IS 661 (2000): Thermal Insulation of Cold Storage - Code of Practice [CHD 27: Thermal Insulation]

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भारतीय मानक

कोल्ड स्टोरेज का ऊष्मा-रोधन — रीति संहिता

(तीसरा पुनरीक्षण)

Indian Standard

THERMAL INSULATION OF COLD STORAGE — CODE OF PRACTICE

(Third Revision)

ICS 27.220; 91.120.10

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

June 2000

Price Group 5

FOREWORD

This standard (Third Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Thermal Insulation Materials Sectional Committee had been approved by the Chemical Division Council.

This standard was originally published in 1955 and subsequently revised twice in 1964 and 1974. In this third revision, insulation requirements for various thermal insulation materials and recommended thickness of insulation have been modified. The use of some new types of thermal insulation materials which have been developed and accepted by thermal insulation industry and trade since the last revision has also been recommended in this revision for the purpose of thermal insulation of cold storages.

There is no ISO standard on the subject. This standard has been prepared based on indigenous manufacturers' data/practices prevalent in the field in India.

Composition of the committee responsible for formulation of this standard is given in Annex D.

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 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

THERMAL INSULATION OF COLD STORAGE — CODE OF PRACTICE

(Third Revision)

1 SCOPE

1.1 This code covers requirements for the construction of cold storages with special reference to insulating and finishing the structures of permanent construction, such as brick, steel and concrete.

1.1.1 A variety of insulation materials are available. They may be classified as expanded foams, fibrous materials, loose fill materials etc. The term insulation is, therefore, used in this standard to mean all these materials.

1.1.2 The requirements laid down in this code are based upon good engineering practice pertaining to adequacy and effective life of insulation. Recommendations are further intended to provide reasonable safeguards against premature deterioration of the insulation and to ensure application practices consistent with safety.

1.1.3 The requirements specified in this code are intended to serve as minimum requirements, and are not to be construed as limiting good practice.

It must be stated that majority of users of cold storage use them to store horticulture, dairy, poultry, marine or meat products which are sensitive to bacterial/fungal or other contaminants. In all such cases washable and hygienic envelopes are demanded. These types of cold storage constructions are briefly described in **1.1.4**.

1.1.4 Cold storage insulation can also be performed by:

a) pre-fabricated insulated panel fitted to inside of supporting structure. These panels may be of composite constructions providing weather barrier, exterior or internal facing and insulation all in one;

b) insulating panels consisting self-supporting structure to form the complete chambers by themselves; and

c) this concept requires specific engineering and detailing which are not covered in this standard.

2 REFERENCES

The Indian Standards listed below contain provisions which through reference in this text, constitute provisions of this Indian Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Indian Standard are encouraged to investigate the possibility of applying the most recent editions of the Indian Standards indicated below:

IS No.	*Title*
702 : 1988	Industrial bitumen (*second revision*)
1322 : 1993	Bitumen felts for water-proofing and damp-proofing (*fourth revision*)
1609 : 1991	Code of practice for laying damp-proofing treatment using bitumen felts (*second revision*)
3067 : 1988	Code of practice for general design details and preparatory work for damp-proofing and water-proofing of buildings (*first revision*)
3792 : 1978	Guide for heat insulation of non-industrial building (*first revision*)
4671 : 1984	Expanded polystyrene for thermal insulation purposes (*first revision*)
7193 : 1994	Glass fibre base coal tar pitch and bitumen felts (*first revision*)
8183 : 1993	Bonded mineral wool (*first revision*)
12436 : 1988	Preformed rigid polyurethane (PUR) and isocyanurate (PIR) foams for thermal insulation
13204 : 1991	Rigid phenolic foams for thermal insulation

3 TERMINOLOGY

For the purpose of this code, the following definitions shall apply.

3.1 Cold Storage — A cold storage shall mean any refrigerated chamber or chambers used for storing goods under controlled conditions at a temperature below ambient.

3.2 Vapour Barrier — Provision made on the warm side of the insulation featuring a suitable material having high resistance to the transmission of water vapour. This application is made to prevent moisture penetration into the insulation and may be factory/field applied to insulation or applied in field to the surface receiving insulation.

