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JOINT FIRE RESEARCH ORGANIZATION

A NEW TEST FOR THE FIRE HAZARD OF INTERNAL LININGS. DEVELOPMENT OF APPARATUS

by

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Summary

The apparatus to measure the fire hazard of internal linings previously described (1) has been modified to improve the repeatability of the test. Limits for the operating conditions are given.

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A NEW TEST FOR THE FIRE HAZARD OF INTERNAL LININGS. DEVELOPMENT OF APPARATUS

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1. Introduction

In an earlier note [1] a new test to assess the fire hazards of the internal linings of enclosures was described and a classification of materials by their performance was given.

Subsequent experience with the test has shown that some modifications to the apparatus were desirable in order to improve its repeatability and that a preliminary test was necessary to grade some materials correctly. The reasons for this are discussed. The modified apparatus is shown in Figure 1.

2. The calibration curve of the apparatus

The temperature-time curve obtained when the apparatus is heated with a standard incombustible material in place of the specimen to be tested is referred to as the calibration curve of the apparatus. When a specimen is tested, a different temperature-time curve is obtained as a result of the heat evolved by the burning material. The new curve is then compared with the calibration curve and since only the difference between these curves is relevant, small variations in the calibration curve would not be expected to be significant.

The extent to which the calibration curve is repeatable, indicates the accuracy with which the test conditions can be reproduced in the apparatus. The average calibration curve of different apparatuses may vary but since it is only used as a reference line the results on different materials should be the same.

3. Operating notes

3.1. Ambient conditions

3.1.1. Temperature

The apparatus including the chimney and cowl should be at the ambient air temperature at the start of each test.

3.1.2. Humidity

The calibration curve is not significantly affected by variation in relative humidity within the limits of the conditions under which the experiments were made, i.e. between ambient temperatures of 10 and 21°C and between relative humidity of 55 and 65 per cent.

3.2. Variation in heat input

3.2.1. Effect of variation of total input

The rate of consumption of gas and electricity can be easily controlled within ± 2 per cent of the nominal values. The effect that varying the heat input within these tolerances has on the calibration curves is shown in Figure 2.

This variation is not significant however in view of the probable variation between the temperature-time curves obtained with different samples of untreated combustible board and board treated with a flame retardant. With the heat inputs controlled to + 2 per cent and to - 2 per cent of the nominal input the resulting temperature-time curves fell within the scatter of several curves for the same materials obtained with the nominal input.

3.3. Effects due to ageing of apparatus

3.3.1. Initial changes in asbestos board

The apparatus should be heated for several hours when any new asbestos board is used. Repeatable conditions are then obtained for all subsequent tests.

The first calibration curves obtained with apparatus made from asbestos board in the "as received" condition are different from subsequent ones.

3.3.2. Oxidation of electric elements

Calibration curves obtained with old and new elements are shown in Figure 3. Any difference due to the oxidation of the heating wires increasing the emissivity of the elements and dissipating more heat by convection through lowering the temperature of the element, is negligible.

3.4. Temperature measurement

3.4.1. Condition of thermocouples

The temperature measured in the test should be the difference between the temperature of the air entering the ventilating slot and the temperature of the thermocouples in the cowl. This means that all cold junctions must be kept at the temperature of the ventilating air. The hot junctions must be cleaned before each test to remove soot deposits which affect the temperature that they register.

3.4.2. Condition of chimney and cowl

The chimney and cowl should be cleared of all soot and scale before each test.

Calibration curves (Figure 4) measured after soot had accumulated on the inside of the chimney and cowl after several tests on combustible materials had final temperatures up to as much as 20°C (68°F) lower than curves recorded with the chimney completely clean.

3.5. Convection losses between specimen and box

Specimens are mounted in a frame which is held against the combustion chamber by springs (Figure 1). A good seal between the frame and the face of the combustion chamber is made by an asbestos paper gasket.

