(b) The department or municipality administering and enforcing this code may grant additional reasonable time in which to comply with a violation order.

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80; am. (1) (a) and (2), Register, February, 1985, No. 350, eff. 3-1-85.

ILHR 20.22 Penalties and violations. (1) VIOLATIONS. No person shall construct or alter any dwelling in violation of any of the provisions of this code.

(a) *Injunction.* When violations occur, the department may bring legal action to enjoin any violations.

(b) *Ordinances.* This code shall not affect the enforcement of any ordinance or regulation, the violation of which occurred prior to the effective date of this code.

(2) PENALTIES. Pursuant to ss. 101.66 and 101.77, Stats., whoever violates this code shall forfeit to the state not less than $25 nor more than $500 for each violation. Each day that the violation continues, after notice, shall constitute a separate offense.

(3) MUNICIPAL ENFORCEMENT. Any municipality which administers and enforces this code may provide, by ordinance, remedies and penalties for violation of that jurisdiction exercised under s. 101.65, Stats. These remedies and penalties shall be in addition to those which the state may impose under subs. (1) and (2). Any municipality invoking a remedy or penalty, including forfeiture, shall promptly notify the department of the remedy or penalty being imposed and the reason therefor.

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80.

SUBCHAPTER IX—ADOPTION OF STANDARDS

ILHR 20.24 Adoption of standards. All dwellings shall be required to be designed by the method of structural analysis or the method of accepted practice outlined in chs. ILHR 20 to 25. Dwellings designed by the method of structural analysis shall comply with the standards and manuals listed in subs. (1) to (5). Pursuant to s. 227.025, Stats., the attorney general and the revisor of statutes have consented to the incorporation by reference of the following standards. Copies of the standards are on file in the offices of the department, the secretary of state and the revisor of statutes. Copies for personal use may be obtained, at a reasonable cost, from the organizations listed.

(1) American Institute of Steel Construction, 1221 Avenue of the Americas, New York, N.Y. 10020, SPECIFICATION FOR THE DESIGN, FABRICATION AND ERECTION OF STRUCTURAL STEEL FOR BUILDINGS, WITH COMMENTARY, November 1, 1978.

(2) American Concrete Institute (ACI), P.O. Box 19150, Redford Station, Detroit, Michigan 48219, BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE, ACI 318-83; BUILDING CODE REQUIREMENTS FOR STRUCTURAL PLAIN CONCRETE, ACI 318.1-83.

(2k) American Society for Testing and Materials (ASTM), 1916 Race Street, Philadelphia, PA 19103, STANDARD SPECIFICATION FOR

MORTAR FOR UNIT MASONRY, ASTM Designation C270-82; STANDARD PRACTICE FOR MEASURING AIR LEAKAGE BY THE FAN PRESSURIZATION METHOD, ASTM Designation E799-81.

(2m) American Society of Heating, Refrigerating, and Air-conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, N.E., Atlanta, Georgia 30329, ENERGY CONSERATION IN NEW BUILDING DESIGN, ASHRAE Standard 90A-80.

(2n) American Wood Preservers Bureau, 2772 S. Randolph St., P.O. Box 6085, Arlington, Virginia 22206, STANDARD FOR SOFTWOOD LUMBER, TIMBER AND PLYWOOD PRESSURE TREATED WITH WATER-BORNE PRESERVATIVES FOR ABOVE GROUND USE, AWPB standard LP-2, 1980; STANDARD FOR SOFTWOOD LUMBER, TIMBER AND PLYWOOD PRESSURE TREATED WITH WATER-BORNE PRESERVATIVES FOR GROUND CONTACT USE, AWPB standard LP-22, 1980; QUALITY CONTROL PROGRAM FOR SOFTWOOD LUMBER, TIMBER AND PLYWOOD PRESSURE TREATED WITH WATER-BORNE PRESERVATIVES FOR GROUND CONTACT USE IN RESIDENTIAL AND LIGHT COMMERCIAL FOUNDATIONS, AWPB standard FDN, 1980.

(3) National Bureau of Standards, U.S. Department of Commerce, Washington, D.C. 20234, MODEL DOCUMENTS FOR THE EVALUATION, APPROVAL, AND INSPECTION OF MANUFACTURED BUILDINGS, NBS Building Science Series 87, July 1976.

(4) National Forest Products Association, 1619 Massachusetts Ave. N.W., Washington, D.C. 20036, NATIONAL DESIGN SPECIFICATION FOR WOOD CONSTRUCTION, 1982 edition, except for sections 2.2.5.3. and 4.1.7., including DESIGN VALUES FOR WOOD CONSTRUCTION, March, 1982, supplement; THE ALL-WEATHER WOOD FOUNDATION SYSTEM, Basic Requirements, Technical Report No. 7, March, 1982, except for sections 3.3.1. and 6.7.

