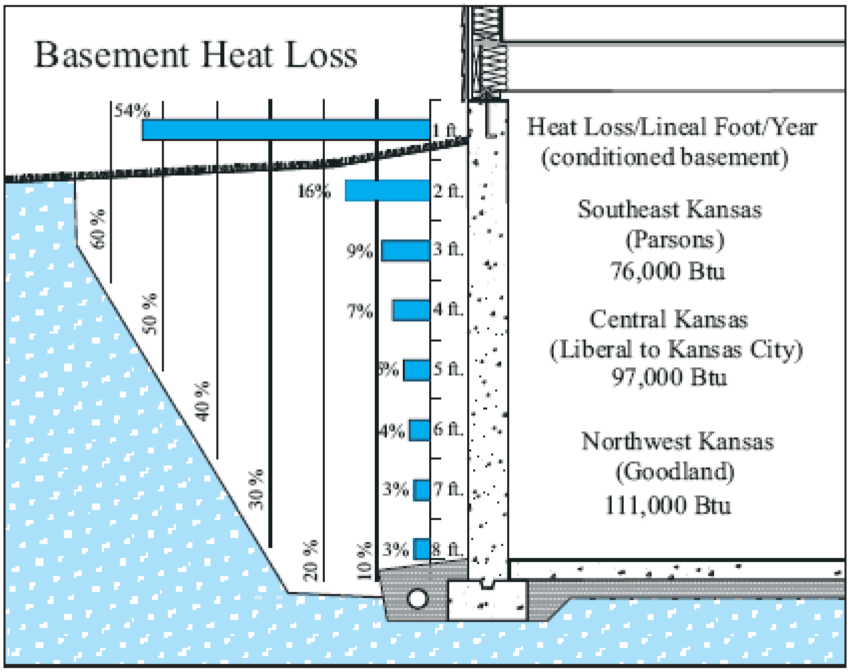
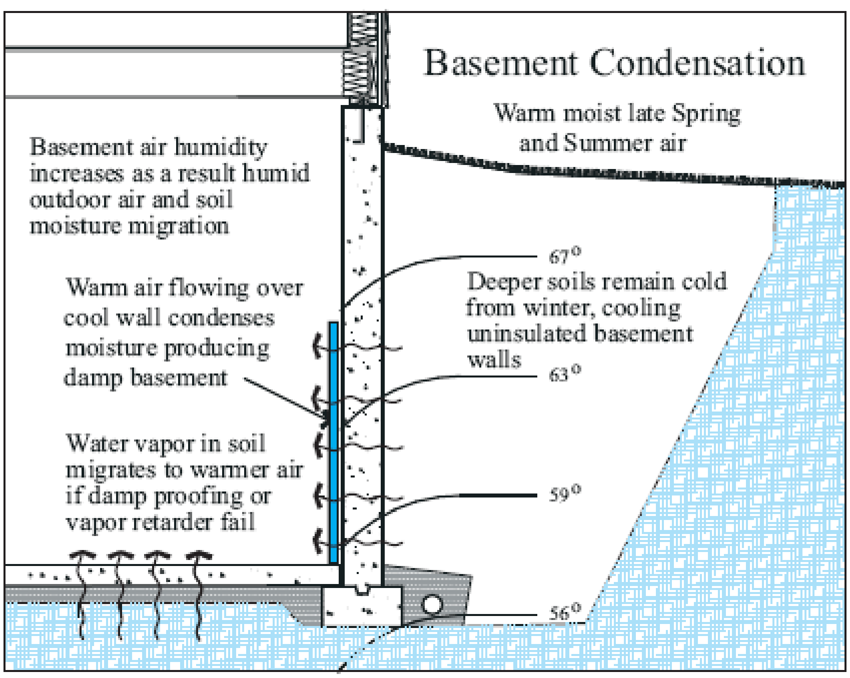
Residential Foundation Insulation Guide for the Homebuilder and Homeowner

Introduction

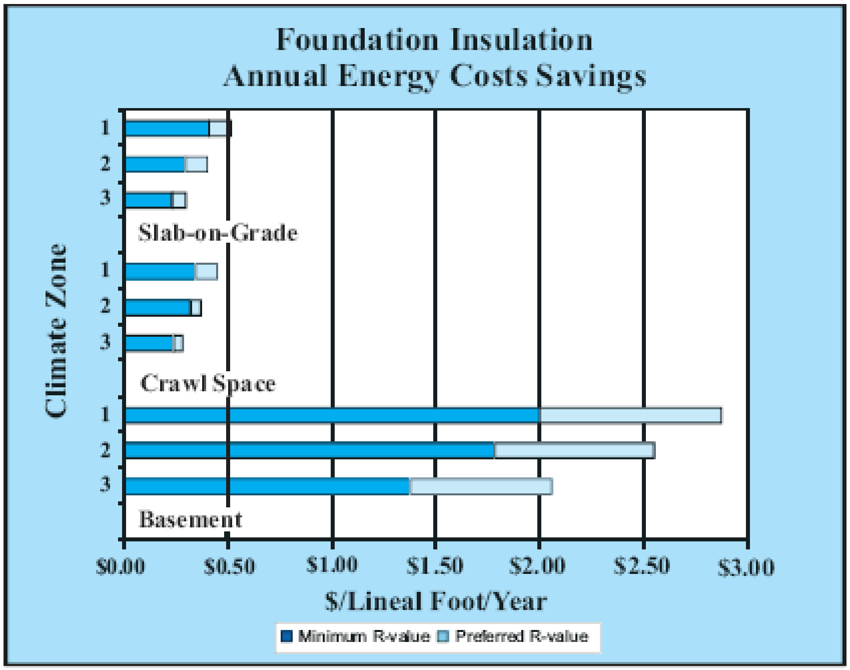
The following information has been derived from ***A Builder's Guide to Residential Foundation Insulation***, Fall 1999. The Illustrations are directly from the report and the sections, as noted.



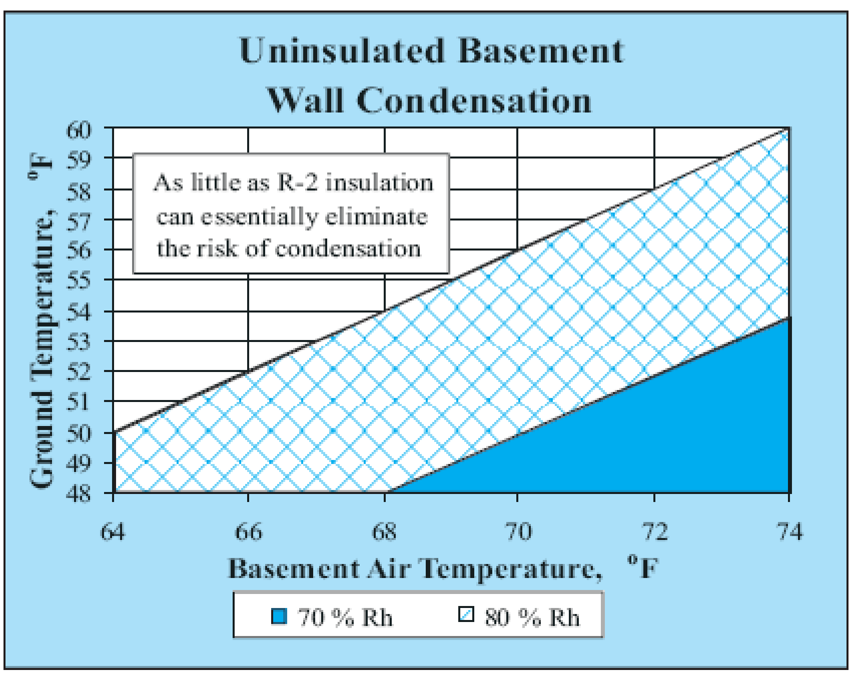
Uninsulated Foundations Lose a Lot of Energy



