

# Insulation for Cold Storage\*

## Tests of Several Insulating Materials

By Prof. Henry Payne

THE author recently had occasion to inquire into the value of some insulating media, in consequence of the erection of certain cool stores, and therefore takes this opportunity of placing the results of his investigations on record.

It may be well to summarize the requirements for a good insulating material as given by a number of writers on the subject.

Material for insulation of cool stores should be: 1. A good non-conductor of heat. 2. Fire-proof. 3. Durable: (a) vermin-proof; (b) fungus-proof; (c) not liable to bacterial action. 4. Non-hygroscopic or deliquescent. 5. Not liable to silt. 6. Not entailing a costly mode of application. 7. Inexpensive. No one material stands pre-eminent in relation to all these requirements, and it must remain for the engineer or architect to select for himself that which most nearly suits the problem he has to deal with.

Experiments were made for the purpose of ascertaining from a number of materials the relative values of the above-mentioned requirements 1 and 5. The materials selected were: (1) silicate cotton (mineral wool); (2) wood charcoal; (3) pumice; (4) buzza chips; (5) cork. The silicate cotton was locally manufactured at Yarraville, and was packed to a density of 13 pounds per cubic foot when used for insulation purposes. Wood charcoal was bought in Melbourne, and readily passed through a half-inch mesh sieve. It was free from dust and dry. Pumice was also purchased in Melbourne, and contained a considerable quantity of small material, together with some dust. Buzza chips, as the name indicates, come from timber yards. Cork was provided in sheets, being compressed into slabs of 2-inch thickness, and the slabs were jointed together with a cork cementing material.

To compare the various materials three sets of experiments were carried through—one set comparing the materials when filling in the space between timber partitions, the second set comparing the materials when placed between thin galvanized iron partitions, both these to determine their relative conductivity, and the third set to determine their liability to silt under a continued shake over extended periods.

The apparatus used for determining the first set of experiments is shown in Fig. 1, which consists of a case A, formed with hollow walls B, into which the insulating material was placed. The partitions forming these walls were each constructed with two thicknesses of 3/4-inch flooring boards with the usual brown refrigeration paper between them, the total thicknesses of these walls being 9 inches. The mode of filling in the material was by turning the case top downward, and carefully filling it with the bottom C removed, uniformity in packing being looked to by pressing each layer of material into the space allotted to it. The cover D was similarly packed from its end E. The case was then placed upon wood blocks K, so as to allow for the free circulation of air around the case during the test. In order to determine the amount of heat that would be conveyed through these walls, ice I was placed in the case on a thin galvanized iron tray F, which drained any water coming therefrom through a 1/4-inch India rubber tube G, when the clip H was opened. This water was collected in the beaker J at intervals and weighed. Through the cover D a 1/4-inch India rubber tube L allowed the introduction of a low reading thermometer M, for the purpose of ascertaining the internal temperature of the case; thus the difference of temperature existing on the two sides of the wall of these cases was determined.

The case in Fig. 1 had the following principal dimensions: Internal volume, 27 cubic feet, the volume of insulating material filled in between the partitions was 40.45 cubic feet, while the total volume of the case was 91.75 cubic feet. The inner area of the case was 54 square feet, its outer area 121.5 square feet, and the mean area (including wooden partitions) was 85.5 square feet, which mean area has been selected for arriving at the relative values of the walls packed with the various insulating materials.

In order to obtain uniform temperature ruling in the room in which the cases were placed, the doors were kept closed, except when the observers passed into an adjoining room for the purpose of weighing the water which was periodically drawn off. This weighing room had no other means of entrance but from the test room, and so was not a greatly disturbing factor. Further, two electric fans were at work during

the whole of the test periods keeping the air in constant circulation, and were similarly placed in relation to the various cases used.

Tests were carried out over extended periods with continuous observations taken every quarter of an hour, and were continued until such time as the internal temperature became constant for a constant external temperature. Such constant external temperature was in each case in the region of 65 deg. Fahr., 80 deg. Fahr. and 100 deg. Fahr. The periods over which observations

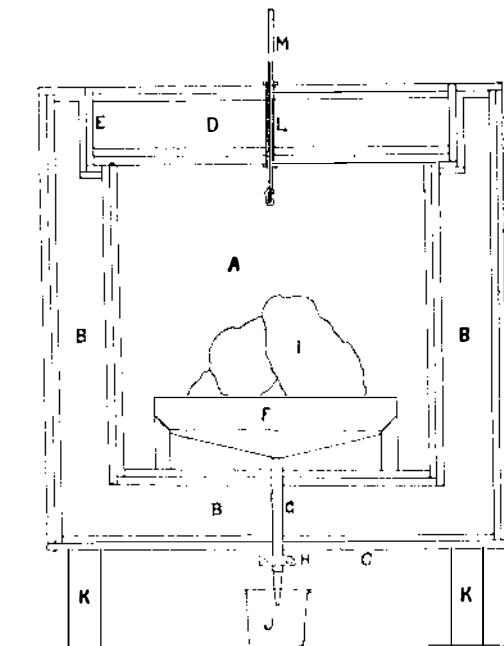


Fig. 1.—Apparatus used to test insulating qualities of different materials.

were taken at these temperatures were such that three and four hour periods of uniform working could be taken for comparison. The total continuous runs varied from 24 hours to 48 hours.