This overcomes a defect in the original method of sealing the specimen to the combustion chamber which was found to be a source of variation because the specimen itself provided one of the surfaces of the seal. The pressure between the sealing faces was subject to serious variation with different operators so that heat losses from the back of the chamber varied.

3.6. Guard rods

The elements are protected without affecting the test conditions by placing ceramic guard rods not more than 1/16 in. (1.6 mm) diameter in front of them (Figure 1). This prevents specimens, notably hardboard, which distort considerably when tested from touching the electric elements causing them to burn out.

4. Performance of modified apparatus

In Figure 5 ten calibration curves are plotted for a version of the apparatus with the standard combustible sheet mounted and sealed as described in Section 3.5. The chimney and cowl were thoroughly cleaned before each test and the heat inputs were controlled to the tolerances given in Section 3.2.1. The tests were carried out at different times on different days with the ambient conditions at the time of the test as given in Section 3.1.2. The repeatability is satisfactory.

5. Change of calibration curve of apparatus

The shape of the calibration curve of the modified apparatus is slightly different from the curves given for the earlier version [1] because of the modifications made. At all times the temperatures on the modified apparatus are higher than those for the earlier model and appear to reach equilibrium earlier.

6. Preliminary test

The test is designed to assess the effect of a material on the flashover times of a room lined with the material. Some materials, however, although they are easily ignited, do not decrease the flashover time of a room because they give off very little heat. While such materials would properly gain a high classification in terms of the criterion chosen, the time to reach the standard curve or the time above the standard curve, they can, sometimes, transfer a small flame from one position to another and thereby increase the chance of igniting a material that will give off larger quantities of heat. The increase in the risk of igniting sources starting a fire does not necessarily affect flashover time and it is, strictly, a different hazard. It has not proved possible to take this factor into account with the present test and a preliminary test is necessary.

The preliminary test is performed as follows.

A specimen 9 in. x 9 in. x normal thickness (22·8 cm x 22·8 cm) is mounted in a vertical plane and a gas flame impinges on the centre of one face for five seconds. The flame is obtained by burning coal gas in a jet issuing from an orifice $^1/_{16}$ in. (1·6 mm) diameter so that the axis of the flame is at an angle of 45° to the vertical and the near edge of the orifice is $\frac{1}{8}$ in. (3·2 mm) from the surface of the specimen. The flame liberates 4·2 B.Th.U./min. The flame is removed after five seconds and the time for which a flame persists on the specimen is recorded.

One specimen is tested and if a flame persists longer than five seconds the material fails the preliminary test.

If the material passes the preliminary test the main test is made.

7. Description of apparatus

Detailed drawings of the apparatus are given in Figures 1 (i) and (ii).

The walls of the apparatus should be made of an incombustible material having a density of 80 - 90 lb/ft^3 (1·3 - 1.45 g/cm^3), a thermal conductivity of 2·0 - 2.5 B.Th.U ft^{-2} hr^{-1} in.$^{-1}$ °F^{-1} (7.0 x 10^{-4} - 8.6 x 10^{-4} cal cm^{-2} s^{-1} cm^{-1} °C^{-1}) and a specific heat of 0·25.

The specimen is mounted in an incombustible frame of asbestos board so that the face to be heated is flush with and does not project beyond the sealing face of the frame.

The frame provides 1 in. of insulation to the back of the specimen.* The specimen in the frame should be mounted to form one vertical face of a combustion chamber ($7\frac{1}{2}$ in. x $7\frac{1}{2}$ in. x $3\frac{3}{4}$ in.) (19.1 cm x 19.1 cm x 9.55 cm) so that the joint between the frame and the chamber is gas tight. This is achieved by mounting the frame on four rods which allow it to move freely horizontally with an asbestos paper gasket 0.010 in. (0.254 mm) thick placed between the smooth plane closing faces of the frame and chamber, whilst maintaining uniform pressure across the faces by compression springs on the rods each applying a load of approximately 3 lb (1.36 Kg). A slot $3\frac{3}{4}$ in. x 1 in. (9.55 cm x 2.54 cm) at the lower edge of the vertical face opposite the specimen allows air to enter the combustion chamber and the hot gases escape through a 20 s.w.g. metal chimney, $1\frac{1}{2}$ in. (3.81 cm) inside diameter on top of the chamber. At the centre of the wall opposite the specimen there is a mica window 2 in. (5.08 cm) square.