Uninsulated Foundations Cause Condensation



Foundation Insulation Heating Cost Savings



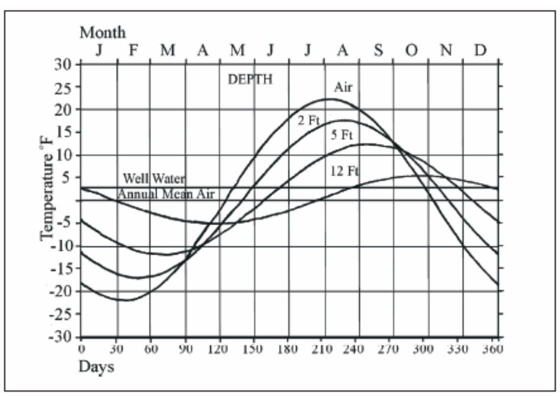
Foundation Insulation Cuts Moisture Problems

Building Foundation – Purpose

The prime function of a building foundation is to connect the structure to the ground and transfer the weight to stable soil. Proper foundation design and construction are essential to ensuring structure durability throughout seasonal changes in temperature and moisture. Movement of the foundation will eventually harm the integrity of the building structure. These principles are just as valid in the 21st century as it has been since the proposed guidelines in the 1st century B.C. by the Greek, Vitruvius.

Foundations also offer a thermal connection to the building. A comprehensive study on the impact of residential foundation insulation practices concluded that an uninsulated basement could result in up to 50% of heat loss from a tightly sealed home despite being well insulated above ground. The findings of the team of building scientists from Oak Ridge National Laboratory can be further examined in ***The Building Foundation Design Handbook***.

The findings of the study dispel the common belief that below grade insulation is of little value due to constant soil temperatures is a misconception. Without the presence of a geothermal heat source, the heat radiating from deep within the earth has an insignificant influence compared to the flow of solar energy at the junction of the air and ground. At depths less than eight feet, soil temperatures greatly vary throughout the year. The following graph illustrates this principle.



Soil Temperature Change with Depth and Season

Illustration indicating soil temperature variations with depth and season from both ground water and mean air temperatures, ranging from 56 to 62 degrees from northwest to southeast Kansas.

Residential Building Energy Standards

Since the 1992 Energy Policy act, states have been strongly urged to upgrade residential building energy standards requiring efficiency levels at least equal to the Model Energy Code (MEC). Check with individual state Energy Departments to determine the requirements to comply with the MEC minimum standards on new home construction. Disclosure forms itemizing energy performance features or compliance with MEC assures homebuyers that the home has an integrated set of energy features. Most minimum standards require foundation insulation.

Foundation Building Code Requirements

The following information is provided as a guideline to homebuilders and homebuyers regarding available foundation insulation materials, installation details and methods, installation costs, and benefits. Because of environmental variances, health concerns, and safety requirements keep in mind that all codes are subject to local jurisdictions, prevailing over the MEC and any outlined suggestions.

Residential Foundation Insulation

Several requirements affect foundation insulation. Below are examples of the widely adopted ***CABO One and Two Family Dwelling Code***.

< Drains are required around all concrete and masonry foundations enclosing habitable or usable space below grade, concrete foundation walls enclosing basements must be dampproofed with a bituminous material from the footing to grade,

< Masonry foundation walls enclosing basements must me parged with Portland cement prior to dampproofing.

< Foundation walls of habitable rooms below grade must be waterproofed,

< Exterior foundation insulation must be protected from weathering, sunlight, and physical abuse,

< All foam plastic exposed to the interior must have a maximum flame spread rating of 75 and a maximum smoke-developed rating of 450 (ASTM E-84) and shall be covered with a ½" gypsum wallboard or equivalent thermal barrier.

Benefits of Foundation Insulation

Insulating the foundation of a home offers numerous benefits, which are evaluated in detail throughout the following sections.

< Foundation heat loss can be reduced significantly and space heating costs can be reduced as much as 50% in an otherwise well insulated home.

< Insulation improves foundation moisture control and indoor air quality. Insulation on either side of the wall results in a warmer interior surface, reducing the potential for condensation and associated mold growth that reduces indoor air quality and can cause material damage.

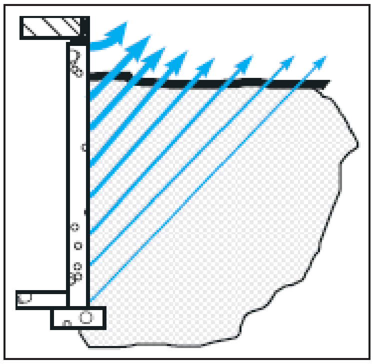
< The warmer surface also results in a more comfortable space, not only in the basement, but also the floor above.

< Exterior insulation provides protection for dampproofing or waterproofing, extending their life.

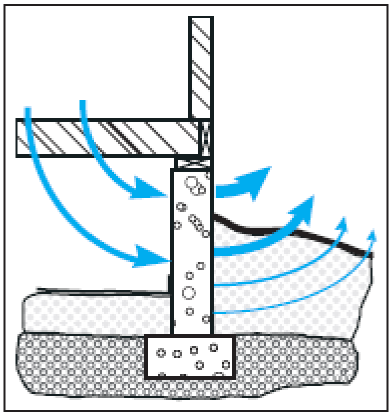
Foundation Heat Loss

Despite soil maintaining a great deal of thermal energy, especially when damp, it is not a good insulator. Two inches of foam or three inches of fiberglass insulation is a much more cost effective protection because it would take 7 -11 feet of soil (depending on type) to provide the same benefit. Foundation heat loss is subject to a number of variables such as, climate zone, soil type, and moisture content, the temperature maintained in the house and other subtle factors.

As illustrated, uninsulated basement walls are vulnerable to heat loss where exposed to winter air above grade and at shallow depths where the ground may be frozen.



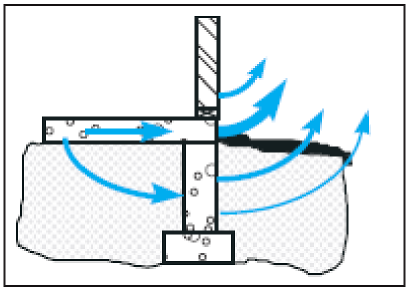
Basement Heat Loss



Crawl Space Heat Loss

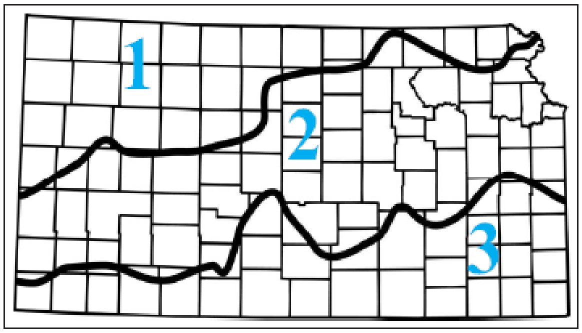
Floors above crawl spaces are also susceptible to heat loss because they are often not insulated to prevent pipes within from freezing. Similar to basement walls, the heat loss results when heat passing from the floor to the crawl space is seeped into the foundation wall.