(5) Portland Cement Association, 5420 Old Orchard Road, Skokie, Illinois 60076, CONCRETE MASONRY HANDBOOK FOR ARCHITECTS, ENGINEERS, BUILDERS, fourth edition, 1976.

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80; am. (intro.) and (2), cr. (2m) and (2n), r. and recr. (4), Register, February, 1985, No. 350, eff. 3-1-85; renum. (2m) to be (2k) and am., cr. (2m), Register, July, 1986, No. 367, eff. 1-1-87.

4. Width. The width of the ladder shall be a minimum of 20 inches wide and a maximum of 30 inches wide.

5. Handrails. a. Handrails shall be required for ladders with pitches less than 65°.

b. Handrails shall be located at least 30 inches, but not more than 34 inches, above the nosing of the treads.

c. Open handrails shall be provided with intermediate rails or an ornamental pattern such that a sphere with a diameter larger than 9 inches cannot pass through.

d. The clearance between the handrail and the wall surface shall be at least 1½ inches.

e. Handrails shall be designed and constructed to withstand a 200 pound load applied in any direction.

6. Clearances. a. The ladder shall have a minimum clearance of at least 15 inches on either side of the center of the tread.

b. The edge of the tread nearest to the wall should be separated from the wall by at least 7 inches.

c. A passage way clearance of at least 30 inches parallel to the slope of a 90° ladder shall be provided. A passage way clearance of at least 36 inches parallel to the slope of a 75° ladder shall be provided. Clearances for intermediate pitches shall vary between these 2 limits in proportion to the slope.

d. For ladders with less than a 75° pitch the vertical clearance above any tread or rung to an overhead obstruction shall be at least 6 feet 4 inches measured from the leading edge of the tread or rung.

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80; r. and recr. Register, February, 1985, No. 350, eff. 3-1-85.

ILHR 21.05 Light and ventilation. **(1)** NATURAL LIGHT. All habitable rooms shall be provided with natural light by means of glazed openings. The area of the glazed openings shall be at least 8% of the net floor area, except under the following circumstances:

(a) *Exception.* Habitable rooms, other than bedrooms, located in basements need not be provided with natural light.

(b) *Exception.* Natural light may be obtained from adjoining areas through glazed openings, louvers or other approved methods. Door openings into adjoining areas may not be used to satisfy this requirement.

(2) VENTILATION. (a) *Natural ventilation.* Natural ventilation shall be provided to all habitable rooms, kitchens and bathrooms by means of openable exterior doors or windows. The net area of the openable exterior doors or windows shall be at least 3.5% of the net floor area of the room. Mechanical ventilation may be provided in lieu of openable exterior doors or windows provided the system is capable of providing at least one air change per hour.

(b) *Exhaust ventilation.* All exhaust ventilation shall terminate outside the building.

(3) ATTIC VENTILATION. Ventilation above the ceiling/attic insulation shall be provided as specified in either s. ILHR 22.05 (3) (a) or s. ILHR 22.11 (3) (a).

(4) CRAWL SPACE VENTING. Crawl spaces shall be vented in accordance with either s. ILHR 22.05 (3) (b) or s. ILHR 22.11 (3) (b). Unheated crawl spaces shall be provided with a concrete slab, roll roofing or plastic film vapor barrier.

(5) SAFETY GLASS. Glass in entrance and exit doors, sliding glass doors, storm doors, bathtub enclosures, shower doors, and fixed glass panels immediately adjacent to doors shall be safety glass.

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80; r. and recr. (1) and (2), Register, February, 1985, No. 350, eff. 3-1-85; r. and recr. (3) and (4), Register, July, 1986, No. 367, eff. 1-1-87.

ILHR 21.06 Ceiling height. All habitable rooms, kitchens, hallways, bathrooms and corridors shall have a ceiling height of at least 7 feet. Habitable rooms may have ceiling heights of less than 7 feet provided at least 50% of the room's floor area has a ceiling height of at least 7 feet. Beams and girders or other projections shall not project more than 8 inches below the required ceiling height.

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80; r. and recr. Register, February, 1985, No. 350, eff. 3-1-85.

ILHR 21.07 Attic and crawl space access. (1) ATTIC. Attics shall be provided with an access opening of at least 14 by 24 inches, accessible from inside the structure.

(2) CRAWL SPACE. Crawl spaces shall be provided with an access opening of at least 14 by 24 inches.

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80.

