

APPENDICES

A-1: Glossary..... A-2

A-2: R-Values for Common Materials A-7

A-3: Insulation Density Calculations..... A-8

A-4: General Information on Spray Polyurethane Foam (SPF) A-13

A-1: Glossary

ACH: Air Changes per Hour, an estimate of building ventilation or air leakage rates.

ACH50: Air Changes per Hour at 50 pascals, a measurement of a building's air leakage rate, as determined with a blower door.

ACHn: Air Changes per Hour (natural), an estimate of building ventilation or air leakage rates.

Add-a-Hole Method: A diagnostic test to measure/estimate serial leakage, involving adding a hole of known size to one side of the series leakage path and measuring the pressure differential before and after adding the hole.

AFUE: Annual Fuel Utilization Efficiency, the seasonal efficiency of a space heating system. It is expressed as the percentage of useful energy delivered to a building, as impacted by long-term weather conditions, compared to the amount of energy consumed.

AGA: American Gas Association, an organization that provides standards for gas appliances and fuel systems.

Appliance: Any device (refrigerator, freezer, etc.) powered by electricity designed for household use. May be replaced as an ECM as approved by the Division.

ASHRAE: American Society of Heating, Refrigeration, and Air Conditioning Engineers, an organization that provides standards for a wide variety of space conditioning and ventilation work.

Base Load Measures: Energy conservation measures that reduce any energy use of the dwelling unit that is not driven by weather. Base load ECMs may include water heater replacement, CFL/LED lamp replacement, or refrigerator and freezer replacement.

Basement: The substructure of a building, with the exterior walls forming the building foundation. Most of the basement is usually below ground. Wall heights vary, but are usually higher than 70 inches. In Wisconsin, the basement is often the combustion appliance zone. If the basement is unintentionally heated by ducts or pipes, the work done on the basement is sealing and insulating the box sill and sealing any large opening in the exterior walls. If the basement is intentionally heated, the walls may be insulated on the exterior, based how much is above grade exposure and the results of modeling the building with the NEAT audit. See *Section 2.5 Floor and Foundation Insulation* for more information on treatments.

Blower Door: a system used to measure air leakage through a building shell, using a calibrated fan coupled with a pressure gauge.

BTU: British thermal unit, an SI unit of heat energy.

BTUH: BTU per hour, a measurement of an HVAC system's capacity to consume fuel or deliver space conditioning energy.

CAZ: Combustion appliance zone.

CFL: Compact fluorescent lamp.

CFM: Cubic feet per minute, a measurement of air flow (as through a furnace air handler or a blower door).

CFM₅₀: Cubic feet per minute @ 50 pascals, a common standardized measurement of air leakage, as determined using a blower door.

CO: Carbon Monoxide, a colorless, tasteless, odorless gas that is poisonous, even in very low concentrations. It is commonly the result of incomplete combustion of a fuel.

CO₂: Carbon Dioxide, a colorless, tasteless, odorless gas that interferes with thinking and alertness when present in moderate concentrations and is poisonous in high concentrations.

Combustion Appliance Zone (CAZ): The area where vented combustion appliances are located. The zone can be located inside or outside the pressure boundary.

Comfort Sealing: Air-sealing work with the primary purpose of controlling drafts, commonly performed with advice from the dwelling unit's occupant. Comfort sealing is performed when blower door testing cannot be performed. When blower door testing cannot be performed, sealing work is limited to: attic bypass and key juncture sealing, glass replacement, and up to one work hour of comfort sealing.

Completed Measure: A measure installed in accordance with all standards and specifications in program policy.

Completed Unit: A dwelling unit that has received all the appropriate weatherization measures required by the measures list or computerized audit, and has passed a final inspection.

Computerized Audit System: The energy audit approved by the Division for use on 1- to 4-unit buildings and mobile homes.

Conditioned: an area or space heated or cooled by a heating or cooling system controlled to maintain habitable temperatures (as by a thermostat).

Crawl Space: An unfinished space under the floor of a building. The exterior walls are usually no higher than 40 to 50 inches. Most crawl spaces have dirt floors. Access hatches sometimes are in the basement through a common wall or in an outside foundation wall. This area often contains plumbing, wiring, and ductwork. Access to this space is usually limited to servicing the plumbing, wiring, or ductwork. The decision on where to insulate in a crawl space depends on if plumbing or ductwork runs through the space. If it does, usually the outside walls and box sill are sealed and insulated using rigid insulation, fiberglass batts, or two-part foam, rated for the application. In unheated crawl spaces, without ducts and pipes, the box sill and floor of the building are sealed and insulated, often with blown cellulose or fiberglass batts. A continuous moisture barrier must be installed if the crawl space has a dirt floor. See *Section 2.5 Floor and Foundation Insulation* for more information on treatments.

