CUSTOMER BULLETIN 0511
Questions You Should Ask
When Selecting Mechanical Insulation

PURPOSE

Too often the specifying and selection processes relating to mechanical insulation are jeopardized either due to confusing information or the absence of important information. "W*hat's not being said*" is sometimes more important than "*what's being said*"! The objective of this document is to itemize key questions that should be asked during discussions with insulant suppliers. Failure to receive a credible response on any question may be an indication that full disclosure is being withheld.

QUESTIONS

1. Third-Party-Verification

Third-party, independent substantiation of claims, advertisements, or representations of physical properties is paramount. This should be the first question raised by specifiers or end-users! Reputable suppliers will be forthcoming with test results and/or audits conducted by independent accredited laboratories.

Question 1: "*Are the physical properties, production processes, and Quality Control procedures verified by an independent third-party auditing organization to ensure the delivered product is as advertised*?

Note regarding audits: Even though a third party may, for example, test a physical or flame/smoke property at a given point in time - - the third-party may have no responsibility to ensure the manufacturing process or QC procedures remain unchanged and enforced.

Dyplast's ISO-C1 has physical properties, production processes, and QC procedures both measured and audited by competent independent third parties such as UL, FM, or RADCO (on behalf of ICC).

2. K-factors and Aging[1]

The thermal conductivity (k-factor[2]) of insulation is determined by ASTM C518 or C177 (or comparable European Standards), that define an *initial* versus an *aged* thermal conductivity.

Question 2: "*Is this a 6 month aged k-factor measured per the pertinent standards and verified per Question 1 above*"?

Dyplast lists both initial and aged k-factors for its products!

Question 3: *This next question is more of a "what is not said" issue. Some insulant suppliers overstate or over-imply that insulation subject to thermal aging will continue to age over the life of the foam. While this may be correct in certain cases, over 95% of any deterioration in k-factor occurs within six months when conditions are at the 75°F and relative humidity requirements of the test. At lower temperatures, and when the insulant is confined within vapor barriers, the deterioration in k-factor may be significantly slower and possibly may not reach the "measured aged k" for years or even decades.* [*See Appendix A for more detail*]

Dyplast strives to disclose all information that may be useful for a specifier or purchaser of insulation system products, and we do not overstate or over-imply performance. In fact, even though our ISO-C1 polyiso is used most commonly for service temperatures below ambient, and its k-factor is improved at lower temperatures, we continue to accept comparisons at 75F to establish an apples-to-apples baseline with competitive products. Neither do we attempt to predict thermal aging at below-ambient service temperatures with in-situ vapor barriers, even though we know that thermal aging is slowed in such conditions. And finally, we develop Customer Technical Bulletins to present our knowledge-base and objectively educate interested parties.

---

[1] For more information on thermal conductivity and aging, see Dyplast's Customer Bulletin 0811 at http://www.dyplastproducts.com/Customer_Bulletins/CUSTOMER_BULLETIN_0811.pdf

[2] Simplified, the k-factor (thermal conductivity) is the measure of heat that passes through one square foot of material that is 1 inch thick in an hour. The lower the K value, the better the insulation. C-factor is the k-factor divided by the thickness of the insulation material. The R-factor can be determined by R=1/C. The higher the R factor, the better the thermal insulating efficiency.

3. Banned Blowing Agents

The Montreal Protocol, ratified by 196 countries, sequentially bans the use of certain blowing agents for making insulation foams among other things - - because of their Ozone Depletion Potential (ODP). The initial bans were on CFC's, and then HCFC's. Developing countries were allowed more time to phase out banned compounds. An unanticipated loophole does not expressly prohibit U.S. corporations from having their products manufactured in Mexico using materials banned in the U.S., for example, and then shipped to the U.S.

Question 4: "*Are any blowing agents used in manufacture of the insulation currently banned in the U.S.*?" (in other words, could a U.S. manufacturer utilize the same blowing agents?)

Dyplast uses blowing agents fully approved by the EPA and the Montreal Protocol!

