Building Envelope FORUM

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The Differences Between a Lexus and a Camry— A Comparison of the Performance Characteristics of Medium (MDSPF) and Light Density (LDSPF) Sprayed Polyurethane Foam Insulation

By: Mike Richmond

Introduction

Spray polyurethane foam (SPF) insulation is rapidly becoming the insulation of choice in an energy conscious new construction market. Similarly, as owners of existing buildings look for conservation ideas, SPF provides multiple solutions for air-sealing, insulation and moisture management problems. Although not a cure-all, sprayed polyurethane foam offers superior thermal resistance, advanced air barrier properties and excellent resistance to vapour diffusion (MDSPF only). To be certain, spray foam is a versatile product – cost effective, productive and able to solve many of the energy conservation problems faced by consultants, general contractors and property owners. But are all spray polyurethane foam products created equally? The short answer is no. There are literally 100's of different type of formulations – one needs to be aware of the differences between the three basic types of spray foams before specifying the product(s). Two types are generally used for building envelope and one type is generally used for roofing. This discussion will focus on the two product types most commonly used.

SPF's physical properties hold the answers to the suitability of application. SPF is available in two basic types – LDSPF – open cell, light density (between 7.37 kg/m3 and 8.47 kg/m3, often referred to as "1/2 lb" foam) and MDSPF – closed cell, medium density (between 30.4 kg/m3 and 35.5 kg/m3, often referred to as 2lb foam). Contrary to manufacturer's claims, chemically, the products available for each type are quite similar. Indeed, when compared within type categories, there is minimal difference in product performance characteristics (see Table 1). Given the similarity between brands within each type, the more significant discussion centres on comparisons between the two types.

	Core Density (kg/m3)	Compressive Strength (kPa)	Tensile Strength (kPa)	Water Absorption (% volume)	Water Vapour Permeance (ng/Pa.s.m2)	Air Leakage (L/s.m2)	Thermal Resistance (m2.0C/W)	Noise Reduction (NRC)	Sound Transmission (STC)
LIGHT DENSITY - LDSPF									
Demilec Sealection 500	7.37	5.0	17.0	47.9	1300	0.040000	0.671 (R3.8)	0.75	39
Icynene Gold Seal	8.47	no data	no data	4.20	1218	0.004900	0.650 (R3.6)	0.72	42
BASF Enertite	8.26	12.4	No Data	3.20	894	0.008000	0.747 (R3.8)	0.60	49
MEDIUM DENSITY - MDSPF									
Heatlok 0240/ Polar 7300	31.3	174	212	0.62	86.6	0.000140	1.11 (R6.30)	No Data	No Data
BASF Walltite	30.4	222	337	2.50	125	0.000418	1.14 (R6.47)	No Data	No Data
Heatlok Soya Polar Soya	35.5	195	355	0.80	58	0.000040	1.02 (R5.79)	No Data	No Data

TABLE ONE *1*
Comparison of Low and Medium Density Foams

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Similarities

Both low density and medium density foams are manufactured from a combination of polyol resins, catalysts, surfactants, fire retardants, and blowing agents on the 'B' side. Both SPF types use a polymeric MDI (methylene diphenyl diisocyanate) on the 'A' side .[2] Thus, the only real difference between brands within a type is negligible ingredient proportions. As seen in Table One, thermal resistance, air leakage properties, water absorption, and water vapour permeance differences between Demilec's Sealection 500, Icynene's Gold Seal, and BASF's Enertite are barely discernible. Similarly, with the exception of the superior water vapour permeance of the Soya products, the physical properties of Heatlok 0240, Polar Foam 7300, Walltite, Heatlok Soya and Polar Foam Soya are without significance.

The distinction between light and medium density products, while more significant, is also measured in recipe. But certainly, the two types are closely tied in chemistry. Because of their similar chemical compositions, both LDSPF and MDSPFs are combustible. Indeed, the average flame spread value for low density foams is 368 as compared to an average flame spread value of 303 for medium density foams. Similarly, the smoke develop index for low density SPF is 156 (average) and 294 (average) for the medium density products. Thus, both foam types, like all plastic insulations, are subject to a thermal barrier requirement as stated in the National Building Code.[3]

Both SPF types are installed with the same equipment. Because both materials are initially installed as a liquid, and then the material once sprayed onto a substrate expands proportional to the original volume (about 100 times for light density; up to 35 times for medium density), the installed materials are able to 'find and fill' cracks and voids that are inaccessible to other insulation materials. Similarly, each SPF type is ideally suited to irregular construction and/or difficult areas to insulate. Asymmetrical framing, turrets with converging rafters, barrel ceilings, and basement ribbon plates are excellent examples of typical application problems when using fibrous and/or rigid insulations that are easily solved when insulated with SPF foam products.