Cold floors in slab-ongrade homes result from the floors absorbing and conducting considerable heat to the exposed slab edge. Heat also disperses through the soil beneath the slab and out the perimeter foundation.



Slab-on-Grade Heat Loss

The map below illustrates three widely recognized Kansas climate zones. The accompanying table indicates typical net annual heat loss, in Btu per lineal foot of foundation, for the three major foundation types in the three climate zones.



Kansas Climate Zones

	Kansas Climate Zone		
	1	2	3
Full Basment	111,000	97,000	76,000
Crawl Space	47,000	41,000	32,000
Slab-on-Grade	60,000	52,000	40,000

Annual Foundation Heat Loss

(Btu per lineal foot per year)

Potential Cost Savings

The economic value of the energy savings is the determining factor for the amount of foundation insulation to be installed. All seasonal weather and other criteria must be thoroughly considered. During the cooling season, foundation insulation may marginally increase the cooling energy use because the foundation loses less heat to the ground in these temperatures. This effect is negligible in the Midwest. Other important considerations are the cost of space heating energy (natural gas, electricity, or propane) and the efficiency of the space heating system.

Check the MEC standards for the affected climate zones of your projects. Recommendations are provided for each type of foundation based upon average energy prices. For example, the following table is based upon the Kansas climate zones featured previously.

The table indicates the MEC required minimum foundation insulation for each of the three foundation types for each of the three Kansas climate zones.

It is rarely possible to comply with the MEC standards without using foundation insulation. However, there is a great deal of flexibility in methods. Building envelope components such as windows, walls, or attic insulation can affect the MEC performance capabilities. The performance compliance method allows the builder to offset the lower performance of these components in another area such as foundation insulation.

	MEC Minimum R-Value		
	Zone 1	Zone 2	Zone 3
Full Basment	10	10	8
Crawl Space	16	16	10
Slab-on-Grade	5 (min. 4 ft)	5 (min. 2 ft)	5 (min. 2 ft)

Foundation Insulation R-values

(MEC prescriptive minimum)

Energy Cost Savings – (MEC Prescriptive Minimum)

The ***MECcheck*** software developed by Pacific Northwest National Laboratory for the U. S. Department of Energy is a great tool for obtaining an assessment of energy cost savings trade-offs. It is very user-friendly and is available from the Kansas State University Engineering Extension Service (785-532-4994), or it can be downloaded from <http://www.energycodes.org>.

The figures below are from the Fall 1999 report, ***A Builder's Guide to Residential Foundation Insulation***. Keep in mind that energy costs have increased in recent years, however, the information will provide insight into evaluating energy cost savings. The energy cost savings were calculated by adhering to the minimum MEC standards indicated in previous table, *the Foundation Insulation R-values*.

Low less than $8.00/million Btu
Medium $8-12.00/million Btu
High more than $12.00/million Btu.

These costs are based on typical energy purchase prices and combustion system efficiencies.

Use the low energy price if you have natural gas heating and conventional air-conditioning, an air-source heat pump with costs below $.05/kWh, or a water-source heat pump with electric costs below $.08/kWh.

Use the medium energy price if you use propane in combination with a conventional air conditioner, an air source heat pump with electric costs below $.07/kWh, or a water-source heat pump with electric costs below $.12/kWh.

Use the high energy price if electric costs exceed those noted above or you use electric-resistance heat.

	Kansas Climate Zone		
	1	2	3
	High Energy Costs		
Full Basement	$256	$197	$160
Crawl Space	$107	$92	$70
Slab-on-Grade	$134	$117	$92
	Medium Energy Costs		
Full Basement	$182	$140	$107
Crawl Space	$75	$63	$48
Slab-on-Grade	$95	$83	$65
	Low Energy Costs		
Full Basement	$126	$92	$68
Crawl Space	$51	$43	$32
Slab-on-Grade	$66	$58	$46

Foundation Insulation Annual Energy Cost Savings
(1700 square foot house with 170 lineal ft. perimeter)

Foundation Moisture Control

Real estate agents will concur that the majority of homebuyers expect basements. Ranging in use from providing extra storage or eventually being utilized as finished space, the appeal can be understood. Judging by the number of basements offered in new home construction, it appears that homebuilders are meeting this expectation.

Given the potential basement uses, it is extremely essential to provide adequate foundation moisture control. A damp, musty-smelling basement is not desirable to any potential homeowner. While broken pipes and flooding are obvious, there are four main causes for dampness, outlined below. The causes and solutions are further explained in the specified sections.

< Free-flowing surface or ground water entering through cracks or openings in the basement wall or floor,

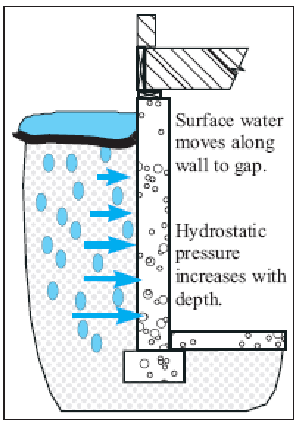
< Soil moisture wicking through the basement wall by capillary action,

< Water vapor migration from cool damp soil to a warmer basement, or

< Condensation of water vapor on cold basement walls.

Surface and Ground Water

Incorporating overhangs in the building design installing gutters and downspouts, capping backfill with impervious clay, and providing proper drainage away from the house can provide effective control of surface water.



Surface Water Entry

Inadequate slope away from the foundation or poor roof drainage control causes surface water problems. As illustrated, water adjacent to the foundation seeps through pervious backfill, gaining entry through a crack, cold joint, or utility penetration.

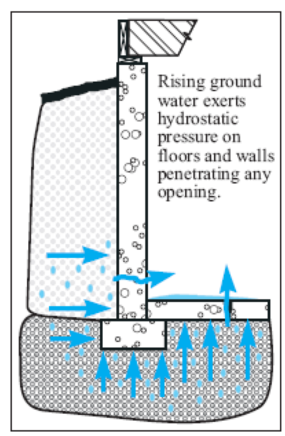
Controlling surface water issues by incorporating features in the building design is very effective. Placement of overhangs, installing gutters, and downspouts are widely used. Overhangs divert rain away from the sides of the home. Gutters and downspouts carry rain water away from the home. Downspouts should be placed at a minimum 5% slope away from the house.

Directing adequate drainage of surface water away from the foundation by capping backfill with impervious clay is a viable solution.

Ground water concerns stem from water levels rising above the house floor resulting in hydrostatic pressure on the floor and wall. In this condition, the ground water will penetrate any opening. Drain tiles are installed on the outside and sometimes both sides of the footings to remove high ground water.

When conditions are unfavorable to allow sloping the drain to "daylight," an electrically powered sump pump is required. Because power outages typically result from storms producing high, it is often wise to invest in a battery back-up installation.

