Hoffmann Architects
Journal

second issue 87

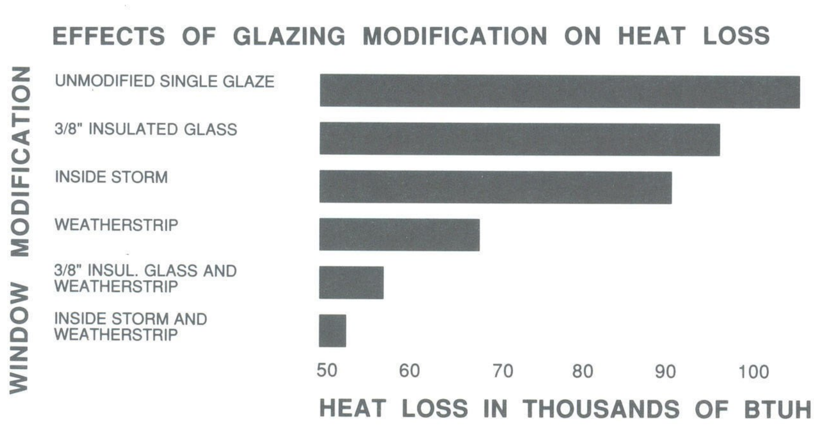
Energy Management and Windows

Must Heating Dollars Go Out Your Windows?

by Harwood W. Loomis, AIA

Windows . . . they are necessary to provide natural light, but at what cost in energy use? Let's look at a typical Manhattan high-rise building about 30 years old, with brick piers, aluminum spandrel covers over structural tiles, and single glazed, double-hung metal windows. In 1,000 sq. ft. of wall surface, there are 340 sq. ft. of pier, 320 sq.ft. of spandrel, and 440 sq. ft. of window. Using a conservative indoor/outdoor temperature difference of 55°F., the heat lost through this wall is 35,750 BTU's per hour.

Simply stated, glass is a poor insulator. The single glass, which comprises 44% of the wall area, conducts heat at a rate of 5 times that of the masonry piers and 3-1/2 times that of the spandrels. This makes the windows a logical target in any attempt to control energy use.



On the other hand, air space is a good insulator. If the glass were replaced with 3/8″ insulating glass, the heat loss through the same wall would be reduced by 34%. If reglazing the prime windows is not a viable option, consider inside-mounted storm windows with an air space of 1″ or more to the prime windows. The heat lost through the wall could be reduced by 40%, compared with the existing condition.

Infiltration of cold air into a building often causes an even greater heat loss than the conduction losses just discussed. A small amount of cold air slips around the edges of the sash of double-hung windows. That air must be heated. Assuming the windows are not weather-stripped, the infiltration loss calculated by the ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers) "crack method" comes to 70,720 BTU's of air per hour. The energy required to heat this air is computed by multiplying the volume times specific

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heat factor times temperature differential. The heat loss in our example is 70,013 BTU's per hour. Weatherstripping the same windows would reduce the heat loss due to infiltration to 31,300 BTU's per hour, a reduction of 55%.

How much money is literally going out the window? Once the heat loss has been calculated, the dollar amount can be found by factoring in the present cost of energy at any location. The same figures can be used to calculate the payback period for making energy saving changes. Although our samples dealth only with heat loss for simplicity, an engineer can perform similar calculation to reflect summer heat gain, which contributes to air-conditioning load, in preparing a comprehensive cost/benefit analysis for a specific application. Many engineers have developed or purchased computer programs to perform these calculations, so the cost of a study may be surprisingly low. The benefits may be surprisingly high.

This article was originally written for publication in 1983 and does not take into account recent differences in low "E" glass which substantially reduces heat loss and heat gain.

If you would like more information about the services we offer, contact Peter Borgemeister or Brian Schafer in the Connecticut office.