ILHR 21.08 Firestopping, draftstopping and fire separation. (1) FIRESTOPPING LOCATIONS. Firestopping shall be provided in the following locations:

(a) In concealed spaces of walls and partitions, including furred spaces, at the ceiling and floor levels;

(b) At all interconnections between concealed vertical and horizontal spaces such as occur at soffits, drop ceilings and cove ceilings; and

(c) In concealed spaces between stair stringers at the top and bottom of the run.

(2) FIRESTOPPING MATERIALS. Firestopping shall consist of 2-inches nominal lumber or 2 thicknesses of one inch nominal lumber or one thickness of ¾-inch plywood with joints backed by ¾-inch plywood. Gypsum wallboard, mineral wool insulation or other noncombustible material may also be used for firestopping.

2. Prevent attaching combustible furring and sheathing to the masonry exterior.

(e) All spaces between the masonry and the framing shall be draft stopped.

History: Cr. Register, February, 1985, No. 350, eff. 3-1-85.

ILHR 21.31 Factory-built fireplace stoves. Factory-built fireplace stoves, consisting of a free-standing chamber assembly, shall be tested and listed by a nationally recognized testing laboratory. The assembly shall be erected and maintained in accordance with the listing.

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80.

ILHR 21.32 Factory built fireplaces. Factory-built fireplaces consisting of a fire chamber assembly, one or more chimney sections, a roof assembly and other parts shall be tested and listed by a nationally recognized testing laboratory.

(1) FIREPLACE ASSEMBLY AND MAINTENANCE. The fireplace assembly shall be erected and maintained in accordance with the conditions of the listing.

(2) DISTANCE FROM COMBUSTIBLES. Portions of the manufactured chimney extending through combustible floors or roof/ceiling assemblies shall be installed in accordance with the distances listed on the chimney in order to prevent contact with combustible materials.

(3) HEARTH EXTENSIONS. Hearth extensions of not less than ⅜-inch thick hollow metal, stone, tile or other approved material shall be provided. The minimum dimensions of the hearth shall be based upon the size of the fireplace opening as specified in Table 21.32-1.

TABLE 21.32-1
HEARTH DIMENSIONS

Fireplace Opening (sq. ft.)	Extension from Firebox (inches)	
	Side	Front
Less than 6	8	16
6 or Greater	12	20

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80; renum. from Ind 21.30 and r. and recr. (3), Register, February, 1985, No. 350, eff. 3-1-85.

Chapter ILHR 22

ENERGY CONSERVATION

Note: Chapter Ind 22 was renumbered to be chapter ILHR 22, Register, February, 1985, No. 350, eff. 3-1-85.

Subchapter I—Scope and Purpose

ILHR 22.01 Scope. The provisions of this chapter shall apply to all newly constructed conventional and manufactured one- and 2-family dwellings.

History: Cr. Register, May, 1978, No. 269, eff. 12-1-78.

ILHR 22.02 Purpose. (1) The purpose of this chapter is to provide design requirements which will improve the utilization of energy in one- and 2-family dwellings as defined in s. ILHR 22.01, including minimum requirements for materials and methods of construction and for heating, cooling and air conditioning equipment and systems.

(2) The requirements of this chapter are intended to be flexible and to permit the use of innovative approaches and techniques to achieve effective utilization of energy.

(3) The requirements of this chapter are not intended to conflict with any safety or health requirements. Where such conflict occurs, the safety and health requirements shall govern.

History: Cr. Register, May, 1978, No. 269, eff. 12-1-78.

Subchapter II—Definitions

ILHR 22.03 Definitions. (1) "Annual fuel utilization efficiency" or "AFUE" means the efficiency rating of the heating plant model determined on average usage conditions as set out in the U.S. Department of Energy test procedures.

Note: The higher the AFUE rating, the higher the heating plant efficiency will be.

(1m) COEFFICIENT OF PERFORMANCE (COP), COOLING OR HEATING. Coefficient of performance (COP) means the ratio of the rate of net heat removal or net heat output to the rate of total energy input, expressed in consistent units and under designated rating conditions.

(2) COMBUSTION EFFICIENCY. "Combustion efficiency" is expressed in percentage and is defined as 100% minus stack losses in percent of heat input. Stack losses are a) loss due to sensible heat in dry flue gas, b) loss due to incomplete combustion, and c) loss due to sensible and latent heat in moisture formed by combustion of hydrogen in the fuel.

(3) COOLING LOAD. Cooling load is the rate at which heat must be removed from the space to maintain a selected indoor air temperature during periods of design outdoor weather conditions.

(4) DEGREE DAY, HEATING. Degree days are figured as the number of degrees the mean outdoor temperature deviates from 65° F each day during the heating season.

