technical bulletin

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RIGID INSULATIONS

This bulletin deals with the basic knowledge about rigid thermal insulating materials for buildings. It is important to understand the advantages and limitations of these materials in order to properly specify or install them.

By definition, a material that retards the flow of heat through the building envelope is considered a thermal insulation. However, when selecting an insulation product for a particular application, a set of secondary criteria in addition to the low thermal conductivity must also be considered. Characteristics such as rigidity, water vapor permeability, air flow resistance, ease of application, applied cost and other parameters may influence the choice among materials that have similar thermal performance values. The issues are further complicated by the fact that thermal insulation can serve several purposes: to conserve energy by reducing heat loss or gain, to facilitate temperature control for human protection, to reduce temperature variations for personal comfort, to prevent vapor condensation, to impede water transmission or lastly to reduce air infiltration.[1]

GENERIC TYPES

Thermal insulation materials can be organic or inorganic, fibrous, particulate, film or sheet, block or monolithic, open or closed-cell. Their physical structure can be cellular, granular or fibrous. They have physical forms such as batt or blanket, loose fill, rigid or foamed-in-place.

Batt or blanket insulations are available in sheets or rolls of inorganic mineral fibre materials with or without binders providing varying degrees of compressibility and flexibility.

Loose-fill insulation consists of nodules, powders, granules or fibres that are usually blown or poured into walls or other spaces.

Rigid insulations are available in rectangular sizes, called blocks, boards or sheets and are preformed during manufacture to standard lengths, widths and thicknesses.

Foamed-in-place insulations are materials available as liquid components that can be sprayed in place to form rigid or semi-rigid foam insulation.

The following lists the different subtypes or these four generic insulations. As well, it summarizes their typical R-value, applications, advantages and limitations.

RIGID BOARD INSULATION

Rigid board insulation is a preformed board for use in roofs, ceilings, floors, interior/exterior walls, above and below ground level, and under concrete slabs. It generally provides a high thermal resistance per inch of thickness, and in addition often serves as backing for exterior wall cladding, concrete floors or as a base for the roofing membrane. The advantages and limitations of a specific product are the result of the

[1] American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., ASHRAE Handbook 2001 Fundamentals, Chapters 23 to 26.

Pub. No. 300596. Printed in Canada. March 2010. *The insulation is manufactured with a blowing agent with 70% less global warming potential as compared to Owens Corning previous blowing agents.

nature of its raw materials and the physical structure that results from the manufacturing process. The following descriptions of glass fibre, expanded polystyrene, extruded polystyrene, polyurethane, and polyisocyanurate raw materials and manufacturing processes will provide the reader with some understanding of the strengths and weaknesses of these rigid board insulations.

GLASS FIBRE BOARD

This board is composed of bonded glass fibres with or without a reinforced vapour retarding membrane cover. The manufacturing process starts by melting sand, limestone, soda ash and other ingredients at temperatures of about 1400^{o}C (2500^{o}F). While the glass is a molten liquid, it is formed in a spinner by flowing through tiny holes that shape it into very fine fibres. A resin binder is applied to the veil of fibres and the fibrous pack compressed, cured and cut to size. Optional reinforced facings are applied and the product is packaged. Products are classified as rigid or semi-rigid on the basis of their sag resistance.

Canadian Standard CAN/ULC-S702-97, “Mineral Fibre Thermal Insulation for Buildings" covers this insulation supplied in the form of batts, blankets, boards, sheets with or without membranes, and loose fill used in light frame buildings (for other applications specify ASTM C 612 Mineral Fiber Boards). This standard defines five types of mineral fibre thermal insulation: (1) preformed without membrane, (2) preformed with a breather membrane, (3) preformed with a vapour retarding membrane, (4) pouring insulation, and (5) blowing insulation. The requirements for types (1), (2) and (3) mineral fibre insulation are: thermal resistance of greater than R2.67 per inch; dimensional tolerances for width, length and thickness of each type; spread rating not greater than 25 (for Type 1); exterior basement insulation boards require a compressive resistance of not less than 7 kPa at 10% deformation; and the water vapour transmission of breather membranes (not less than 300 ng/Pa.s.m^2) and vapour retarding membranes (not more than 60 ng/Pa.s.m^2). This standard does not apply to preformed insulation used above roof decks.

