TECHNICAL BULLETIN 0214 (update of 0111)
PERFORMANCE/COST COMPARISON OF POLYISO vs. XPS PIPE INSULATION SYSTEMS

PURPOSE

Increased focus on energy savings and improvements in the properties of polyisocyanurate make it appropriate to present an apples-to-apples comparison of extruded polystyrene (XPS) pipe billets and polyisocyanurate. This Customer Bulletin provides fabricators, specifiers, engineers, and end-users a quantitative comparison of the performance of XPS pipe insulation versus polyiso insulation in a low-temperature scenario. An ammonia refrigerant (R717) application was selected with process pipe operating at an average -50°F (-46°C) within a 75°F ambient environment since this is a common application where decision-makers may consider either XPS or polyiso. Yet our conclusions herein are generally applicable to any application with service temperatures below ambient [the dollar savings will of course vary with service temperature]. We selected Dyplast's ISO-C1® (2 lb/ft^3 density[1]) as the best-in-class polyiso product and ITW[2] XPS PIB[3] (pipe insulation billet) as the best-in-class XPS product.

This Customer Bulletin strives to provide factual and objective information which should allow an objective comparison of Dyplast's ISO-C1® with the competing XPS Billet product. We solicit your feedback if you believe the information herein can be improved.

Economic conclusions are based on results using 3E-Plus software[4] from the North American Insulation Manufacturers Association (NAIMA) which has become the standard for such calculations. Interested parties can replicate the information in this Customer Bulletin or can revise for different service temperatures.

[Note: the extensive use of footnotes is very important to ensure clarity of statements.]

COMPARISON OF INSULANTS

An installed insulation system for a refrigerant piping application consists of one or more layers of the core insulant, vapor retarders, tapes, jackets, bands, mastics, and adhesives. Even though any component that is improperly selected, poorly installed, or substantially abused can lead to *system* failure, it is of course the core insulant that will have the greatest impact on system

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[1] PIR Grade 2, Type IV per C591-07

[2] Illinois Tool Works, Inc. (ITW Insulation Division)

[3] Polystyrene Pipe, Type XIII, C578-07

[4] The PIR insulation data within 3E-Plus does not reflect the improved physical properties of ISO-C1; therefore the model was updated to reflect actual characteristics of 3E-Plus.

performance. To keep the scenario relatively simple while achieving the objective of an *apples-to-apples* comparison, identical vapor retarders and jackets were assumed within 3E-Plus for both XPS and polyiso, with the following assumed as a representative example:

- Refrigerant pipe operating continuously at -50°F covered with a single layer of either ISO-C1 or XPS;
- Ambient temperature of 75°F;
- 1 inch, 3 inch, and 6 inch O.D. pipe were considered;
- Insulation thicknesses of 1 inch and 2 inches included;
- New stainless steel jacket (emissivity 0.13) selection within the 3E-Plus software;
- Wind at average 15 mph;
- System operating 8,320 hours/year;
- 30% overall process efficiency using electricity at $0.10 kwh as energy source.

SUMMARY OF RESULTS

There are two major differences between XPS PIB and ISO-C1 that have a dominant effect[5] on long term economic performance: 1) initial capital cost, and 2) energy savings due to thermal conductivity[6]. On the first note, the initial capital investment for an XPS insulant, ignoring fabrication[7,8], is generally ~45%[9] higher than ISO-C1. On the second, assuming a conservative 20-year life of an insulation system, and an optimistic 4% energy cost inflation rate, a 1 inch thick ISO-C1 insulation system on a 3 inch pipe would save $22,721[10] per 100 linear feet, and $40,081 per 100 linear feet on 6 inch pipe versus a comparable XPS insulation system.

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[5] *All physical properties of ISO-C1 are better or on a par with XPS PIB, establishing a "second-line-of-defense" in case of accident or abuse, and can thus be considered to have "material" positive effects, yet two are dominant.*

[6] *XPS at 75°F has an aged k-factor of 0.259 while ISO-C1's k-factor is 0.176 (or R-value of 3.86 vs. 5.7, respectively; k-factors at lower temperatures are even lower).*

[7] *The cost of fabricating XPS billets into shapes for pipe is assumed roughly comparable to that of polyiso, yet for certain pipe sizes the limited size of XPS billets requires the fabricator to either 1) consume labor and materials to glue billets together before cutting or 2) manufacture smaller pieces that must then be pieced together in the field, resulting in higher installation costs.*

[8] *ISO-C1 is produced as continuous bunstock that can be produced in variable sizes; for instance 2 lb/ft^3 foam can have widths up to 4 feet and virtually any length. Variable bunstock sizing and subsequent cutting into precisely sized "chunks" can lead to efficiencies in shipping (optimization of truck volumes) and during fabrication into pipe shapes (less waste). ISO-C1 can also be produced in multiple densities, including 2.5, 3, 4, and 6 lb/ft^3; higher densities provide significant flexibility for various applications, including pipe hangars. XPS is commonly produced only in 1.6 lb/ft^3 billets, with limited size alternatives (7"x14", 8"x16", or 10" x 20" in 9 foot lengths).*

[9] *The purchase price per board-foot of an XPS billet is approximately 45% more expensive than a polyiso bun.*

[10] *In 2014 U.S. dollars.*

PERFORMANCE COST ECONOMICS[11]

