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TECHNIQUE FOR MEASURING THE REFLECTIVE PROPERTIES OF BUILDING INSULATION

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TECHNIQUE FOR MEASURING THE REFLECTIVE PROPERTIES OF BUILDING INSULATION

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ABSTRACT

This paper outlines a method for measuring the total hemispherical emissivity of large sheet samples using a guarded hotbox technique.

INTRODUCTION

Reflective foil insulation has been commonly used in New Zealand for many years and the Building Research Association of New Zealand has undertaken to determine how these reflective surfaces perform in practice. Natural hazards to these surfaces include:

1. Mechanical damage during or prior to installation;
2. Deposits of dust accumulated in service;
3. The corrosive action of salts leached out from treated framing timber;
4. Moisture precipitation on the surface under suitable conditions.

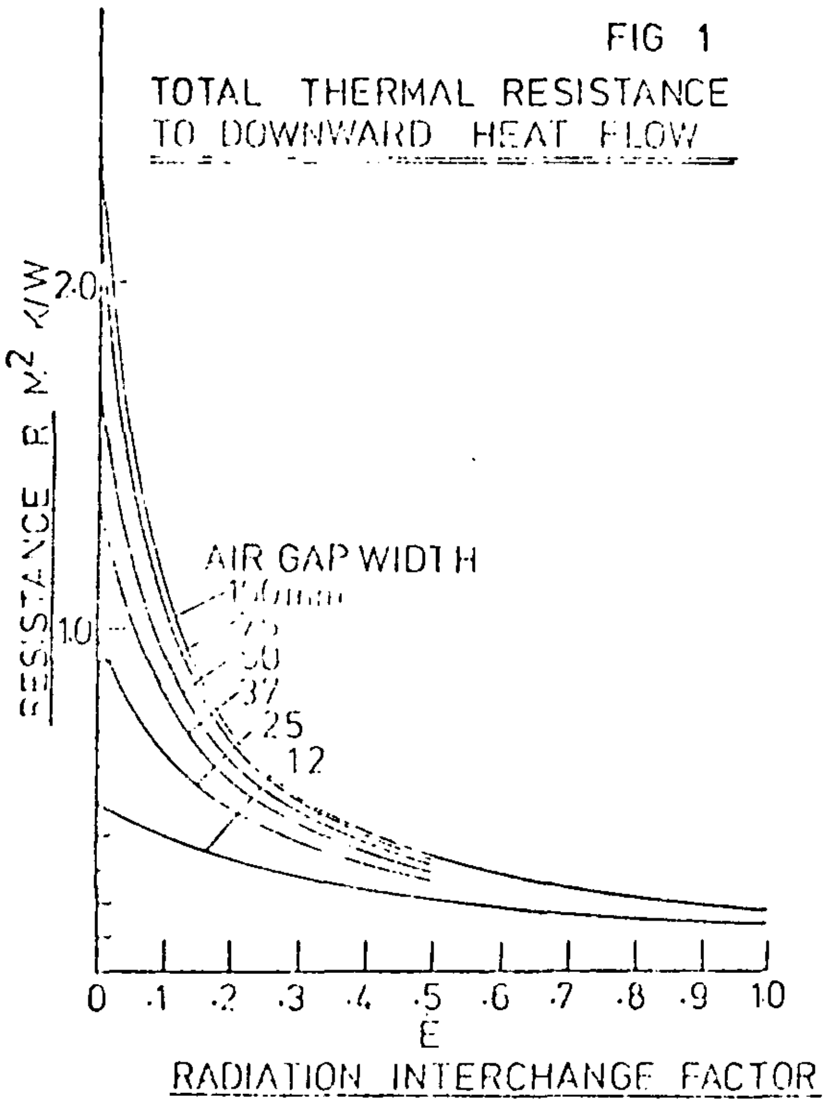
This paper outlines a method for measuring the total hemispherical emissivity of large sheet samples using a guarded hotbox technique. Some results are included, but many more are expected as samples of used foil insulation come to hand.