CRF: Cannot Reach Fifty, blower door procedure when 50 pascals of pressure cannot be reached.

Damaged Materials: Materials specifically assigned or designated for a specific dwelling unit/job and are damaged and made unusable either during transit to the job site or at the job site.

DOE: Department of Energy.

Energy Audit: An inspection of the dwelling unit documenting its conditions from a thermal, structural, appliance, lighting, and safety perspective. This may be based on Required Measures List or the Division approved software program that generates a list of recommended weatherization measures for the dwelling unit, according to the software program's specifications.

Energy Conservation Measures (ECMs): The measures installed in a home that return energy cost savings. ECM measures are in contrast with Health and Safety and Repair measures that do not return an energy cost savings benefit

ENERGY STAR®: An EPA/DOE program providing incentives for manufacturers to make energy-efficient products and encouraging consumers to buy these products.

EPA: Environmental Protection Agency.

Final Inspection: The inspection performed on a dwelling unit by a non-crew member. The final inspection follows the completion of on-site work. The final inspection must be performed before the owner can sign off.

Friable Asbestos: Any asbestos-containing product that can be crumbled, pulverized, or reduced to powder by hand pressure.

GFCI: Ground fault circuit interrupter.

Guideline Sealing: Air sealing work completed using the Weatherization Cost-Effective Sealing Guidelines, that includes sealing work between the house and the outside. This work often addresses air leakage sealing near the neutral pressure plane.

Heating Costs: Costs of any source of heating in a dwelling unit used for residential heating purposes. All heating costs for commercial, business or any purpose other than the dwelling unit of the applicant are excluded.

Home Energy: All fuel sources used in a dwelling unit. It includes all heating costs and non-heating costs. Non-heating costs are often referred to on utility bills as base load costs (the base costs before heating costs are included).

HVAC: Heating, ventilation, and air conditioning.

IFGC: International Fuel Gas Code.

Infiltration: The uncontrolled air entering the building, usually at the lower portion of the building.

Intentionally Conditioned: An area or space intended to be heated or cooled by a heating or cooling system, usually to the level controlled by a thermostat in the space.

IWC: Inches of water column—an SI measurement of pressure.

Key Junctures: Junctions between building components, which require careful sealing and/or insulating, (e.g., wall-floor junctions).

kW: Kilowatt, a measurement of electrical power.

kWh: Kilowatt hour, a measurement of electrical use

Lead Based Paint: Paint with a lead content of not less than 0.06% by weight or 0.7 milligrams per square centimeter of painted area.

Lead Safe Working Conditions: Conditions that meet the OSHA and EPA requirements for adequate protection from lead exposure, for both the building occupants and the workers performing the weatherization activities.

LED lamp: Light-emitting diode light bulb.

Make-up Air: Air ducted into a home intentionally to make up for air being exhausted out of the home by exhaust fans or chimneys.

Manual J: The ASHRAE-approved method for calculating building heat loss and estimating the correct capacity for space conditioning systems to be installed.

MHEA: Manufactured Home Energy Audit, energy audit software by DOE for evaluating and prioritizing weatherization work in manufactured housing.

MSDS: Material safety data sheet, describing the hazards of a material and treatment for exposures to the material.

NEAT: National Energy Audit Tool, energy audit software by DOE for evaluating and prioritizing weatherization work in site-built housing.

Non-Guideline Sealing: Major air-sealing work needed prior to other shell-measure activities, to control gross air leakage and protect the building from deterioration caused by air and moisture migration.

NFPA: National Fire Protection Association, an organization that establishes standards for materials and systems that affect building fire safety.

OSHA: Occupational Safety and Health Administration, the agency that establishes rules and regulations to promote worker safety and health.

Pa: Pascal.

pascal: The metric unit of pressure.

ppm: Parts per million, a measure of concentration of one material dissolved in another (as in CO contaminating breathing air).

Pressure Boundary: The various materials and components that make up the air barrier of a home.

psi: Pounds per square inch, the SI unit for measurement of pressure.

PVC: Polyvinyl chloride, material used in PVC pipe and plastic sheeting.

SEER: Seasonal Energy Efficiency Ratio, a measurement of air-conditioning efficiency, as impacted by long-term weather conditions.