Until recently only LDSPF could claim status as a 'Zero Ozone Depletion Substance' (Zero ODS). However, legislative changes require the eventual elimination of HCFCs (Hydochlorofluorocarbons) in medium density foam. Today, CFC and HCFC free, medium density products are being produced, meeting the requirements of the legislation. Thus, both SPF types are now commercially available with zero ODS. As such, both spray foam types are now environmentally friendly.[4]

There can be no question of the shared characteristics of light and medium density spray foam. But while the similarities are many, it is the differences that are most important when identifying when and where to use the different variations of SPF.

Differences

The most significant distinction between the two types is the cell configuration. Light density foam is an open-cell material as opposed to medium density foam that is closed-cell product. The difference has implications for every performance criteria. The obvious physical characteristics such as dimension stability and tensile/compressive strengths equate to superior performance of closed cell SPF over open cell spray foams. Again, although there are small variations between brands, the real significances are between types—

- Medium Density SPF has superior thermal resistance – 33% (on average)
- Medium Density SPF is a better air barrier – 10 times greater protection (on average)
- Medium Density SPF is a vapour retarder—Low Density SPF requires an additional vapour retarder
- Medium Density SPF strengthens frame walls by a factor of 2 to 3 times in comparison to Low Density SPF (and all other non-closed cell insulations)
- Low Density SPF has superior sound absorption qualities than Medium Density SPF

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Similar to fibrous insulations, open cell foams use still air as an insulator; thus, thermal resistance values for light density foams are similar to fibrous insulations. Conversely, medium density SPF is has superior thermal performance because the still air is replaced with less thermally conductive gases.

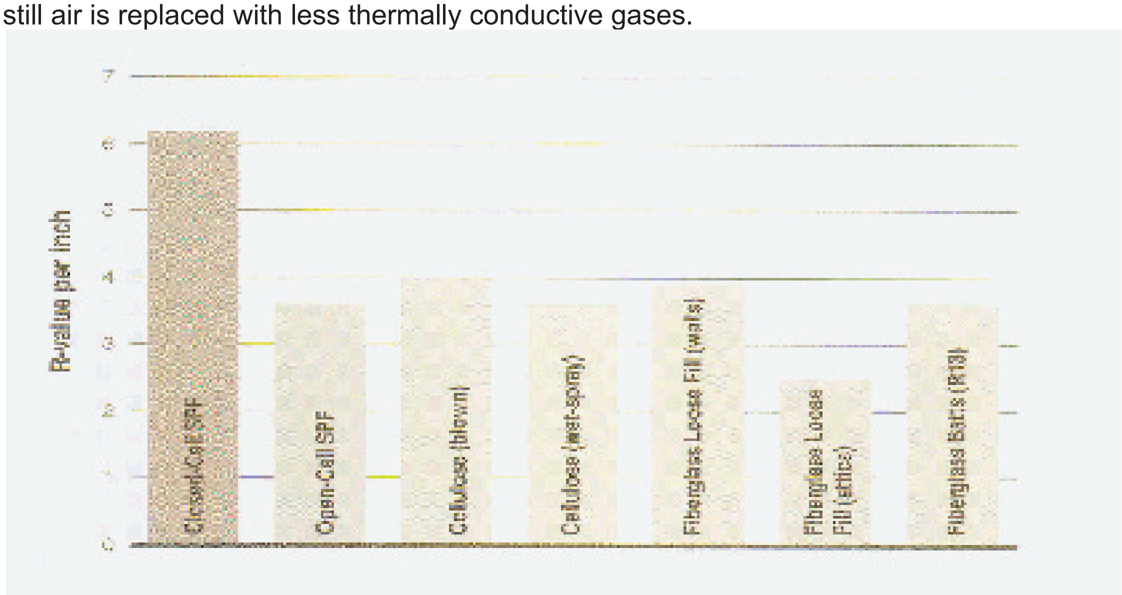

Figure 1 - r-value comparison

Medium density SPF, because of its closed cell structure and tenacious ability to bond to other construction materials, provides an impermeable air barrier for all building substrates. Medium density SPF's air permeability is ten times less than low density foam when tested as a material only (and 100,000 times less permeable than cellulose insulation).