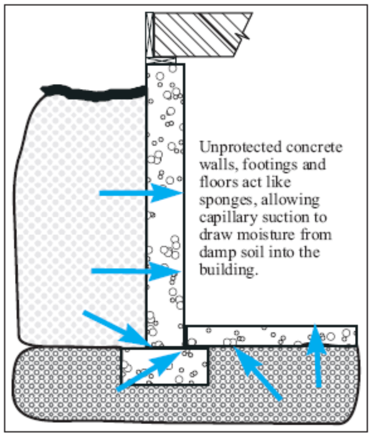
Waterproofing products are necessary for persistently wet sites. When ground water is known to rise to or above floor level, or where habitable spaces are below grade, there is no other solution than to waterproof the basement wall. Waterproofing products are available in a variety suitable for each individual situation, including liquid and sheet membranes, cementious coatings, built-up tar and felt, and bentonite clay.



Ground Water Entry

Some liquid membranes and adheshives used with other systems chemically dissolve foam insulation. Therefore, it is essential to ensure all components in a waterproofing product are compatible with any exterior foam foundation insulation that will be installed.

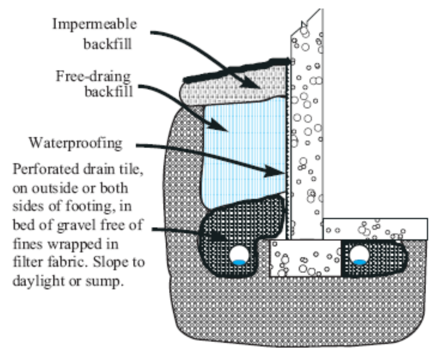
Capillary Moisture Migration



Capillary Movement of Ground Moisture

Even with adequate free flowing water, considerable moisture can still be retained in soil. This occurrence is the result of capillary movement, which results when ground moisture is wicked up through materials with small pore size. Capillary action between a basement wall and soil outside the surface of the wall can become a source of unwanted moisture penetration.

Dampproofing materials function ideally to prevent wicking by filling the concrete pores in the basement walls. Even when a basement wall does not require waterproofing, dampproofing must be applied. Similar to waterproofing products, approved dampproofing materials include spray or roller applied bituminous and acrylic modified cement-based coatings. Preventing capillary moisture absorption through the floor is accomplished by using a gravel base. The pore size between stones (3/4 inch stones with fines omitted) is too large to permit capillary suction.



Drain Tiles and Water Proofing

Vapor Diffusion Moisture Movement

Vapor diffusion occurs when water vapor moves from high vapor pressure to low vapor pressure. Usually, as this occurs above grade, the water vapor moves from the warm (winter) interior to the cold exterior. Depending on the circumstances, water vapor can move in either direction below grade.

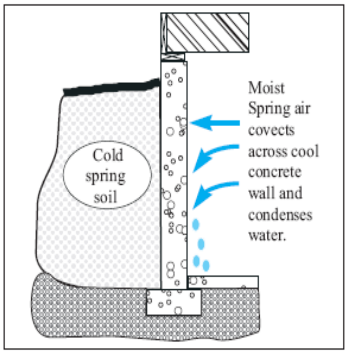
Diffusion retarders are used to combat these occurrences. These materials possess a perm rating of 1.0 or less and are installed on the exterior of below grade concrete, reducing the inward seepage of water vapor from the soil into the building. Dampproofing and waterproofing products are utilized as effective diffusion retarders on walls. Polythylene vapor barriers either are used below floors on top of the gravel bed or may be used on exterior walls.

Moisture Condensation on the Inside of Foundation Walls

Typically in the Spring, there is a gradual temperature rise in shallow soil. However, at the approximately the depth of five feet, the temperature hovers steadily between 50 – 60 degrees through mid-June.

Because of the ground temperature influencing the temperature of an uninsulated wall and the air temperature of the basement environment at approximately 72 degrees, there is a likelihood of condensation occurring when the relative humidity ranges at a typical 45 – 65%. The risk of condensation is lowered when the walls are insulated. This solution shifts the thermal profile by equalizing the inside surface temperature and the indoor air temperature.

Improved Indoor Air Quality



Condensation on Cool Basement Walls

While moisture is not classified as a pollutant, its presence can cultivate a thriving environment to produce mold, mildew and dust mites as the relative humidity in a home rises above 60%. It becomes quite the blending of techniques to control moisture because ironically the tighter, more energy efficient homes tend to experience higher relative humidity. The sources of moisture in a home can be numerous. However, it is well known that excessive moisture in basements and crawl spaces can exacerbate moisture problems in upper floors.

Controlling basement and crawl space moisture is an essential method of increasing Indoor Air Quality (IAQ). Some examples of contributing factors include moisture diffusing through the floor system, moist air flowing through cracks and stairs and subsequently replacing air drawn out of the home by wind or stack pressure, or basement air being distributed through a forced air heating system while intentionally or accidentally drawing air from the basement.

Improved Comfort

Proper foundation insulation not only conserves energy usage and costs, but it improves the comfort of the living space within the home. Insulating the basement walls raises the surface temperature of the wall and the above floor, increasing the floor temperature of the main floor living space. The same principle applies to the insulation of crawl spaces. Increasing the slab floor temperature through proper insulation of slab-on-grade foundations eliminates the homes inside air from seeping out.

Installing the foundation insulation during the original construction is more cost effective and usually much more easily installed than when retrofitted. It also increases the chances that the foundation insulation will be properly and adequately placed.

< Foundation insulation can often result in smaller and therefore less expensive heating equipment.
< Foundation insulation makes a basement more attractive for future owner conversion to finished space.
< Reduction in fossil fuel use and associated green house gas emissions has long-term environmental benefits.

Insulation Material Properties

The following section can be found verbatim in the Fall 1999, ***A Builder's Guide to Residential Foundation Insulation***
I
Insulating performance is measured in R-values with units of hr, ft², and ºF / Btu. R-values of multiple layers can be added. The inverse of the R-value (1/R) is the U-value, the coefficient of overall thermal transmission, with units of Btu /hr, Btu /ft², and Btu /ºF. U-values cannot be added.

An uninsulated concrete foundation wall has an overall R-value of about 1.1 and a U-value of 0.9. For each degree of temperature difference between the inside and outside, each square foot of wall will transmit .9 Btu each hour from the warm side to the cold side (U-value x Area x Temperature difference = Heat flow). If insulation with an R-value of two is added to the wall, the total R-Value becomes 3.1, the U-value .32 Btu/hr, Btu /ft², Btu /ºF, and the heat flow .32 Btu per hour, a 65% reduction.

If the insulation is increased to R-6, the U-value and heat flow becomes .14, an 84% reduction. The first Rs have the most impact. Sound detailing and proper installation are essential for achieving real performance. Gaps and thermal bridges of conductive material can significantly reduce the effective R-value.

Strength, beyond the ability to remain intact, matters little for batt insulation. For board insulation below grade on an exterior wall or beneath a slab, compressive strength must be considered.

Water Absorption is the amount of water absorbed by an insulating material as a percent of total volume when fully immersed for 24 hours. Water absorption reduces effective R-value and materials with higher absorption should not be used in locations where they will likely encounter water.
Permeability is the ability of water vapor to pass through a material in response to differing vapor pressure on opposite sides. When water vapor moves through a material and reaches a temperature below its dew point, condensation will occur. Water in sufficient quantity will cause insulation performance to deteriorate and material damage may occur.

