DESIGN AND CONSTRUCTION GUIDELINES AND STANDARDS

DIVISION 7 • THERMAL & MOISTURE PROTECTION

07 20 00 • BUILDING INSULATION & MOISTURE PROTECTION

SECTION INCLUDES

Batt Insulation
Insulating Sheathing
Rigid Insulation
Blown-In Loose Fill Insulation
Blown-In Foam Insulation
Water Barrier
Vapor Retarder
Air Sealing

RELATED SECTIONS

03 30 00	Concrete
04 20 00	Unit Masonry
06 10 00	Rough Carpentry
07 10 00	Waterproofing and Dampproofing
07 40 00	Siding
07 50 00	Membrane Roofing
07 90 00	Sealants

INTRODUCTION

The standards for effectiveness of building insulation have increased substantially as energy importing has become a state and national issue, the climate-changing effects of greenhouse gases has become known, and as the cost of energy has increased.

In recognition of the fact that energy use has impacts well beyond the individual building owner and occupants, the Massachusetts State Building Code (780 CMR) now contains requirements for building insulation.

The use of increased insulation in new construction and the retro-fitting of insulation in existing structures has created unforeseen problems, especially with moisture and mold growth. Building scientists continue to study the physics of the building envelope and have focused attention on the need for air barriers, moisture retarders, and interior ventilation, as well as the traditional weather (bulk water) barrier and insulation. For a comfortable, durable, cost-effective, healthful building, all these factors must be considered together.

Additions and partial renovations of existing structures present special issues for building envelope systems due to the fact that the entire envelope is not being addressed. Wherever possible the new portions of the envelope should be designed to the latest standards. Connections to the existing envelope should be made as effectively as possible with the idea that eventually the entire envelope may be upgraded. Analyse the existing and new construction and consider adding insulation to the existing building envelope where possible. In older buildings with knob and tube wiring remove or tent over wiring before installing insulation.

SELECTING INSULATION SYSTEMS

GOAL

The designer's goal should be to design an effective, low-cost, durable, non-toxic building envelope which is feasible to build and which contributes minimal greenhouse gas to the environment. The insulation materials should be selected to work effectively with the other components of the envelope.

REQUIREMENTS

Refer to the latest codes, as the requirements for insulation, and water, moisture and air barriers get more stringent with each edition. When possible, DHCD favors exceeding code requirements. For new and major renovation projects, Energy Star certification is required by DHCD. There are also utility funded weatherization programs available in many communities served by an investor-owned utility company.

The building envelope should include an air barrier, a moisture retarder and a water barrier, as well as the thermal insulation. Insulation can perform multiple functions, depending on the type of insulation, where it is located, and the overall design of the assembly.

OTHER FACTORS TO CONSIDER

Type of insulation: Insulation can be in the form of batts or rigid boards, or it may be blown-in or sprayed in. There is a unique set of pros and cons for each insulation product as noted in the insulation products section below.

Effectiveness: Note the aged insulation values when designing and calculating the insulation's thermal value in assemblies and to meet MA Energy Code requirements. Foam insulations may degrade over time, while loose fill insulations may settle.

Cost and Availability: Be aware of what's actually available and cost-effective. Prices may fluctuate widely from year to year and the industry is constantly evolving to produce new, safer and more cost-effective products.

Life Cyle Cost: Analyse the cost benefit of adding longer lasting more expensive insulating material options.

Constructability: Make certain to design a system that can be built. Consider construction sequences and divisions of labor and sub-contracts.

Durability: Insulation assemblies should remain intact and effective for very long periods of time, generally for the life of the building, which could be 50 to 100 years, or longer.

Toxicity: Consider what is included in the insulation product, such as flame retardants, insecticides, formaldehyde, or other potentially toxic materials. Reduce the potential for toxic chemicals in the environment wherever feasible.

Global Warming Potential (GWP): One reason for using insulation is to reduce the emissions of greenhouse cases into the environment. The designer should consider the GWP of the insulation manufacture and transportation, as well as the nature of the blowing agents in foam. Blowing agents may leak out of the foam over time and may have a GWP that is 1,000 or more times that of CO_2.