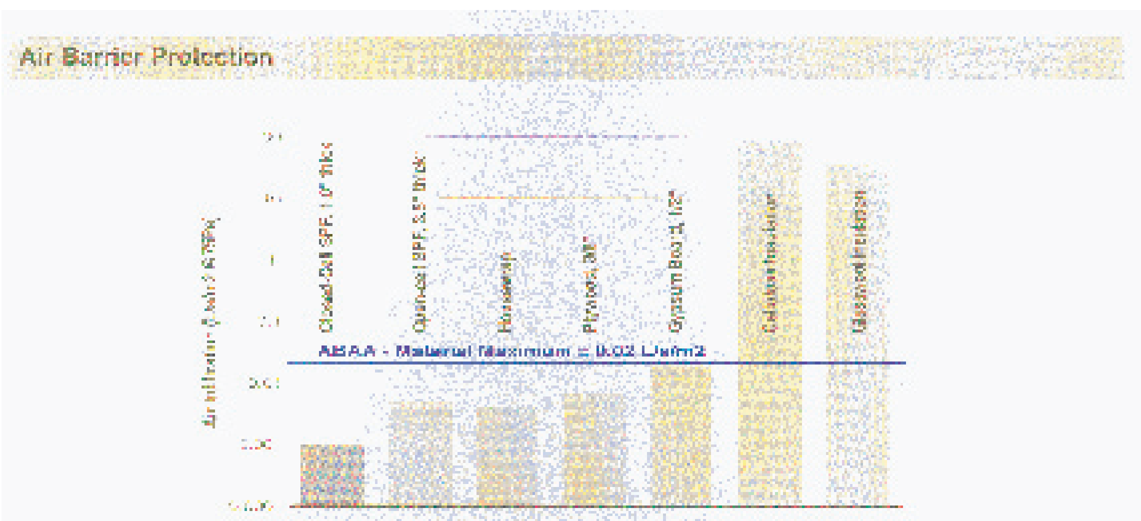

Figure 2 - air barrier protection

Fibrous and open-cell insulations allow free movement of water vapour through their products. As such, alone, they do not serve as a vapour retarder. ***5*** Conversely, closed cell SPF alone is considered a semi-impermeable vapour retarder. Further, "…at 1 perm, closed-cell SPF is semi-impermeable, enabling it to allow for controlled breathing and drying.

Foam continued on page 4

Foam continued from page 3

SPF uniformity and consistency enables it to resist passage of vapour equally well in all directions". ***6*** The conclusions of Dr. John Straube's research into the area of SPF's vapour diffusion control validate previous conclusions. Dr. Straube concludes that light density, open-celled SPF "…had insufficient vapour resistance" and that medium density, closed-celled SPF "…did have sufficient vapour resistance…for the same conditions". ***7***

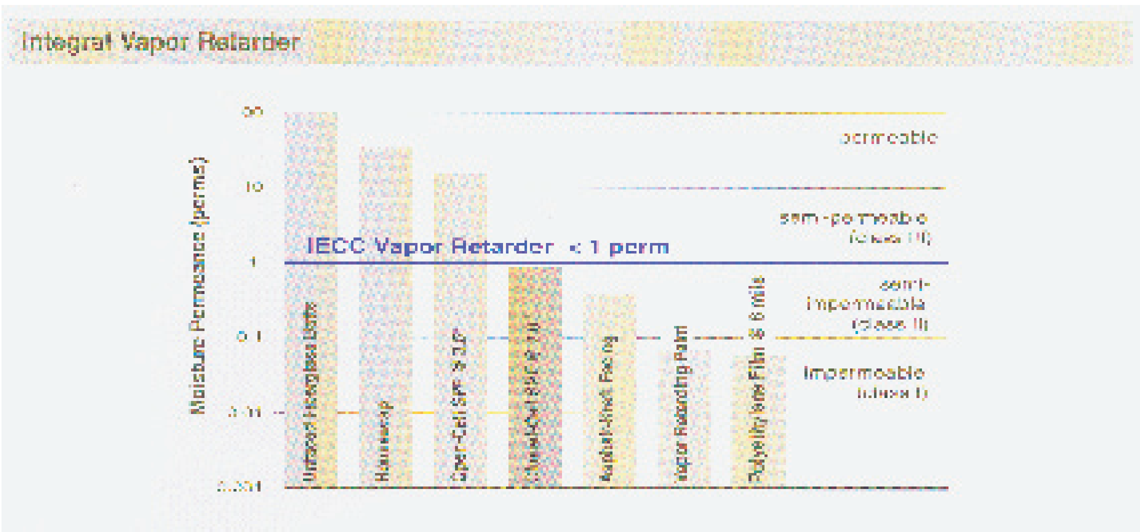

Figure 3 - moisture permeance comparison* Meets air barrier association of America (abaa) criteria as stated in product specification sheet only when applied to tar impregnated paper