Note: For example, if, on December 15, the low temperature was + 30° F and the high temperature was + 50° F, the mean temperature would equal (30° + 50°) ÷ 2 = 40°; therefore, 65° - 40° = 25 degree days.

(4m) "Electrically heated" means provided with permanently installed electrical space heating equipment which has an input capacity of 3 kilowatts or more to meet all or part of the space heating requirements.

(5) ENERGY EFFICIENCY RATIO. The energy efficiency ratio is the ratio of net cooling capacity in Btu per hour to total rate of electric input, in watts, under designated operating conditions.

(5m) "Equivalent leakage area" or "ELA" means the estimated area of a hole in the thermal envelope of a building which would exist if all the leakage openings were gathered into one location.

(6) HEATED SPACE. Heated space is any space provided with a supply of heat to maintain the temperature of the space to at least 50° F. Heat supplied by convection from the energy-consuming systems may satisfy this requirement in basements if the energy-consuming systems are not insulated.

(7) HEATING LOAD. Heating load is the probable heat loss of each room or space to be heated, based on maintaining a selected indoor air temperature during periods of design outdoor weather conditions. The total heat load includes: the transmission losses of heat transmitted through the wall, floor, ceiling, glass or other surfaces; the infiltration losses or heat required to warm outdoor air which leaks in through cracks and crevices, around doors and windows, or through open doors and windows; or heat required to warm outdoor air used for ventilation.

(7m) "Infiltration barrier" means a material which restricts the movement of air and liquid water, but is permeable to water vapor.

(7r) "Overall thermal transmittance" or "U_O" means the area-weighted average of the thermal transmittance values of all materials, including framing and fenestration, which make up a building section.

Note: Additional explanatory material is contained in the appendix.

(8) PERM. Perm is the designation for the unit permeance which is a substitute for the unit, one grain per (hour) (square foot) (inch of mercury vapor pressure difference).

(9) RESISTANCE, THERMAL (R). Thermal resistance (R) is a measure of the ability to retard the flow of heat. The R-value is the reciprocal of a heat transfer coefficient, expressed by U (R = 1/U). The higher the R-value of a material, the more difficult it is for heat to flow through the material.

(9m) "Thermal envelope" means the collective assemblies of the building which enclose the heated space and define the surface areas through which the design heating loss is calculated. The components which make up the thermal envelope form a continuous, unbroken surface.

(10) THERMAL TRANSMITTANCE (U). Thermal transmittance (U) is the coefficient of heat transmission or thermal transmittance (air to air) expressed in units of Btu per (hour) (square foot) (degree F). It is the time rate of heat flow. The U-value applies to combinations of different materials used in series along the heat flow path and also to single materials that comprise a building section, and includes cavity air spaces and surface air films on both sides. The lower the U-value of a material, the more difficult it is for heat to flow through the material.

History: Cr. Register, May, 1978, No. 269, eff. 12-1-78; renum. (1) to be (1m), cr. (1), (4m), (5m), (7m), (7r) and (9m), Register, July, 1986, No. 367, eff. 1-1-87.

Subchapter III—Design Criteria For Dwellings Which Use Fuels Other Than Electricity For Space Heating

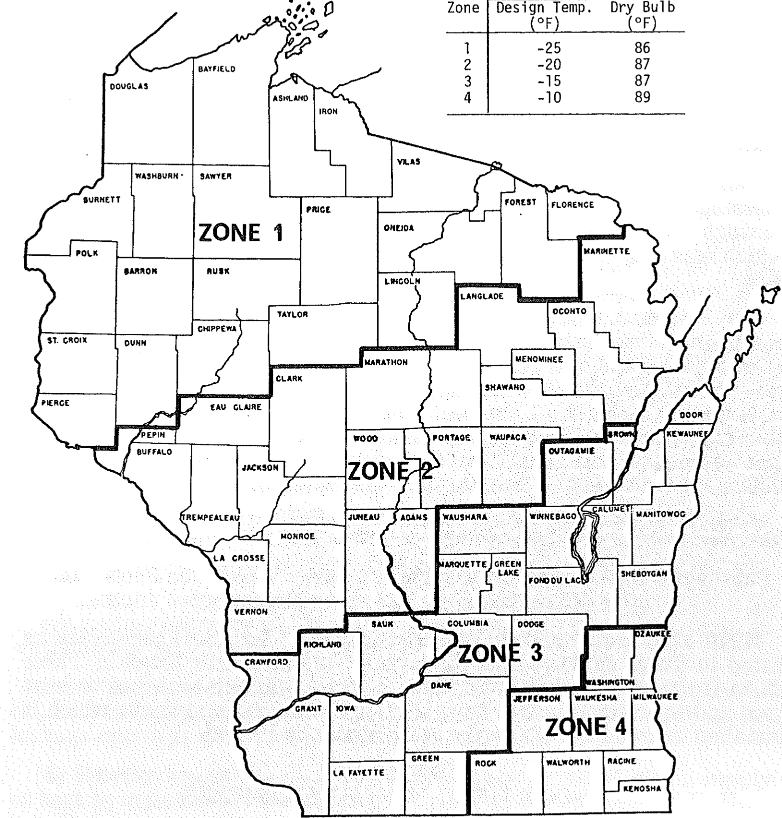
ILHR 22.04 Indoor and outdoor temperatures. The indoor temperatures listed in Table 22.04-A and the outdoor temperatures listed in Table 22.04-B shall be used to determine the total building heat loss or heat gain and to select the size of the heating or cooling equipment which is installed in dwellings which are not electrically heated.

