Appliances.
2. British Standard 2773 : 1965 Domestic single-room space heating appliances for use with liquefied petroleum gas.
3. FR Note 996 ROGOWSKI Z W, PITT A I. Investigation on safe operation of Radiant Portable LPG Heaters.
4. British Standard 3300 : 1963 Kerosine (paraffin) unflued space heaters, cooking and boiling appliances for domestic use.

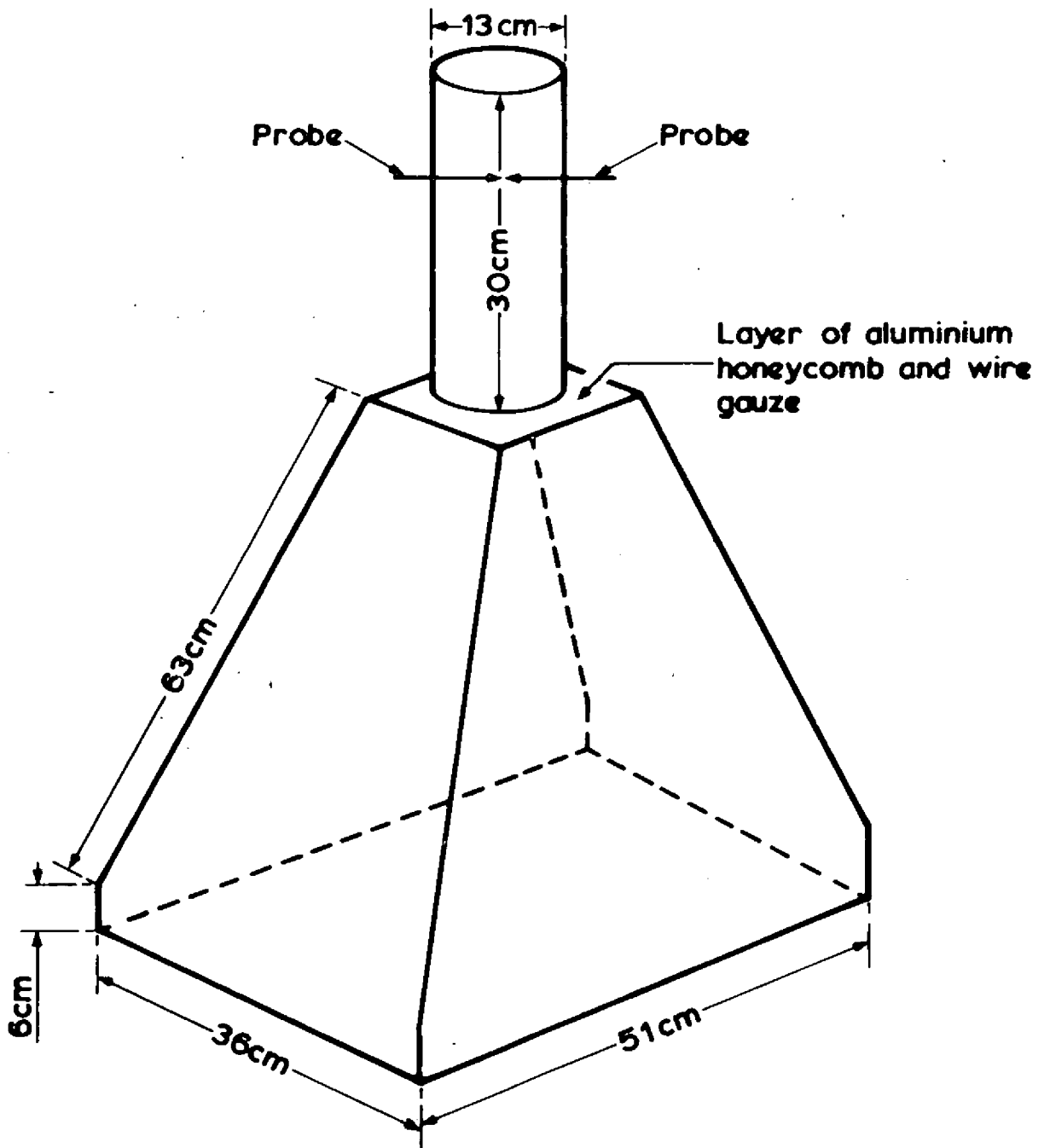


Figure 1 Gas sampling hood

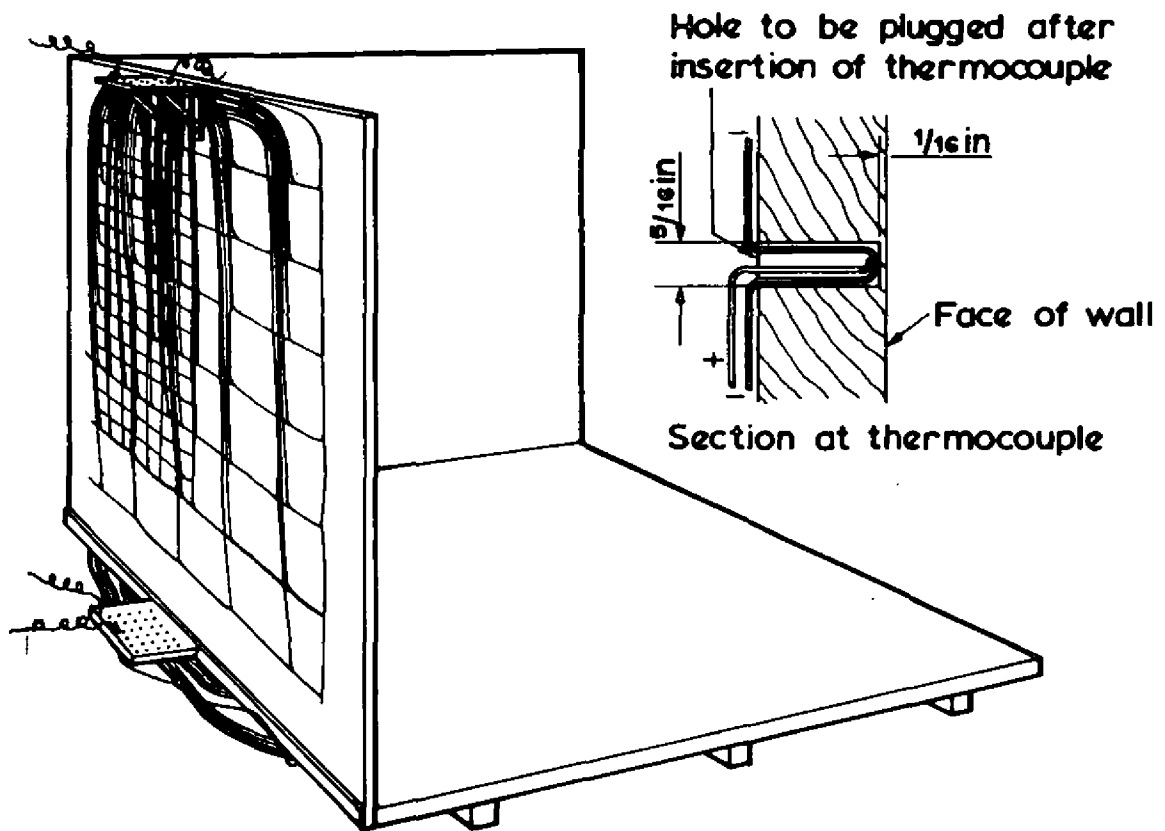


Figure 2 Apparatus for measuring floor and wall temperatures