The Many Faces of Polystyrene

The Basic Ingredient

Polystyrene is made by reacting benzene with ethylene to form styrene monomer (single molecules of styrene). The monomer is then polymerized to form *poly*styrene—a chain of styrene molecules. Various additives are mixed into the foam for fire retardency and other physical characteristics, but the basic polymer is the same for all the foams discussed below.

For thermal insulation, two distinctly different processes are used to make rigid polystyrene foam—molding and extrusion.

The Two Basic Kinds of Polystyrene Foam Insulation

1. *Molded Expanded Polystyrene (MEPS) or "Beadboard"*

MEPS production begins with "expandable beads" of polystyrene, which contain a small amount of liquid pentane. The expandable beads are heated with steam to about 200 degrees Fahrenheit, causing the styrene to soften and the pentane to expand, puffing the beads to a low-density form commonly referred to as "pre-puff." The pre-puff is poured into a mold where the beads are further expanded and fused into a billet. The foam billet is then cut into boardstock.

2. *Extruded Expanded Polystyrene (XEPS)*

XEPS is manufactured by a completely different process than MEPS. EPS granules are fed into an extruder where they are melted into a viscous fluid. Then a blowing agent (usually a type of Freon) is injected to make the mixture foamable. Under carefully controlled conditions the foamable mixture is forced through a die, at which time foaming and shaping occurs.

The rigid foam is then trimmed to the final product dimensions.

The original extruded polystyrene to be used as thermal insulation was blue Styrofoam brand, produced by Dow Chemical Company and commonly referred to as blueboard. Unfortunately (or maybe fortunately for Dow), people use the term Styrofoam to refer to all types of styrene foam products, for example "styrofoam cups." (The more accurate term would be beadboard cups.)

The Nine Types of Polystyrene

In addition to the two physically distinct types of EPS, there are nine categories of "Types" defined according to *ASTM Standard C 578-85,* promulgated by the American Society for Testing and Materials (ASTM). The nine ASTM Types designated by Roman numerals I, II, and IV through X, (that's right, no III), are defined according to several specific physical properties including compressive strength, flexural strength, density, water vapor transmission rate, and R-value.

Table 1 lists the physical requirements of polystyrene foam according to the ASTM Standard.

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Type	MOLDED BEAD I	II	VIII	IX	EXTRUDED IV	V	VI	VII	X
R-value per inch	3.6	4.0	3.8	4.2	5.0	5.0	5.0	5.0	5.0
Density (lb/ft^3)	0.9	1.35	1.15	1.8	1.6	3.0	1.8	2.2	1.35
Compresssive Strength (psi)	10	15	13	25	25	100	40	60	15
Flexural Strength (psi)	25	40	30	50	50	100	60	75	40
Water Vapor Permeability (perm-in)	5.0	3.5	3.5	2.0	1.1	1.1	1.1	1.1	1.1
Water Absorption (%)	4.0	3.0	3.0	2.0	0.3	0.3	0.3	0.3	0.3
Dimensional stability (%)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Oxygen Index	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0

Table 1—Physical Requirements of Expanded Polystyrene Foam

For the extruded foams, the most significant property with respect to the Type classes is probably compressive strength. In applications with vertical loading, Type VI or VII foam may be required. In some situations, such as under a freezer warehouse slab, Type V foam, with a compressive strength of 100 psi may be specified.

On the other hand, for siding application where compressive strength is less important, Type II (beadboard) or Type IV (extruded), both with compressive strength of 25 psi, would be fine. In fact, for siding application, 10 to 15 psi compressive strength is OK, which is why UC Industries brought out its less expensive Type X low-density foams (Foamular 150) for siding.

Which Types Are Beadboard and Which Types Are Extruded Polystyrene?

The ASTM Standard does not specify whether any particular Types are molded or extruded polystyrene. Technically, any of the Types could conceivably be either kind of foam. But in reality, molded EPS as normally manufactured can only meet the minimum requirements of Types I, II, VIII, and IX.