4. Made in America

Several U.S. laws and subsequent bills have aimed at varied yet increasingly stringent levels of definition and enforcement to promote awareness and disclosure of "country of origin" in order to engender a demand for "Made in U.S" and hopefully shift manufacturing back to the U.S. Yet many companies continue to exploit loopholes in the legislation. For example, a foreign manufacturer can manufacture in another country, ship to the U.S., perform some modification on the product or "add some value", and claim "substantial transformation" in the U.S. - - risking only the possibility that a U.S. company will take them to court to resolve the definition of "substantial" (meaning the Government does not enforce these provisions). In the insulation industry, for instance, a foreign company can manufacture an insulant outside of the U.S. with blowing agents banned for use within the U.S. and then claim their product was "substantially transformed" in the U.S. by simply cutting into the necessary slabs or shapes within U.S. borders.

Question 5: "*Where was the product manufactured? What aspects of production actually occurred in the U.S.*?

Question 6: "*What 'substantial transformation', if any, was performed in the U.S.*?"

Dyplast's C1 polyisocyanurate foam is fully manufactured in the U.S. All fabrication of pipe insulation for North American projects is by U.S. companies!

5. Thermal Conductivity: The "Thickness Effect"

Low-density thermal insulants (nominally defined for this discussion as less than 1.9 lb/ft^3) have been demonstrated to lose some of their insulating capability otherwise predicted as thickness of the insulation increases[3]. For example, assume that the thermal conductivity (k-factor) is measured on two *low-density* specimens: one 4 inches thick, and the other 1 inch thick. The per unit (e.g. per inch) k-factor of the thicker specimen is greater than (worse than) the k–factor as measured from a 1 inch thick specimen.

This is somewhat counter-intuitive and calls into questions some of the typical "thumbrules" used to calculate C-factor and R-factors (such as C=1/k; R=1/C, etc). It also adds a caveat to the definition of an *intrinsic property*, since what may be an intrinsic property at one thickness may not be an intrinsic property at higher thicknesses.

The paper referenced in Footnote #2 expressed that glass fiber 6 inches thick will have an *apparent* thermal conductivity up to 3% worse than one would expect given the *intrinsic* k-factor at 1 inch; yet there is insufficient information about the product, densities, and conditions of the test to extrapolate to any particular product. Thus it could materially be more than 3% for some products/conditions. Also, the paper references deterioration of thermal conductivities of a 1.8 lb/ft^3 polyurethane (not polyiso) sample at greater thickness, although there is again insufficient information about the sample (blowing agents, cell size, percent of closed cells, etc.) to extrapolate findings to other products.

Dyplast Products measured the thermal conductivity of a 4 inch thick specimen of expanded polystyrene (both 1 and 2 lb/ft^3) and polyisocyanurate at 2 lb/ft^3. The results are shown in the Table below.

In summary, 1 lb/ft^3 density EPS at a thickness of 2 inches shows a deterioration in thermal conductivity of 5.3%, and 9.5% at 4 inches. A 2 lb/ft^3 EPS specimen shows less deterioration, which is to be expected. The 2 lb/ft^3 polyiso sample (ISO-C1) show virtually no change.

Thermal Conductivity versus Thickness

Sample Thickness	EPS (1.0 pcf)		EPS (2.0 pcf)		ISO (2.0 pcf)	
	K-factor	% change re: 1 inch	K-factor	% change re: 1 inch	K-factor	% change re: 1 inch
4"	0.289	9.5%	0.232	2.7%	0.161	0.0%
2"	0.278	5.3%	0.229	1.1%	0.160	-0.6%
1"	0.264		0.226		0.161	

[3] Conductive and Radiative Heat Transfer in Insulators; Akhan Tleoubaev, Ph.D.; LaserComp, Inc.; December;1998(http://www.lasercomp.com/Tech%20Papers/Papers/Conductive%20and%20Radiative%20Heat%20Transfer%20in%20Insulators.pdf)

Question 7: *Do the thermal conductivities or resistivities for insulants at thicknesses above one inch take into consideration the "thickness effect"? If so, are they the direct results of tests, other auditable adjustment, or thumbrules?*

Dyplast's ISO-C1 family of polyisocyanurate insulants have a minimum density of 2.0 lb/ft^3 and do not exhibit deterioration of thermal conductivity at greater thicknesses.