4 THERMAL INSULATION MATERIALS

4.1 Various types of insulating materials are available, which may be used in cold storages. The most important characteristics of a cold storage insulation are:

a) low thermal conductivity,
b) low thermal diffusivity, and
c) stability at low temperature.

Other properties like easy workability, negligible capillary absorption, resistance to vermin, rodents and insects and adequate fire resistance, should also be taken into consideration while making a selection. The physical and thermal properties of the insulating materials are given in Annex A.

4.2 The amount of insulation required shall be determined chiefly:

a) on heat balance calculations for attaining desired storage temperature with a given refrigeration capacity and optimum compressor running time,
b) on consideration of costs by balancing the cost of insulation against the savings in refrigeration, and
c) to prevent surface condensation.

4.2.1 For large structures, the thickness of insulation shall be calculated on actual studies of these factors under different conditions. Insulation should be applied in multi-layers whenever thermal insulation thickness is more than 50 mm. For average climatic conditions in India, the recommended thickness of insulation for various materials for different storage temperatures are given in Annex B.

4.2.2 The more the insulation used on any given surface, the less is the heat gain. This means a lower initial cost of refrigeration machinery, consequently less depreciation charge, a saving in the cost of power or fuel required and lower maintenance costs of mechanical equipment. The less the insulation used, the more will be the heat to be removed and the greater will be both the initial and maintenance costs of the mechanical equipment. It is, therefore, necessary to strike a careful balance between the cost of insulation and the capital cost plus maintenance of the mechanical plant and then determine the thickness of insulation for any given cold room.

4.3 Moisture in Insulation

4.3.1 It is essential to prevent the infiltration of moisture into the insulation system. Once the moisture is trapped in the insulation, its insulation value is highly reduced. Therefore, it is always preferable to select an insulating material with lesser moisture absorption and a proper vapour barrier.

4.3.2 The presence of water as a vapour, liquid or solid in insulation decreases its insulation value; it may cause deterioration of the insulation and eventual structural damage by rot, corrosion or the expansion action of freezing water. Whether or not moisture accumulates within the insulation depends on the extent of open cells of the insulation, operating temperatures, ambient conditions and the effectiveness of the water vapour retarders in relation to other vapour resistances within the composite structure.

4.3.3 Moisture resistance depends on the basic material and physical structure of the insulation. High open cell insulants gain or loss moisture in proportion to the relative humidity of the air in contact with them. Fibrous and granular insulation freely permit transmission of water vapour to the colder side of the structure. A vapour retarder should, therefore, be used with all these materials since moisture transmission is a major factor. Insulation with a close cellular structure is relatively impervious to water and water vapour, but may still require vapour retarder treatment as demanded by design consideration. Properties that express the influence of moisture include, absorption (capillary), adsorption (hygroscopicity) and water vapour transmission rate.

4.4 The success of any cold insulation system depends upon the correct application of a proper vapour seal/ barrier. The vapour seal/barrier should always be applied on the warm side of the insulation since the saturated vapour pressure differential is the lowest across this location. Water vapour transmission rates (permeance) of the vapour barriers shall be related to the cold surface temperature of the plant and the relationship are given in Annex C.

The permeance of a vapour seal of cold storage operating in temperature range of 0 to + 5°C and relative humidity of 70 to 90 percent should always be less than 0.001 g/m^2.24 h mm Hg.

5 INSULATION REQUIREMENTS

5.1 For the different fabrics of the cold storage building, the insulation systems shall be as indicated in Fig. 1. As the heat transmission rates are maximum for exposed roofs and minimum for floors, the insulation thickness shall also be proportional by the same magnitude. The maximum heat transmission coefficients (U-values) for exposed walls, intermediate walls, roof and floor are given in Table 1.This insulation material used in the floor shall be of sufficient compressive strength and rigidity specified in consonance with the load expected to be incident on the floor of the cold storage. It is recommended that rigid insulation materials of sufficient compressive strength are used for insulation of floors.

Table 1 Recommended Overall Heat Transmission Coefficients for Cold Storage Structures

(*Clause* 5.1 and *Annex* B)

Storage Temperature Range °C	Maximum U- Values W/m²K			
	Exposed Walls	Intermediate Walls/Ceiling	Roofs	Floors
(1)	(2)	(3)	(4)	(5)
−30 to −20	0.17	0.47	0.14	0.20
−20 to −15	0.21	0.47	0.17	0.23
−15 to −4	0.23	0.47	0.21	0.27
−4 to 2	0.27	0.58	0.24	0.29
2 to 10	0.35	0.93	0.29	0.47
10 to 16	0.47	0.93	0.29	0.64
16 and above	1.28	1.47	1.05	1.63

NOTE — Surface coefficient values can be taken as per IS 3792.