The specimen is heated during the first three minutes of the test by a row of 14 gas jets issuing from orifices 1/16 in. diameter (1.59 mm) and liberating 30 B.Th.U/min. (7720 cal/min) $\pm$ 2 per cent.† The jets impinge on the specimen 1 in. above the bottom of the exposed face. After three minutes, additional heating is supplied from two pencil-type electric elements supported horizontally with their centres $1\frac{3}{4}$ in. (4.45 cm) in front of the face of the specimens and arranged symmetrically in the combustion chamber at $2\frac{1}{2}$ in. (6.35 cm) vertical centres.

The rate of electrical heating is 1500 watts (358 cal/s) $\pm$ 2 per cent and this continues for 17 minutes. The temperature differences between the ingoing air and the thermo-junctions at the exit to the cowl is recorded continuously during the test.

The thermo-junctions in the cowl are 26 s.w.g. chromel/alumel bare for $\frac{1}{8}$ in. (3.17 mm).

7. References

HIRD, D. and KARAS, G. C. E. A method of classifying the fire hazard of internal linings and their finishes. Joint Fire Research Organization F.R. Note No. 166/1955.

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*It is convenient to make frames to accommodate specimens 0 - $\frac{1}{2}$ in. thick, (0 - 1.27 cm), $\frac{1}{2}$ - 1 in. (1.27 - 2.54 cm), 1 in. - $1\frac{1}{2}$ in. (2.54 - 3.81 cm), and $1\frac{1}{2}$ in. - 2 in. (3.81 - 5.08 cm). If the thickness of the specimens is not $\frac{1}{2}$ in. (1.27 cm) or a multiple of $\frac{1}{2}$ in. (1.27 cm), then the gap between the specimen and the frame should be filled with thicknesses of asbestos board or asbestos paper.

†The rate of heat liberation of 30 B.Th.U/min. was obtained by burning 0.0625 cu. ft/min. (1770 cm^3/min.) of town gas which had a calorific value of 490 B.Th.U/cu.ft (4350 cal/m^3).