Short Basement: A cross between a crawl space and a basement. Short basements often have dirt floors and are accessed through doors in the floor or from the exterior of the building. The exterior walls are usually higher than 40 inches but shorter than 78 inches and may vary if the floor is not level. This space often contains the building's heating and water heating

equipment. Rarely used on a day-to-day basis, they are often only accessed to service the equipment. If a short basement is unintentionally heated by ducts or pipes, the work done in the space is focused on sealing and insulating the box sill and sealing any large openings in the exterior walls. If a short basement is intentionally heated, the walls may be insulated on the exterior, depending on how much wall is exposed above grade, and based on the results of modeling the building with the NEAT audit. The decision on installing a moisture barrier should be made based on the site conditions. See *Chapter 2.5 Floor and Foundation Insulation* for more information.

Sone: Measurement of noise used in rating exhaust fans.

SSE: Steady State Efficiency, expressed as a percentage; a ratio of the amount of useful energy delivered to a building compared to the amount of fuel consumed.

TESP: Total External Static Pressure, a measurement of resistance to air flow in furnace duct systems.

UDC: Wisconsin Uniform Dwelling Code.

Ventilation: The intentional exchange of indoor air with outdoor air to remove pollutants, especially moisture.

Venting: The system of flues, vent connector, and chimney that exhausts combustion gases out of the home.

WRT: With reference to; used to describe the configuration blower door gauge setup during blower door testing.

A-2: R-Values for Common Materials

Material	R-value
Fiberglass or rock wool batts and blown 1"	2.8–4.0
Blown cellulose 1"	3.0–4.0
Vermiculite loose fill 1"	2.7
Perlite 1"	2.4
White expanded polystyrene foam (beadboard) 1"	3.9–4.3
Polyurethane/polyisocyanurate foam 1"	6.2–7.0
Extruded polystyrene 1"	5.0
Sprayed 2-part polyurethane foam 1"	5.8–6.6
Icynene foam 1"	3.6
Oriented strand board (OSB) or plywood 1/2"	1.6
Concrete or stucco 1"	0.1
Wood 1"	1.0
Carpet/pad 1/2"	2.0
Wood siding 3/8–3/4"	0.6–1.0
Concrete block 8"	1.1
Asphalt shingles	0.44
Fired clay bricks 1"	0.1–0.4
Gypsum or plasterboard 1/2"	0.4
Single pane glass 1/8"	0.9
Low-e insulated glass (Varies according to Solar Heat Gain Coefficient (SHGC) rating.)	3.3–4.2
Triple glazed glass with 2 low-e coatings	8.3

A-3: Insulation – Density Calculations

Step 1 – Calculate area of attic: Multiply length time width of the attic to get t of attic.

$$30 \text{ FT} \times 50 \text{ FT} = 1500 \text{ SQ FT}$$

Width Length Area of Attic

Step 2 – Calculate R-value needed to add: Subtract existing R from desired R to get the R-value need to add.

$$R-50 - R-26 = R-24$$

Desired R Existing R R Needed to Add

Step 3 – Calculate bag count: Divide area of attic by coverage per bag from the chart on the bag (number double circled in chart on *Table 1-1* on Page 1-11) to get the estimated bag count.

$$1500 \text{ SQ FT} \div 29.1 = 52 \text{ BAGS}$$

Net wall Area Sq. Ft. Coverage per Bag (from chart) Estimated Bag Count

Divide area of attic by coverage per bag from the chart on the bag to get your Estimated Bag Count.

Attic Insulation – Calculating Density

Step 1 – Calculate volume of installed insulation: Multiply area times the depth of the attic insulation to get the volume of insulation.

$$1500 \text{ SQ FT} \times 6.4/12 \text{ FT} = 800 \text{ CU FT}$$

Area Depth in Inches Inches per Foot Volume of Insulation

Step 2 – Calculate the weight of insulation installed: Take the number of bags times the weight per bag to get the total weight.

$$52 \text{ BAGS} \times 24 \text{ LBS/BAG} = 1248 \text{ LBS}$$

Number of Bags Weight of a Bag Installed Weight

Step 3 – Calculate the density of installed insulation. Divide pounds of insulation by cubic feet of insulation volume to get the density.

$$1248 \text{ LBS} \div 800 \text{ CU FT} = 1.56 \text{ LBS/CU FT}$$

Pounds of Insulation Insulation Volume Installed Density

Note: Density should be between 1.3 and 2.0 pounds per cubic foot or conform to the manufacturer's instructions for density, coverage, and bag count for the desired R-value.