The three requirements that set molded polystyrene apart from extruded polystyrene are R-value, water vapor permeability, and water absorption. Types IV, V, VI, VII, and X all require a minimum R-value of R-5.0 per inch (at 75 F). The only way to obtain that R-value with polystyrene is to use Freon or other low-conductivity gas as the blowing agent. Molded bead polystyrene, as normally produced, is always expanded with pentane. Thus it cannot be produced with an R-value as high as R-5.0. Water vapor permeability and water absorption are always higher with molded bead foam because of the nature of the material; water can migrate through the bead structure much more easily than through the continuous cell structure of extruded foam.

Notice, however, that with regard to compressive strength and flexural strength, Type IX beadboard can perform just as well at Type IV extruded foam and better than Type X extruded foam.

How to Tell the Type Class of a Particular Foam

Beadboard

Beadboard is usually identified by density rather than ASTM Type classification. Unlike extruded foam, the R-value changes with density, so when looking for a certain type beadboard foam, both R-value and density (and possibly compressive-strength) should be checked.

Extruded Foam

The manufacturers of extruded foam each produce specific products that fall into various ASTM Type categories. The following is a partial listing:

Type	Styrofoam	Foamular	Amofoam	CertiFoam
IV	TG,SM	250	Regular	Regular
V	HI 115	none	none	none
VI	HI 40	400	none	40
VII	HI 60	600	none	60
X	PFS 002(?)	150	none	none

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services

Representative Projects

Over the last few months we have been involved in a variety of projects. The following is a representative sample of recent work:

Roofing
Hoffmann Architects was called in to evaluate the existing silicone/polyurethane foam roof at the Sterling Chemistry Laboratory, New Haven, Connecticut and provide repair recommendations for Yale University;

Reroofing, masonry repairs and HVAC modifications for the CBS Records building in Milford, Connecticut for CSB, Inc.;

Hoffmann Architects performed a condition survey of three roof levels of the GTE Products Plant located in Fall River, MA for GTE;

Prepartion of outline specifications for reroofing, review of contractor proposals, construction monitoring and contract administration services for 46,000 square feet of roof at the Days Inn South in Mobile, AL;

Existing conditions of a five acre warehouse/machine room complex were inspected for Georgia Pacific as well as a review of plans and specifications for the roof of a 300,000 square foot addition.

Facade Rehabilitation
Preparation of plans and specifications for facade rehabilitation at the Whitehall Building in New York City for the Edward S. Gordon Company, Inc.;

Mattatuck Museum

At the 65th floor of Rockefeller Center's RCA Building, work is proceeding on reroofing and window replacement outside the Rainbow Room which is being remodeled;

Hoffmann Architects is directing the repointing work of limestone joints on the east, north and part of the west elevations fo the 70 story RCA Building;

An exterior condition survey for Southern New England Telephone has recently been completed on their twelve story equipment building in New Haven, Connecticut;

Schematic design has been started for rehabilitation of the 1866 former Mattatuck Museum building as well as design for a small addition to the building for the present owners, Bank of Boston Connecticut.

Structural Engineering
Dunnage design for two new HVAC units at Schick Safety Razor in Milford, Connecticut for Warner Lambert Company.

Parking Deck Reconstruction
Design, negotiate and administer temporary waterproofing for Norwalk CO#2 parking deck, for Southern New England Telephone Company;

Following a survey of the condition of the concrete decks of a major, multi-level parking structure on the north-east, we were asked to prepare contract documents for the repair of deteriorated portions of the concrete slabs and the application of an elastomeric waterproofing membrane over the entire surface of all suspended concrete decks and ramps, together with replacing all expansion joints in the parking structure. The area involved is nearly 1 million square feet of surface.

Journal *is a publication of Hoffmann Architects, specialists in investigative and rehabilitative architecture/engineering, including the analysis and solution of roofing, masonry, glazed curtain wall and structural problems. Our offices are located at 3074 Whitney Avenue, Hamden, CT 06518, Phone (203) 281-4440*