Materials with a perm rating of 1.0 or less are considered effective vapor barriers, although some prefer the term vapor retarder because completely effective barriers are almost impossible to achieve. Uninsulated foundation walls often have an interior surface temperature below dew point allowing condensation to occur resulting in a damp and often moldy smelling basement even though no water leakage has occurred.

Exterior foundation insulation generally raises the wall temperature above dew point preventing condensation. Interior foundation insulation actually causes the foundation wall surface temperature to drop, increasing the risk of condensation. A vapor barrier is required on the inside surface of the insulation. Early installation of the vapor barrier can create other moisture problems. The new concrete contains a great deal of water. Because the exterior is dampproofed or waterproofed and in contact with soil most of the excess moisture must escape to the inside as the concrete cures.

Early installation of a vapor barrier can trap water vapor allowing it to condense inside the wall or within the insulation. Delay installing interior foundation insulation until late in the construction process to allow the concrete to cure. When the insulation will be left exposed, consider use of a vapor barrier with small perforations, such as CertainTeed basement wall insulation.

Flame spread and **smoke development** ratings of combustible building materials are based on the ASTM E84 test. Values for foam insulation may not exceed 75 and 450 respectively. Unless specifically approved otherwise by the building code official, all foams must be covered with ½ inch of gypsum wallboard or other approved thermal barrier, regardless of location. Surface protection is required for all exterior insulation above grade. All types must be shielded from structural damage and foams must be protected from degradation from the ultraviolet (UV) portion of the solar spectrum.

Environmental Impact Issues

Yet another benefit beyond cost saving benefits of foundation insulation is the environmental impact of reducing greenhouse gas emissions. The scope of the benefits vastly outweigh the environmental detriments of manufacturing and installing the insulation. As professional consumers of foundation insulation, we can maximize the positive benefits through selecting products that minimize negative environmental impacts during their production processes. Reading product labels and brochures regarding the following topics will enable you to make informed decisions on the most beneficial products.

Embodied energy is present in the material and consumed during its manufacture, delivery, and installation processes. Materials with lower embodied energy are most highly recommended.

Ozone depletion is the destruction of the protective stratospheric ozone layer of the earth. Until recently harmful ozone depleting gases were commonly used in the production process to inflate the bubbles ensuring effective foam insulators. As more industries are continuing to modify their production processes insulation manufacturers have adopted the use of other gases with lower ozone depletion potential, including HCFs and HCFCs.

Global warming potential (GWP) refers to the impact carbon dioxide and other gases have on increasing global temperatures. Carbon dioxide has a global warming potential of 1. CFC 12, a common foam-blowing agent, has a GWP of 7,100. The gases now in common usage have GWPs ranging from 1 - 1,300. Ironically, the lowest is carbon dioxide, but its use reduces insulation performance by about 1/6 and other gases are selected to increase the efficiency of the insulation material.

Recycled content is another popular environmental feature alternative of building insulation production. Most cellulose and mineral wool insulations are manufactured from recycled materials. Fiberglass and foam insulation manufacturers are continually increasing the amount of recycled material used. The U.S. Environmental Protection Agency (EPA) at: <http://www.epa.gov/epaoswer/non-hw/procure/products/building.htm#productinfo> maintains an active list of insulation manufacturers using recycled materials.

Insulation Materials

The vast selection of suitable materials for insulating foundation walls can be relegated to three general categories: board, batt, and blown. While some products may be used on the inside or outside of the wall, others are only suitable for interior use. The following outline provides general information, advantages, and disadvantages of the major types of products.

Board Insulation materials for foundation usage commonly include extruded polystyrene (XPS), expanded polystyrene (EPS), polyisocyanurate, fiberglass, and rockwool.

Extruded Polystyrene (XPS) manufactured from polystyrene resin and a gas-blowing agent in a continuous extrusion process resulting in a homogeneous cellular structure.

Advantages

< High R-value per inch, high compressive strength, low moisture absorption, low perm rating.
< Widely available in various sizes and thicknesses and easily installed.

Disadvantages

< Requires UV and structural protection above grade when applied on the exterior and thermal protection when installed on the interior.
< Chemically attacked by some adhesives, dampproofing and waterproofing compounds.

Expanded Polystyrene EPS differs from XPS significantly in its production process. Styrene beads placed in a mold are expanded under heat and pressure with a foaming agent.

Advantages

< The least expensive foam board, available in a wide range of densities, sizes, and thicknesses.
< Available with borate additives to reduce termite risk.

Disadvantages

< Somewhat lower R-value than other foams and more easily damaged, particularly if used on the exterior.
< Higher permeability and water absorption than other foams.
< Like all foams, requires exterior protection above grade and thermal protection when used on the interior.

Polyisocyanurates are manufactured from a plastic resin and a foaming agent and often have fiberglass or foil facing.

Advantages

< Highest R-value of any foam. Available with foil face which can serve as vapor barrier and can provide increased R-value when installed with dead air space.
< One product, Thermax by Celotex, can be installed without a thermal barrier when approved by the local code official.

Disadvantages

< Generally higher in cost than other foams and initially very high R-values declines a bit with age.
< Low compressive strength.

Batts Batt insulation materials include fiberglass and rockwool. Fiberglass in made from sand and recycled glass cullet. Mineral wool is made from iron ore blast furnace slag and natural rocks. Batts can be unfaced, kraft paper faced, foil faced, or poly wrapped. In addition to the many sizes commonly installed in above grade frame walls, specialty batts are available for interior basement walls and crawl space walls.

Advantages

< Inexpensive and widely available in many sizes, thicknesses, and facings.

Disadvantages

< Batt insulation can be saturated and difficult to dry if moisture penetration occurs.
< Furring required for installation and easily damaged in high traffic areas if not protected by drywall or paneling.

Blown Insulation-Foundation insulation applications are typically blown into the cavity behind a non-load bearing 2 x 4 or 2 x 3 stud walls erected directly adjacent to or set back from the basement wall. Batts are typically utilized in the stud cavity with this installation process. However, blown cellulose, glass fiber, or mineral wool insulation can be used. Cellulose is mostly manufactured from waste paper blended with fiber and insect retardant chemicals are applied. A netting may be installed over furring to hold insulation in place.

Advantages

< Inexpensive, completely fills cavity.

Disadvantages

< Like batts, sprayed insulations can be quickly saturated and difficult to dry if significant moisture penetration occurs.
< Again, like batts, furring required for installation and needs protection in high traffic areas.
< Special installation equipment required.

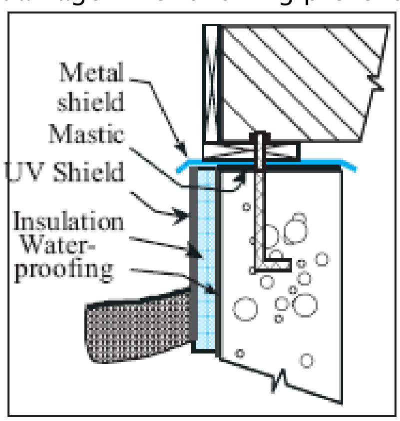
Termites

The natural habitat for subterranean termites is 15 – 20 feet underground. The colonies are large and they live entirely on plant matter. They enter buildings in their search for food through a system of tunnels. Their common entry points are found where they come across wood in contact with the ground, cracks in foundation walls or slabs, the dry joint between the footing and foundation wall, utility penetrations, and through and behind foundation insulation.

