IS 10754 (1983): Method of determination of thermal conductivity of timber [CED 9: Timber and Timber Stores]

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Indian Standard

METHOD FOR DETERMINATION OF THERMAL CONDUCTIVITY OF TIMBER

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METHOD FOR DETERMINATION OF THERMAL CONDUCTIVITY OF TIMBER

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Indian Standard

METHOD FOR DETERMINATION OF THERMAL CONDUCTIVITY OF TIMBER

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 13 December 1983, after the draft finalized by the Timber Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 It is well known that timber is a very poor conductor of heat. This property of timber is used to utilize it for thermal insulation purposes and is evaluated in the form of thermal conductivity. IS : 3346-1980* covers the general procedures for determining thermal conductivity of thermal insulation materials that are sufficiently uniform with regard to their composition, pores, etc. Thermal conductivity of timber species, however, depends on a number of its characteristics, moisture content, grain direction in the specimen, various types of defects like knots, splits, etc, besides the experimental procedures and temperature range. This standard has, therefore, been formulated to lay down the general procedures for determining thermal conductivity of timber, keeping in view these characteristics. It is based on two slab, guarded hot plate method, described in IS : 3346-1980*. There are several other methods in vogue and in developmental stages for determining thermal conductivity of timber and these may be included at a later date when the investigations are complete.

0.3 In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Method for the determination of thermal conductivity of thermal insulation materials (two slab, guarded hot-plate method) (*first revision*).

†Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard covers the general procedure for determining the thermal conductivity of timber by 'Two slab, guarded hot-plate method'.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 3069-1965* and IS : 707-1976† and the following shall apply.

2.2 **Thermal Conductivity** — It is defined as the quantity of heat which flows in one second across unit area of a slab of timber of unit thickness when the temperature of the faces of the slab differs by one degree. In SI units it is expressed as watt per metre kelvin (w/mK).

3. APPARATUS

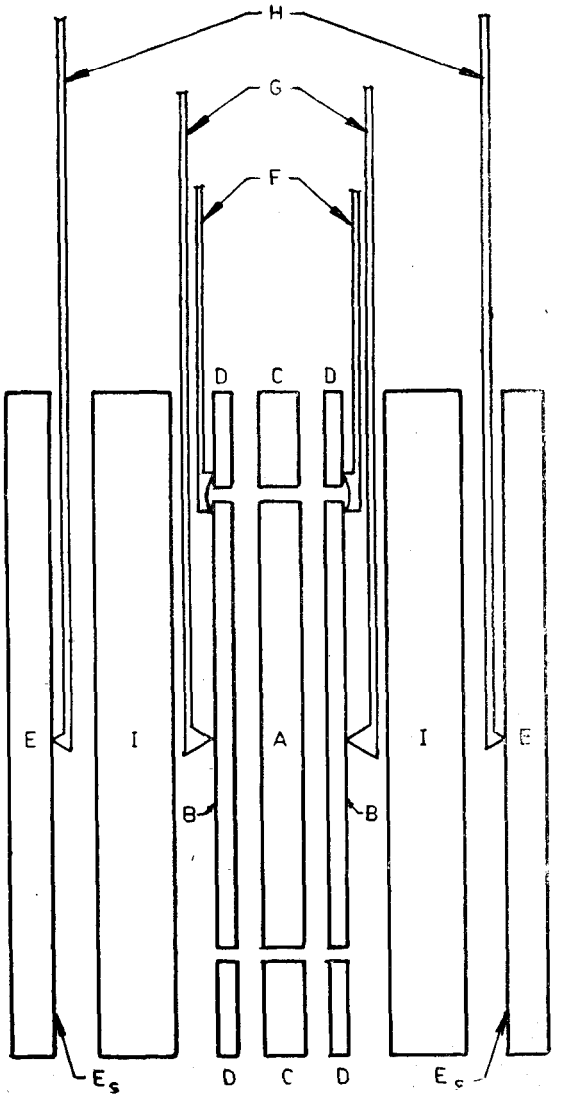
3.1 Metal surface guarded hot plate as shown schematically in Fig. 1 shall be used in determining thermal conductivity of timber. The plate shall be square or round The heating unit consists of a central section and a guarded section. The central section consists of a central heater and central surface plates. The guarded section consists of a guard heater and the guard surface plates. The surface plates shall be made of non-corroding metal of high thermal conductivity. The working surface of the heating and cooling unit shall be smoothly finished and shall conform to a true plane as closely as possible.

3.2 Care shall be taken to ensure that the two faces of the central section and the guard section are substantially at the same uniform temperature and the heating units do not warp or depart from planeness at the operating temperature. The surface of all plates shall be painted lamp black or otherwise treated, to have a total emittance greater than 0·8 at the operating temperatures.

3.3 The cooling unit shall have surface area equal to central surface plate plus the guard surface plate. The surface plates of this unit shall be maintained at the uniform desired temperature by means of a constant temperature fluid or other suitable means. Heating unit shall consist of suitable heating element which shall emit constant heat energy at a constant and known voltage and amperage.

3.4 For measuring the surface temperature of the central section of heating unit and cooling unit, appropriate number of thermocouples shall be set in grooves or under the working surfaces. Thermocouples shall also be used to detect temperature imbalance between the areas of central and guard surface plates. IS : 3346-1980‡ may be referred to for the number of thermocouples at various places, their specifications and other details of the equipment.

