HEAT TRANSMISSION OF COMMERCIAL WALLBOARD

By G. A. CUMINGS

FIGURE 1.—Heat transmission test box, showing clamping frame, test specimen, and arrangement of boxes.
Heat Transmission Test Box

FIGURE 2.—Location of thermometers and heating elements.
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Commercial wallboard has been extensively used during recent years in the construction of temporary buildings. It looks well, is easily handled, and requires little labor and skill in its application. Information on coefficients of heat transmission of wallboard has not been published, making it impossible to compare the value of wallboard with that of other types of wall construction as a heat insulator.

The object of these investigations is to determine approximately the rates at which heat is transmitted through the leading makes of commercial wallboards. Such information is necessary in calculating the radiating surface of heating plants, designing or specifying material for a building, and making a comparison with other building materials.

Heat is transmitted from one region to another region of lower temperature by conduction, convection, and radiation. During these investigations the total amount of heat transmitted was measured and no attempt was made to measure conduction, convection, or radiation separately.

METHOD AND APPARATUS

LABORATORY: The investigations were carried on under actual conditions in a large laboratory of the Mechanical Engineering building.

TEST BOX: The method employed was that of using a double test-box arrangement, having the open side of each box in the same plane. See Figures 1, 2, 3, and 4. Inside dimensions of the outer box were 2 feet 4.5 inches by 2 feet 4.5 inches by 1 foot 8.25 inches, and of the inner box 1 foot by 1 foot by 1 foot. The walls of the boxes were built up of three layers of ¼-inch asbestos mill-board, a ⅜-inch air space and ¼-inch wooden frame. The corners were well sealed with strips of wallboard tape. The face of the inner box was made of ⅜-inch by 2-inch strap iron brought to a knife edge, one foot square. Adjustable supports were provided for the inner box to maintain perfect alignment of the bearing surfaces or open faces of the two boxes.

An adjustable clamping frame carrying twenty-eight ½-inch by 6-inch adjusting bolts was supported at the corners of the box by ½-inch threaded rods. The whole frame could be easily removed by loosening the four nuts at the corners. A sub-frame was used for each box to distribute the pressure equally over the bearing surface.

TEST SPECIMENS: Test specimens were cut 2 feet 9 inches square. They rested on the knife edge of the inner box and asbestos pad of the outer box. Pressure applied on the specimen by the clamping frame sealed the boxes air-tight. One-fourth-inch holes were bored in the specimen, through which the thermometers were inserted.
Electrical Apparatus: The heating element for the inner box was 14 feet of Westinghouse heater coil wire, evenly distributed across the box at a distance of 2.5 inches from the bottom as shown in Figs. 2 and 3. The lead wires were taken through an insulator tube and packed with powdered asbestos. The heating element of the outer box was one complete Westinghouse heater coil, 500 W., 110 V., placed 2.5 inches from the bottom of the box.

A Westinghouse portable, single phase wattmeter, 100 to 200 V., 2.5 to 5 A., 250 to 500 W., from the standardization laboratory of the University of Colorado, was used to measure the electric current supplied to the heating element of the inner box.
A 110 V., 7.55 A., 830 W. rheostat was used to control the temperature of the outer box. A 50 ohm, 3 to 1.5 A., 125 V. rheostat was used to vary the temperature of the inner box.

The source of electric current was the 110 V. alternating current power line of the College.

**FIGURE 4.—Test box in operation.**

**THERMOMETERS:** Twenty-four-inch engraved stem chemical thermometers with a range of 0 to 100 degrees Centigrade, graduated to one-tenth of one degree and capable of being read to one-twentieth of one degree, were used for all temperatures affecting the results of the investigations. Engraved stem chemical thermometers with a range of 0 to 300 degrees Fahrenheit, graduated to two degrees, and capable of
being read to one-half of one degree, were used for various temperatures not directly affecting the results of the investigations. The thermometers were not checked against any standard instrument, since the difference in temperature was desired rather than actual temperatures. The thermometers were checked against each other by holding all of them at certain temperatures and recording the readings.