Wall Insulation – Calculating Numbers of Bags

Step 1 – Calculate the perimeter of a house: If the house is a simple rectangle or near a simple rectangle, use the formula below. If the house has numerous unequal sides, simply add the lengths together to find the perimeter.

$$(2 \times 50 \text{ FT}) + (2 \times 30 \text{ FT}) = 160 \text{ FT}$$

Length Width Perimeter of House

Step 2 – Calculate the total wall area: After calculating the perimeter of the house, multiply it times the wall height. This will give the total wall area.

$$160 \text{ FT} \times 8 \text{ FT} = 1280 \text{ SQ FT}$$

Perimeter of House Height of Wall Total Wall Area

Step 3 – Calculate the net wall area: Calculate the sum of the areas of the windows and doors. Subtract them from the total wall area to get the net wall area.

$$1280 \text{ SQ FT} - 150 \text{ SQ FT} = 1130 \text{ SQ FT}$$

Total Wall Area Area of Windows and Doors Net Wall Area

Wall Insulation – Calculating Number of Bags (Continued)

Step 4 – Calculating bag count: Multiply the net wall area by 1.1 to 1.5 pounds per square foot for a 2 x 4 wall. Then divide the number of pounds per bag to get the bag count.

$$\frac{1130 \text{ SQ FT} \times 1.2 \text{ LBS/SQ FT}}{24 \text{ LB PER BAG}} = 57 \text{ BAGS}$$

Net Wall Area

Weight of a Bag

Pounds per Sq. Ft. (based on)

Bags of Insulation Needed

Wall Insulation – Calculating Density

Step 1 – Calculate the wall volume: Multiply the wall's surface area times the depth of the wall cavity converted to feet.

$$57 \text{ BAGS} \times 24 \text{ LBS/BAG} = 1368 \text{ LBS}$$

Bags Installed
Weight of a Bag
Pounds of Insulation

Step 2 – Calculate the weight of the insulation: Multiply the number of bags installed times the weight of a single bag to get the weight of the installed insulation.

$$1280 \text{ SQ FT} \times 3.5/12 \text{ FT} = 373 \text{ CU FT}$$

Net Wall Area
Inches of Wall Depth
Inches per Foot
Wall Volume

Step 3 – Calculate the density of the installed insulation: Divide the pounds of insulation by the cubic feet of insulation volume to calculate the density.

$$1388 \text{ LBS} \div 373 \text{ CU FT} = 3.67 \text{ LBS/CU FT}$$

Pounds of Insulation
Insulation Volume
Installed Density

A-4: General Information on Spray Polyurethane Foam (SPF)

Low-Pressure SPF

Low-pressure SPF systems are two-component polyurethane foam products. They are typically delivered to the job site in pressurized canisters (~250 psi), dispensed through unheated hoses through a disposable mixing nozzle system, and applied as a froth-like material to substrate. This type of SPF product is typically used for air sealing and small-scale insulation projects and most commonly come in 200 or 600 board foot disposable kits.

High-Pressure SPF

High-pressure SPF systems are two-component polyurethane foam products. They are typically delivered to the job site in unpressurized drums or totes, and dispensed by a proportioner pump where heat and pressure are added. These chemicals travel through heated hoses to a spray gun where the material mixes and is aerosolized during application. This type of SPF product is typically used for larger insulation applications.

Once installed, there is essentially no difference in product performance between low- and high-pressure foams. It should be noted that the main differences between the two types of systems are the application rate, PPE requirements, air borne concentrations of chemicals during application, and capital equipment investment.

Applicators should obtain training from the suppliers of SPF to help assure installation quality and use of all equipment as well as safe handling, use, and disposal of all chemicals used in the process. Spray Polyurethane Foam Alliance (SPFA) also offers additional resources for low and high-pressure SPF products.

Safety and Application

During application of SPF products chemicals are released into the air during the mixing of the chemicals. Chemical fumes can be inhaled and chemical dust can be absorbed through the skin making proper ventilation and appropriate PPE critical in preventing exposure to the applicator. Exposure to SPF chemicals can occur even at low exposure levels. Customers should be informed about the use of SPF products in their home, and installers should be well informed about the procedures used to keep them safe. Employers must assure compliance with OSHA's hazard communication requirements. Customer's belongings must be protected from overspray during use, and the substrate that the foam is being applied to must be free of excessive dirt as the foam will expand in all directions. If the area is not properly prepared prior to application the foam may not adhere or can pull away from the surface.

Manufacturer Installation Instructions

SPF applicators should follow all manufacturer installation instructions for the product being used. These instructions include product-specific documents such as application instructions, Safety Data Sheets (SDS), and evaluation reports.