1in = 2·54 cm

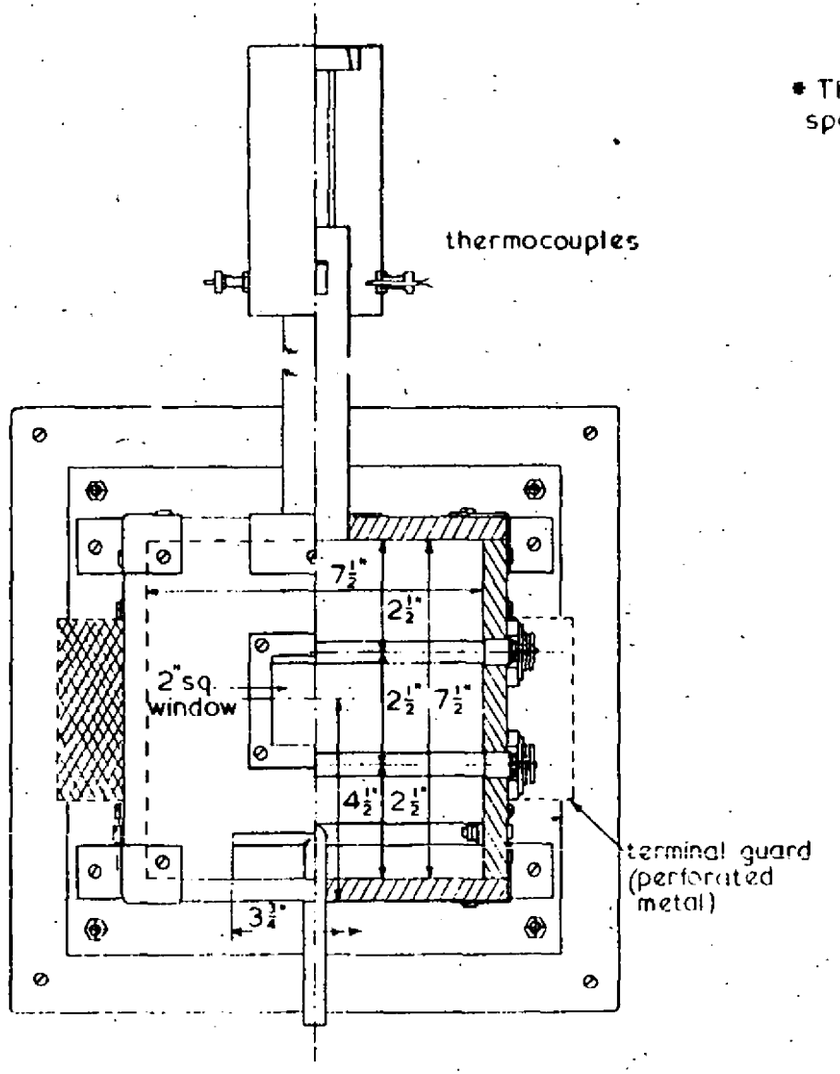


FIG. 1. (i) FRONT ELEVATION OF APPARATUS

* This dimension is larger for specimens more than ½" thick