Ozone Depleting Potential (ODP): Although foam blowing agents in the past sometimes had high ODP, these agents have generally been phased out.

BUILDING ENVELOPE SUB-SYSTEMS

PHYSICAL BARRIER & BUILDING STRUCTURE

Walls and roofs have structural elements to support and protect the other elements of the assembly and to resist intrusion by people and animals. Sheathing, which may form a part of the structural system, may also serve as insulation or as one or more of the other required sub-systems.

WATER BARRIER

Water barriers are required for all new construction, additions, and siding replacements. The most effective wall assemblies have a primary water barrier (the exterior cladding: brick, clapboards, shingles, etc.) and a secondary water barrier (house wrap, peel-and-stick membrane, or other product). Some sort of spacer is usually applied exterior to the secondary water barrier to facilitate drainage of any water that penetrates past the exterior cladding.

Water barriers placed to the exterior of the insulation should be moisture permeable so that moisture is not trapped in the assembly. Water barriers may also perform as air barriers if properly detailed.

THERMAL INSULATION

Thermal insulation is included in envelope assemblies to reduce the flow of heat into or out of the enclosure. Sufficient insulation must be provided to meet code requirements. The designer should consider providing additional insulation to further reduce energy requirements and its attendant GWP.

Insulation is most effective when it is continuous rather than being interrupted by studs and other elements. Studs act as thermal bridges, significantly reducing the effectiveness of the insulation and creating cold spots in the envelope. Metal studs are much worse than wood studs. Even fasteners can act as thermal bridges. For instance, siding nails driven through exterior foam insulation and through the sheathing may become cold points in the wall cavity and may cause moisture to condense on the fasteners, eventually rusting them out.

MOISTURE RETARDER

Moisture retarders are often included in wall and roof assemblies to inhibit moisture diffusion into envelope cavities where it may condense and damage the assembly. Moisture tends to diffuse from areas of higher humidity (typically the interior, heated space) to areas of lower humidity (typically cold outside air). The wall or roof assembly needs to be designed to avoid moisture getting into the cavities, cooling down below its dew point, and condensing in the cavity. Placing materials with low perm ratings on the heated side of the assembly is an effective way to block moisture diffusion.

Kraft faced insulation which adjusts its permeability with temperature conditions may be the best choice at wall cavities.

High permeability materials should be used on the cold side of the envelope assembly to permit moisture that does get into the assembly to diffuse to the exterior, allowing the assembly to dry out. Assemblies should be analyzed to ensure that the materials used will not trap water. The Building Science Corporation website lists permeability of many common building materials. (http://www.buildingscience.com/documents/information-sheets/building-materials-property-table/)

Although penetrations or gaps in the moisture barrier are not a serious matter, if the moisture barrier is also the air barrier, care must be taken to seal all openings, electric boxes, seams, tears, etc.

AIR BARRIER

Air barriers are required for all new construction, additions, and siding replacements. Air barriers may be formed of rigid materials or flexible membranes that are securely fastened to resist air pressure. All seams and penetrations must be sealed and all transitions from wall planes to foundations, floors, ceilings or roof planes, as well as doors and windows, must be fully detailed for a continuous barrier covering the entire building.

An air barrier may be placed anywhere within the wall or roof assembly. It can be a “house wrap” or “peel-and-stick” membrane placed outside the sheathing, air-tight sheathing with taped joints, air-tight drywall construction, spray foam insulation, or some combination of these products. Continuity is important as a small opening can allow a large volume of air to move through it. The air may carry moisture which will condense within the wall or roof assembly, causing mold or rot to form, or it may just leak unconditioned air into the building or conditioned air out of the building. Special attention should be paid to transitions from walls to roofs and at other building elements which may tend to interrupt the barrier.

The air barrier may also function as a water barrier or moisture retarder. It is important that the membrane’s physical properties and position in the assembly are consistent with the functions (intentional or not) that it will perform. A well installed building wrap can function both as a water barrier and an air barrier, thus serving two of the four building envelope functions. Building wraps are often placed outside the insulation where they perform as a secondary water barrier behind the siding. They are designed to be vapor permeable to allow moisture to migrate from the wall assembly to the outside.