Termite invasions can inflict extensive and costly damage to wood structures. Foundation insulation does not attract termites as a food source or increase the infestation chances of any building. However, the presence of foundation insulation does make detection more difficult.

Previously popular insecticides such as chlordane were very effective for providing long-term protection because they remained in the soil for many years. When it was found these insecticides were carcinogenic, other types of insecticides were used as an alternative. The current termiticides are effective in treating infestations, but the drawback is that they dissipate much more quickly than the carcinogenic types and require retreatment. Borates are another effective deterrent.

The best defense in dealing with termite invasions is to avoid the initial infestation. Termites are small, persistent, capable of squeezing through the tiniest of cracks, and can cause costly damage. The following preventive strategies will help avoid infestations.



Termite Shield

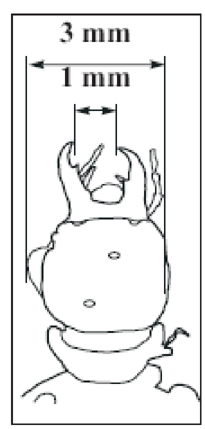
< Avoid attracting them. During construction keep all wood, including framing scraps, sawdust, paper, and tree roots, and trimming out of the ground for as far back from the house as feasible.

< Keep all wood at least six inches above grade and use only termite resistant or treated wood in contact with the foundation. Do not use wood mulch near the house. Install a continuous metal termite shield with soldered or sealed lap joints. Termites can tunnel around it, but they can then be detected and treated.

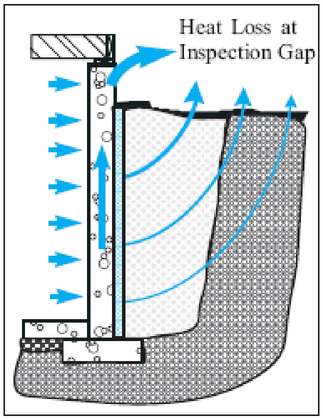
< Consider pretreating all wood framing within four feet of the ground with borates.

< Consider installing termite bait systems marketed by professional pest treatment companies. They
permit detection of termite presence and the use of highly effective targeted insecticides.

< Consider installing sand barriers. While still experimental and more expensive than conventional treatment, sand barriers provide a non-chemical method of protection. Sand that just passes through a 16 grit wire screen takes subtle advantage of the termite anatomy. The gaps within the sand are too small for them to crawl through, but their jaws do not open wide enough for them to pick them up and move them. Sand barriers can be placed around a foundation wall at grade and around potential entry points in slabs.



Termite Size



Inspection Gap

< Consider pretreating the soil with EPA approved termiticides.

< Have the house inspected annually.

< Avoid heat losing inspection strips.

Foundation Insulation Cost

The table provides estimated figures from the 1999 study conducted by the Kansas State University Engineering Extension Service. Keep in mind the cost of materials have increased and other individual project factor variances may influence the results, but this information can provide a general guideline. The figures include foundation insulation installed costs per lineal foot of perimeter. Costs featured include materials, labor, and contractor overhead, and profit.

Estimated Foundation Insulation Cost per Lineal Foot

Actual project costs are region and project specific. Variation from the values below should be expected.

Foundation/Material	Height (depth)	Thick-ness	Material R-value	Exterior	Interior
Basements - Foam Boards					
Extruded Polystyrene (XPS)	8 ft.	½ in.	2.5	$7.60	$12.50
(Blue, pink, yellow, green)	8 ft.	1 in.	5	$8.80	$13.60
	8 ft.	1-1/2 in.	7.5	$10.70	$15.60
	8 ft.	2 in.	10	$12.70	$17.60
Expanded Polystyrene (EPS)	8 ft.	1 in.	3.8	$7.80	$12.70
(White beadboard)	8 ft.	1-1/2 in.	5.6	$9.10	$13.90
	8 ft.	2 in.	7.7	$10.30	$15.20
Polyisocyanurate	8 ft.	¾ in.	5.4	$8.50	$13.40
(If foil faced and furring is	8 ft.	1 in.	7.2	$9.00	$13.80
on top to create a dead air space	8 ft.	1- ½ in.	10.8	$9.50	$14.40
increasse the R value by 2.8)	8 ft.	2 in.	14.4	$10.70	$15.60
Exterior cost includes metal flashing protection, reduce $0.40 for cement board, increase $1.70 for stucco. Interior cost includes furring and ½ in. drywall. Reduce cost $7.00 if omitted (requires code approval)					
Glass Fiberboard	8 ft.	1 in.	4.3	$9.00	$13.80
	8 ft.	1-1/2 in.	6.5	$12.20	$17.10
Basements - Batts					
Std densifty, 48 in. or 72 in.	8 ft.	3- 1/8 in.	11	n.a.	$4.20
Std density, 23 in.	8 ft.	3-1/2 in.	11	n.a.	$11.60
High density, 23 in.	8 ft.	3-1/2 in.	15	n.a.	$12.10
Mineral wool (kraft faced)	8 ft.	3-1/2 in.	12	n.a.	$12.00
Cost includes furring and faced batt or vapor barrier. Add $5.30 for drywall.					
Crawl Spaces - Foam Boards					
Extruded Polystyrene (XPS)	4 ft.	1 in.	5	$10.30	$4.90
(Blue, pink, yellow, green)	4 ft.	2 in.	10	$12.10	$6.80
Expanded Polystyrene (EPS)	4 ft.	1 in.	3.8	$9.80	$4.50
(White beadboard)	4 ft.	2 in.	7.7	$10.90	$5.60
Polyisocyanurate	4 ft.	1 in.	7.2	$10.40	$5.00
(See note above on foil facing)	4 ft.	2 in	14.4	$11.10	$5.70
Exterior includes 2 feet of stucco, interior includes 3 feet of furring and drywall thermal protection.					
Crawl Space Batts					
Perimeter installation (wrapped batts)		8-3/4 in.	25	n.a.	$3.50
Floor installation	Sq. ft.	3-1/2 in.	11	n.a.	$0.60
(Includes wire retainers, turn	Sq. ft.	6 in.	19	n.a.	$0.74
facing up)	Sq. ft.	8-1/2 in.	30	n.a.	$1.08
Slab-on-Grade - Foam Boards (protection same as for basements above)					
Extruded Polystyrene (XPS)	2 ft.	1 in.	5	$3.60	$1.20
(Blue, pink, yellow, green)	4 ft.	1 in.	5	$4.60	$2.20
	2 ft.	2 in.	10	$4.50	$2.20
	4 ft.	2 in.	10	$6.40	$4.10
Expanded Polystyrene (EPS)	2 ft.	1 in.	3.8	$3.30	$1.00
(White beadboard)	4 ft.	1 in.	3.8	$4.10	$1.80
	2 ft.	2 in.	7.7	$3.90	$1.60
	4 ft.	2 in.	7.7	$5.20	$2.90
Polyisocyanurate	2 ft.	1 in.	7.2	$3.60	$1.30
	4 ft.	1 in.	7.2	$4.70	$2.30
	2 ft.	2 in.	14.4	$4.00	$1.70
	4 ft.	2 in.	14.4	$5.40	$3.00
Exterior cost includes metal flashing protection, reduce cost $0.40 for cement board, increase cost $1.70 for stucco.					