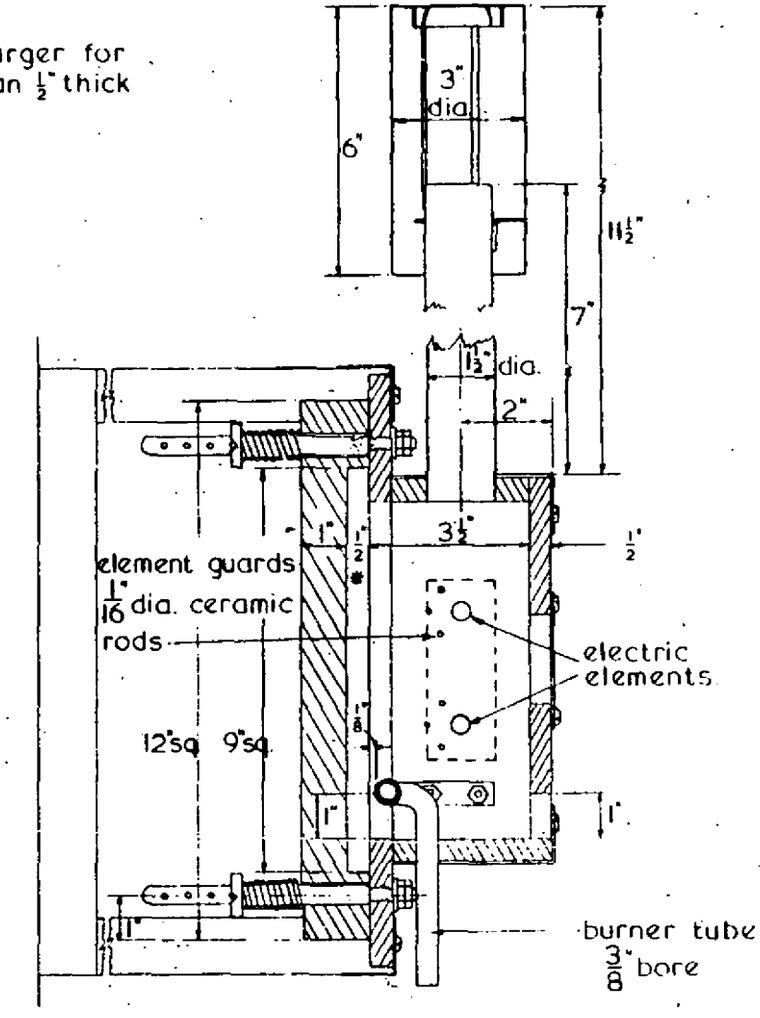


FIG. 1. (ii) SECTIONAL SIDE ELEVATION OF APPARATUS

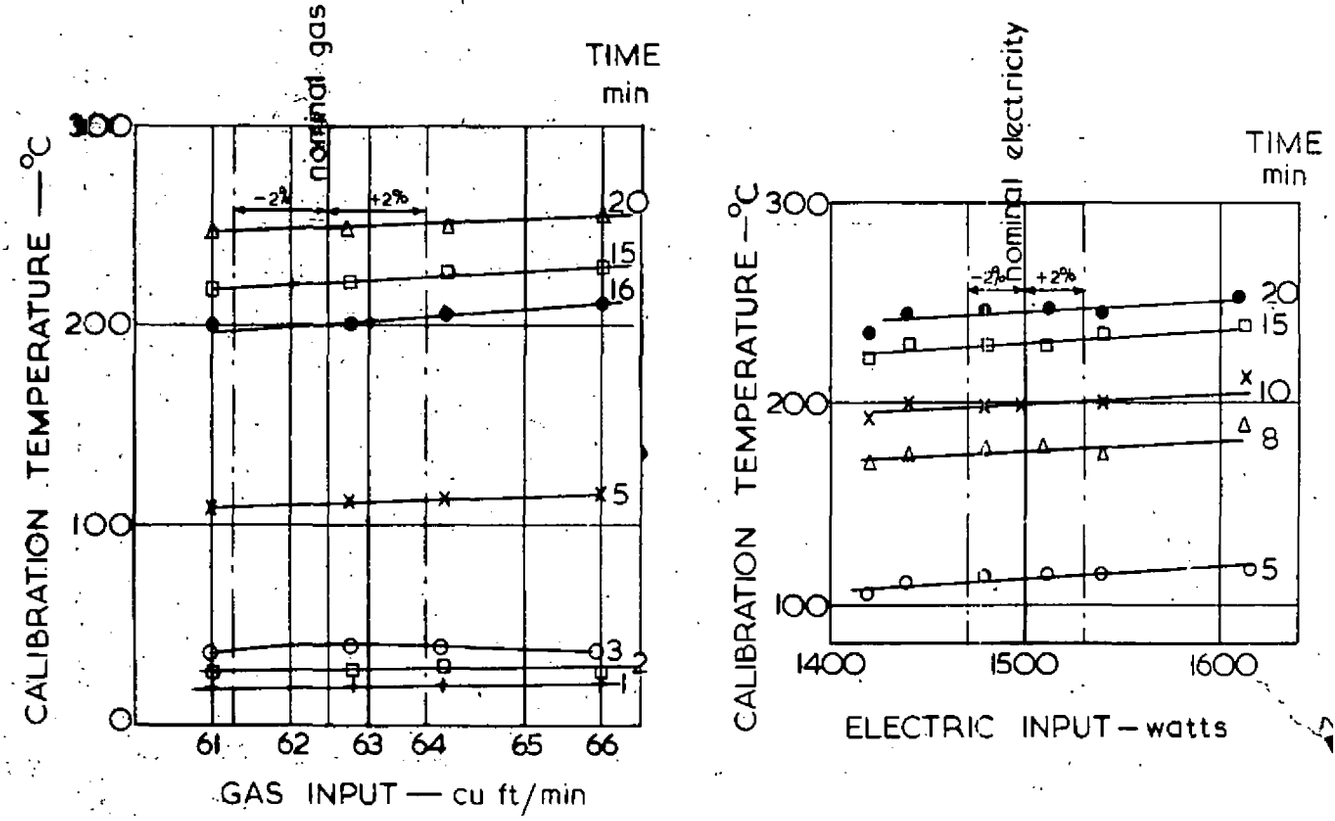


FIG. 2. EFFECT OF VARYING HEAT INPUT