TABLE 22.04-A
INDOOR DESIGN TEMPERATURES

Season	Temperature
Winter	70° F
Summer	78° F

TABLE 22.04-B
OUTDOOR DESIGN CONDITIONS

Zone	Winter Design Temp. (°F)	Summer Dry Bulb (°F)
1	-25	86
2	-20	87
3	-15	87
4	-10	89



History: Cr. Register, May, 1978, No. 269, eff. 12-1-78; am. Register, July, 1986, No. 367, eff. 1-1-87.

ILHR 22.05 Moisture control for non-electrically heated dwellings. The provisions of this section for moisture control shall apply to non-electrically heated dwellings.

(1) VAPOR BARRIERS. Where thermal insulation is used, a vapor barrier shall be installed. The vapor barrier shall be installed on the interior side of the insulation, facing the heated interior, and behind the interior finish at the wall, ceiling and roof/ceiling assemblies. The vapor barrier shall cover the exposed insulation and interior face of studs, joists and rafters. Vapor barriers shall also be provided in crawl spaces, under slab floors, and around the exterior insulation installed around ducts in unheated areas. The transmission rate shall not exceed one perm.

Note: In truss floor/ceiling systems, the vapor barriers may be applied to the bottom chord of the truss, extending up along each side of the truss and across the back side of the insulation in the truss cavity. Rigid plastic insulation board may be applied to the bottom chord, if protected with ½-inch gypsum wallboard.

(2) RELATIVE HUMIDITY. Where a power humidifier is installed, the humidifier shall be equipped with a control to regulate the relative humidity.

(3) VENTILATION. (a) *Attics.* Ventilation above the ceiling/attic insulation shall be provided.

1. The free ventilating area shall be at least 1/300 of the horizontal area of the ceiling. At least 50% of the required free ventilating area shall be distributed at the low sides of the roof, the remainder of the vents shall be provided in the upper one-half of the roof or attic area.

2. If all the ventilating area is provided at one level, then the ventilating area shall be at least 1/150 of the horizontal area of the ceiling.

3. The ventilation space above any non-rigid insulation in a cathedral ceiling assembly shall be at least one inch in height.

(b) *Crawl spaces.* Ventilation shall be provided in crawl spaces which are outside the thermal envelope. The area of ventilation shall be at least 1/1500 of the floor space. At least 50% of the ventilating area shall be provided at opposite sides of the crawl space or as far apart as possible.

History: Cr. Register, May, 1978, No. 269, eff. 12-1-78; cr. (intro), r. and recr. (3), Register, July, 1986, No. 367, eff. 1-1-87.

Subchapter IV—Thermal Envelope Requirements For Dwellings Which Use Fuels Other Than Electricity For Space Heating

ILHR 22.06 Insulation standards for non-electrically heated dwellings. The thermal envelope of dwellings which are not electrically heated shall be insulated to meet the requirements of this section.

Note: If the office of state planning and energy certifies that there is a shortage of insulating materials that are routinely used in construction of one- and 2-family dwellings, the department will modify the requirements of s. ILHR 22.06 in accordance with the available supply of insulating material, with an emergency rule. When the office of state planning and energy certifies that shortages have been remedied, the department will reinstate the requirements of s. ILHR 22.06.

(1) SLAB-ON-GRADE. The overall thermal transmittance (U_0 value) through slab-on-grade floors shall not exceed .11 Btu per (hour) (square foot) (degree F). All slab-on-grade floors located within 24 inches of the exterior grade shall be insulated. The insulation shall extend downward from the top of the slab to below the frost depth, but not less than 48

inches; or downward vertically from the top of the slab 24 inches and 24 inches horizontally under the slab.