In high-rise construction, a "peel-and-stick" membrane is often installed on the sheathing to act as a moisture, water, and air barrier in one product. These products are designed to be moisture retarders. In the Massachusetts climate they should only be used where insulation is applied exterior to the membrane. The membrane also acts as a secondary water barrier. The insulation to the exterior is generally a foam that will perform when wet from water leaking past the siding. It may also have to be dense enough to provide support for the siding.

Refer to Energy Star "Thermal Enclosure System Rater Checklist" (http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Energy_Star_v3_TERC_Guidebook.pdf) for specific requirements for fully-aligned air barriers. See also the Energy Star "Water Management System Builder Checklist" in the same document for required drainage plane (water barrier) behind exterior cladding.

Fire Protection

In general, insulation should not be left exposed in living spaces or basements. Code requirements- flame spread/smoke developed. Batt facings, and foam ½" gyp board required.

Insulation Products

Batts

Batt insulation, whether fiberglass, mineral wool, or some other material is relatively inexpensive and is easily installed in stud wall framing, as well as other locations. The effectiveness of batt insulation may be significantly reduced by internal air circulation as well as by gaps allowing air to move around the insulation, by compression of the insulation, and by conduction through framing (thermal bridging). It can be difficult to install properly at electric boxes, wires, and pipes, where it should be cut to avoid being compressed.

Mineral and glass fibers are skin and respiratory irritants and should be isolated from occupied spaces. Protective gear should be required for installers. There has also been some concern regarding the use of phenol-formaldehyde binder in many products. While listed as a carcinogen, very little phenol-formaldehyde remains in the products.

Mineral and glass fibers typically have 20-30% recycled content and a very low global warming potential (GWP).

Foam Boards

While foam insulation boards may be more expensive than batts, they allow for a more effective thermal layer when placed across the exterior of the sheathing or interior of the framing. Some board products can also be used for the moisture barrier, air barrier, and/or secondary water barrier, when joints are properly sealed and taped. Boards can also be installed within the framing, but coordinating the dimensions and sealing the perimeters may be labor intensive.

Foams are made from petrochemicals, which are a limited resource. They are inherently flammable and so are generally manufactured with flame retardants. Some also have termiticides to fend off termites who would otherwise consider the foam an excellent place to colonize. Bromated flame retardants, as used with polystyrene, present a greater health concern than the nonbromated retardants used in other foams. As noted above under Fire Protection, foam boards generally should not be left exposed.

Polyisocyanurate (polyiso) insulation board has the highest R-value of the common insulation boards. It also has a fairly low GWP based on the use of Pentane for the blowing agent. Polyiso is often provided with aluminum facings, which can make it an effective air and moisture barrier. All seams have to be taped and other joints need to be sealed for a complete air barrier. Polyiso may contain TCPP flame retardants, although this fact may not show up in the MSDS sheet. TCPP is regarded as environmentally preferable to HBCD used in polystyrene.

Polystyrene can be either extruded (XPS) or expanded (EPS). These products are significantly different from each other. XPS has often been preferred for building insulation in the past as it had a higher R value and was more durable. However, the XPS blowing agent has been changed to avoid ozone depleting chemicals and this has lowered its R value to be comparable to EPS.

Expanded polystyrene has a low GWP, comparable to that of polyiso, but still ten times that of cellulose. It comes in varying densities and its quality may vary. One test for a good quality EPS board is that when it is broken, it breaks through the polystyrene beads rather than between them. The flame retardant in both XPS and EPS is HBCD, which may be toxic to human beings.

LOOSE FILL

Cellulose, Rock Wool, Fiberglass or Slag-Wool are all acceptable choices for blown in insulation. The Designer should specify the most cost effective choice based on local availability.

If wet-blown cellulose is specified be sure the specifications require ample drying time; minimum 3 days in the construction schedule and additional time if climatic conditions require or higher amounts of water than 1.5 lbs. per bag, are used in the installation.

<u>Cellulose:</u>
If cellulose is used, specify baffles or some method for holding down insulation in areas of potential high velocity air movement, such as adjacent to gable vents and also provide rigid insulation hatch covers for all moveable portions of attic floor, such as stairs and access hatches.