5.2 Insulation of Concrete/Masonry Walls Finished with Plaster

The surface to be insulated shall be brushed free of all loose and foreign materials and shall be thoroughly dried. Rough surfaces shall be filled with a coat of cement plaster consisting of one part cement and four parts of clean sand. When dry, the surface shall be primed with a coat of primer, if necessary and a suitable vapour barrier applied. For anchoring the first layer of insulation, wooden battens 40 mm wide and of thickness equal to that of first layer of insulation shall be suitably placed and fixed to the wall vertically to enable the first layer to fit snugly between them. These battens are to be anchored securely to the walls conforming to good engineering practice. For walls exceeding 4.5 m in height, suitably placed horizontal battens of same section, as the vertical battens shall be anchored in a similar manner to the wall to carry weight of the insulation.

5.2.1 Insulation should be applied in multi-layers whenever the insulation thickness is more than 50 mm. In case of expanded foam materials the joints shall be properly sealed and in case of fibrous material the joints shall be properly butted together.

5.2.2 The second layer is to be similarly applied to walls over the first layer, taking care to see that all joints are staggered.

5.2.3 Wire netting shall be fixed to the exposed surface of insulation and after pulling tight, shall be suitably fastened by galvanized U-nails on the battens, which shall then be finished with cement plaster in two coats. Cement plaster shall be applied in such a way that the wire netting acts as a reinforcement to the plaster.

5.3 Floors

The surface shall be clean, dry, smooth and level. In the case of a concrete floor, hot asphalt shall be spread

