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Product Information Bulletin

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PlastiSpan® Insulation Performance Properties

What is PlastiSpan insulation?
PlastiSpan moulded expanded polystyrene (EPS) insulation is an air-filled, closed cell, rigid foam plastic insulation that does not contain any HCFC or HFC blowing agent.

Applicable product standards for PlastiSpan insulation
PlastiSpan insulation material properties per CAN/ULC-S701-05[1] are specified in Table 1 below.

Table 1 – PlastiSpan Insulation Types per CAN/ULC-S701

Material Property	Test Method[2]	Units	Type 1	Type 2	Type 3
Thermal Resistance *Minimum @ Mean temperature 24 C (75 F) for 25 mm (1-inch)*	ASTM C518	$m^2 \cdot {}^oC/W$ ($Ft^2 \cdot hr \cdot {}^oF/BTU$)	0.65 (3.75)	0. 70 (4.04)	0.74 (4.27)
Water Vapour Permeance[3] *Maximum*	ASTM E96	$Ng/Pa \cdot s \cdot m^2$ (perms)	300 (5.2)	200 (3.5)	130 (2.3)
Compressive Strength *Minimum @ 10% Deformation*	ASTM D1621	kPa (psi)	70 (10)	110 (16)	140 (20)
Flexural Strength *Minimum*	ASTM C203 Procedure B	kPa (psi)	170 (25)	240 (35)	300 (44)
Dimensional Stability *Maximum*	ASTM D2126 7 Days @ 70 ± 2°C	% Linear Change	1.5	1.5	1.5
Water Absorption *Maximum*	ASTM D2842	% By volume	6.0	4.0	2.0
Limiting Oxygen Index *Minimum*	ASTM D2863	%	24	24	24

Table 2 – Additional Material Properties Not Included in CAN/ULC-S701

Material Property	Test Method	Units	Type 1	Type 2	Type 3
Shear Strength *Minimum*	ASTM C 273	kPa (psi)	83 (12)	125 (18)	165 (24)
Compressive Modulus *Minimum*	ASTM D 1621	kPa	2,500	5,000	7,500
Poisson's Ratio	NA	NA	0.1	0.1	0.1
Nominal Density[4]	NA	kg/m^3 (pcf)	16 (1.0)	22 (1.4)	29 (1.8)

1 ***Standard Specification for Thermal Insulation, Polystyrene, Boards and Pipe Covering,*** National Standard of Canada published by Underwriters' Laboratories of Canada.
2 The ASTM test methods used to determine the above material properties provide a means of comparing different cellular plastic thermal insulation. They are intended for use in specifications, product evaluations and quality control. They are not intended to predict end-use product performance.
3 Values quoted are maximum values for 25-mm (I-inch) thick samples with natural skins intact. Lower values will result for thicker materials.
4 Product density is not a required material property in CAN/ULC-S701. The nominal density provided here is included for reference only.

For United States applications, the minimum material properties for PlastiSpan insulation are specified based upon requirements ASTM C 578-10a[5] as per Table 3 below.

Table 3 – PlastiSpan Insulation Properties per ASTM C 578

Material Property	Test Method[6]	Units	Type I	Type VIII	Type II	Type IX	Type XIV
Density *Minimum*	C303 or D1622	kg/m^3 (pcf)	15 (0.90)	18 (1.15)	22 (1.35)	29 (1.80)	38 (2.40)
Thermal Resistance *Minimum @ Mean temperature 24 C (75 F) for 25.4-mm (1-inch)*	C518	$m^2 \cdot {}^oC/W$ ($Ft^2 \cdot hr \cdot {}^oF/BTU$)	0.63 (3.60)	0.67 (3.80)	0.70 (4.00)	0.74 (4.20)	0.75 (4.33)
Water Vapour Permeance[7] *Maximum*	E96	$Ng/Pa \cdot s \cdot m^2$ (Perm-inch)	287 (5.0)	201 (3.5)	201 (3.5)	143 (2.5)	143 (2.5)
Compressive Strength *Minimum @ 10% Deformation*	D1621	kPa (psi)	69 (10.0)	90 (13.0)	104 (15.0)	173 (25.0)	276 (40.0)
Flexural Strength *Minimum*	C203	kPa (psi)	173 (25.0)	208 (30.0)	240 (35.0)	345 (50.0)	414 (60.0)
Dimensional Stability *Maximum 7 Days @ 70 ± 2°C*	D2126	% Linear Change	2.0	2.0	2.0	2.0	2.0
Water Absorption *Maximum*	C272	% by volume	4.0	3.0	3.0	2.0	2.0
Limiting Oxygen Index *Minimum*	D2863	%	24	24	24	24	24

