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ALUMINUM FOIL INSULATION
June 4, 1936.

At the time Circular C376 of the National Bureau of Standards was prepared (1929), insulating materials of the reflective type had not come into prominence. This letter circular is to be considered as a supplement to Circular C376 pending its revision.

In Circular C376 it is stated: Commercial insulating materials can be divided into two general groups -

(1) fibrous materials either in loose form or fabricated into soft flexible quilts confined between relatively thin layers of paper or textile, and

(2) more or less rigid boards in which the components are bonded together in some way.

To this classification must now be added a new and distinctive group, as follows:

(3) reflective materials, such as aluminum foil, deriving their insulating properties from the fact that they reflect radiant heat.

Since the principles involved in the use of aluminum foil or other bright metal sheet as thermal insulation are not generally understood, a brief discussion will be given here. Aluminum foil is used to increase the insulating value of air spaces by reducing heat transfer by radiation. It is of value only in conjunction with air spaces, and has no value when placed in continuous contact with solid material on both sides, except in so far as it may act as a building paper in preventing air leakage.

Clean metallic surfaces in general are good reflectors and poor emitters of radiant heat. Since a large proportion of the heat transfer across air spaces bounded by non-metallic materials takes place by radiation, the use of aluminum as one or both boundaries of a space will materially reduce the heat transfer across the space. It will be evident that the insulating effect does not depend on the thickness of the metallic foil, while the insulating value of ordinary types of insulating materials depends mainly on their thickness. The insulating value of air spaces bounded on one or both interior surfaces with aluminum foil increases with increasing

width of space up to about 3/4 inch width. Spaces wider than about 3/4 inch have substantially the same insulating value, regardless of width.

There is little definite information on the permanency of the reflective surfaces of aluminum under various conditions of use over long periods. Installations are reported where no appreciable deterioration of the aluminum has occurred over a considerable period of years. Thin layers of dust readily visible to the eye do not cause any very serious lowering in the reflecting power. If aluminum is wetted over considerable periods of time, there is possibility of corrosion. The reflectivity is not appreciably reduced until the aluminum is covered by an easily visible layer of corrosion products (Gregg, Refrigerating Engineering, May, 1932).

The use of lacquer to resist possible corrosion under severe conditions of use reduces the reflecting power to a greater or lesser extent. The effect of a very thin coat of lacquer is small, but relatively thick lacquers, even though they are almost invisible to the eye, may seriously reduce the effectiveness of the foil.

The effect of reduced reflectivity on heat transfer across an air space is less marked the narrower the space, since heat transfer by conduction and convection plays a more important role than radiation in the case of narrow air spaces.

The available data in the literature on the insulating value of aluminum foil used in various ways show considerable variation. The numerical data in the following table are therefore necessarily only approximate, but are sufficiently accurate for practical purposes in connection with house insulation. In this table the data in Column 1 on clean aluminum foil are calculated from test results. The data in the other columns are calculated from the figures in Column 1, assuming that the reflecting power of clean aluminum is 95 percent. All air spaces are assumed to be 3/4 inch or more in width. The figures given represent the number of inches of insulating material having a thermal conductivity of 0.3 Btu/hr sq ft (deg F/inch) to which each combination of reflective material is equivalent.

A material having a conductivity of 0.3 Btu has been selected as a basis for comparison because this figure is about the average of insulating materials now being sold.

The figures in the table represent the total insulating values of the air-space combinations described. Since the original single air-space bounded by ordinary materials such as paper has insulating value equivalent to about 1/4 inch of insulating material (Column 4), the insulating value which is actually added by the use of reflective material is about 1/4 inch less than the figures given in the table.

There are a number of ways in which insulating value may be expressed. The method of expressing insulating value in the table has been chosen as being most readily intelligible to persons not familiar with the technical side of the subject. Anyone who wishes to have the results expressed in terms of heat transfer in Btu per hour per square foot and per degree F temperature difference, may do so by dividing 0.3 (the conductivity of an average insulating material) by the numbers given in the table. For example, the number 1.5 represents 0.3/1.5 or 0.2 Btu per hour per square foot and per degree F temperature difference.

Aluminum foil is also applied in a crumpled form so that it is self-spacing. If two or three crumpled sheets are hung in the air space of a frame wall, there is so little contact between the sheets that the insulating values are essentially the same as those given for the spaced sheets.

Combination	Insulating value in inches of insulating material			
	Clean aluminum (95% reflecting)	Reflecting surface (85% reflecting)	Aluminum paint (65% reflecting)	Ordinary paper (10% reflecting)
1 Space, reflective material on one side	0.75	0.61	0.45	0.26
1 Space, reflective material on both sides	.80	.70	.54	.26
2 Spaces, formed by dividing wide space by 1 reflective sheet	1.50	1.21	.90	.53
3 Spaces, formed by dividing wide space with 2 reflective sheets	2.30	1.90	1.43	.72
4 Spaces, formed by dividing wide space with 3 reflective sheets	3.10	2.61	1.97	1.05