POLYSTYRENE BOARDS

There are very specific and meaningful differences between polystyrene insulations as a result of their manufacturing processes. The raw material, styrene, is made from derivatives of natural gas and crude oil, ethylene and benzene It is polymerized to form polystyrene resin. Boards are made by moulding or extrusion of polystyrene resin.

MOULDED BEAD POLYSTYRENE

Moulded bead polystyrene is formed from beads which are steam heated until they expand and fill a mould resulting in a product called "bead board".

There are several manufacturers of bead board across Canada (Beaver Plastics, Isolofoam, Legerlite, PlastiFab, Truefoam, etc.)

It can be used to insulate flat and cathedral roofs, ceilings, the exterior and interior faces of walls above ground level, the interior faces of walls below ground level, as insulation in built-up floors and to provide a slope to roofs. One application of beadboard that is controversial is as exterior foundation insulation. Beadboard's physical structure is composed of small beads that are fused or moulded together much like in popcorn balls. Therefore, its properties are for the most part dependent on how well the beads are fused to each other and on material density. Regardless, there are always connected voids between the fused beads. This open cell structure allows for moisture pick up, which in turn may result in significant loss of insulation effectiveness and reduced mechanical properties. Some research with drainage protection has shown reductions in the amount of absorbed water. A decision to use beadboard below soil grade, should be carefully considered.

EXTRUDED POLYSTYRENE

For extruded polystyrene, virgin resin is fed into an extruder where it is melted and mixed with critical additives. A blowing agent is then injected to make the mixture

foamable and, under carefully controlled heat and pressure conditions, the mixture is forced through a die to initiate foaming. Afterwards shaping occurs. This extrusion process produces a consistent quality foam product with a closed-cell structure and a continuous smooth skin.[10]
Another important development over the past 2 decades in insulation technology in general, and in extruded polystyrene insulation in particular, is the introduction of low density extruded polystyrene. This product has moisture resistance properties and a design R5/in. rating which equals conventional extruded polystyrene but uses less raw materials resulting in a high performance and economic insulation.
The technology that has made this material possible is called HYDROVAC® (hydrostatic-vacuum extrusion process). When leaving the die, the material quickly expands in a vacuum chamber (which permits control of the density) and then is water cooled (which increases manufacturing speed).

In Canada, there are two manufacturers of extruded polystyrene insulation. Owens Corning Canada (which produces extruded polystyrene using the Hydrovac technology), and Dow Chemical Canada Inc., a wholly-owned subsidiary of Dow Chemical USA (Midland, Michigan), which produces extruded polystyrene in a conventional fashion but uses methylene chloride (auxiliary blowing agent) to produce lower density products.

Dow Chemical Canada Inc. manufacturers: Styrofoam® SM, Styrofoam® – Cladmate™ Wallmate™, Cavitymate™ SC, Cavitymate™ Ultra, Decmate and Roofmate™ roof insulation in Ontario, Quebec and Alberta plants. Owens Corning Canada manufactures: Foamular® C-200, Foamular® C-300, Foamular® Cel-Lok®, Foamular® CodeBord® and Foamular® 350 in Valleyfield, Quebec.

Extruded polystyrene is suitable for insulating commercial and industrial roofs - whether new or retrofit - under the membrane (conventional system) or over the membrane (PMR system). It is suitable - even preferable - when insulating interior or exterior faces of walls. Its exceptional moisture resistance, makes it ideal for use as foundation insulation and under concrete slabs. Lower density extruded polystyrene (Foamular® C-200) covers the same applications, as described above, except where extra-compressive strength is required (inverted roof-system and under concrete slabs). Boards are available in thicknesses from 1" to 4" and in standard dimensions of 2' X 4' (600mm X 1200mm), 2' X 8' (600mm X 2400mm) and special order metric sizes. In addition to these sizes, extruded polystyrene is available in 4' X 8' (1200mm X 2400mm) and 4' X 9' (1200mm X 2700mm) with shiplapped edges.