Table 4 – Additional Material Properties Not Included in ASTM C578

Material Property	Test Method	Units	Type I	Type VIII	Type II	Type IX	Type XIV
Shear Strength *Minimum*	C 273	kPa (psi)	85 (12)	104 (15)	125 (18)	165 (24)	210 (30)
Compressive Modulus *Minimum*	D1621	kPa (psi)	2,500 (360)	4,000 (580)	5,000 (730)	6,500 (940)	10,300 (1,500)
Poisson's Ratio	NA	NA	0.1	0.1	0.1	0.1	0.1

While these product standards were developed mainly for thermal insulation applications, in many cases the material properties may be being applied to a much wider range of product applications. As indicated within this bulletin, material properties in product standards may not provide complete answers with regard to required product performance in all end-use applications.

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5 **Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation**.
6 The ASTM test methods used to determine the above material properties provide a means of comparing different cellular plastic thermal insulation. They are intended for use in specifications, product evaluations and quality control. They are not intended to predict end-use product performance.
7 Values quoted are maximum values for 25.4-mm (I-inch) thick samples with natural skins intact. Lower values will result for thicker materials.

Key advantages of PlastiSpan insulation
PlastiSpan insulation is a rigid, closed cell foam plastic insulation that provides constant thermal properties, is dimensionally stable, provides excellent mechanical properties, is non-corrosive, and is recyclable where facilities exist. Plasti-Fab Technical Bulletin 115-01 provides information regarding PlastiSpan insulation chemical resistance.

Typical PlastiSpan insulation applications
Some typical applications for PlastiSpan insulation include:
- Roofs - both commercial and residential
- Above-grade walls - e.g. insulating sheathing
- Foundation wall insulation and drainage – i.e., exterior below-grade wall
- Floor slab applications – above or below concrete slab
- Frost-protected shallow foundations

Technical Brochures describing PlastiSpan insulation use for the above applications are available in the Plasti-Fab Design Manual.

Based upon the application requirements, performance characteristics that may be considered include:
- Thermal resistance
- Compressive strength
- Flexural strength
- Moisture resistance
- Water vapour permeance
- Freeze-thaw performance
- Drainage capabilities
- Resistance to vermin attacks
- Protection from ultraviolet light

Thermal Resistance/Thickness Relationship
Thermal resistance value an insulation material is stated as R-Value (inch-pound units) or RSI (SI System). The thermal resistance (R-Value/RSI) and the thermal resistivity (R-Value/RSI per unit of thickness) of thermal insulation vary with thickness. The R-Value/RSI of insulation is a relative measure of the ability of the material to resist heat flow, with a higher R-Value/RSI indicating a greater resistance to heat flow.

The thermal resistance of PlastiSpan insulation is closely related to the density of the finished product. Within the normal range of PlastiSpan insulation densities, as the density increases, the thermal resistance values also increase.

Long-term thermal resistance (LTTR) properties of PlastiSpan insulation
The major mechanism of heat transfer in foam plastics is by conduction. Heat transfer by conduction occurs through both the gas and solid portions of the foam. Since gases occupy approximately 90 to 98 percent by volume of cellular plastics, conduction through the gas portion of the foam is by far the most significant.