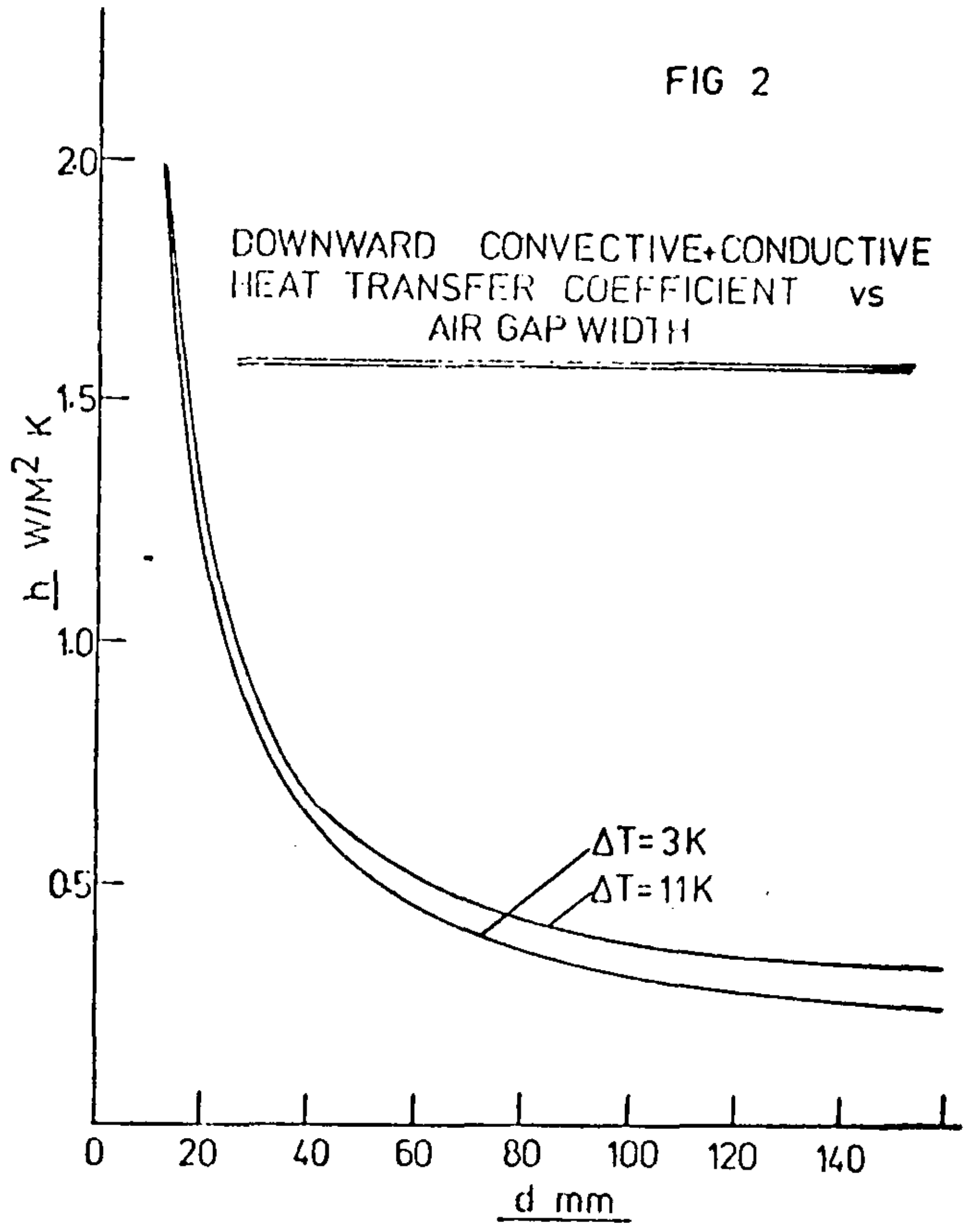
BASIS OF METHOD

The method measures heat transmission in a downward direction in air and is able to take separate account of the convected, conducted and radiated components. The basis of this is the well known measurements of Robinson, Cosgrove and Powell (1957). Their data, as illustrated in Fig 1, show that heat transfer in a vertical, downward direction is a sensitive function of the radiation interchange factor, E, where:

$$\frac{1}{E} = \frac{1}{e_1} + \frac{1}{e_2} - 1$$

and e_1 and e_2 are the total hemispherical emissivities of the infinite parallel plane surfaces. A radiation interchange integral must be evaluated where the plane surfaces are bounded but this term goes to unity if the boundary surface is made totally reflective.





In Fig 2 we plot the convective and conductive heat transfer coefficients against the air space width. This levels out beyond 100 mm to h values below 0.3 W/m^{2}K, and these are small compared to the radiated term with E set equal to unity. Indeed, E needs to fall below 0.05 before the radiated contribution falls below half of the total heat transfer. Beyond this we expect falling experimental resolution and there is little that can be done to extend the limit. Further increases in air space depth offer little reduction in the conductive and convective components.

There would, therefore, appear to be an experimental basis for measuring total hemispherical emissivities in the range of 0.05 to 1 giving adequate resolution for engineering purposes. The following sections discuss the implementation of this technique.

EXPERIMENTAL EQUIPMENT AND PROCEDURE

The experimental arrangement is illustrated in Fig 3.

The downward heat flux was measured using a metering box which generated the required quantity of heat to maintain a zero temperature difference across the well-insulated walls of the metering box. The temperature gradient across the air space was measured using Cu/Con thermocouple pairs attached immediately below, and in good thermal contact with, the surfaces under test. The test panel holder was made with solid dividers placed to match the perimeter of the heat metering box. These were installed to prevent convection which might arise through lateral temperature differences between metered and guard areas. In addition a bright foil facing was applied to make both the metered and guard areas infinite in length.