Insulant Type	Pipe OD	Insulant thickness	Cost of Energy Lost $/ft/yr[12]	ISO-C1 Advantage per 100 linear feet of pipe over 20 year life[13]
XPS PIB	1"	1"	$12.30	
ISO-C1	1"	1"	$ 8.64	$11,900
XPS PIB	1"	2"	$ 8.42	
ISO-C1	1"	2"	$ 5.89	$ 8,232
XPS PIB	3"	1"	$25.87	
ISO-C1	3"	1"	$18.24	$24,828
XPS PIB	3"	2"	$15.57	
ISO-C1	3"	2"	$10.92	$15,131
XPS PIB	6"	1"	$46.06	
ISO-C1	6"	1"	$32.60	$43,798
XPS PIB	6"	2"	$25.21	
ISO-C1	6"	2"	$17.70	$24,437

Yes, it can be argued that by simply adding greater thicknesses of XPS insulation the ISO advantage can be narrowed. Yet the real argument must be why should an end-user pay more in capital cost to narrow the energy-savings gap with an insulant that is inherently less expensive and exhibits better or comparable performance.

[11] *In 2011 U.S. Dollars.*
[12] *Assuming electricity at $.10/kwh and 30% process efficiency.*
[13] *Assuming 4% energy cost escalation per year, and ignoring higher capital costs of XPS .*

RISK MITIGATION

While the above Summary of Results readily demonstrates that ISO-C1 pipe insulation for refrigerant applications delivers superior ROI, ISO-C1 also mitigates risk over the life cycle. For instance:

- An ISO-C1 insulation system utilizes a zero-perm vapor barrier, whereas the ITW installation guide[14] recommends use of Saran 540 or 560, which are rated at 0.02 and 0.01 perm-in, respectively; in many circumstances the differences are immaterial, yet in high humidity environments the engineer should evaluate the risks;
- ISO-C1 Water Absorption per ASTM C272 is superior to XPS PIB (0.04% by volume compared to 0.5%); thus if there is a breach of the vapor barrier, ISO-C1 provide a second line of defense;
- ISO-C1 has <0.1% change in volume or length at -40F; the dimensional stability of XPS at any "below-ambient" temperature is not listed; better dimensional stability results in fewer failures in seams/joints where thermal shorts or water vapor penetration can compromise an insulation system[15];
- ISO-C1 ASTM E84 tests demonstrate 25 flame spread index and 130 smoke developed index[16] up to 4 inches in thickness; the XPS datasheet lists a 5/165 FSI/SDI; while both products qualify as Class 1 rigid foams, this data is difficult to interpret; on a more apples-to-apples comparison it should be noted that XPS is a thermoplastic which will melt at temperatures from 212-239°F; ISO-C1 on the other hand is a thermoset which does not melt and rather retains its integrity even as it chars at temperatures above 400°F;
- ISO-C1 utilizes hydrocarbon blowing agents with ODP ratings of zero, and GWP ratings of approximately 10; the XPS PIB MSDS indicates XPS uses HFC 134a and HFC-152a which also have zero ODP; but HFC-134a has a GWP of between 1200-1400, and HFC-152a a GWP of 140; HFC-134a additionally has a 14 year atmospheric life.

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[14] *Installation Guideline For Xps Pipe Insulation Billets In Refrigeration Applications* (-70°F To 35°F); http://www.itwinsulation.com/trymer/library/Data_Sheets/ITW_XPS_PIB_Refrigeration_Applic.pdf.

[15] *XPS does list dimensional stability of 1.0% volume change per ASTM D2126 at 158°F (70°C) at 97% relative humidity for 7 days; the comparable ISO-C1 dimensional stability is <1.0%; [note it is unlikely that refrigerant process piping would be exposed to these conditions].*

[16] *Per Factory Mutual ASTM E-84 tunnel tests*

FRIABILITY

The friability (surface dust) of polyiso is often raised by XPS suppliers as a disadvantage, yet among installers this physical property is sometimes praised as an advantage when "shaping" in the field is required. In other words, a field installer can use abrasion to alter the shape of a polyiso shape to precisely fit the application, whereas it is difficult to refine an XPS shape in the field. Installation Guides for both XPS and ISO note that dust is created when the material is cut. Fabricators and installers should wear masks to filter dust from polyiso, and depending on whether XPS shapes are fabricated with a fast wire or hot wire profiler filter masks may be similarly appropriate. Once the insulation system installation is completed, dust is not an issue.

THIRD PARTY INDEPENDENT TESTING

Dyplast Products is the only manufacturer of polyiso that has independent audits and approvals by FM and ICC. Dyplast utilizes independent testing facilities to evaluate the physical properties of its polyisocyanurate products. Further, all densities of ISO-C1 are manufactured using the same manufacturing quality control and internal auditing process. When comparing competitive foam insulations, buyers and specifiers should request third party verification information in order to ensure their comparisons are credible.

RESISTANCE TO CONSTRUCTION MATERIALS

Extruded polystyrene can be attacked by many petroleum based solvents in adhesives, paints, stains, water repellent and preservative coatings, and in bituminous waterproofing. As many contractors have discovered, the application of these common construction materials causes the extruded polystyrene to dissolve. This problem is solved by using ISO-C1 polyiso insulation, which is not affected by these materials.