Some cellular plastics depend upon captive blowing agents – e.g. HFC's or HCFC's – inside their cellular structure to increase the thermal resistance value. However, since the foams are not enclosed within gas impermeable barriers, some of the blowing agent in the cellular structure diffuses out over time and is replaced by air, which has a lower thermal resistance value. This phenomenon is known as thermal aging. Designers must request design thermal resistance values based upon long-term thermal resistance (LTTR) test values in order to ensure performance of the insulation material for the life of the structure.

The Canadian thermal insulation industry has adopted a test method for determining the design R-value of foam plastic insulation. **Reporting of LTTR Values is now a requirement in updated National Standards of Canada for foam plastic insulation.** CAN/ULC-S770, ***Determination of Long-Term Thermal Resistance of Closed-Cell Thermal Insulating Foams***, a National Standard of Canada, is recognized as the **test method for determining the LTTR of closed-cell foam plastic insulation containing a gas other than air**. It provides a means for predicting LTTR for foam plastic insulation with a captive blowing agent based upon an accelerated laboratory test. See Plasti-Fab Technical Bulletin 111-08 for additional information on LTTR requirements.

The closed cellular structure of PlastiSpan insulation contains only stabilized air; therefore, the thermal resistance of PlastiSpan insulation does not decrease with age. In other words, published thermal resistance values are design values and do not require any adjustments for aging over the life of the structure.

Compressive strength of PlastiSpan insulation
Compressive strength is determined using ASTM Test Methods C165 or D1621. The value included in material standards and specifications for cellular plastics, including PlastiSpan insulation, is the compressive stress at 10% strain (deformation from original thickness). This value is not failure strength, but rather is intended for product evaluations and quality control, as well as for comparing relative compressibility of different cellular plastics. The compressive strength of PlastiSpan insulation is closely related to product density.

The compressive strength at 10% deformation should not be used for design purposes when a cellular plastic is to be subjected to short or long term compressive loads. If specific compressive loads are anticipated, either short or long term, the PlastiSpan insulation compressive strength required for design purposes can be provided for specific PlastiSpan insulation types. Refer to Plasti-Fab Product Information Bulletin 218 for additional information.

Flexural strength of PlastiSpan insulation
The flexural strength of PlastiSpan insulation is provides a relative measure resistance to bending. It may be important when considering the handling characteristics of the product, as well as the ability to resist point loads. The values given in material standards are not intended for design purposes as they are breaking strengths.

Moisture resistance characteristics of PlastiSpan insulation per laboratory test methods
PlastiSpan Insulation is a closed cell foam plastic insulation and as such it resists the absorption of moisture into the cellular structure. Current foam plastic insulation standards specify maximum water absorption (% by volume) obtained from laboratory test method. Maximum water absorption specified in CAN/ULC-S701, the Canadian product standard, is determined using ASTM Test Method D 2842, Test Method for Water Absorption of Rigid Cellular Plastics, which states the following under section 2, "Significance and Use":

> *The purpose of this test is to provide a means for comparing relative water absorption tendencies between different cellular plastics. It is intended for use in specifications, product evaluations, and quality control.* ***It is applicable to specific end-use design requirements only to the extent that the end-use conditions are similar to the immersion period (normally 96 h) and 5.1 cm. (2 in.) head requirements of the test method.*** (Bold print added for clarity.)

The above note from ASTM D 2842 is also included as a note in CAN/ULC-S701-05.

Similarly, Clause X1.4 in the Appendix of ASTM C 578 contains a note that states water absorption characteristics may have significance when the end-use of the material requires exposure to water for extended periods of time.

Moisture resistance of EPS insulation in actual applications

There are now a number of published reports demonstrating moisture resistance of EPS insulation in actual applications exposed over extended periods of time is much better than indicated by water absorption laboratory test methods. Below are a few examples:

1. The results of an NRC/CPIA study of EPS insulation installed below grade for 2 years confirmed water absorption less than 0.7% by volume.
2. A Finnish study[8] comparing results from laboratory water absorption test methods to values from field applications found actual that actual water absorption in below grade applications was less than half that predicted by Laboratory test values.
3. Published report from Norway[9] for EPS lightweight fill material samples retrieved from applications after up 30 years in service in a drained position found moisture contents less than 1% by volume.
4. Plasti-Fab Product Information Bulletin No. 268 provides test results for ASTM C578, Type I EPS insulation and Type X extruded polystyrene (XPS) insulation installed side-by-side on a below-grade foundation application. The bulletin highlights test results from an independent, third-party test laboratory[10] for each insulation type removed after 15 years of service from the exterior of a commercial building in St. Paul, MN at a depth of approximately 6 feet below grade.