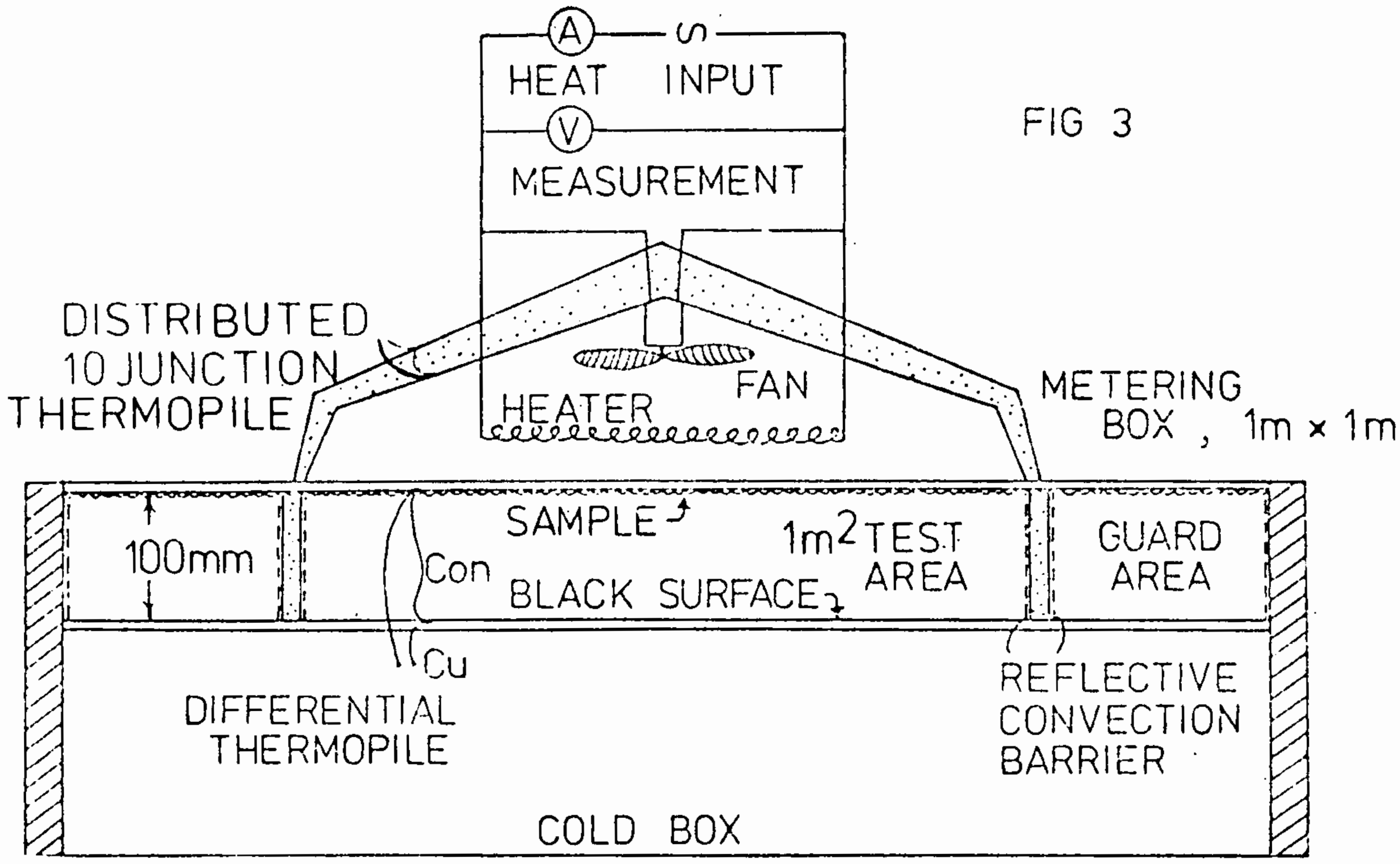


FIG 3

TYPICAL RESULTS

Measurements with black-painted and reflective surfaces were made and compared to measurements obtained with a spectroscopic technique. Fig 4 indicates the predicted calibration curve based on the data of Robinson, Cosgrove and Powell together with our two calibration points. It is evident that the "predicted" calibration yields only slightly different E values from the "measured" calibration.

The effects of condensation are immediately noticed when the foil surface is placed on the cold side of the cavity. It should, therefore, be possible to manipulate the amount of condensation by controlling the test environmental conditions. So far it is clear that minute quantities of condensation, barely discernible to the eye, are sufficient to change the emissivity of aluminium foil to near unity.

Further results are given in Table 1, together with some values recorded by Fishenden (2).