Foundation Insulation Properties

The table below is provided to showcase the vast range of residential foundation insulation materials available. It is not meant as a comprehensive overview but will illustrate common physical properties. For current information, consult the individual manufacturer's technical product data sheets. The majority are available on the web.

Foundation Insulation Material Properties									
	Resistance	Size	Thickness	Density	Strength	Water		Fire	
	(R per in.)	(w x l)	(inches)	(lb/ft^3)	Compress	Absorp-tion	Vapor	Flame Spread	Smoke Development
Material		(Inches)			(lb/in^2)	(%)	(Perm)	E84	E84
Boards									
Plastic Foams									
Polystyrenes									
Type VIII (EPS)	3.8	24, 48, x 96	1 - 40	1.15	13	3.0	3.5	10	125
Type II (EPS)	4.0		1 - 40	1.35	15	3.0	3.5	10	125
Type X (XPS)	4.2	16, 24, 48, x 96	1, 1.5, 2, 2.5, 3, 3.5	1.30	15	0.3	1.1	5	165
Type IV (XPS)	5.0	16, 24, 48, x 96 48 x 108	.75, 1, 1.5, 2, 2.5, 3, 3.5, 4	1.60	25	0.3	1.1	5	165
Type IX (EPS)	4.2	24, 48, x 96	1 - 40	1.80	25	2.0	2.0	10	125
Type VI (XPS)	5.0	24 x 96	1.5, 2, 2.5, 3, 3.5, 4	1.80	40	0.3	1.1	10	125
Type VII (XPS)	5.0	24, 48,x 96		2.20	60	0.3	1.1	10	125
Type V (XPS)	5.0	24, 48,x 96		3.00	100	0.3	1.1	10	125
Polyisocyanurate									
Fiberglass faced	5.8	48 x 96 48 x 108	.75, 1, 1.5, 2, 2.5, 3, 3.5	1.5 - 2.5	20	2.0	4.0	25	45
Foil faced	7.0	16, 24,48 x 96, 108, 120	.75, 1, 1.5, 2, 2.5, 3, 3.5, 4	1.5	20	<1.0	<1.0	20	65 (1 in)
(Add if foil faces dead air space)	2.8								
Glass Fiber	3.9			1.4 - 1.6	0.3 - 2.4	high	high		
Rockwool	4.2	36 x 48 48 x 72	1	11 - 13	25	.25	high		
Batts									
Glass Fiber (std density)	3.2	16, 24 x 48, 93 48 x 50 ft	3.5, 5.5, 6.25 8.5 (+others)		minimal		1 Kraft .5 foil	25	50
Glass Fiber (high density)	3.8	16, 24 x 48, 93	3.5, 5.5,6.25, 8.5		minimal				
Rock Wool					minimal				
Blown									
Glass Fiber (BIB)	4.0	To fit	To fit	1.8-2.3	minimal			5	5
Rock Wool	2.8	To fit	To fit		minimal				
Cellulose	4.0	To fit	To fit	1.6	minimal				

Frequently Asked Questions

Should a foundation still be isolated even if the basement is ufinished?

Yes, the basement is thermally connected to the remainder of the home and benefits from foundation insulation. Many basements are used for storage and heating and cooling equipment. Another alternative is to insulate the floor above, but this does not often provide the greatest benefit.

Does floor insulation above a basement or crawl space provide an alternative to foundation insulation?

Yes, but there are factors that may not prove to offer the best approach. Pipes, ducts, and HVAC equipment located in the basement should all be insulated to adhere to the MEC and to prevent pipes from freezing. These features can often be grouped in a small area with insulated walls while the floor above the rest of the basement is insulated.

Can placing insulation on the exterior improve energy performance?

The benefits of exterior insulation are dependent on whether the basement incorporates passive solar design with a large amount of south facing windows. As long as the walls are exposed to solar gain, there will be some energy savings. The energy savings are marginal in a typical basement.

What are the considerations of using vapor barriers in the interior of foundation walls?

If interior insulation is used, a vapor barrier is beneficial. Allow the concrete to dry thoroughly. The vapor barrier prevents the condensation that forms when warmer summer air reaches a cool interior basement wall. Commonly in the Midwest, there is a higher degree of moisture in the air of the basement. Batt insulation is specifically designed for the interior of foundation walls. It prevents air from circulating through the batt and enables water vapor from the walls to disperse because of a perforated poly facing.

Does foundation insulation increase the risk of termite infestation?

No, foundation insulation does not increase the risk. The threat of termite infestation stems from the presence of termites in the soil and wood is utilized in the building. Exterior insulation can complicate the early detection of a termite infestation and can inhibit treatment after discovery.

Is it advisable to include an inspection band where foundation insulation is omitted, permitting ease of inspection for termites?

A number of states, with a likelihood of high termite infestations, do not allow rigid foam insulation in contact with the soil. These states include Florida, South and North Carolina, Georgia, Alabama, Mississippi, Louisiana, eastern Texas, southern and central California, Georgia, Tennessee, and Hawaii. It is best to check the requirements of the local building codes. The results of an ORNL study indicated that inclusion of a vision strip for inspection dispels any benefit of foundation insulation. Some areas require a six inch gap between the top of the foundation insulation and any wood framing member.

Can exterior foundation insulation materials be chemically affected by dampproofing?

Yes, this is a risk. The situation can be avoided by carefully adhering to the instructions of the insulation and dampproofing manufacturers.

What about water proofing?

If the wall is adjacent to habitable space, the codes often require waterproofing as opposed to dampproofing. Check the manufacturer specifications of the foam products utilized. They often include specific recommendations for waterproofing.

How long will exterior foundation insulation last?

When installed properly, interior and exterior foundation insulation should last as long as the insulation installed everywhere else in the building.

Should foam insulation above grade be protected?

Yes. Foam above grade must be protected from both sun and physical damage.
Ultraviolet light degenerates or destroys most foams. Damage from other common yard items such as lawnmowers, balls, and other incidental contact can compromise the appearance and performance of the foam. An assortment of materials commonly used to protect the foam include two- or three-layer stucco finishes, brush-on elastomeric or cementitious finishes, vertical vinyl siding, cement board, aluminum coil stock, and fiberglass panels.

Will insulating the foundation reduce the risk of radon concerns?

Radon enters a home through cracks and other openings below grade. Installing foundation insulation minimizes thermal stresses on the foundation. Thereby reducing the occurrences of cracking and the risk of radon entry.

Should crawl space be ventilated?

In accordance with the CABO One and Two Family Code, every 150 square feet of floor space area requires one square foot of crawl space ventilation. If a vapor barrier is installed, operable vents 1/10 as large can be used. It is difficult to control condensation of warm, damp summer air on cool earth, even with the installation of a poly vapor diffusion retarder. Installing a vapor barrier and closing the operable vents is the preferred method to decrease the risk of crawl space moisture concerns. However, if interpretation of local code requires crawl space ventilation, the preferred method is to insulate the floor and incorporate a vapor barrier.

Do foam insulation boards installed on the interior require fire protection?

Yes. The thermal protection requirement is equal to ½ inch of gypsum wallboard for all interior installations, which include crawl spaces. When approved by a local building code official, Celotex Thermax polyisocyanurate may be installed without a thermal barrier.