Equilibrium moisture content (EMC) is the moisture content of a material at which the material is neither gaining nor losing moisture when exposed to a specific relative humidity and temperature. Although it is a dynamic equilibrium, after the moisture content of EPS insulation has attained its equilibrium value under given conditions, EMC changes that take place as conditions change would not exceed 0.15% of the mass of the material. This EPS insulation material property is another reason why actual moisture absorption measured from field applications differs greatly from results obtained in laboratory tests that expose test specimens to conditions that are not experienced in actual intended product applications.

Water vapour permeance of PlastiSpan insulation

The ability of a material to resist water vapour movement through it depends upon its water vapour permeability. Water vapour permeability characteristics of rigid cellular plastic insulation are determined using ASTM Test Method E 96. Maximum water vapour permeability values can be varied with thickness. Values for various types of PlastiSpan insulation given in the table of physical properties on page 1 of this Technical Bulletin are for a 25-mm thickness. For additional information on water vapour permeability as it relates to other product thickness, see Plasti-Fab Technical Bulletin 112-05.

Water vapour transmission through a material is the passage of water through the material in the vapour phase. Capillary movement of moisture is eliminated in closed cellular plastic insulation such as PlastiSpan insulation; therefore, redistribution of moisture occurs through vaporization and condensation mechanisms as a result of the prevailing thermal gradient. Most moisture gain in field applications is restricted to either the surface cells or as water vapour in the interstitial spaces, rather than absorbed moisture.

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8 Oajnen, Tuomo, Kokko, Erkki, ***Moisture Performance Analysis of EPS Frost Insulation***, ASTM STP 1320, Insulation Materials – Testing and Applications, 3rd Volume, April 1997.
9 Norwegian Public Roads Administration, ***Long-Term Performance and Durability of EPS as a Lightweight Fill***, Nordic Road Transport Research Report 1-2000
10 Stork Twin Cities Testing Corporation, ST. Paul, MN – IAS Accreditation TL-217.

The following points should be noted regarding water vapour permeability in relation to PlastiSpan insulation performance in the building system:

1. Water vapour pressure rises significantly as temperature rises.
2. A significant vapour drive (i.e. temperature/pressure differential) is required in order to induce a significant water vapour movement for the typical range of water vapour permeability values provided by PlastiSpan insulation.
3. The water vapour movement that could be expected at moderate temperature differentials encountered in below-grade applications would be minimal - e.g. vapour pressure differential for 22 °C inside and 5 °C outside = 1772 Pa.
4. A University of Minnesota Underground Space Centre 1986 study of existing research related to foam plastic used in below grade applications offered the following comment on water vapour pressure differentials encountered in below-grade applications:

Building/ground vapour pressure differentials should seldom exceed 0.30" Hg (1015 Pa vapour pressure) outwards and 0.50" Hg (1690 Pa vapour pressure) inwards. Laboratory test results at this level of vapour differential did not result in a significant absorption of moisture.

PlastiSpan insulation resistance to freeze-thaw action

An accepted laboratory freeze-thaw durability test procedure has not been developed for cellular foam plastic insulation. One laboratory test method that has been used in the past is a modified version of ASTM C 666, Test Method for Resistance of Concrete to Rapid Freezing and Thawing. This procedure calls for up to 600 cycles of full-thickness freezing of an insulation sample in air and thawing by complete submersion in water. This test procedure does not correlate to conditions encountered with typical application for an insulation product. The question becomes how many cycles of an inappropriate test procedure are required to **create** a "failure" of the product, rather than how an insulation product will perform in an application.