CALIBRATION OF EMISSIVITY MEASUREMENT CAVITY

FIG 4

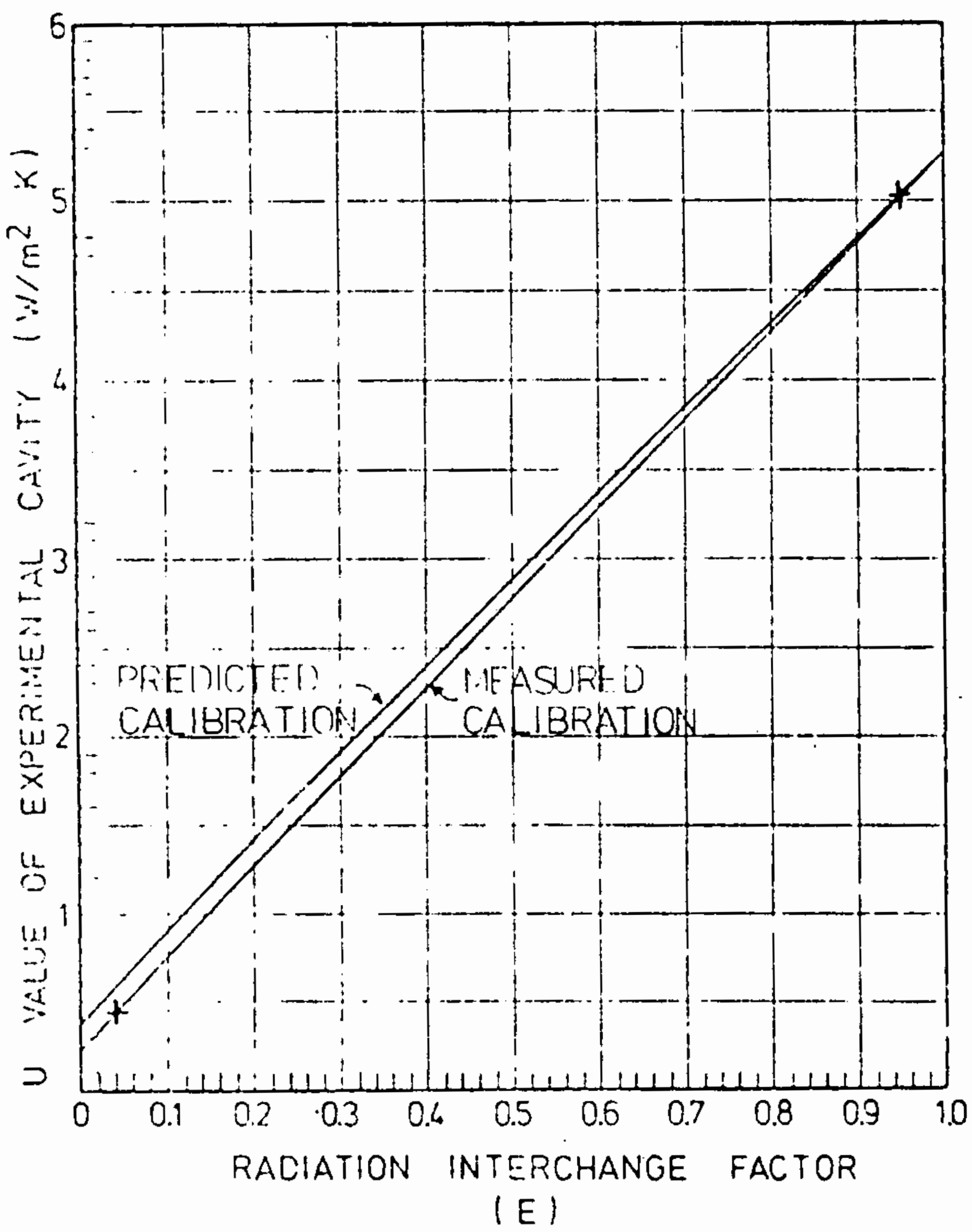


TABLE 1

Surface type	Values measured using guarded hot box. Hemispherical total emissivity
Black paint	0.95 ± 0.01
Polished aluminium foil	0.04 ± 0.01
New building foil	0.04 ± 0.01
Heavily dust-coated building foil	0.74 ± 0.01
Foil with condensation	0.52 ± 0.01
Foil with light mechanical damage	0.15 ± 0.01
Six-year-old building foil	0.10 ± 0.01
	Literature values (Fishenden) (2)
Acetylene soot	0.97
Lamp-black paint	0.96
Water, 0.1 mm thick	0.96
Glass	0.88
Polished aluminium	0.04
Polished aluminium oxidised	0.05

CONCLUSIONS

The method described is capable of measuring long-wave hemispherical emissivities in the range 0.05 to 1.0 with sufficient accuracy for engineering purposes. Suggested applications involve the measurement of average emissivities over large areas and situations where the influence of condensation needs investigation.

REFERENCES

1. Robinson, H.E., L.A. Cosgrove and F.J. Powell. Thermal resistance of airspaces and fibrous insulations bounded by reflective surfaces. Washington, D.C., National Bureau of Standards, 1957, (Building Materials and Structures Report 151).

2. Fishenden, M. Tables of emissivity of surfaces. Journal of Heat and Mass Transfer, 5, 1962: 67-76.