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SPECIFICATION FOR TESTING OF PORTABLE  
DOMESTIC BUTANE CATALYTIC SPACE HEATERS

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**Department of the Environment and Fire Offices' Committee  
Joint Fire Research Organization**

## SPECIFICATION FOR TESTING OF PORTABLE DOMESTIC BUTANE CATALYTIC SPACE HEATERS

### INTRODUCTION

For some years there have been new trends in the design of portable domestic heaters and a number of new appliances have appeared utilising the catalytic burning of liquefied petroleum gases with air. The appliances are portable and the gas container is either carried within the case of the heater or the catalytic bed assembly is attached to the container itself. The fuel is fed to the catalytic bed where it reacts with oxygen diffusing from the atmosphere. The hot combustion products rise with the entrained air thus supplying convective heat. There is also some radiant heat emitted from the surface of the bed which operates at a black heat temperature. There is no British Standard applicable to such heaters as yet. Although many safety aspects of catalytic heaters are similar to those associated with portable gas and paraffin fire heaters, nevertheless liquid petroleum fuel and its catalytic combustion presents new specific hazards.

This Note contains a specification of tests for portable catalytic heaters as regards their fire hazard, together with some appropriate constructional requirements, mainly based on work carried out at the Building Research Establishment, Fire Research Station.

### GENERAL

This specification applies to domestic flueless portable catalytic heaters for use with commercial butane only.

The maximum output of the appliance shall not exceed 12000 Btu/h (3.5 kW).

### MARKING

The appliance shall be permanently marked using lettering of height not less than 3 mm ( $\frac{1}{8}$  in) showing:

- a) maker's name
- b) description or designation of the model
- c) indication of the gas and the gas container to be used and the working pressure: 28 cm (11 in) water gauge

d) instructions for use

1. Any special instruction
2. Use only in ventilated room. The minimum open area required for adequate ventilation should be stated.
3. If there is smell of gas shut the valve on the cylinder and notify the suppliers.

## CONSTRUCTION

### Catalytic bed

The catalytic bed shall be cased in a corrosion resistant metal support, eg stainless steel, and shall be leak-tight. See also section below on Gas Soundness. The bed shall be retained by a temperature resistant and corrosion resistant grid. The bed shall be protected by a metal guard complying with BS.1945.

### Piping

All pipes with the exception of the tube connecting the regulator with the appliance shall be rigid metal and corrosion resisting. All connections shall be welded, brazed, sweated or screwed. The tube connecting the regulator with the appliance may be flexible, but shall be reinforced with textile fabric to the requirements of BS.3212 : Part 3 : 1960. Connections at the regulator and the appliance shall be screwed union with press-on joints to the tube and they shall be able to withstand a pulling force of 15 kg (33 lb) applied for one minute. All pipes shall have external diameters equal to, or bigger than, 5 mm ( $\frac{1}{5}$  in).

### Taps

All taps shall be of a glandless type. They shall be so designed that they cannot be fitted incorrectly. They should be placed in such a position that they cannot be displaced accidentally. The function of each tap shall be indicated. The lighting up taps shall return to the 'off' position as soon as the hand pressure is removed. It shall not engage with a force less than 3 kg (7 lb). It should not be possible to have the lighting up tap in the 'on' position unless the rate-of-burning tap is in the 'off' position. This can be achieved by interlock devices or by using a single multiple port tap for the lighting up and the rate of heating control.

### Rigidity

The appliance shall be so designed that it is impossible to change the relative positions of catalytic bed and the body of the heater. The appliance shall withstand the following tests: it shall be placed in a horizontal plane on a concrete floor, brought up to the point of balance and allowed to fall on its back, front and both sides. In no test shall the gas cylinder be dislodged from the casing and no damage shall be done to the catalytic bed, guard, taps and piping. The heater shall work normally after these tests.

### Regulator

The regulator shall comply with BS.3016 : Part 1 : 1958.

### Stability

The appliance shall be so designed that it cannot be easily overturned. All appliances shall withstand the following tests: the heater shall be placed on a plane inclined at an angle of  $15^{\circ}$  to the horizontal and shall not fall. This test shall be applied to the four sides of the heater.

### Gas soundness

Components. Gas cocks and taps which form part of the assembly, and castings which are intended to carry gas under pressure shall be sound at an internal air pressure of  $35 \text{ kN/m}^2$  ( $5 \text{ lb/in}^2$ ).

