Rigid Foam Update

by Rick Stacy

Over the past two decades, the use of rigid foam insulation in residential construction has grown enormously. From below-grade foundation insulation to structural insulated panel systems, from vinyl siding backers to cathedral ceiling insulation, rigid foam has proved to be an effective means of reducing air infiltration, adding R-value, and eliminating conductive heat loss, particularly where conditions limit the allowable thickness of the insulation.

Although several foam recipes have come and gone, three main types of rigid foam boards are still readily available today: expanded and extruded polystyrene, and polyisocyanurate (see Figure 1, next page).

Expanded polystyrene (EPS), commonly referred to as "beadboard," is a closed-cell foam made of dense polystyrene crystals that are steam-expanded to 40 times their original volume. Although the resulting beads can be used as loose-fill insulation, EPS beads are commonly steam-molded into rigid blocks or sheets. Densities range from .9 pcf (pounds per cubic foot) to around 1.8 pcf, with corresponding compressive strength from 10 psi to 25 psi. Higher densities are available by special order. EPS has an insulating value of R-4 per inch and a perm-rating of 5 per inch.

There are at least 45 manufacturers listed with the EPS Molders Association. Foam quality, density, and compressive strength can vary substantially among them, because of varying amounts of recycled polystyrene, known as re-grind, mixed with virgin polystyrene beads during manufacture. Because re-grind content may compromise panel quality, it's best to use only EPS products with a grade stamp or third-party certification of conformance to ASTM-C578.

Extruded polystyrene (XPS) is made by mixing polystyrene crystals, additives, and a blowing agent under high

Foam board is a great problem-solver, but you have to match the type to the application

heat and pressure. As the liquified material emerges from an extrusion die, it expands and is shaped and cooled. The extrusion process produces a closed-cell foam panel with a natural "skin" that makes the board more resistant to moisture than EPS, with a perm-rating of about 1.2 per inch, and an R-value of 5. Residential XPS has a density of about 2 pcf and an average compressive strength of 30 psi. (According to one manufacturer, this is the same compressive strength as that in the foam used under highways and airport runways. Higher density XPS, with compressive strength from 40 to 100 psi, is available for heavy construction.) Re-grind content in XPS is limited to the reintroduction of manufacturing waste, and has no adverse effect on the quality of the foam.

There are only four manufacturers of XPS, identifiable by their products' color: blue (Dow), pink (Owens-Corning), green (Tenneco), and yellow (Diversifoam).

Polyisocyanurate (PIR) is a member of the urethane family of chemical compounds. PIR, or "polyiso," boards are formed by a chemical reaction in a laminator that controls the temperature and thickness. The resulting closed-cell foam cures almost instantaneously, and the density is controlled by the amount of HCFC blowing-agent introduced into the mixture — the less blowing-agent, the denser the foam — and compressive strength is between 16 and 25 psi. HCFC gas trapped in the closed-cell structure gives polyiso the highest initial per-inch R-value (about 7.4) among rigid foams. Although the R-value of polyiso degrades somewhat over time as explained below, the use of foil and other facing materials slows the process. Perm rating is also affected, ranging from .4 to 1.6 per inch, depending on the facing material.

Figure 1. The individual "beads" of foam in expanded polystyrene (EPS) are visible in the rigid blocks or sheets, commonly called "beadboard" (top). Extruded polystyrene (XPS) is uniform throughout its thickness and forms a "skin" while curing, making it impervious to moisture penetration (middle). Polyisocyanurate (bottom) is most susceptible to moisture damage, but has the highest R-value of the three types of foam.

Figure 2. Because of its high resistance to moisture, XPS is the best material to use in wet locations or in contact with the ground. At foundations, a waterproofing membrane is still required, however, since water can still migrate through joints between sheets.

Common Characteristics

While the benefits of using rigid foam seem clear, determining which one is best for a given application can be confusing. No single type of foam is categorically better than the rest; each type has advantages and disadvantages.

R-value. While both strength and R-value increase with density, thermal performance is best improved by increasing the thickness of the foam. In EPS, for example, doubling the density from 1 pcf to 2 pcf more than doubles the compressive strength, but the R-value increases by only about 12%. However, doubling the thickness of any rigid foam doubles the R-value.

The R-values of EPS and XPS are close to that of dead air, so the value remains stable over the life of the product. In polyiso, however, R-value deteriorates over time. The HCFC trapped in the cellular structure is a better insulator than air, so polyiso has a high initial R-value. But as the gas gradually migrates through the cell walls, it is replaced by air — called "thermal aging" or "thermal drift." This puts the long-term R-value of polyiso closer to between R-5 and R-5.6, although due to disparate testing methods, manufacturers may publish higher aged values.