Medium density SPF is stiffer and stronger than light density SPF. When installed inside framed wall cavities, medium density SPF can strengthen the framed wall by a factor of 2 to 3 times. Further, according to the National Association of Home Builders (U.S.), "…during a design racking event like a hurricane, there would be less permanent deformation of wall elements and possibly less damage to a structure that was braced with [medium density] SPF filled walls". ***8*** Presently, the Canadian Urethane Foam Contractors Association and SPF industry is participating in research to determine if SPF can increase the resistance to sheathing up-lift under high wind loads . ***9***

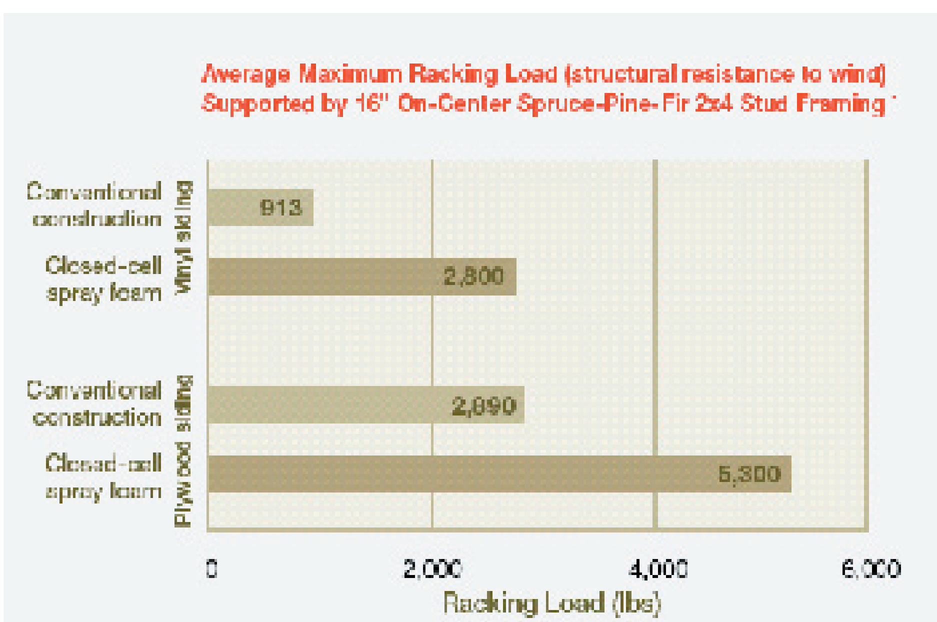

Figure 4 - structural strength of wall assembly

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Both light and medium density SPFs have air barrier characteristics that contribute to the sound ‘tightening’ of the building envelope. SPF’s ability to seal air leakage reduces sound transmission through ‘flanking’ sound waves that move through cracks and gaps in the building envelope. Light density SPF offers additional sound absorption qualities. Thus, while both types of SPF reduce sound transmission, light density SPF provides an additional level of protection in terms of sound absorption.

To be sure, light and medium density products share a chemical lineage, and thus, many similarities, but the differences are significant. The SPF industry combats this problem every day. While the products look and act in a similar manner, once installed, the two types perform quite differently. Light density SPF looks the same, is installed with the same equipment, but costs considerably less to install—therein lays the potential for problems (even disaster). The design professional needs to be diligent about what product is best suited for what application.

Determining Application Suitability

Some application choices are straightforward. When dealing with thermal resistance and air barrier requirements, medium density absolutely outperforms light density materials. However, the cost of performance might be prohibitive. Everyone knows the difference between a Lexus and a Camry, but we also realize that both cars will get us to work. LDSPF products provide the required thermal resistance at a greater thickness. Further, light density SPF also provides air retarder protection that is 100,000 times superior to fibrous materials. In terms of thermal resistance and air barrier protection the design choice is uncomplicated—if you want unsurpassed thermal resistance and air barrier protection, chose a medium density SPF. If you can settle for less performance, then light density SPF may provide better value.

Other design decisions are even less divisive than the thermal resistance/air barrier protection debate. If you are looking for noise reduction and sound absorption, low density SPF is as good as any product on the market—medium density SPF is a higher cost, less effective alternative.