Are insulating concrete form (ICF) systems less expensive than an insulated poured in place concrete wall?

Costs for ICFs are project specific and need to be reviewed for benefits gained. Foam used in these systems should adhere to the same building code requirements and address the identical guidelines mentioned above for foam board.

Information References and On-line Resources

Builders Foundation Design Handbook
by J. Carmody, 1991.

Christian, Jeffrey E., ***Energy Efficient Residential Building Foundations,*** ASHRAE Journal, November 1991.
Insulation Materials: Environmental Comparisons, Environmental Building News, Vol. 4, No 1, January/February 1995.

The Model Energy Code and
One and Two Family Dwelling Code
International Code Council (formerly CABO)
5203 Leesburg Pike, Falls Church, VA 22041
Tel: 703-931-4533 Fax: 703-379-1546
Email: staff@intlcode.org
Web site: http://www.intlcode.org

Kansas Corporation Commission
Energy Programs
1500 SW Arrowhead Road Topeka, Kansas 66604
Tel: 785-271-3349
Web site: http://www.kcc.state.ks.us/energy

Kansas State University
Engineering Extension
Ward Hall
Kansas State University
Manhattan, Kansas
Tel: 785-532-4994
Web site: http://www.OZNET.ksu.edu/dp-nrgy

DOE Energy Standards and Guidelines
Pacific Northwest National Laboratory
Richland, Washington
Tel: 509-417-7554 Fax: 509-375-3614
Web site: www://energycodes.org/

EPA Energy Star Homes
U.S. Environmental Protection Agency
Climate Protection Division
401 M Street SW MC:6202J
Washington, DC 20460
Tel: 888-782-7937
Web site: http:/www.energystar.gov

Energy Efficient Building Association
490 Concordia Avenue, St. Paul, MN 55103-2441
Tel: 651-268-7585 Fax: 651-268-7597
E-mail: info@eeba.org
Web site: http://www.eeba.org

Environmental Building News
122 Birge Street Brattleboro, Vermont 05310
Tel: 802-257-7300 Fax: 802-257-7304
Web site: http://www.ebuild.com

Material Sources (manufacturers)
(Consult industry associations for more detailed lists)

Insulation

Boards

Expanded Polystyrene

AFM Corporation
24000 W. Hwy 7 Excelsior, MN 55331
Phone: 612-474-0809 Fax: 612-474-2074
E-mail: m-tobin@r-control.com
Website: www.afmcorp-epsfoam.com

Contour Products
4001 Kaw Drive Kansas City, KS 66102
Phone: 800-638-3626 Fax: 913-321-8063
E-mail: contour@unicom.net
Web site: http://www.contourfoam.com

Polyfoam Packers
2320 Foster Avenue Wheeling, IL 60090
Phone: 847-669-1176 Fax: 847-398-0653
Web site: http://www.polyfoam.com

Extruded Polystyrene

Dow Chemical Co.
200 Larkin Center, 1605 Joseph Drive
Midland,MI 48674
Tel: 800-441-4369 Fax: 517- 832-1465
Web site: http://www.dow.com/styrofoam

Tenneco Building Products
2907 Log Cabin Drive Smyrna, Georgia 30080
Tel: 800-241-4402
Web site: http://www.tennecobuildingprod.com

Polyiscyanurate

Celotex Corporation
4010 Boy Scout Blvd. Tampa, FL 33607
Tel: 813-873-1700 Fax: 813-873-4058
Web site: http://www.celotex.com

Johns Manville Corporation
717 17th St Denver,CO 80202
Tel: 800- 654-3103 Fax: 303-978-2318
Web site: http://www.jm.com

Rock Wool

Roxul, Inc.
551 Harrop Drive Milton, ON L9T 3H3 Canada
Tel: 905-878-8474 Fax: 905-878-8077

Batts

Fiberglass

CertainTeed Corporation
P.O. Box 860 Valley Forge, PA 19482
Tel: 610-341-7000 Fax: (610) 341-7571
Web site: http://www.certainteed.com

Johns Manville Corporation
717 17th St Denver,CO 80202
Tel: 800- 654-3103 Fax: 303-978-2318
Web site: http:// www.jm.com

Owens Corning
Fiberglas Tower Toledo, OH43659
Tel: 419-248-8000 Fax: 614/321-5606 (fax)
Web site: http://www.owenscorning.com

Knauf Fiber Glass GmbH
One Knauf Drive
Shelbyville,IN 46176
Tel: (800) 825-4434 Fax: (317) 398-3675
E-mail: rmg2@knauffiberglass.com
Web site: http://www.knauffiberglass.com

Blown

Cellulose

Central Fiber Corporation
Wellsville, Kansas 66092
Tel: 800-654-6117

Blown-in-batt (BIB) Rockwool

American Rockwool, Inc.
P.O. Box 880
Spring Hope, NC 27882
Tel: 254-478-5111 Fax: 252-478-4172
Web site: http://www.amerrock.com

Insulating Concrete Foam Systems

AFM Corporation
24000 West Hwy 7 Exelsior, MN 55331
Tel: 800-255-0176 fax: 612-474-2074
E-mail: m-tobin@r-control.com
Website: www.afmcorp-epsfoam.com

Greenblock WorldWide Corporation
P.O.Box 749 Woodland Park, CO 80866
Tel: (719) 687-0645 Fax: (719) 687-7820
E-mail: greenblock@building.com
Web site: http://www.greenblock.com

ICE Block
PO Box 3089 Odessa, TX 79761
Tel: 800-ICE-BLOC Fax: 915-561-5622
E-mail: iceblock@concentric.net
Web site: http://www.concentric.net

Lite-Form, Inc.
PO Box 774 Sioux City, IA 51102
tel: 800-551-3313, tel: 712-252-3704
E-mail: info@liteform.com
Web site: http://www.liteform.com

Reward Wall Systems
4115 S. 87th St. Omaha, NE 68127
Tel: 800-468-6344 fax: 402-592-7969
E-mail: info@rewardwallsystem.com
Web site: http://www.rewardwallsystem.com

Termite Treatment

Sentricon Colony Eliminator System

Dow AgroSciences
9330 Zionsville Road Indianapolis, IN 46268-1054
fax: 800-905-7326
Web site: http://www.sentricon.com

Systematic Termite Control

FMC
Chicago, IL Tel: 800-321-1FMC
Web site: http://www.fmc-apgspec.com

Industry Associations

North American Insulation Manufacturers Association
44 Canal Center Plaza Alexandria, VA 22314
Tel: 703-684-0084, Fax: 703-684-0427
E-mail: insulation@naima.org
Web site: http://www.naima.org

Cellulose Insulation Manufacturers Association
136 Keowee Street Dayton, OH45402
Tel: 513-222-2462 Fax: 937-222-5794
E-mail: cima@dayton.net
Web Site: http://www.cima.org

Polyisocyanurate Insulation Manufacturers Association

1331 F Street, NW, Suite 975 Washington, DC 20004
Tel : 202-628-6558 Fax: 202-628-3856
E-mail: pima@pima.org
Web site: http://www.pima.org

Insulating Concrete Form Association
1807 Glenview Road, Suite 203
Glenview, Ilinois, USA 60025
Phone: 847-657-9730 Fax: 847-657-9728
E-mail: icfa@forms.org
Web site: http://www.forms.org