(2) FLOORS OVER UNHEATED AREAS. The overall thermal transmittance (U_0 value) through floors over unheated areas shall not exceed .09 Btu per (hour) (square foot) (degree F). Insulation is not required in floors over heated crawl space areas or basement areas.

(3) WINDOWS. All windows, except for basement windows, shall be double glazed or have storm windows.

Note: See Table A-1 of Appendix A which was developed to serve as a guide to indicate the percentage of glass which can be used for different types of wall construction.

(4) BOX SILL. The box sill area shall be insulated to the same level as the wall.

(5) ROOF/CEILINGS. The overall thermal transmittance (U_0 value) through roof/ceiling assemblies shall not exceed .029 Btu per (hour) (square foot) (degree F).

(6) EXTERIOR WALLS. The exposed exterior walls above grade shall be insulated in accordance with par. (a) or pars. (b) and (c).

(a) *Exposed exterior walls above grade.* The overall thermal transmittance (U_0 value) through exposed exterior walls above grade shall not exceed .13 Btu per (hour) (square foot) (degree F).

(b) *Exterior walls above the foundation wall.* The overall thermal trasnmittance (U_0 value) through exterior walls above the foundation wall shall not exceed .12 Btu per (hour) (square foot) (degree F).

(c) *Exposed foundation walls above grade.* The overall thermal transmittance exposed foundation walls above grade shall not exceed the following U_0 values:

1. If 25% or less of the foundation wall is exposed, U_0 = .25 Btu per (hour) (square foot) (degree F).

2. If more than 25% of the foundation wall is exposed, the thermal transmittance of 25% of the wall shall not exceed .25 Btu per (hour) (square foot) (degree F) and the remaining exposed portion shall have a thermal transmittance of not more than .12 Btu per (hour) (square foot) (degree F).

(7) ELECTRICAL BOXES. Insulation shall be provided behind electrical boxes located in exterior walls.

(8) BELOW GRADE FOUNDATION INSULATION. A thermal transmittance (U_0 value) of .20 Btu per (hour) (square foot) (degree F) shall be required for below grade foundation walls to a level of 3 feet below grade or to the top of the footing.

(9) SYSTEM DESIGN. The overall transmission of heat (U value) through any one component (such as wall, roof/ceiling or floor) may be increased and the U-value for other components decreased provided that the overall heat loss for the entire building enclosure does not exceed the total heat loss resulting from complying with subs. (1) through (8).

Note: See Appendix A for an example of the system design procedure.

(10) ACCURACY OF CALCULATIONS. The thermal transmittance (U_0) values and building dimensions used in heat gain or loss calculations shall have a minimum decimal accuracy of 3 places rounded to 2, except that the U_0 values used for calculating ceiling transmission shall have a minimum decimal accuracy of 4 places rounded to 3.

History: Cr. Register, May, 1978, No. 269, eff. 12-1-78; r. (5) and (6) eff. 3-31-79 and cr. (5a) and (6a), eff. 4-1-79; r. (6a), eff. 3-31-80 and cr. (6b), eff. 4-1-80; am. (intro.), renum. (5a) and (6b) to be (5) and (6) and am., Register, July, 1986, No. 367, eff. 1-1-87.

ILHR 22.07 Air leakage. Provisions for the limitation of air leakage in dwellings which are not electrically heated shall be made in accordance with this section.

(1) GENERAL. All windows and doors shall be constructed and installed to minimize air leakage.

(2) DOORS AND WINDOWS. Manufactured windows shall be constructed and installed to limit infiltration to .5 cubic feet per minute per foot of sash crack. The air infiltration rate of sliding glass doors shall not exceed .5 cubic feet per minute per square foot of door area. The air infiltration rate for swinging doors shall not exceed 1.25 cubic feet per minute per square foot of door area.

Note: The department will recognize windows and doors tested in conformance with ASTM E-283, Standard Method of Test for Rate of Air Leakage Through Exterior Curtain Walls and Doors.

(3) EXTERIOR OPENINGS. Exterior joints around windows and door frames; between wall cavities and window or door frames; between walls and foundations; between walls and roofs; between walls and floors; between separate wall panels; at penetrations of utility services through walls, floors and roofs; and all other openings in the exterior building envelope shall be caulked, gasketed, weatherstripped or otherwise sealed.

(4) INTERIOR OPENINGS. Openings through the top plate of frame walls shall be caulked, gasketed, packed with insulation, or otherwise sealed.

History: Cr. Register, May, 1978, No. 269, eff. 12-1-78; Cr. (intro.), Register, July, 1986, No. 367, eff. 1-1-87.