The design choice becomes a little more difficult when dealing with the two SPF types’ ability to deal with vapour diffusion. Simply put, light density SPF requires an additional vapour barrier; it absorbs significantly more water than medium density SPF and is unable to withstand direct and prolonged contact with floodwaters without sustaining significant damage. Conversely, medium density SPF is an integral insulation, air barrier, water resistive barrier and vapour barrier. Medium density SPF absorbs minimal amounts of water when compared to light density SPF or any fibrous insulation material. Finally, “closed-cell [medium density] foam is the only insulation classified as an “acceptable flood resistant material” by FEMA . [10]

MDSPF has a long history of performance as a stand alone insulation and vapour barrier. LDSPF, a relatively new insulation is demonstrating its limitations in regards to vapour diffusion management. As a result of a Vermont litigation case, “Icynene now recommends that a vapor retarder be installed whenever its foam insulation is installed in a climate with 7,500 [Fahrenheit] or more heating degree days” [11] Icynene’s position that a vapour retarder is required mirrors Demilec and BASF’s requirements for their light density products. In short, if an application calls for an insulation material that provides resistance to vapour diffusion, or requires performance in moisture laden environments, medium density SPF is the best available choice. Swimming pools, humidity controlled environments, freezers and coolers are all applications that are better suited to a medium density, rather than a light density SPF.

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Similarly, medium density SPF is a better fit for applications that require product rigidity or impact resistance. Any application that is outside of an enclosed cavity – Quonset huts, parking garage ceilings, warehouse walls or metal deck ceilings, especially those that require a spray-applied fire protection material, are better suited to medium density SPF. Medium density SPF is a rigid product; light density SPF is a semi-rigid product. As such, medium density can withstand impact—it is a durable product that can function as a finished surface. Light density SPF must be covered for protection—and the product can not withstand the weight of a spray-applied thermal barrier without delaminating.

Where the material will be installed also impacts the type of SPF that you choose. Light density open cell spray polyurethane shall only be installed on the interior of the building shell and only between framing members with a maximum spacing. Medium density SPF can be installed on the interior or the exterior of the building shell and is not restricted to be installed between framing members. An example would be cavity wall insulation where MDSPF is installed on the exterior of the building, providing the thermal insulation, air barrier, water resistive barrier, and the vapour barrier functions. The material is then covered with a cladding system. Light density open cell spray polyurethane foam cannot be installed in this application. It would always be installed on the interior of the structure and provide only the thermal insulation function.

Above are some of the limitations based on type. The listed restrictions of light density SPF might imply inferiority. That is simply not the case. Rather, when compared to medium density SPF, there are significant differences that need to be recognized. Light density SPF is similar in appearance and application to medium density SPF, but does not perform like medium density SPF in all cases. The comparison is not necessarily a fair one for light density SPF—medium density SPF outperforms every insulation. To extend our car analogy, everyone knows the difference between a Lexus, a Camry and a Tercel. Each car gets us to our destination, but each performs differently. The performance differences between medium density and light density SPF are similar to the performance variations between light density SPF and fibrous insulations.

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Foam continued from page 6

Acknowledgements

Three influences are patent in this paper. First, Dr. John Straube's body of work in regards to Spray Polyurethane Foam is a constant authority and his paper, Field Performance of Spray Polyurethane Foam: The Role of Vapour Diffusion Control is a continual source of information in regards to SPF's ability to manage moisture. Second, the body of work published by Honeywell in regards to SPF is also a consistent source of information. Finally, the influence of Mason Knowles' paper Learning the Difference Between 1/2lb and 2lb Polyurethane Foam is obvious in this article.

Endnotes

The majority of the data was obtained from each product's CCMC Evaluation Report as generated by the National Research Council of Canada. Note: significant variations of physical properties is only evident when using data obtained by the chemical supplier. Test results done that conform to exact testing standards demonstrate similarity rather than variation.

Discussion is loosely based on a discussion by Mason Knowles, "Learning the Difference Between ½-lb and 2-lb Spray Polyurethane Foam", Modern Materials, November 2004, page 15.

As per 3.1.5.12 Combustible Insulation and its Protection.

Presently, the Demilec and Polyurethane Foam Systems' 'Soya' products are the only medium density, Zero ODS products available with CCMC approval. The products are available in two brand names: Demilec 'Heatlok Soya' and PFSI 'Soya'.

Initial tests indicate that the Demilec 'Heatlok Soya' material actually conforms to the National Building Code requirement as a vapour barrier (9.25.4.2.1…"not greater than 60ng/(Pa*s*m2). Demilec 'Heatlok Soya' initial tests demonstrate 58ng/(Pa*s*m2).

David Frame, Journal of Light Construction.

Dr. John Straube, Field Performance of Spray Polyurethane Foam: The Role of Vapour Diffusion Control.

NAHB Racking Test Report 5-29-92.

Dr. John Straube, University of Waterloo is beginning a research project aimed at the effects/benefits of SPF in vented and unvented cathedral ceilings. A component of the research will include the effects of SPF on wind uplift on sheathing.

FEMA Technical Bulletin 2-93

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About the Author

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