According to Canadian Standard CAN/ULC-S701, "Thermal Insulation, Polystyrene, Boards, and Pipe Covering", there are four types of rigid polystyrene insulations distinguished on the basis of their physical properties. Type 1 polystyrene insulation has a typical thermal resistance value or R3.7/in., while Type 2 polystyrene insulation has a minimum thermal resistance value of R4.0/in. Type 1 is moulded bead polystyrene. However, Type 2 is moulded expanded polystyrene (design R4/inch) or of extruded polystyrene (design R5/inch). Type 3 and Type 4 polystyrene insulation are generally extruded polystyrene. The closed-cell structure provides long-term water resistance properties and excellent mechanical properties to this foam. The cells retain a gas that provides a high thermal resistance value of R5.0/in.

As with other plastic insulations, polystyrene may be a fire hazard if improperly installed. It needs to be covered with a fire-resistant material. Protection against extensive exposure to ultra-violet rays is also recommended, to avoid surface deterioration.

POLYURETHANE AND POLYISOCYANURATE BOARDS

Rigid polyurethane foam is formed by the reaction of two liquid chemicals (isocyanates and polyols) in the presence of certain additives and catalytic agents. The mixture begins to foam instantly and quickly expands to about 30 times its original volume. To create rigid board insulation, the material is formed into slabs. The slabs are cured and then cut to a specified size. Finally, protective skins are applied. Polyisocyanurate is produced by a chemical process much like that used to produce polyurethane. However, a slight chemical variation results in polyisocyanurate having greater thermal stability and lower combustibility level than polyurethane. It is also more brittle than polyurethane.

Canadian Standard CAN/ULC-S704 applies to rigid cellular urethane and isocyanurate thermal insulation in the form of faced preformed boards. It covers insulation boards with various facing materials with three types of boards distinguished on the basis of their physical properties, and three classes on the basis of water vapour permeability. It does not apply to clad and composite materials.

Regarding physical properties, thermal resistance (with a minimum thermal resistivity of R5.6 per inch thickness) after 180 days conditioning and Long-Term Thermal Resistance according to CAN/ULC-S770 are reported by manufacturers. According to their described mechanical properties Type 1 has a minimum compressive strength of 16 psi, Type 2 a minimum of 18 psi and Type 3 a minimum of 20 psi. Of significant importance is the water vapor permeance, Class 1 has a low permeance (≤15 ng/Pa.s.m^2); Class 2 has a water vapour permeance range from > 15 to ≤ 60 ng/Pa.s.m^2, and Class 3 has a relatively high water vapour permeance > 60 ng/Pa.s.m^2.

According to surface burning characteristics membrane-faced rigid urethane and isocyanurate thermal insulation boards are available in two categories based on building code requirements. For category (a) the flame spread classification is <500, in order to be used in cavity walls, low temperature applications and as thermal sheathing. Category (b) is unrated, it is recommended mainly for roof insulation.

Rigid polyurethane and polyisocyanurate insulation has a conditioned thermal resistance per unit of thickness of about R5.6 to 6.0. Applying an impermeable skin to both faces will retard the thermal drift process but eventually air is able to penetrate cells and the Long Term Thermal Resistance (based on CAN/ULC-S770) is not significantly higher than for permeable faced products.

In addition, like most other insulations, polyurethane and polyisocyanurate insulation will suffer a loss of insulation value if it is exposed to moisture and high relative humidity. As stated earlier, polyisocyanurate foam has greater thermal stability, but it is more brittle and great care should be taken in handling the material during installation. Polyurethane and polyisocyanurate foam is combustible and may be a fire hazard so it also requires the installation of a thermal barrier on building interiors. It also has a well documented history of blistering and requires overlayment protection in most conventional membrane roofing applications.

It also needs to be protected against ultra-violet light.

Codes & Standards Compliance:

- Meets Montreal Protocol 2010, CFC, HCFC Free
- Zero Ozone Depletion Potential
- 70% Less Global Warming Potential*

NOTE: Technical Services recommendations are for the information of the project designer. The project designer, engineer or architect is responsible for the suitability and performance of a design. If there are any inquiries regarding this bulletin, please telephone the Technical Services Manager directly.