Permeability. With regard to moisture penetration, polyiso is least resistant — the facing material protects the face, but board edges are still exposed. Since moisture reduces R-value, polyiso is best confined to above-ground, indoor applications (Figure 2). XPS, however, is virtually impervious to moisture, making it a good choice for wet locations, such as in contact with the ground.

Moisture penetration in EPS has long

been a subject of debate. In below-grade applications, for example, the concern has been that while moisture can't penetrate the foam beads themselves, the voids between the beads will absorb moisture and permit water to pass through the molded boards. However, an extensive field-test study of EPS foundation insulation, conducted over a three-year span in Canada by the National Research Council, has concluded that EPS performs on an equal footing with extruded polystyrene, showing no ill effects from moisture or freeze/thaw cycles, and no appreciable loss in R-value. As a result of this testing, Canada lifted its restriction (*National Building Code,* Part 9) against the use of EPS in ground-contact.

Insect infestation. Termites and other wood-boring insects find easy nesting in rigid foam, particularly in below-grade applications (see "Insect Infestations in Buried Foam," 10/98). In response to this problem, AFM Corp. makes *Perform Guard*, a line of borate-treated EPS that has shown success in resisting insect infestation (Figure 3). The company's *Vanguard* fanfold underlayment is also borate-treated. Insects can avoid or circumvent the foam board, however, so borate-treatment should not be considered a deterrent to infestation of a structure, but only to nesting in the foam itself.

XPS and polyiso manufacturers have yet to find a practical means of incorporating insecticide into their products.

UV exposure. If left exposed to direct sunlight, rigid foam will become dusty, eventually losing thickness and R-value. The facing on polyiso blocks ultraviolet light, but board edges are unprotected. It's important to keep all three types of foam covered when stored, and protected from exposure after installation.

Facings. All three foam types are available with foil, polyethylene, or kraft-paper facings (Figure 4). Polyiso is also made with fiberglass-mat facing for EIFS or stucco underlayment, and organic asphalt facing for roofing applications. Facings serve several purposes: They reduce breakage from handling;

Figure 3. While borate-treated EPS does not protect a building from insects, it does protect the foam itself from infestation by ants and termites.

Figure 4. A polyethylene skin, whether plain or reinforced, protects XPS foam from damage during installation and provides a better bonding surface for adhesives. Other facings, such as foil or kraft paper, also serve as radiant barriers, protect against UV degradation, and reduce permeability.

Figure 5. An incompatible construction adhesive (darker bead in photo) will dissolve rigid foam — including poly-faced XPS (on left in photo).

improve surface cohesion for nailing; retard thermal drift; increase perm rating; provide a bonding surface for adhesives and coatings; and protect the board from ultraviolet degradation.

Foil- or poly-faced foam performs as a vapor barrier when installed on interior wall surfaces. Foil has the better perm rating, but is more easily damaged during installation. Use adhesive-foil tape to repair tears and punctures, and to seal all seams.

Reflective foil facing also serves as a radiant barrier when used in conjunction with a minimum 3/4-inch air space. Concern over the potential for heat buildup has led some vinyl siding manufacturers to void their warranties if their products are installed over reflective-foil-faced foam sheathing. One solution is to use foam board with non-reflective facing on one side and a reflective facing on the other.

Adhesive compatibility. Petroleum-based solvents found in many adhesives and bituminous coatings will dissolve polystyrene foam on contact (Figure 5). Even polystyrene faced with polyethylene is susceptible to damage because vapor emissions from petroleum-based compounds can penetrate the facing. Polyiso isn't affected by petroleum-based solvents, but a polystyrene-compatible adhesive may not bond to polyisocyanurate (see "For More Information," page 56).

Fasteners. To secure rigid foam sheathing, manufacturers recommend using 3/4-inch crown staples, asphalt-roofing nails, or plastic or metal cap nails. Fasteners should be long enough to penetrate 3/4 inch into studs. Foundation insulation can be secured to concrete or block with powder-actuated fasteners, concrete screws such as Tapcons, or a compatible adhesive.

Fire resistance. EPS and XPS are classified as "thermo-plastic" materials, which means that they will soften at 165˚F and melt at just over 200˚F. Polystyrenes also fail to meet the standard as a Class 1 roofing material, according to the *Factory Mutual Approval Guide*. Without a thermal barrier between the foam and a roof deck, flaming droplets of molten polystyrene can run ahead of a fire through seams in the deck, spreading the fire.

Polyiso, on the other hand, is a "thermo-set" material which, while it does burn, retains its shape and some structural integrity at its recommended maximum service temperature of 250˚F. For this reason, polyiso is commonly chosen for roof insulation in areas where roof-surface temperatures reach the limits of polystyrene.