If cellulose is specified which contains ammonium sulfate fire-retardant require the insulation to be isolated from metals and pipes, particularly in wet-spray applications, due to corrosive effects of chemicals in insulation with metal.

SPRAY FOAM

Urethane/Icynene Foams are among the most durable insulation materials, have excellent bonding characteristics and ability to fill cracks and crevices, and may be cost-effective where these particular attributes are required or for hard to access cavities and crevices.

Evaluate product availability and cost prior to specifying, choose ASTM C1303-rated products with low thermal drift and which do not employ HCFC blowing agents. Some of these product may not be cost effective on moderniation applications because of the high cost of mobilization.

Typical products are closed cell polyurethane open cell polyurethane and cementitious foam insulation. The should be used as the scenario dictates.

OTHER INSULATION PRODUCTS

Other products, such as insulated sheathing may be used if approriate. Less common are Aerogel and cotton batts.

RELATED BUILDING ENVELOPE PRODUCTS

PRODUCTS

An air barrier is not a product; it is a system including sheets or membranes, tapes, and sealants, forming a barrier which is continuous over the entire building envelope. Products comprising this system may include the following:

Building wraps may be manufactured from polyethylene or polyolefin.

- Building Wrap: ASTM E 1677, Type I air retarder; with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, when tested according to ASTM E 84; UV stabilized; and acceptable to authorities having jurisdiction.
  - Water-Vapor Permeance: Not less than 10 perms using
  - ASTM E 96, Desiccant Method (Procedure A).
  - Allowable UV Exposure Time: Not less than three months.
- Building-Wrap Tape: Pressure-sensitive plastic tape recommended by building-wrap manufacturer for sealing joints and penetrations in building wrap.

- ❑ Building-Wrap Fasteners: Fasteners as recommended by the manufacturer to resist pull-through due to air pressure from the interior of the building.

OPENINGS & PENETRATIONS

Foamed in place low-expansion polyurethane (1.5-1.75 pcf), acoustic sealant, or gasketing is required around windows, doors, ducts, and all other building envelope penetrations including pipes, wiring, tops of chase walls, flues, access panels, elevator shafts, etc. At flanged windows the sealant should be behind the flange at the side flanges. Lap the building wrap in the direction of water flow.

Installation of low-expansion foam should be sufficient to fill void with out causing window or door operation problems by overfilling.

INSTALLATION

Install wraps following manufacturers instructions. Seal all seams, edges, fasteners, and penetrations with tape. Extend into jambs of openings and seal corners with tape. Wrap must be installed with manufacturer-approved fasteners or furring strips in order to resist billowing and fastener pull-outs due to air pressure from either inside or outside. It is imperative that the wrap be protected from abuse during construction.

Seal wrap where new construction abuts existing and at all adjacent construction including roofs, foundations, windows and doors. Designer must provide details for all such conditions.

Some peal and stick membranes may require that a primer is stalled on the substrate in order for the membrane to stick.

SPECIFIC APPLICATIONS

FOUNDATIONS

Rim Joists: Specify and detail insulation at rim joists and chases at exterior walls. Fully insulate at rim joists.

Crawl spaces: For slab-on-grade and crawl space foundations, perimeter insulation should extend down at least 4 feet from grade unless ventilated. For unvented crawl spaces, mechanical ventialion is prefered.

Basement foundations: perimeter insulation should extend all the way down to the top of the footing to help keep it in place during backfill. Insulation can be anchored higher up on the wall with a construction adhesive specifically formulated for adhering extruded polystyrene.

Use 2" rigid insulation, min. 25 psi under the entire slab in basements which are occupied or for slab-on-grade multi-family residential construction. Consider ship-lapped or tongue and groove insulation during design, if it is available and cost-effective at the time of construction.

Interior foundation insulation is prefered. Where exterior foundation insulation must be used, cover exterior exposed portions of the foundation insulation with a reinforced cement board or rigid fiberglass reinforced plastic protection board (such as Glasbord by Kemlite Company Inc. or equal). For very large exposed areas of foundation insulation, consider providing strapping and covering with siding.