*Glossary of terms, symbols and units relating to thermal insulation materials.
†Glossary of terms applicable to timber technology and utilization (*second revision*).
‡Method for the determination of thermal conductivity of thermal insulation materials (two slab guarded hot-plate method) (*first revision*).



Heating unit
- *A* — Central heater
- *B* — Central surface plates
- *C* — Guard heater
- *D* — Guard surface plates

Central section of heating unit
Guard section of Heating unit

E — Cooling units
E_s — Cooling unit surface plates
F — Differential thermocouples
G — Heating unit surface thermocouples
H — Cooling unit surface thermocouples
I — Test specimens

FIG. 1 GENERAL FEATURES OF THE METAL SURFACED HOT PLATE

4. TEST SPECIMEN

4.1 Test specimen shall be 0·02 m thick and shall be in the form of square or disc of side/diameter 0·15 m. Care shall be taken that the specimen completely covers the heating unit surfaces. For this thickness and size of the specimen, the minimum linear dimensions of the heating unit and width of guard area around heater unit shall be 0·10 m and 0·05 m, respectively. The specimen shall have a smooth and plane surface so that intimate contacts between the specimen and plates is effected. The specimen shall either be cut from a plank (radial or tangential direction), or from the cross-section of a log or scantling (longitudinal direction). At least 10 sets of samples (each set consists of two identical samples) shall be taken from a lot. Out of 10 sets, 3 sets, of samples shall be of thickness in longitudinal direction. Care shall be taken that both the samples in the set have exactly same thickness.

4.2 The specimens shall be straight grained without any defects which are likely to influence the results. All the specimens shall be conditioned to a constant mass at 60±5 percent relative humidity and temperature 27±1°C before test.

5. PROCEDURE

5.1 The thickness of the specimen shall be measured correct to 10^{-5}m and other dimensions correct to 10^{-4}m. The specimens shall be weighed correct to 10^{-4}kg. The specimens shall be placed in the equipment and a constant pressure shall be imposed on the plates against the specimen to have good thermal contact. The pressure shall be such as not to effect the thickness of the specimens. The heating unit shall be connected to the electrical supply through a stabilizer so that there may not be any appreciable fluctuation or changes in the input power during the experiment. Care shall be taken that the temperature of the guard section and central section may remain the same. The temperature of the hot plate shall be set between 300 and 310°K.

5.2 The cooling unit shall be adjusted so that temperature drop through the two specimens does not differ by more than 1 percent and the difference of temperature of hot plate and cold plate may be between 5 and 10°K.

5.3 Temperature of hot plate and cold plate shall be recorded at intervals of 30 minutes until four successive sets of uniform readings are obtained to ascertain the thermal equilibrium. After getting the thermal equilibrium, experiment shall be continued for one more hour. For further precautions and experimental details, IS : 3346-1980* may be referred to.

*Method for the determination of thermal conductivity of thermal insulation materials (two slab, guarded hot-plate method) (*first revision*).

5.4 The temperature difference across the specimens, at the thermal equilibrium in Kelvin, electrical power input to the central section in terms of volts and amperes, hot and cold plate temperature and the centre-to-guard temperature balance in Kelvin shall be recorded.

5.5 The area of the specimen enclosed by the boundry running midway through the air gap between the central and guard heater in square metre shall be recorded.

5.6 The specimens shall be removed from the equipment after the experiment and weighed again. The specimen shall then be kept in a well ventilated oven maintained at temperature $100 \pm 2°C$ till it attains a constant mass.

6. CALCULATIONS

6.1 The moisture content before the test and after the test along with the density of dry specimen shall be calculated by the following formulae:

$$D = W_3 V;$$

$$M_1 = [(W_1 - W_3)/W_3] \times 100; \text{ and}$$

$$M_2 = [(W_2 - W_3)/W_3] \times 100.$$

where

D = density of dry material in kg/m^3;

M_1 = moisture content before test in percent;

M_2 = moisture content after test in percent;

W_1 = mass of specimen before test in kg;

W_2 = mass of specimen after test in kg;

W_3 = oven dry mass of the specimen in kg; and

V = volume of the specimen in m^3.

6.2 Thermal conductivity shall be calculated by the following formula:

$$K = \frac{ivl}{2A(T_h - T_c)}$$

where

K = thermal conductivity in W/mK;

i = current through the central heater in amperes;

v = potential drop in volts;

l = thickness of specimen in m;

A = specimen area enclosed by the boundry running midway through the air gap between the central and guard heater in m^2;

T_h = hot face temperature in k; and

T_c = cold face temperature in k.

6.3 In case the thickness of two specimens is not exactly the same and consequently their hot and cold faces temperatures are not identical, K shall be determined by the following formula:

$$K = \frac{iv}{A\left\{\frac{T_{h1}-T_{c1}}{l_1}+\frac{T_{h2}-T_{c2}}{l_2}\right\}}$$

where suffix 1 and 2 stand for first and second sample.

7. REPORT

7.1 Report shall include the following:

a) Species of timber;

b) Grain direction/orientation of the specimen, that is, longitudinal or radial/tangential;

c) Defect, if any;

d) Thickness of the specimen;

e) Moisture content before and after test;

f) Temperature (average) of hot and cold faces;

g) Thermal conductivity:

i) range for each orientation, and

ii) average.

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