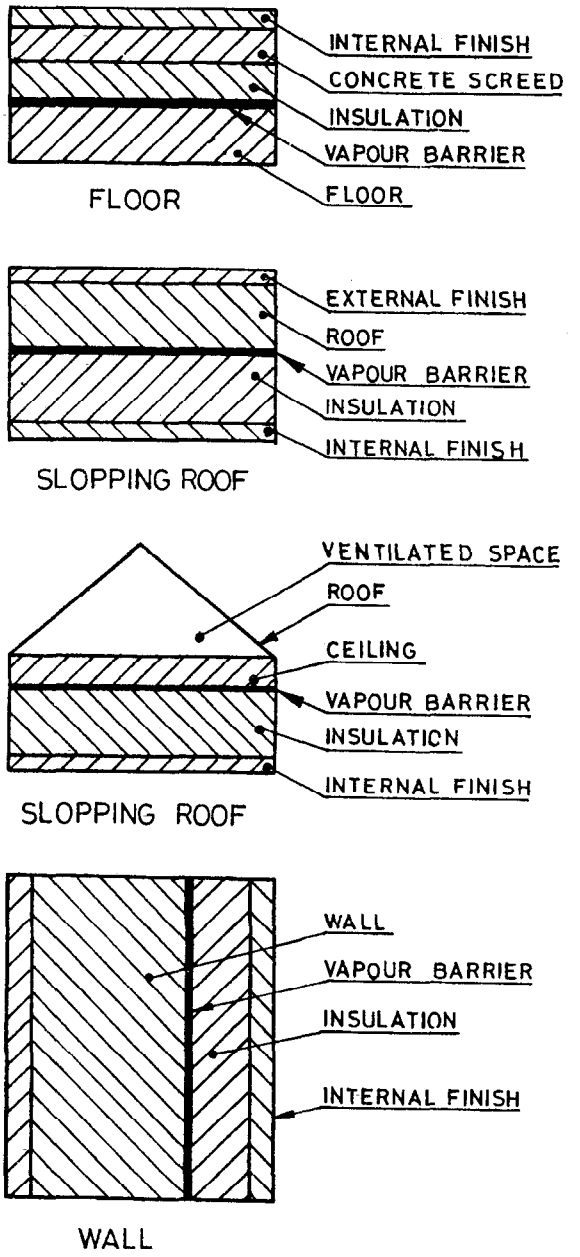


FIG. 1 INSULATION REQUIREMENTS FOR WALL ROOF AND FLOOR

to a thickness of 3 mm by simply pouring the molten asphalt uniformly over the surface to provide a moisture/vapour seal, making sure that all the joints and cracks are filled with asphalt. If the floor is of timber, bitumenized Kraft paper shall be first applied with properly sealed lapped edges, which is mopped with hot asphalt. The first and second layer of insulation shall then be laid making sure that all the joints and cracks are filled with asphalt. Whenever there is a possibility of water seepage either from the floor or from the walls, the walls and the floor shall be provided with water proofing treatment in

accordance with IS 1609 and IS 3067 before the application of insulation.

5.3.1 For the wearing course on floors, concrete of 75 mm thickness at the lowest point (at drain) shall be laid slope at 1 in 125 or more if the floor is subject to frequent flushing with water. Protective layer of water proofing shall be laid between the insulation and topping to protect the insulation (for example while concrete is laid) and to prevent water ingress from washing etc. For extremely wet floor, two layers of roofing felt are recommended. This treatment shall be turned 230 mm and sealed along walls and around column.

5.4 Ceiling

Flat concrete ceiling shall be insulated in the same manner as the walls. Care is required to render such roofs water-tight by ensuring proper sealing of structural expansion joint and ensuring proper slope with effective water proofing treatment. In the case of truss roofs, a false ceiling of 20 mm thick BWR grade plywood panelling may be provided on wooden joints of suitable cross section supported securely to the steel member of the truss roof. While fixing the plywood panelling it shall be ensured that the entire surface of the false ceiling is even and smooth. Fixing of insulation, treatment of joints, application of wire netting and cement plaster shall be as described in case of the wall insulation. However, the final finishing recommended is either fibre reinforced cement sheets, fibre reinforced plastics or aluminium sheets. All joints in such facings shall be protected with beading, sealed and secured to prevent direct exposure of insulation to the interior. In case of truss roofs, space above insulated ceiling shall be adequately ventilated.

5.5 Any internal iron or steel column in the external walls and steel girders in the exposed ceiling projecting into the cold storage shall be insulated in a similar manner and with the same materials as used for walls and ceilings. The concrete beams shall be similarly insulated since they also represent heavy conduction path.

5.6 Floors for frozen storage and freezers shall not be laid directly over soil. However for any reason if this is inescapable, provision shall be made to maintain the ground temperature above freezing point by freeze protecting sub-floor electrical heater or/by ventilation pipe arrangements. Proper drainage shall be provided under the floor, so that no water can accumulate which can freeze and consequently lift/crack the flooring and foundations.

It is ideal to have a ventilated crawl space between the floor and the ground with good insulation provided to the top of floor. Prior to the application of insulation on the floor, the surface of the floor shall be covered with a minimum of three layers of bituminous water proofing felt conforming to IS 1322, IS 7193 and laid in accordance with IS 1609. The top of this treatment shall be covered with flood coat of suitable grade of bitumen conforming to IS 702. This damp course of bitumen and felt shall extend to a height of 300 mm along all peripheral walls.

5.7 Wherever frozen storage and freezers are to be located below ground level (such as basements), the retaining walls and the floor of the basement shall not be used directly as part of such storage unless properly designed freeze protection with electrical heat tracing with impermeable heat rigid insulation system provided on the outer surface retaining wall before backfilling. A separate inner enclosure with ventilated space shall be constructed.

