



## BUILDING AMERICA TOP INNOVATIONS HALL OF FAME PROFILE

### INNOVATIONS CATEGORY:

1. Advanced Technologies and Practices
- 1.1 Building Science Solutions

## Basement Insulation Systems

Efficient and durable construction practices are critical for basements because basements can account for 10% to 30% of a home's total heat loss and provide significant risk of moisture problems due to extensive cold surfaces at the walls and slab.

"Mold is a water problem.  
No water, no mold."

**Joseph Lstiburek**, Building Science Corporation



### BUILDING AMERICA TOP INNOVATIONS

*Recognizing Top Innovations in Building Science* – The U.S. Department of Energy's Building America program was started in 1995 to provide research and development to the residential new construction and remodeling industry. As a national center for world-class research, Building America funds integrated research in market-ready technology solutions through collaborative partnerships between building and remodeling industry leaders, nationally recognized building scientists, and the national laboratories. Building America Top Innovation Awards recognize those projects that have had a profound or transforming impact on the new and retrofit housing industries on the road to high-performance homes.

*Building America research has provided essential guidance for one of the most challenging construction assemblies in cold-climate high-performance homes.*

Basements can easily develop mold, rot, and odor problems if not designed properly. Building America researchers have investigated basement insulation systems that keep the space dry, healthy, and odor-free. These systems effectively address the complexity of heat and moisture movement through basement walls.

The moisture that can contribute to potential mold and rot problems in basements can come from both inside and outside the house. Interior air carries vapor that will condense on the basement walls and floor if those surfaces are below the dew point temperature. Rainwater or groundwater can wick through foundation footings or walls if moisture barriers are missing. In new construction, freshly poured concrete can be a significant source of moisture (Smegal and Straube 2010). When cellulose or fiberglass insulation is installed in contact with basement walls, it can absorb large amounts of moisture and stay chronically damp. The problem is compounded when an impermeable vapor barrier such as plastic is used on the interior because it will trap moisture in the wall.

Through extensive field tests and analyses, Building America researchers have developed insulation strategies that can keep a basement dry and warm. Two factors are key: choosing the right insulation and installing it the right way. The following recommendations are from Building America research (BSC 2009, CARB 2005, Lstiburek 2006, Smegal and Straube 2010).

Good basement insulation begins with protection from groundwater. To prevent the diffusion of groundwater through the basement wall, plastic sheeting should be installed as a capillary break between the footings and foundation wall. In cold climates, the concrete slab should be poured over a layer of rigid foam insulation that is covered by a vapor barrier. The warmer floor will discourage condensation of interior airborne vapor. In existing homes, rigid foam insulation can be installed on top of the slab, with a floated floor or a new concrete slab above it.

For basement walls, exterior insulation is an effective way to control moisture and save energy. In very cold regions, it protects the foundation from the risk of freeze-thaw cycles. Either rigid fiberglass or XPS (extruded polystyrene) rigid foam can be used on the exterior of basement walls. Exterior insulation should not be used, however, where termites are a problem, and it must be carefully protected from moisture during installation.

Insulation on the interior of basement walls must be installed in an airtight manner that keeps airborne vapor from condensing on cold walls. At the same time, the material must be a vapor retarder that is semi-permeable so any moisture coming through the wall can dry to the interior. Some foam insulation meets these requirements if properly installed.

Closed-cell spray foam provides the best moisture control of all interior foundation insulations (Smegal and Straube 2010). It is an excellent air barrier and can be a Class I, II, or III vapor retarder, depending on thickness. Open-cell spray foam is also an excellent air barrier but must be applied more thickly to achieve vapor protection. Spray foam must be covered with ignition-barrier paint or 1/2-inch gypsum board.

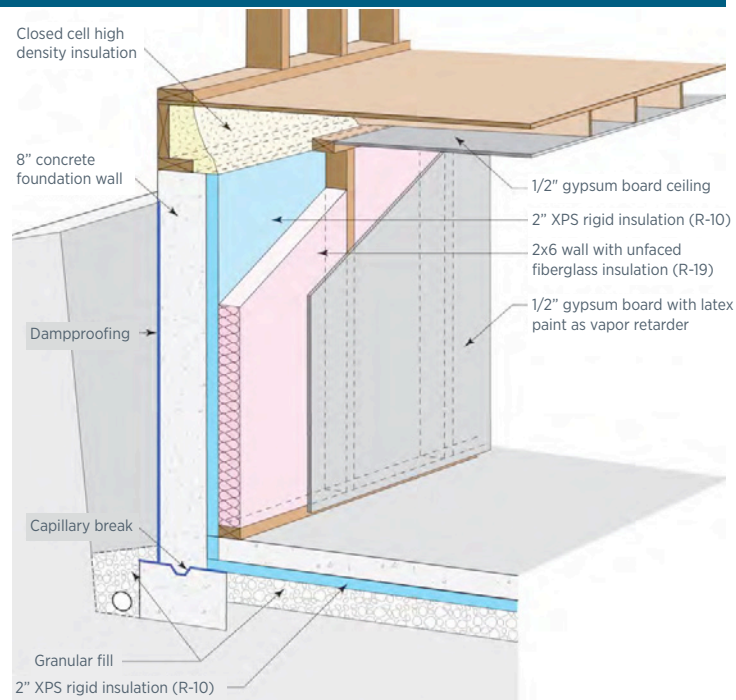
Three types of rigid foam can be used to insulate the interior of basement walls: XPS, EPS (expanded polystyrene), and polyisocyanurate. For moisture control, the foam panels must adhere completely to the foundation wall, with no air gaps behind them. Edges and seams must be tightly sealed with acrylic-latex caulk, foam sealant, or mastic. When finishing the wall, leave at least a 1/2-inch gap between the drywall and the floor.

Building America's recommendations make it possible to insulate basements with little risk of moisture problems, and the insulation will reduce homeowner's energy bills. The savings depends on climate, fuel cost, the type of heating system, and the occupants' lifestyle. The savings can be significant, since 10% to 30% of a home's total heat loss occurs through the basement.

## Key Lessons Learned

- Air sealing is a crucial defense against condensation. The rim joists must be air sealed and insulated. Air seal the basement ceiling, the foundation walls, and any ductwork as well. Also air seal the home's ceiling or attic to minimize the stack effect, which pulls air up and out of leaks in the top of the house while drawing air in through leaks at the foundation.
- Fiberglass batt or cellulose insulation should not be in contact with foundation walls.
- Do not install polyethylene sheeting, vinyl or foil wallpaper, or epoxy, oil, or alkyd paint on the interior of basement walls. These are Class I vapor retarders and will trap moisture in the walls.
- If the slab floor of a basement is uninsulated, do not install carpet or vinyl flooring. These trap moisture, inviting mold.
- Do not insulate a basement ceiling unless the home is in a dry climate and the basement will not be used as living space.

Recommended R-values for basement insulation in each climate can be found at [www.energysavers.gov](http://www.energysavers.gov).



Basement walls can be insulated with rigid foam. For moisture control, the panels must adhere completely to the foundation wall, with no air gaps behind them, and edges and seams must be tightly sealed. Another option that avoids moisture problems is to use insulated concrete form foundation walls with a layer of foam inside the walls.

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