Subchapter V - Insulation and Infiltration Standards For Electrically Heated Dwellings

ILHR 22.08 Purpose and authority. The purpose of this subchapter is to provide design requirements to improve energy efficiency of conventionally built and manufactured one- and 2-family dwellings which use electricity for space heating as required by ss. 101.63 (1m) and 101.73 (1m), Stats.

History: Cr. Register, July, 1986, No. 367, eff. 1-1-87.

ILHR 22.085 Applications. (1) NEW DWELLINGS. The provisions of this subchapter shall apply to any new electrically heated dwelling or dwelling unit for which a uniform building permit was issued on or after January 1, 1987.

(2) DWELLINGS EXISTING BEFORE DECEMBER 1, 1978. The provisions of this subchapter shall not apply to any dwelling or dwelling unit for which a uniform building permit was issued before December 1, 1978, or to additions or alterations to such dwellings.

(3) ADDITIONS TO DWELLINGS OR DWELLING UNITS. (a) Additions to a dwelling or dwelling unit shall be constructed in compliance with the requirements of this subsection whenever one of the following conditions apply:

1. The uniform building permit for the original dwelling or dwelling unit was issued on or after January 1, 1987, and the dwelling or dwelling unit is electrically heated; or

2. The uniform building permit for the original dwelling or dwelling unit was issued on or after January 1, 1987, and the combined input capacity of permanently installed electrical space heating equipment of the original dwelling or dwelling unit and the new addition exceeds 3 kilowatts; or

3. The uniform building permit for the original dwelling or dwelling unit was issued on or after December 1, 1978, but before January 1, 1987, and the addition is provided with permanently installed electrical space heating equipment with an input capacity of 3 kilowatts of more.

(b) An addition to a dwelling or dwelling unit to which one of the 3 conditions of par. (a) apply, shall be insulated to meet the requirements of s. ILHR 22.12 with one of the following methods.

1. The addition alone may be insulated in accordance with s. ILHR 22.12 (1) via the component method;

2. The addition alone may be insulated in accordance with s. ILHR 22.12 (2) via the system method; or

3. The entire dwelling, including the addition, may be insulated in accordance with s. ILHR 22.12 (2) via the system method.

(4) ALTERATIONS TO DWELLINGS OR DWELLING UNITS CONSTRUCTED AFTER JANUARY 1, 1987. (a) *Electrically heated dwellings or dwelling units.* Any alteration made to an electrically heated dwelling or dwelling unit for which a uniform building permit was issued on or after January 1, 1987 shall be made in accordance with the provisions of this subchapter which are in effect at the time the permit for the alteration is issued.

(b) *Non-electrically heated dwellings and dwelling units.* 1. Whenever an alteration to a non-electrically heated dwelling or dwelling unit for which a uniform dwelling permit was issued on or after January 1, 1987, results in the addition of permanently installed space heating equipment so that the combined input capacity of all sources of permanently installed electrical space heating equipment in the dwelling or dwelling unit exceeds 3 kilowatts, the alteration shall be performed in accordance with the requirements of this subchapter which are in effect at the time that the permit for the alteration is issued.

2. Alterations which do not result in an increase in the electric space heating input capacity to over 3 kilowatts, shall be made in compliance with the provisions of subchapters III and IV which are in effect at the time the permit for alterations is issued.

(5) ALTERATIONS TO DWELLINGS OR DWELLING UNITS CONSTRUCTED AFTER DECEMBER 1, 1978, BUT BEFORE JANUARY 1, 1987. Any alteration which is made to a dwelling or dwelling unit for which a uniform building permit was issued on or after December 1, 1978, but before January 1,

1987, shall be made in compliance with the requirements for non-electrically heated dwellings specified in this chapter which are in effect at the time the permit for the alteration is issued.

Note: The intent of this subsection is to assure that a dwelling which is built in accordance with this code continues to meet minimum health, safety and energy conservation standards whenever additions and alterations are made to the dwelling. It is not the intent of this section however, to require additional modifications beyond those necessary to achieve the intended alteration or addition. For example, if a window is being replaced, the replacement window must meet the infiltration and thermal transmission requirements of the current code. If new windows are to be cut into the exterior wall, the new windows must meet code requirements and, because insulation had to be removed from the wall to put in the windows, the insulation requirements of the current code must be met by using either the component or system method. As another example, when electric heat is added to the basement area and the walls are not to be altered, insulation does not have to be installed. If insulation is removed from the basement ceiling, however, to create a heated basement, the insulation requirements of the current code must be met by the component or system method.

History: Cr. Register, July, 1986, No. 367, eff. 1-1-87.