Complete assembly. The fully assembled appliance shall be sound at an internal air pressure of  $14 \text{ kN/m}^2$  ( $2 \text{ lb/in}^2$ ) when connected to an air supply which maintains a constant pressure and which embodies a suitable meter for measuring air flow.

The duration of the test shall be at least 1 minute and the assembly shall be deemed sound if the leakage rate does not exceed  $80 \text{ ml/h}$  ( $0.003 \text{ ft}^3/\text{h}$ ) in each of the following conditions:

1. With all gas taps closed.
2. With each control (other than the thermostat) in turn closed but all other taps and controls open.
3. With the jets on the feed-pipe behind the catalyst bed sealed and all taps and controls open.
4. When the combustion failure device is closed the total gas passing, other than the pilot, shall not exceed  $2.8 \text{ l/h}$  ( $0.1 \text{ ft}^3/\text{h}$ ) with an inlet pressure of 28 cm (11 in) water gauge of test gas.

### Combustion failure device

A combustion failure device shall be fitted to the appliance, and shall meet the requirements of BS.2773 : 1965.

### PERFORMANCE

#### Test Gas

Commercial butane to BS.4250 shall be used in all tests.

#### Pre-treatment of Catalytic Bed

Prior to the performance tests the appliance shall be checked and examined to ensure that the appliance is in a proper working order. The appliance shall then be operated at the maker's recommended full heat rate for four periods of 8 hrs with not less than one hour interval between individual periods.

#### Ignition

The fuel consumption during the ignition period shall not exceed the following value:

Fuel consumption at the maximum burning rate x 1.5.

The lighting up period shall not exceed 1 min.

#### Pilot Flame

Pilot flames must be stable and burn without lifting or depositing soot at gas supply pressures equivalent to between 96 per cent and 113 per cent of the normal rated input of the test gas.

#### Surface temperatures of Appliance

When the appliance has reached thermal equilibrium at the maximum rate of burning the surface temperature shall be measured by means of a surface pyrometer, by thermocouples soldered or spot welded to the surface, or by other acceptable methods. The temperatures, excluding those of working surfaces, shall not exceed the values given in the following table, at all heat settings.

Working surfaces include the catalytic bed and its reflectors, guard and the preheating jet.

TABLE 1

Surface temperature when ambient temperature is 20°C

Description of Surface	Maximum allowable temperature	
	C°	F°
a) surfaces which in normal use have to be touched for short periods, eg taps, handles, door handles:		
(i) Metal	57	135
(ii) Non-metal	74	165
b) handles, grips, etc which in normal use are held for longer periods. This includes carrying handles:		
(i) Metal	49	120
(ii) Non-metal	66	150
c) Nozzle for flexible inlet connections	54	130
d) Regulators and hoses	49	120
e) Gas container surface	32	90

The inlet connection shall be so designed that the tube connecting the regulator with the appliance cannot come in contact with any surface exceeding 130°F 54°C.

The maximum and minimum temperatures of the catalytic bed

The maximum and minimum temperatures of the catalytic bed shall be determined using T<sub>1</sub> and T<sub>2</sub> alloy thermocouples not thicker than 28 SWG. Not less than 7 mm ( $\frac{1}{4}$  in) of the thermocouple adjacent to the hot junction should be placed along the hottest isothermal and if this is not possible the hot junction shall be inserted perpendicularly into the bed at the depth when the highest reading is obtained. These positions should be ascertained by preliminary exploration. The hot junction positions shall be symmetrically spaced over the whole area of the catalytic bed. There shall be not less than 6 temperature determinations over 0.1 m<sup>2</sup> (1 ft<sup>2</sup>) of the catalyst area.

No thermocouple shall register a temperature higher than 500°C or lower than 400°C.



### Test for the temperature rise of floor and walls

The object of this test is to ensure that under normal working conditions the maximum temperature attained by a wooden floor beneath the appliance, or by a wooden wall against which the back or side of the appliance may be placed while in use is such that the possibility of fire is eliminated.

A suitable apparatus consists of a wooden floor with detachable side and back walls. The floor is two inches thick and consists of a one-inch layer of pine below a one-inch layer of oak with a thickness of building paper between them. The oak is finished in clear varnish. The side and back walls are both one inch pine and are painted dull black. The thermocouples are embedded in each wall at 152 mm (6 in) centres. The thermocouples enter the wall from the side remote from the appliance, the junctions being fixed 1.6 mm ( $\frac{1}{16}$  in) from the surface of the wood nearest to the appliance.