The conductivity results obtained from a large number of calculations are:

Wall packed with silicate cotton.....	0.230
Wall packed with wood charcoal.....	0.265
Wall packed with pumice.....	0.332
Wall packed with buzza chips.....	0.305

These figures are at 90 deg. Fahr., and represent the number of British thermal units transmitted per hour, per degree difference of temperature on the two sides, per square foot of area (mean area of insulation being taken) per inch thickness of insulating material; or if the results are compared on the basis of wall packed with silicate cotton at 100 they are:

Wall packed with silicate cotton.....	100
Wall packed with wood charcoal.....	114
Wall packed with pumice.....	144
Wall packed with buzza chips.....	132

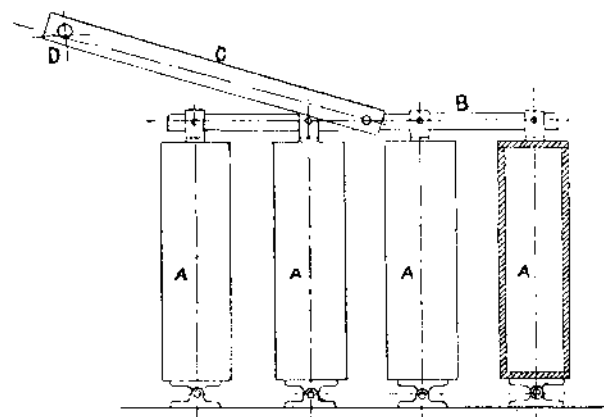


Fig. 2.—Apparatus employed to determine degree of settlement of insulating material.

The weights of material used for packing the walls were:

Silicate cotton.....	13.03 pounds to the cubic foot
Wood charcoal.....	13.62 pounds to the cubic foot
Pumice.....	23.60 pounds to the cubic foot
Buzza chips.....	6.87 pounds to the cubic foot

Since, in the above results, it was clear that the wooden partitions were in a measure shrouding the relative values of the four materials, the second series of tests were carried out, but the cases were of light galvanized sheet iron. The inner cube was 1 foot by 1 foot by 1 foot, and the outer cubes were constructed so as to

provide thicknesses for the insulating material of 2 inches and 6 inches for silicate cotton; 6 inches for wood charcoal; and 2 inches, 4 inches and 6 inches for cork, the inner temperatures being observed in the same manner as in Fig. 1. A similar method of withdrawing the water due to meltage was adopted.

With this second set of experiments a large number of results were obtained for conductivity which do not differ from the following figures:

Silicate cotton.....	0.203
Wood charcoal.....	0.298
Cork.....	0.219

Or when based on silicate cotton at 100 they are:

Silicate cotton.....	100
Wood charcoal.....	146
Cork.....	108

These figures were determined from the difference of temperature between the room and the inside of the cases, and do not vary with the temperature or with the thickness of material for the 2-inch, 4-inch and 6-inch walls.

Taking the results obtained from this second set of experiments and applying them to the first set, it would appear that the value for the conductivity of the wooden partitions (see Fig. 1) as constructed is 0.255 British thermal unit per hour, per degree, per square foot of mean area, per inch thickness. So that the shrouding effect, when comparing walls packed with silicate cotton and walls packed with wood charcoal, is that silicate cotton appears in a worse aspect than wood charcoal when packed in between timber partitions (0.230—0.265 or 100—114) than when acting by themselves (0.203—0.298 or 100—146).

The third series of tests, namely, those to determine the amount of silting or settlement, were carried out in the apparatus shown in Fig. 2. Shake-boxes A were constructed so that each contained a cubic foot of material 6 inches by 12 inches by 24 inches, the top of the box receiving a to-and-fro motion of one half inch at a distance of 25 inches above the rocking point. The four shake-boxes were coupled to a rod B by pins, this rod receiving its to-and-fro motion through the connecting rod C worked from an eccentric D. The rate of the to-and-fro motion, that is, the number of revolutions of the eccentric, was about 320 per minute.

The weights of material packed into these shake-boxes were respectively:

Silicate cotton.....	13.0 lbs.
Wood charcoal.....	14.9 lbs.
Pumice.....	23.2 lbs.
Buzza chips.....	6.8 lbs.

The author is not aware of a shake test on similar lines being carried out heretofore, hence the following table:

Time.	Revolutions of Eccentric.	Settlement in 1/16th inch.			
		Silicate Cotton.	Wood Charcoal.	Pumice.	Buzza Chips.
0 min.	0	0	0	0	0
1 min.	333	0	1	1	2
5 min.	1,620	0	5	3	7
12 min.	3,727	0	9	5	9
30 min.	9,705	0	15	6	13
60 min.	19,432	0	17	7	16
2 hrs.	39,522	0	22	8	18
5 hrs.	.....	0	26	11	21
12 hrs.	.....	0	33	14	24
24 hrs.	.....	0	36	16	25
48 hrs.	.....	0	38	24	27

Unfortunately the counter became disarranged when running between the two and five hour periods, and was no longer used.

The wood charcoal on the top surface became very rounded, due to the constant abrasion. The top two inches of pumice also consisted of somewhat more rounded material than before the test. On unscrewing the sides of the boxes after the test it was evident that the materials had settled themselves into a closely packed uniform mass. The wood charcoal showed considerable powdered material in the bottom six inches; the pumice also exhibited some increase in its dust, but this dust was uniformly distributed throughout the mass except in the top two inches; the buzza chips showed by pressure of the hand less indentation at the bottom than at the top, and appeared to gradually taper in density from bottom to top, and the silicate cotton remained uniform; it did not appear to have changed in the least during the test.

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