When burned, EPS and XPS produce the same combustion gases as wood — carbon monoxide and carbon dioxide. Burning polyisocyanurate, however, also produces hydrogen cyanide and nitrogen oxides, both chemical asphyxiants. Most manufacturers and building

Figure 6. For interior basement insulation, wide shiplaps on some XPS boards accept furring strips, which can be fastened through the foam to poured concrete or masonry (left). Diversifoam's "CertiStud" EPS board has plywood furring strips bonded to the foam (above).

codes call for a minimum 1/2-inch drywall to be installed over rigid foam when used on the interior side of a living space. For safety, rigid foam insulation should be left exposed only if it has a flame-spread index at or below 25 (the label should say FS-25), but check your local codes.

Foam and the environment. Of the three foam types, EPS probably is the least threatening to the environment, because it's considered to be recyclable and uses pentane as a blowing agent (5% to 8% by volume). Although classified as a pollutant, pentane isn't considered harmful to the ozone layer. XPS and polyiso were originally manufactured using CFCs, which many scientists believe to be harmful to the earth's stratospheric ozone layer. Under pressure from environmental legislation, manufacturers switched to less harmful HCFCs, some of which are themselves slated to be phased out by the year 2002. This will affect mainly polyiso manufacturers, who are beginning to switch to pentane as a blowing agent, with no measurable effect on performance.

Common Applications

All three foam types are available for use under exterior stucco finishes. Some products, such as Apache's Iso Shield Supreme, are coated with a fiberglass-mat finish; others, such as Iso Shield Supreme II, have foil and coated-mat facings. Atlas Energy also recommends its coated fiberglass-mat R-board for use behind wood, brick, vinyl, hardboard or aluminum sidings when a foil product is not compatible.

Foundations. Because of its superior moisture resistance, polystyrene is the best choice for below-grade and buried insulation (Figure 6). It's available in 2x8- and 4x8-foot boards, from 3/4 to 4 inches thick, with square, tongue-and-groove, and shiplap edge treatments. Make sure solvents in bituminous foundation coatings are completely evaporated before installing EPS or XPS, and note regional code bans on below-grade applications in insect-prone areas.

Finished basements. For interior basement walls, some foam boards are grooved to accommodate 1x3 or 2x3 furring strips. Panels sized to fit between conventional framing centers are also available.

Roof insulation. Polyiso is common in roofing applications, partly because of the reflective foil-facing, and partly because of its stability in high temperatures. For flat roofs (typically commercial), a tapered polyiso is available in 1/8-, 1/4-, and 1/2-inch-per-foot slopes to introduce positive drainage to a level surface.

EPS and XPS can be successfully installed over residential wood roof decks, if covered with a layer of plywood or OSB, which not only provides a nail base, but also serves as a buffer against damage following installation, and reduces heat buildup in roofing material.

Sheathing. Rigid foam sheathing is commonly available in 2x8-, 4x8-, and 4x9-foot sheets, and in thicknesses of 1/2 inch to 4 inches. Applied over wood sheathing or directly to diagonally reinforced framing, the foam adds between R-3 and R-5 to a standard wall system, and reduces conductive heat loss through studs and headers. Poly facing helps prevent damage from handling, and foil facing adds a radiant barrier behind siding. Proper installation can also eliminate the need for an air-barrier house wrap, especially when seams are taped to block air infiltration between panels.

Siding underlayment. Available in 4x8 sheets and in 4x50 fanfold panels, siding underlayment is designed to bridge irregularities when applying new siding over existing, or to reduce air infiltration of the building envelope. At 1/4- to 3/8-inch thick, however, the underlayment doesn't add much R-value.

Some EPS fabricators have gained widespread industry approval for foam drop-ins or backers made to match the profiles of many vinyl siding manufacturers (Figure 7). However, some vinyl siding manufacturers won't honor warranties if an unapproved backer is used with their siding.

Under-floor insulation. Both wood and concrete floors are commonly insulated with rigid foam. Compressive strength of all three foam types is adequate for under-slab duty, but polyiso's tendency to absorb moisture makes it less suitable for ground-contact application. Rigid foam can also be used to provide a firm, low-profile layer of insulation under "floating" wood or laminate floor installations.

Figure 7. Some foam producers, such as Progressive Foam Products, mold EPS to match common vinyl siding profiles and accessories. However, not all such EPS moldings are approved by all siding manufacturers, and some siding companies will not warrant their products when installed over EPS.