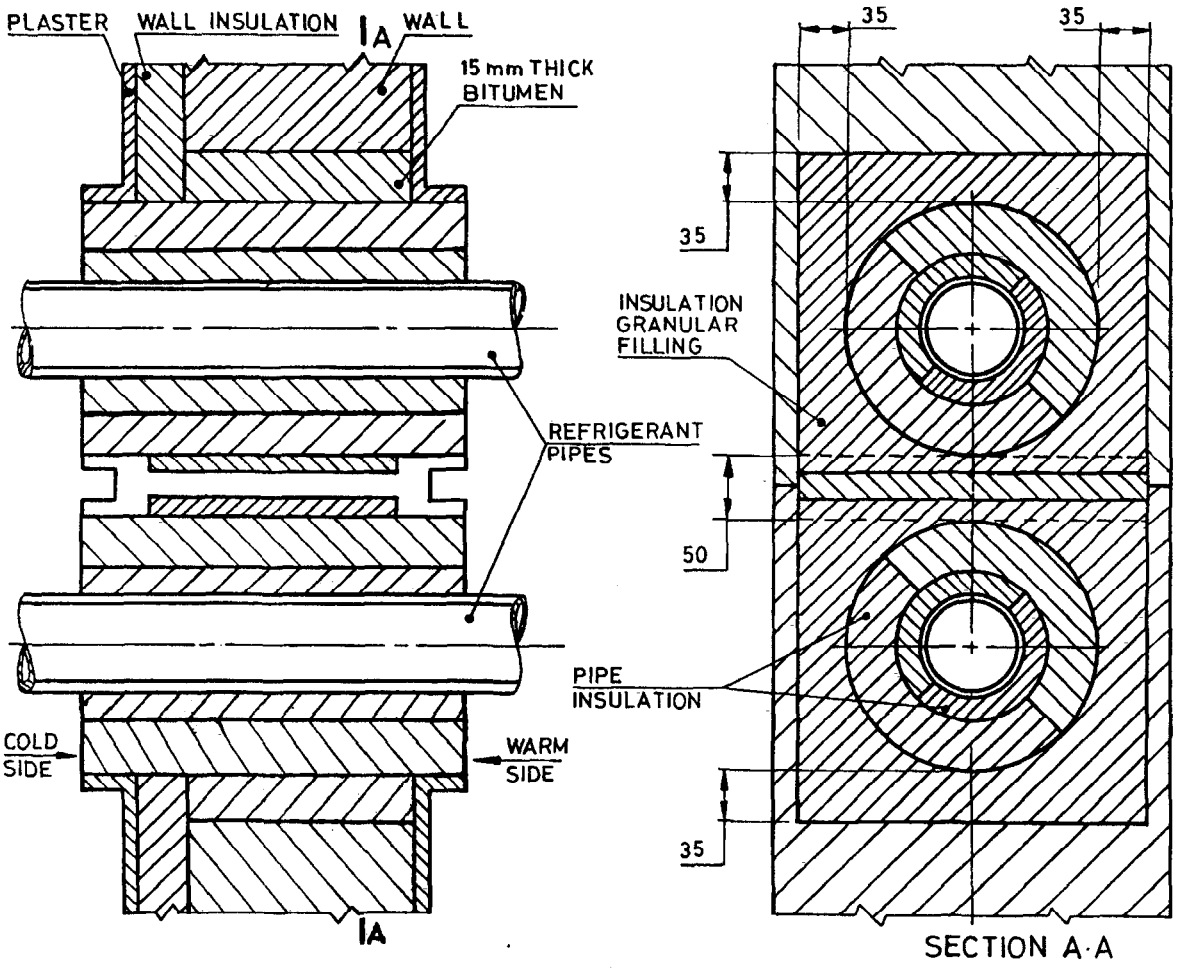
5.8 Crawl space under the frozen storage and floors of freezers shall be provided proper drainage so that run off of water shall be quick with non-return traps to prevent backing up of the drains. Storm water or sewage drains shall not be located in the crawl space.

5.9 Pipe Boxes

The refrigerant pipes are at usually 10 to 15°C lower than the room temperature and thus are susceptible to heavy frosting. The opening in the wall or ceiling through which the refrigerant pipes enter the refrigerated space, should be of size providing clearance of at least 50 mm between the pipes and a clearance of 35 mm between the pipe surface and the inside surface of the opening, after the pipes are insulated with the normal thickness of insulation. The insulation on the pipes shall be of double layers and of pipe sections. After the pipes are insulated annular spaces shall be filled with loose fibrous insulation materials mixed with cold emulsion bitumen leaving an empty space of 15 mm deep on the warm side (exposed to atmosphere) as shown in Fig. 2. This space shall be filled with cold suitable grade of bitumen or the penetration provided with specially designed escutcheon.

5.10 Doors

Doors for cold storage shall have adequate insulation with well designed frames, hinges, seals and locking devices. Insulation shall be of form stable and rigid construction covered on either face with metal sheets. They can be hinged, sliding, or of roll-up types. All



All dimensions in millimetres.

