BUILDING DIGEST

CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

THERMAL INSULATION AT LOW TEMPERATURE

Introduction

In recent years, there has been a very large expansion of the refrigeration and cold storage Industry in the country. This has brought the problem of scientific approach to the low temperature Insulation, to the forefornt. The application of insulation at low temperatures has to satisfy certain specific requirements. This digest aims to provide the necessary background information on low temperature insulation application, in a simplifed form, for the benefit of the user.

Good insulation contributes to the efficient and economic operation of the refrigerated spaces. The importance of insulation in overall investment can be evidenced by a recent survey conducted by the Institute on a few Cold Storage structures. The Survey shows the following breakup of the total cost for a potato cold storage structure of 2000 tonnes capacity.

	Percent
Land, Building and Racks.	50-55
Insulation	10-25
Refrigeration plant and electrical installation etc.	25-35

In recent years several materials in the form of slab, loose fill, granular and fibrous insulation have appeared in the Indian market. The Institute has carried out a detailed study on the insulation characteristics of these materials at low temperatures. The most important properties which a material should satisfy are insulating efficiency, resistance to water vapour migration and durability at low temperatures. In addition to the above, a low temperature insulation should also satisfy the standard specifications on weight, fire-resistance, structural strength, insect and vermin resistance and surface finish.

Insulating Efficiency

The insulating efficiency of a material is governed by its thermal conductivity, which depends upon a number of factors Some of them are due to the nature of the materials themselves, such as composition, density and pore structure, other factors are mean temperature, moisture content, location and direction of heat flow.

Thermal conductivity of a few common building and insulating materials, used in refrigeration and cold storage industry, are given in table 1 (a) and I (b). The values are representative for a particular type of product tested and should be taken as guide values only. There may be variations in the physical properties of similar products marketted and it is advisable to test the specific sample of the material before application. The Institute provides test facilities on thermal conductivity and over all heat transmission coefficient of insulating materials within the mean temperature from +75°C to+0°C

Recommended Thickness of Insulation

The IS Code of practice for safe operation and insulation of cold storage (IS: 661-1955 revised in 1964) specifies the economical insulation in terms of cork thickness for various storage temperatures. This has been done so that any alternative material which provides an insulation value equivalent to the specified thickness of cork can be used. Table 2 provides equivalent thickness of various insulating materials.

The recent survey on potato cold storages in Northern India indicate that commonly used insulating materials are expanded polystyrene, saw dust rice husk, fibre glass and foam concrete. The variations in thickness of insulation used for walls, roofs and floors are given in table 3.

Tables : I (a)

Thermal Conductivity of Building Materials at Normal Temperatures

S.No.	Name of the Material	Density Kg/m³	Mean Temperature°C	Thermal conductivity Kcal/hr°Cm.
1	Brick	1820	45.0	0.697
2	R.C.C.	2288	42.0	1.360
3	Reinforced Brick	1920	42.0	0.945
4	Lime Concrete	1446	41.0	0.628
5	A.C. Sheet	1520	44.0	0.240
6	Timber	720	41.0	0.124

Table : I (b)

Thermal Conductivity of Insulating Materials at Low Temperatures

S. No.	Name of the material	Density Kg/m³	Mean Temperature°C	Thermal Conductivity Kcal/hr°Cm
1	Saw Dust	170	25	0.059
2	Rice Husk	165	25	0.060
3	Cork	164	15	0.036
4	Foam Glass	127	14	0.047
5	Foam Concrete	321	15	0.062
6	Foam Concrete	405	16	0.072
7	Glass Wool	69	12	0.030
8	Mineral Wool	75	15	0.026
9	Expanded Polystyrene	22	14	0.027
10	Expanded Polyurethane	18	11	0.016
11	Fibre Glass	49	15	0.028

Table : 2

Recommended Thickness of Cork and other Insulating Materials at Various Storage Temperature Ranges

S.No.	Insulating Materials	Density Kg/m³	Thickness in centimeters					
			From −30°C Upto −20°C	From −20°C Upto −15°C	From −15°C Upto −4°C	From −4°C Upto +2°C	From +2°C Upto +10°C	From +10°C Upto +16°C
1	Cork	164.0	23.0	20.0	15.0	12·5	10.0	7.5
2	Foam Glass	127.0	29.0	27.0	20.2	16.8	13.5	10.1
3	Foam Concrete	321.0	39.8	34.6	26.0	21.6	17.3	13.0
4	Glass Wool	69.0	19.1	16.6	12.4	10.4	8.3	6.2
5	Mineral Wool	75.0	16.8	14.6	10.6	9.1	7.3	5.4
6	Fibre Glass	49.0	17.7	15.4	11.5	9.6	7.7	5.7
7	Expanded Polystyrene	22.0	17.2	15.0	11.3	9.4	7.5	5.5
8	Expanded Polyurethane	18.0	10.6	9.2	6.9	5.7	4.6	3.4
9	Saw Dust	170 0	—	—	—	—	16.5	12.3
10	Rice Husk	165.0	—	—	—	—	16.5	12.4

Table 3

Variation in Thickness of Insulation

Material	Walls	Thickness (cm)	
		Roofs	Floors
Saw Dust and Rice husk	30 to 45	45 to 75	30 to 45
Expanded polystyrene	7 to 10	7 to 11	5 to 7
Cork	10 to 15	10 to 15	7.5 to 10.0
Fibre glass and glass wool	7 to 10	7 to 11	5 to 10
Foam Concrete	17 to 20	20 to 25	15 to 20

The refrigeration load and plant capacity of a storage comprises of transmission load, product load and infiltration load. The insulation helps in reducing the transmission load only. The initial cost of refrigeration plant and insutation should be balanced. An increase in the insulation thickness reduces the plant capacity and operating costs.