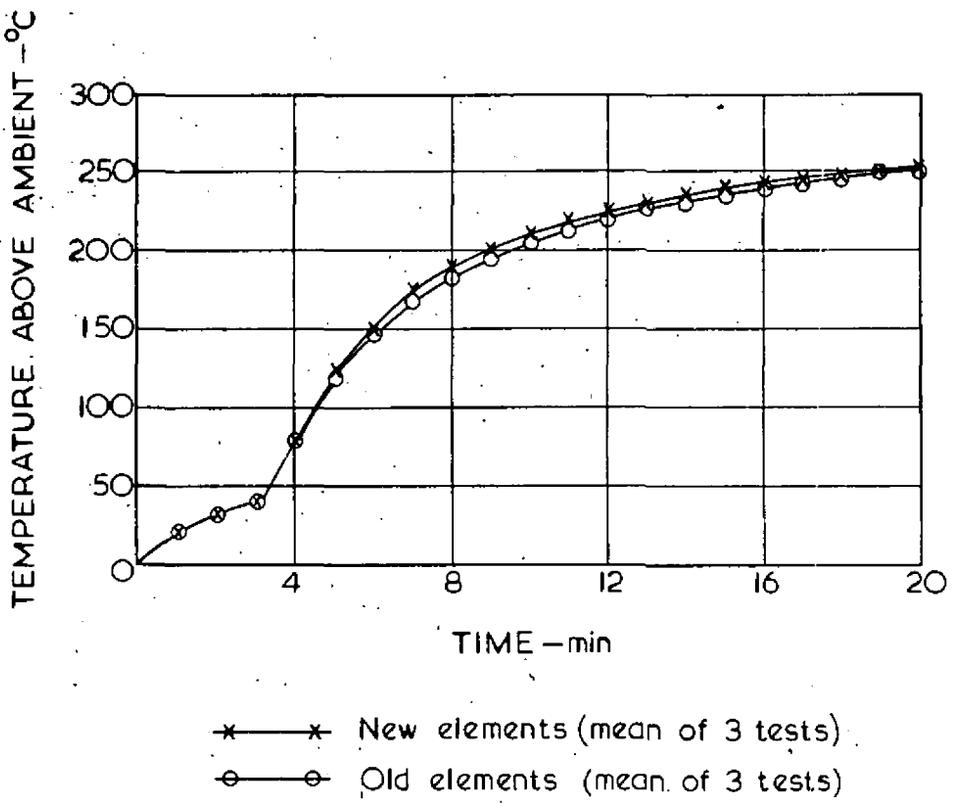


FIG. 3. EFFECT OF OXIDATION OF ELEMENTS

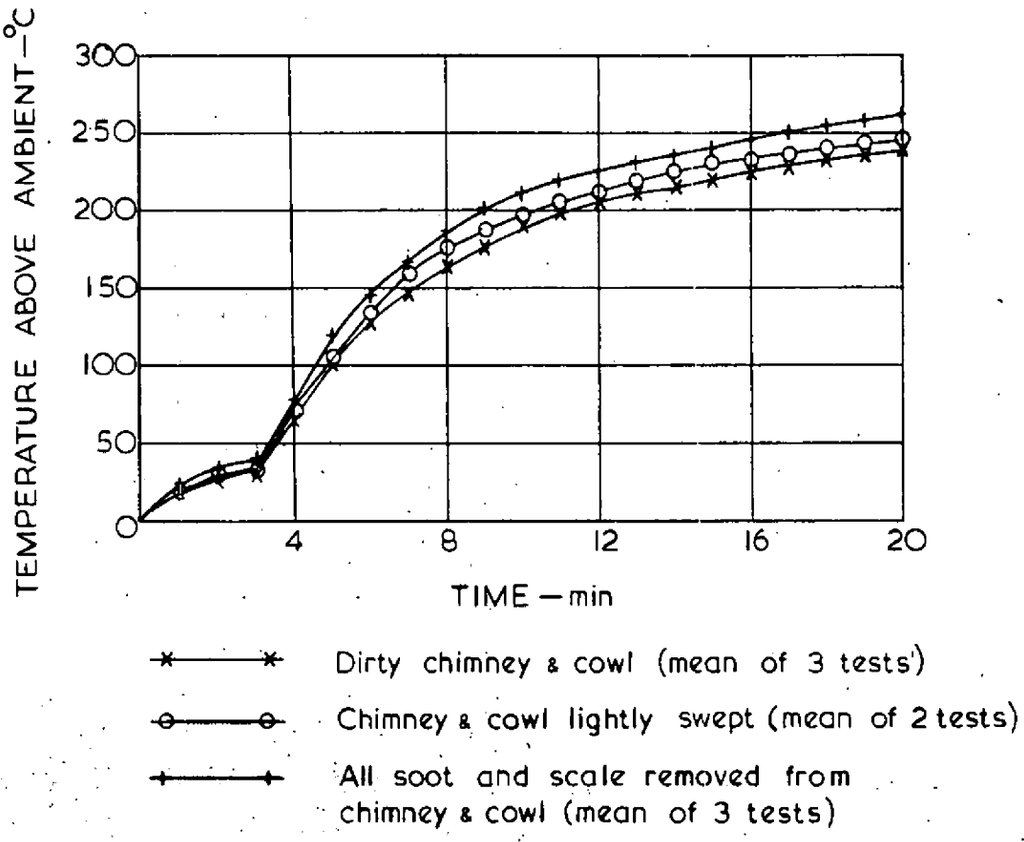
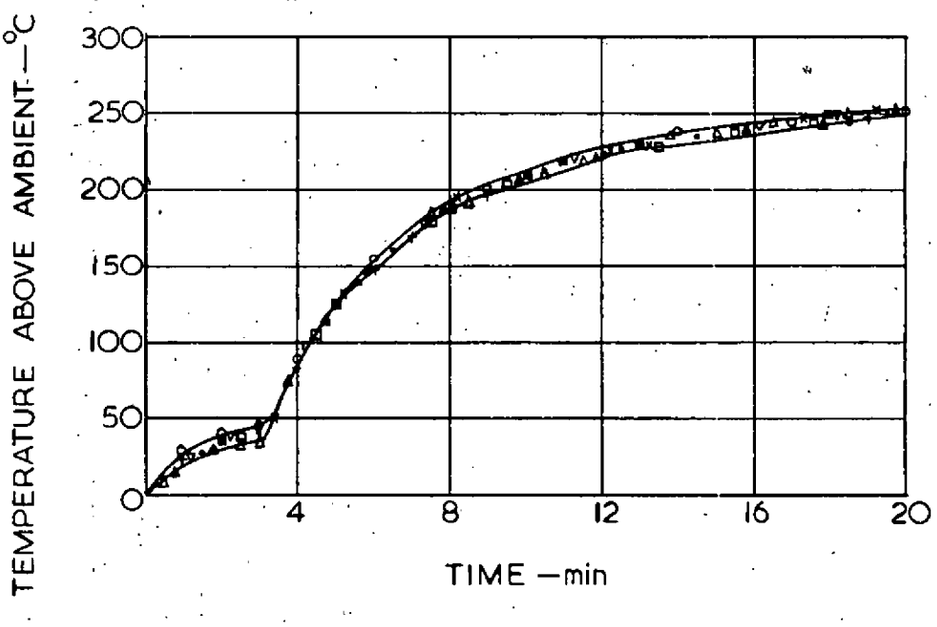


FIG. 4. EFFECT OF SOOT DEPOSITS IN CHIMNEY



SYMBOL	OPERATOR	RH%	TEMPERATURE—°C
○	A	55	21
•	B	56	18
△	C	52	23
▲	B	49	24
▽	C	60	21
×	A	59	20
+	C	58	19
□	A	61	22
■	B	54	25

FIG. 5. REPEATABILITY OF CALIBRATION