The woodwork should have been thoroughly dried out, either as a result of previous tests or by heating for twenty-four hours with an appliance in position and operating at maximum rate. The appliance to be tested shall be arranged so that its back and one side are as close as possible to the back and side walls. The appliance shall then be lit and run for 3 to 4 hours at full output. The thermostat, if any, should be at its maximum setting. Readings shall be taken of the temperatures at the junctions most affected by the heat of the appliance. The surface temperature shall be corrected to a standard room temperature of 16°C (60°F).

Appliances shall not give rise to floor and wall temperatures exceeding 66°C (150°F).

### Combustion gas sampling

The combustion gases shall be collected in a hood terminating with a flue as advocated in BS.3300. It is important that the gas composition shall be uniform across the whole cross-section of the flue. With the catalytic heaters discharging combustion products along one side, the rising gas stream tends to be helical, thus creating a non-homogenous gas composition. This can be rectified by baffles and flow straightening devices.

### Combustion gas analysis and composition

The analysis of carbon dioxide and carbon monoxide shall be carried out by methods capable of accuracies to 0.01 and 0.001 per cent respectively. For the determination of the unoxidised liquified petroleum gases an accuracy of not less than 0.0005 per cent is required.

At any rate of heat output the CO : CO<sub>2</sub> ratio shall not exceed 0.01. The percentage of unoxidised hydrocarbons shall not exceed 0.5 per cent by weight of fuel supplied at all recommended rates of burning.

#### Draught test

A steady draught shall be produced by a fan or a wind tunnel. The flow over the area where the heater is positioned shall not vary by more than 15 per cent from the mean value.

The heater while operated at the maximum and the minimum rates of burning shall be exposed to a steady draught at a speed 3 m/sec (10 ft/sec) for a period of 15 min. For one test the catalytic bed shall be facing the draught; in the other test the side of the heater shall be facing the draught.

No deleterious effects which would affect the safe working of the heater shall be apparent during or after the tests. If damage to the catalytic bed or hot spots occurs the test shall be repeated with the temperature of the bed measured as in a test in still air. The temperatures shall be recorded. If any thermocouple reaches a temperature differing from the temperature in still air by more than  $\pm 150^{\circ}\text{C}$  the heater shall be deemed to have failed the test.

#### Effectiveness of guard in preventing floor covering fires

A concrete floor shall be covered by flannelette to BS.1945 Appendix B of dimensions not less than those of the catalytic bed. The heater shall be working at the maximum rate of heat output and after attaining thermal equilibrium shall be laid on the flannelette, with the catalytic bed facing and covering the flannelette, and shall be left there for 5 min. When the heater is removed the flannelette shall not burn or smoulder, and the heater shall resume normal burning equilibrium in 15 min.

#### Endurance test

The appliance shall be run at the maximum heat output for 8 hours and then remain in the 'off' position for 16 hours. This cycle shall be repeated until 300 hours of continuous functioning have elapsed. After this test the appliance shall comply with the test in air for maximum and minimum temperatures of the catalytic bed, CO/CO<sub>2</sub> ratio, the maximum permissible level of unburnt fuel, and all tests in a vitiated atmosphere.

### Estimation of the safe operating life of the catalyst

At present there is no information available, which would allow prediction of the safe operating life of the catalyst without long term testing. Further work is required to enable such evaluation to be made.

### Test for strength of the regulator

With the regulator attached to the container a force of 100 kg (220 lb) shall be applied perpendicularly at the centre of the regulator for a period of 3 min. If no distortions in the regulator are detected, the regulator complies with the test.

### Tests in vitiated atmospheres

There should be tests as soon as relevant information is available. The CO and CO<sub>2</sub> production in a nominally closed room is a function of the room volume, ventilation rate, rate of oxygen consumption by the appliance and the accumulative effect of flame or catalyst reaction kinetics which may change with the gas composition. There are indications that catalytic heaters produce little CO even in vitiated atmospheres; they may however, under those conditions, produce substantial quantities of unburnt gas.

For the time being French Standard N.F.35-352 1969 shall be accepted for the assessment of CO : CO<sub>2</sub> ratio and unburnt hydrocarbons.