**BAROMETER:** Barometer readings were taken during every test with a standard mercurial barometer.

**METHODS OF CONDUCTING THE TESTS**

Tests were made on each specimen at intervals of 10 degrees for a range of 25 to 75 degrees Fahrenheit difference in temperature of outside and inside air. No readings were taken until the temperatures indicated a constant flow of heat. Temperatures were taken at sufficient number of points to give an average temperature, as shown in Fig. 2.

![Graph showing heat transmission (U) curves.](image)

**FIGURE 5.—Heat transmission (U) curves.**

The test box was placed in an upright position during the tests, to permit an even flow of heat upward from the heating elements to the test specimen. See Figs. 2 and 4. Holding the temperatures in the two boxes the same would prevent any transmission of heat through the walls of the inner box or conduction along the test specimen. Then, theoretically, all the heat given off by the inner heating element must pass directly through the test specimen. However, in actual practice, even by experimentally locating the heating elements and controlling the heat input, it was found impossible to keep the temperatures of the two boxes exactly the same. But due to the insulating quality of the walls of the box, practically no heat was transmitted through the walls with a slight difference of temperatures. To bring the results within a greater degree of accuracy the approximate rate of heat transmission of the walls of the inner box was measured and the correction applied.
The test box was designed with a 6-inch fan driven by a motor on the outside, to circulate the air in the outer box. The circulation was incomplete and variations in the temperatures were produced. Eliminating the fan, properly arranging the heating elements, and setting the test box in an upright position, gave a natural, even flow of heat upward to the specimen.

The test specimen covering only one side of the test box and resting on the knife edge eliminated any question as to the heat transmitting area to be considered. There was no influence of air currents upon the surface resistance of the test specimen, since fans were not used to circulate the air.

Temperatures of the outside air were taken at different distances from the test specimen to get a temperature gradient showing the point at which the outside temperature became constant. Since the temperatures were taken directly above the specimen, the gradient could not be applied to actual conditions and will not be considered of much importance in connection with these investigations.

**CALCULATION OF RESULTS**

**Symbols:**

\[ W = \text{Watts supplied to the heating element.} \]
\[ t_1 = \text{Inside air temperature.} \]
\[ T = \text{Outside air temperature or room temperature.} \]
\[ A = \text{Heat transmitting area in square feet.} \]
\[ H = \text{Time in hours.} \]
\[ U = \text{Total heat transmission, B. T. Us. per hour, per square foot, per degree Fahr. difference in temperature, per actual thickness.} \]
\[ 3.412 = \text{Factor to convert watts into B. T. Us. per hour.} \]

**Formula:**

\[ U = \frac{3.412 \ W}{A \ (t - T) \ H} \]

**FINAL RESULTS**

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<tr>
<th></th>
<th>( t - T )</th>
<th>( U )</th>
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<td>Ave. ( U )= .80</td>
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DISCUSSIONS AND CONCLUSIONS

The results of these investigations deal only with heat insulating qualities of the wallboards and, as previously mentioned, have not been obtained from a purely scientific point of view. Corrections have been applied to bring the results within some degree of accuracy, but certain minor variations were immeasurable. However, the results are considered sufficiently accurate to be used for any practical purpose and should represent a fair comparison of the heat-insulating qualities of the various kinds of wallboard investigated.

The tests were not of long enough duration to indicate any effect of barometric pressure upon the rate of heat transmission.

INFORMATION OF GENERAL INTEREST ABOUT WALLBOARD

1. As an insulator of heat, it is a little inferior to common lath and plaster one-half inch thick.
2. It is quickly and easily applied.
3. It has a great number of uses other than wall construction.
4. It is superior to wood in many cases of light construction, for it is light, uniform, and leaves no cracks.
5. Contraction and expansion are not noticed under ordinary conditions.
6. In places of high temperatures or extreme temperature-changes the edges are liable to warp or come loose unless well stripped.
7. When exposed to moisture for any length of time it tends to soften and expand.
8. Types of wallboard such as Sheet Rock are fire-proof.
9. It lends itself very well to painting and tinting.
10. It is not as durable as lath and plaster.
11. It is in general more expensive than other kinds of material used for similar purposes.