Effect of Moisture and Importance of Vapour arrier

Water is a good conductor of heat if it gets into the insulation, the insulating value is reduced. In some situations it may also cause severe damage to the insulating material itself. This is of special significance for low temperature refrigerated chambers and cold storages which operate at temperatures below freezing. The moisture in the insulation freezes involving dimensional changes and breakage of the structure due to the vapour pressure gradient existing on either side of the structural element. When the temperature at any point across the building or insulation section goes below the dew point temperature, condensation will take place. Even if the insulation is made impervious to water, to some extent water vapour leaks into the refrigerated space and gets condensed. One gramme of water thus formed would require 0.6 to 0.7 Kcal/r hof additional refrigeration to offset the latent eat component.

Different types of building and insulating materials have different vapour transmission characteristics. As none of these are ideally suited for effective prevention of moisture and vapour migration, special vapour proof materials should be used along with the insulation materials. Water vapour transmission rates of a few materials are given in table 4. The lower the value of the permeance, better will be its performance as a barrier. A vapour barrier should have the value of permeance less than 0.025 gm/m^2 hour mm of Hg.

The correct practice is to make outer skin as impervious as possible. The inner should be of more permeable type so that no condensation takes place within the insulation. The troubles connected with the condensation and frequent freezing of water in the insulation can be minimised if the following precautions are taken.

(1). Apply the materials such as bitumen based composition, aluminium foil, and polyethylene paper as water vapour barrier on the warm side of the insulation as this is the zone of higher vapour pressure potential.

(2). Take adequate care to seal the joints of vapour barrier materials properly.

(3) Do not place a vapour barrier on the cold side of the insulation. This will ruin the insulation since, it would trap the moisture that might have leaked within the insulation due to several reasons.

It is essential to choose an insulating material which has not only a low value of thermal conductivity but also is least affected by moisture penetration. Other requirement of structural, fire resistance and durability should be considered in the final selection of insulating materials. Good insulating materials like expanded polystyrene, resin bonded fibreglass and foam glass have a higher initial cost but provide trouble free service for a long time.

Table 4
Water Vapour Transmission Rates (permeance) of Building and Insulating Materials, Vapour Barriers and Paints

BUILDING MATERIALS

S.No.	Name of the Material and thickness	Permeance (gm/m^2 mm of mercury hour
1	20 cm Brick Work	0.07
2	10 cm R.C.C.	0.04
3	10 cm R.B.C.	0.09
4	1.25 cm Cement Sand Plaster	1.12
5	0.6 cm A.C.C. Sheet	0.67
6	0.6 cm Plywood	0.93
7	Structural Steel	0.00
8	Window Glass	0.00
9	2.5 cm Softwood.	5.00

INSULATING MATERIALS

1	2.5 cm Foam glass	0.03
2	2.5 cm Expanded Polystyrene	0.40
3	2.5 cm Cork Slab	1.50
4	2.5 cm Wood Wool board	18.00
5	2.5 cm Fibre board	6.00
6	2.5 cm Glass Woo	6.50
7	2.5 cm Mineral Woo	6.50
8	2.5 cm Foam Concrete	4.50
9	2.5 cm Saw Dust	14.50
10	2.5 cm Rice Husk	12.60

VAPOUR SEALS

1	Metal sheet with Bituminous Coating	0.00
2	Aluminium foil	0.0002 to 0.0015
3	Bitumen based coating	0.0002 to 0.014
4	Polyethylene building sheet	0.00017 to 0.017

PAINTS AND CRAFT PAPER

1	Roofing Felt (without Bitumen Coating)	0.35 to 1.4
2	Craft Paper	
	(1 sheet)	10.36
	(2 sheet)	5.24
	(3 sheet)	2.40
3	Primer sealer (1 undercoat+1 coat gloss paint)	0.80
4	Chlorinated Rubber paints (2 coats)	0.15
5	Thin coat flat paint+One full coat oil paint (brush)	0.19
6	Ditto but spray applied	0.25

Advantage in using these materials is that for the same external dimension of the structure, more storage space is available because of reduced thickness of insulation as compared to cheap insulating materials like saw dust and rice husk. The saving in the space amounts to 8 to 9 percent by volume and 3 to 4 percent by floor area. Locally available materials like saw dust and rice husk are used for insulation primarily to save initial capital investment. Insulation requirement specified in the codes of practice can no doubt be achieved by providing these in adequate thickness but they have certain inherent draw-backs. Since thermal conductivity of these materials increases rapidly with moisture, it is essential to use about 50 percent extra thickness. A proper check on their moisture absorption has also to be made and these should be replaced at a regular interval of time to keep the insulation dry. The insulation should in no case remain wet for long periods.

Proper care should be taken to make the vapour barrier perfectly impervious. Two to three coats of bitumen with a polyethylene sheet should be used as a vapour seal. Since these materials require frequent checking and replacement, provision should be made for this during the design of structure itself.

There is a demand for short notes summarising available information on selected building topics for the use of Engineers and Architects in India. To meet the need, this Institute is bringing out a series of Building Digests from time to time and the present one is the 72nd in the series. Readers are requested to send to the Institute their experience of adopting the suggestions given in this Digest.

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