Wall insulation. Because of its higher R-value and moisture resistance, rigid foam can take the place of fiberglass batts, particularly during rough framing in areas that won't be easily accessible later, such as behind partition backers, corner studs, and rim joists, and in built-up headers. Installed on the interior side of exterior walls, rigid foam can serve as a combination thermal and vapor barrier, provided low-perm tape is used at the seams.

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For More Information

Makers of EPS

Apache Products
107 Service Road
Anderson, SC 29625
800/777-3707
www.apacheproducts.com

AFM Corp.
P.O. Box 246
Excelsior, MN 55331
800/255-0176
www.r-control.com
Perform Guard (borate-treated)

Cellofoam North America
1961 Industrial Blvd.
Conyers, GA 30012
888/985-3626
www.cellofoam.com

Georgia-Pacific
P.O. Box 105605
Atlanta, GA 30348
800/284-5347
www.gp.com

Progressive Foam Products
6753 Chestnut Ridge Rd.
Beach City, OH 44608
800/860-3626
www.progressivefoam.com
ThermoWall foam backers or drop-ins

Shelter Enterprises
P.O. Box 618
Cohoes, NY 12047
www.shelter-ent.com
800/836-0719
Underlayment; sheathing; Geofoam; stress-skin panels

Makers of Polyisocyanurate

Atlas Energies
817 Spangler Road
Camp Hill, PA 17011
800/688-1476
www.atlasroofing.com
Energy Shield

Celotex Corp.
4010 Boy Scout Blvd.
Tampa, FL 33607
800/235-6839
www.celotex.com
Tuff-R; Super Tuff-R; Thermax; Quik-R; Sturdy-R

Firestone Building Products Co.
2500 W. Higgins Rd., #850
Hoffman Estates, IL 60195
800/428-4442
www.firestonebpco.com
Iso-R

Homasote Co.
Box 7240
W. Trenton, NJ 08628
800/257-9491
www.pakline.com
Ultra-R

Hunter Panels
15 Franklin Street
Portland, ME 04101
888/746-1114
www.hpanels.com

Johns Manville Corp.
P.O. Box 5108
Denver, CO 80218
800/654-3103
www.jm.com
AP foil-faced board

Rmax
13524 Welch Rd.
Dallas, TX 75244
800/527-0890
www.rmax@rmaxinc.com
Durasheath; Thermaroof; Multi-Max; Vented Nailable Base

Makers of XPS

Diversifoam
9091 County Rd. 50
Rockford, MN 55373
612/477-5854
www.diversifoam.com
XPS and *Polyiso*

Dow Chemical Co.
1605 Joseph Drive
Midland, MI 48674
800/232-2436
www.styrofoam.com
Styrofoam; Perimate; Bluecor underlayment; Stuccomate

Owens Corning
World Headquarters
One Owens Corning Parkway
Toledo, OH 43659
800/438-7465
www.owenscorning.com
Foamular

Tenneco Building Products
2907 Log Cabin Drive
Smyrna, GA 30080
800/241-4402
www.tennecobuildingprod.com
Amocor fanfold; Amofoam insul board

Makers of Foam-Compatible Adhesives

ChemRex International
889 Valley Park Dr.
Shakopee, MN 55379
800/433-9517
www.chemrex.com
PL300
PL Premium Construction Adhesive

Franklin International
2020 Bruck St.
Columbus, OH 43207
800/877-4583
www.franklini.com
TiteBond Solvent-Free Construction Adhesive
Foam-Board Adhesive

GE Silicones
260 Hudson River Rd.
Bldg. 25
Waterford, NY 12188
800/626-2000
Silicone II

H.B. Fuller Tech.
1200 Willow Lake Blvd.
St. Paul, MN 55110
www.hbfuller.com
888/423-8553
Maxbond Adhesive

Hilti Construction Chemicals
P.O. Box 21148
Tulsa, OK 74146
800/879-8000
Hilti CA3200

Macco
925 Euclid Ave.
Cleveland, OH 44115
800/634-0015
www.liquidnails.com
LN601 Synthetic Rubber Adhesive
LN901 Construction Adhesive
LN603 Trowel-on Adhesive
LN604 Latex Adhesive

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100 North Riverside Plaza
Chicago, IL 60606
312/807-2000
www.mortonintl.com
MOR-AD M601

OSI Sealants
7405 Production Dr.
Mentor, OH 44060
800/321-3578
www.osisealants.com
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Pro-Series (QU-300, SF-550, & PR-255)
Ultra-Plus-LM

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485 Kenmore Blvd.
Akron, OH 44310
216/253-8148
383 High-Tack Mastic
Plio-Nail Panel, Foam & Construction Adhesive

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5608 Soto St.
Huntington Park, CA 90255
213/583-4961
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