6. Closed Cells vs. Non-closed Cells

Cellular foams include both open and closed cell foams. Closed cell foams are capable of having (and typically do have) gases *trapped* within the cells other than air that enhance the k-factor. Beyond the improved k-factor, closed cell foams can offer better moisture resistance, strength, dimensional stability, and better thermal aging characteristics. Also, the higher the percentage of closed cells, the better the general characteristics. Cellular foams with *open* cells and/or fibrous insulants have no closed cellular structure and are typically more susceptible to moisture infiltration, water absorption, and likely have lower compressive strength at comparable densities.

Question 8: "*Is the product truly a closed cell foam? What gas is present in the cells? Can it diffuse out of the cell, and if so over what time period?*"

Dyplast's ISO-C1 polyiso is truly a closed cell foam!

The extent to which cell walls crack, rupture, or holes occur, determines the percentage of closed cells. The production process itself as well as the density of the foam can influence closed cell content, with higher densities generally having a higher percentage of closed cells. When cell walls are breached, entrapped blowing agent within the cells will leak out, exacerbating any thermal aging. Some foams classified as *closed cell* may actually have some or even a majority of cell wall holes.

Question 9: "*What is the percentage of closed cells*"?

The percentage of closed cells in ISO-C1 is >95%!

[Note: The percentage of closed cells and the strength of the cell walls will vary with density. Above densities 2.50 pcf the closed cell content will remain high and constant. Within the density range typically used as pipe insulation (i.e. ≤ 2.50 pcf), there won't be any material differences in closed content until the density is below about 1.75 – 1.80 pcf. As the density is lowered further, the closed cell content will decrease.]

7. Fire Test Performance

The International Mechanical Code requires pipe and duct insulation to have a 25/50 Flame Spread Index/Smoke Developed Index rating per testing under ASTM E84 when installed in an *indoor air plenum*. Typical refrigeration piping, cryogenic piping, and similar installations are either outdoors or outside the *air plenum* definition, and thus require only Class 1 FSI/SDI (25/450).

The ASTM E84 test method is intended to provide only comparative *measurements* of surface flame spread and smoke density measurements; in fact, the FSI and SDI of red oak form the standard to which test specimens are compared. The test was developed over time to gauge the relative burning behavior of a subject material such as insulation. The current test method suspends within a long *tunnel* a nominal 24-ft long by 20-in. wide specimen to a controlled air flow and flame exposure (as high as 1200F) to ignite the specimen - - allowing an observer to then monitor the spread the flame along the length of the specimen for ten (10) minutes. Some materials do not spread the flame - - some do; some flames spread quickly, some more slowly over the duration.

This FSI test protocol is a *witness test* where the *experienced technician* observer watches the spread of flame along the length of the specimen, and records the distance versus time along the length at which the specimen no longer supports a flame. The SDI test protocol depends on a *calibrated* smoke opacity meter that allows correlation to smoke density.

Some insulation, typically the polystyrenes (expanded and extruded) and polyethylenes begin to soften and melt at temperatures as low as 165F to 200F, respectively. Since the flame temperature in the *tunnel test* is substantially higher than 200F, the specimen melts quickly, falls through the suspension structure, and may continue to burn and generate smoke on the bottom of the tunnel. Thus the observer cannot see a flame spread across the length. Because of the test protocols, some flame spread technician observers may interpret what they see differently. For instance, they may indicate in the test report that the flame did not spread, for example, beyond 5 feet - - when in fact the material was still flaming in a puddle at the bottom of the test chamber ("*the test got fooled*").

Specifiers and purchasers of insulants are cautioned to insist on test reports, ask questions, and assess the risks associated with the *in-situ* installation of such insulants during a fire.

Question 10: *"What is the Flame Spread/Smoke Development ratings of the insulant per ASTM E84? Up to what thicknesses[4] are the ratings valid? Was the test conducted by an accredited lab and can I see the test report? Will the company represent that the specimen did not melt and remained suspended during the duration of the E84 test?"*

Dyplast's uses only accredited laboratories. ISO-C1 is a Class 1 foam up to 4 inches. Polyiso may char, but will remain in position during the E84 test.

[4] Adding layers of insulation to a pipe system to achieve greater thicknesses will not meet FSI/SDI compliance with the International Mechanical Code.