FIG. 2 INSULATION REQUIREMENTS FOR PIPE (BOXES) PENETRATION THROUGH INSULATED WALLS

doors shall have counter frames and pads constructed of materials capable of sustaining temperatures from the lowest operating temperature to +130°C without deterioration. Normally cold storages operating at +10°C and above can be provided with uninsulated doors. Doors for service at and below –5°C shall be supplied with freeze protection electrical tracers and gaskets. Strips curtains of polyvinyl chloride are essential part of cold storages in which frequent opening and closing of doors are required.

5.11 Prevention of Ice Formation on Superfreeze Doors in Air Blast Freezers Used Below –30°C

Since cold storages are hermetically sealed, lowering of internal temperature gives rise to partial vacuum. A pressure relief valve is to be provided to balance the pressure inside with that of the atmosphere to ensure that additional mechanical stresses, which get imposed on the doors and cold storage envelope, are relieved.

ANNEX A

(*Clause* 4.1)

PHYSICAL PROPERTIES OF INSULATING MATERIALS

Sl No.	*Characteristics*	*Rigid Polyurethane Foam*	*Rigid Phenolic Foam*	*Expanded Polystyrene*	*Bonded Rockwool*	*Bonded Slagwool*	*Bonded Glasswool*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Relevant IS code	IS 12436	IS 13204	IS 4671	IS 8183	IS 8183	IS 8183
ii)	Useful forms	Slabs and pipe sections	Slabs and pipe sections	Slabs and pipe sections	Slabs and pipe sections	Slabs and pipe sections	Slabs and pipe sections
iii)	Density, kg/m^3	32 - 38	32 - 60	15 - 32	Slab: 48 pipe:144 section	Slab:48 pipe:144 section	Slab:32 pipe:80 section
iv)	Thermal conductivity at + 10°C, W/m.K	0.021 at 32 kg/m^3	0.026 at 50 kg/m^3	0.033 at 15 kg/m^3	0.033 at 48 kg/m^3	0.033 at 48 kg/m^3	0.033 at 32 kg/m^3
v)	Thermal diffusivity, m^2/h	0.0018-0.0024	0.0016-0.0029	0.0037-0.0078	0.0006-0.0018	0.0006-0.0018	0.0011-0.0027
vi)	Water vapour transmission rate, ng/Pa.sm, *Max*	5.5	5.5	7.95	—	—	—
vii)	Water absorption after 24 h immersion, percent by mass	0.1	0.1	1.0	2.3	2.3	2.3

ANNEX B

(*Clause* 4.2.1)

RECOMMENDED THICKNESS OF INSULATION FOR DIFFERENT STORAGE TEMPERATURES WITH DESIGN AMBIENT TEMPERATURE OF 40°C AND 50 PERCENT RELATIVE HUMIDITY

Name of Material	*Minimum Density* kg/m^3	*Thickness,* mm *Temprature Range* °C						
		−30 to −20	−20 to −15	−15 to −4	−4 to +2	+2 to +10	+10 to +16	+16 and above
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Rigid polyurethane foam	36	110	90	75	60	45	30	30
Rigid phenolic foam	50	110	90	75	60	45	30	30
Expanded polystyrene	18	175	150	125	100	75	50	50
Bonded rockwool	48	175	150	125	100	75	50	50
Bonded slagwool	48	175	150	125	100	75	50	50
Bonded glasswool	32	175	150	125	100	75	50	50

NOTE — Thicknesses specified are for walls. Thickness for roofs and floors are to be calculated using Table 1. For exposed surfaces, the above thicknesses may have to be increased in case of adverse climatic conditions.

ANNEX C

(*Clause* 4.4)

REQUIRED WATER VAPOUR PERMEANCE IN RELATION TO PLANT TEMPERATURE

Temperature of a Plant (Cold Surfaces)	*Water Vapour Permeance of Barrier,* g/m^2.*24* h *mm Hg*
(1)	(2)
0	0.001 0
− 5	0.000 4
−10	0.000 2
−15	0.000 15
−20 to −40	0.000 10

ANNEX D

(Foreword)

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(Continued on page 9)

(*Continued from page* 8)

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Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards: Monthly Additions'.

This Indian Standard has been developed from Doc : No. CHD 27 (518).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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