In reviewing performance of foam plastics in below-grade applications, the University of Minnesota Underground Space Centre concluded that:

1. Freeze-thaw testing involving hundreds of full-thickness freeze-thaw cycles of a fully or partially submerged insulation is poorly related to the expected performance of insulation for below-grade applications over a reasonable economic life for a building.
2. The impact of freeze-thaw cycling in a drained, below-grade building foundation application should not be large since the annual number of freeze-thaw cycles is small below grade, and little of the insulation thickness will experience sub-freezing temperatures.

The performance of EPS insulation in a below-grade application was further demonstrated as part of a joint NRC/CPIA research project. In this project, EPS insulation was installed as exterior foundation insulation for a period of two years. The in situ thermal performance of the insulation was continuously monitored over the period and found to be constant. In addition, the mechanical properties of samples of the material tested after removal from the application were unchanged.[11, 12]

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11 Swinton. Bomberg, Kumaran and Maref, **In situ Performance of Expanded Molded Polystyrene in the Exterior Basement Insulation System (EIBS)**, Journal of Thermal Envelope & Building Science, Vol. 23, October 1999.
12 Swinton, Bomberg, Kumaran, Normandin and Maref, **Performance of Thermal Insulation on the Exterior of Basement Walls**, NRC Construction Technology Update No. 36.

PlastiSpan insulation drainage properties in below-grade applications
When used as below-grade foundation insulation, the surface of PlastiSpan insulation will act as a capillary-breaking layer. The surface of the insulation resists movement of water into the insulation and provides a drainage plane. If adequate provision for drainage is provided at the base of the wall, water not removed at the ground surface will drain to the base of the wall. Plasti-Fab GeoDrain foundation insulation board is a proprietary product designed specifically as a drainage product.

Effect of sunlight (ultraviolet light) on PlastiSpan insulation
Ultraviolet light (sunlight) will cause surface degradation on all types of cellular plastic insulation, including PlastiSpan insulation. If the product is to be stored outside for extended periods of time (more than 3 or 4 days in a bright summer sun), it should be covered with a tarpaulin or opaque light-coloured polyethylene film.

PlastiSpan insulation subject to attack by insects, parasites or animal and plant life
PlastiSpan insulation does not provide any nutritive food value and will not attract insects, parasites or animal and plant life. However, care should be taken to minimize possible exposure to carpenter ants and termites as these wood-boring insects are known to use any insulation material, with the exception of foam glass, as a nesting or tunneling medium.

Industry Acceptance
Since 1951, EPS has been one of the most widely used thermal insulations in the world and is a key component in a number of energy-efficient building systems. Its versatility and high R-value per dollar make EPS insulation the preferred product of architects, specifiers and application contractors.

Buy with confidence
The industry provides a voluntary, third-party quality assurance program to help participating manufacturers control product quality and monitor compliance to Canadian Standards. Consumers, architects, specifiers, building owners, home builders, roofers and insulation contractors can benefit from this nation-wide program by specifying the purchase of labeled products.

CCMC Evaluation Listings
Canadian Construction Materials Centre (CCMC) evaluation listings 12424-L, 12425-L and 12426-L address PlastiSpan insulation material property requirements per CAN/ULC-S701, types 1, 2 and 3. PlastiSpan insulation was evaluated to demonstrate compliance with the National Building Code of Canada.

ICC-ES Evaluation Report
ICC-ES ESR-1587 PlastiSpan insulation addresses material property requirements per ASTM C578, Types I, VIII, II and IX. PlastiSpan insulation was evaluated to demonstrate compliance with the requirements of the International Building Code and the International Residential Code.

Research and Development
Providing a material to the market is one thing, but sustaining it as a market leader over a number of decades and assuring its lasting effectiveness is another. Plasti-Fab has provided customers with innovative expanded polystyrene (EPS) product solutions for over forty years. Recognized as experts in the design and manufacture of EPS products for a wide variety of applications, we provide our customers with professional assistance to select the right EPS product solution for their application.