Waterproofing rigid insulation board with grooves cut into it that channel water toward drain lines (such as Thermadry by Dow or equal) may be used at basements in lieu of, or in addition to, drainage fill.

Sill sealer: Provide a non-water absorbing sealant between the foundation and sill such as Ethafoam by Dow Chemical USA. Seal rim joist penetrations prior to insulating.

FLOORS

Batt insulation having facings with flame-spread ratings above 25 and smoke-developed indexes above 450 should not be left exposed in open joists above basements and crawlspaces. This applies to most batt insulation products with facings. See fire resistant construction requirements of the Residential Building Code and thermal and sound insulation materials in the Base Building Code for finish materials over the batt insulation.

Unfaced batts, properly secured, may be installed above crawl spaces, but should not be left exposed above basements as the glass fibers will get into the air and irritate the skin of occupants and as batts may contain small quantities of phenol-formaldehyde binder, which is a carcinogen.

EXTERIOR WALLS

The prefered location for the air barrier is outside of the framing in stud wall construction. In that location it will be less impacted by wiring, electric boxes, interior partitions, and so forth.

Insulating sheathing should be installed continuous without penetrations by blocking, furring strips or framing members. For best thermal performance, it is preferred that insulation extend up to the rough opening of windows and that low expansion foam be used to seal at the perimeter of windows.

Expanded polystyrene foam (EPS) is not so durable as extruded products, but is recommended for its reduced environmental impact. EPS quality varies; look for breaking through beads, not between them.

Use tongue & groove foam board in order to prevent gaps and air infiltration. Ensure that all components of the building envelope run continuously behind tubs and shower units. These are often installed before interior insulation and wallboards, which can result in a lack of insulation or other components in that area. In bath retrofit situations apply insulation to exterior walls. Partition walls may interrupt interior components of the envelope assembly.

Pay close attention to detailing, especially if the air barrier will be impacted. Chases, stairways and other items on the perimeter can present special difficulties.

OPENINGS & PENETRATIONS

Do not use fiberglass to seal around window openings, outlets or exterior wall penetrations; use low expansion foam instead.

Install only sealants rated for high-temperatures around furnace flues or chimney penetrations in attics. Do not use spray foam.

Consider building flashing shrouds around metal furnace and water heater flues which will provide a minimum of 1" separation between inner flue and outer flue, while sealing air penetrations and allowing insulation to be placed around the outer flue.

ROOFS/ATTICS

When there are existing water pipes running through attics, use batts to provide an insulation tent whereby pipes are fully covered with insulation and exposed to ceiling drywall below which will allow conditioned air to reach the pipes. See the detail.

Insulate interior access hatches to attics with layers of rigid insulation in conjunction with weatherstripping to create a well sealed and insulated opening. Follow Energy Star guidelines, available at www.energystar.gov.

Under roofing, specify only rigid insulation that is approved by the roofing membrane manufacturer. Tapered insulation is required on roofs where framing does not provide positive drainage pitch. Insulation used with built-up roofing must have a layer of fiberboard or other material that will absorb water vapor, otherwise blistering will occur. When using two layers of insulation, stagger the joints to avoid a through seam.

At the perimeter of attics, the full depth of blown-in insulation should cover the top plate but should not extend out beyond into the unheated eave space; about 12 inches clear is needed to allow for full insulation. This requires use of raised heel trusses unless the roof pitch is about 8 in 12. Blown in insulation is suseptible to being blown around in the attic space - leaving areas uninsulated, in some instances pipes can be left unprotected if special provisions are not taken to prevent such insulation drifting. Provide blocking to keep ventilation air from infiltrating the insulation. To ensure adequate attic ventilation, provide a baffle or other means for a channel for air flow from the soffit vent to the ridge vent. (see illustration).

Combine fiberglass batts with blown-in insulation to provide an insulation tent for water pipes that are run through attics (see illustration). Do not install insulation between the pipes and the ceiling below. Air seal floor of attic before insulation is added. Use flags (witness stakes) to determine the depth of cellulose as it is blown in.

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