ILHR 22.09 Accuracy of calculations. The thermal resistance or thermal transmittance values used in heat gain or loss calculations for electrically heated dwellings shall be supplied by the material manufacturer or as given in the ASHRAE Handbook of Fundamentals. The thermal transmittance values used in heat gain or loss calculations shall have a minimum decimal accuracy of 4 places, rounded to 3. Thermal envelope areas shall have a minimum decimal accuracy of 3 places, rounded to 2.

Note: ASHRAE is an acronym for the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. Copies of the ASHRAE Handbook of Fundamentals may be purchased from the ASHRAE Publications Sales Department, 1791 Tullie Circle, N.E., Atlanta, Georgia 30329. A list of R-values for most building materials reprinted from ASHRAE Fundamentals is given in Appendix A.

History: Cr. Register, July, 1986, No. 367, eff. 1-1-87.

ILHR 22.10 Indoor and outdoor temperatures. The indoor temperatures listed in Table 22.10-A and the outdoor temperatures listed in Table 22.04-B shall be used to determine the total building heat loss or gain and to select the size of the heating or cooling equipment which is installed in electrically heated dwellings in accordance with s. ILHR 22.15.

TABLE 22.10-A
Indoor Design Temperatures

Season	Temperature
Winter	70° F
Summer	78° F

History: Cr. Register, July, 1986, No. 367, eff. 1-1-87.

ILHR 22.11 Moisture control for electrically heated dwellings. Provisions for the control of moisture in electrically heated dwellings shall be made in accordance with this section.

(1) VAPOR BARRIERS. A vapor barrier shall be installed to prevent water vapor from condensing within the insulated cavities of the thermal envelope. All joints in the vapor barrier shall be overlapped and secured or sealed. Rips and punctures in the vapor barrier shall be patched with vapor barrier materials and taped or sealed. Openings in the vapor barrier around electrical boxes and other utility services shall be taped or sealed. The transmission rate of the vapor barrier may not exceed 0.1 perm.

(2) RELATIVE HUMIDITY. Where a power humidifier is installed, the equipment shall be provided with a control to regulate the relative humidity.

(3) VENTILATION. (a) *Attics.* Ventilation above the ceiling/attic insulation shall be provided.

1. The free ventilating area shall be at least 1/300 of the horizontal area of the ceiling. At least 50% of the required free ventilating area shall be distributed at the low sides of the roof, the remainder of the vents shall be provided in the upper one-half of the roof or attic area.

2. If all the ventilating area is provided at one level, then the ventilating area shall be at least 1/150 of the horizontal area of the ceiling.

3. The ventilation space above any non-rigid insulation in a cathedral ceiling assembly shall be at least one inch in height.

(b) *Crawl spaces.* Ventilation shall be provided in crawl spaces which are outside the thermal envelope. The area of ventilation shall be at least 1/1500 of the floor space. At least 50% of the ventilating area shall be provided at opposite sides of the crawl space or as far apart as possible.

(c) *Clothes dryers.* If clothes dryers are provided, the dryers shall be vented to the outside of the building. The dryer vents may not terminate in an attic space or crawl space or basement.

(4) AIR QUALITY. (a) *General.* All electrically heated dwellings shall be provided with mechanical ventilation equipment.

1. The equipment shall be capable of providing 0.5 air changes per hour upon demand to the living space within the thermal envelope, or shall be capable of providing 0.5 air changes per hour to individual rooms of the living area during periods of occupancy.

2. The mechanical ventilation equipment may consist of one or more exhaust fans.

3. The air intakes may be operable windows or dampered openings.

4. All exhaust vents shall terminate outside the building.

5. Habitable spaces within basements shall be considered to be part of the living space.

(b) *Dwellings with combustion appliances and high ventilation rates.* Dwellings which are provided with gas-fired, oil-fired, solid fuel burning appliances or fireplaces and are also provided with mechanical ventilation systems capable of providing one air change per hour or more to the living space shall be provided with dampered outside air intakes.

Note #1: Residences with low levels of infiltration or occupants who smoke or situations which release pollutants or large quantities of moisture to the air may require a more extensive mechanical system or a greater number of air changes to assure a sufficient level of air quality.

Note #2: Information on ventilation capacity calculations is contained in Appendix E.

History: Cr. Register, July, 1986, No. 367, eff. 1-1-87.

ILHR 22.12 Insulation standards. Electrically heated dwellings shall be insulated to meet the requirements specified in sub. (1) or (2).

(1) COMPONENT METHOD. Each component of the thermal envelope of an electrically heated dwelling shall meet the thermal performance values specified in Table 22.12-1.

Note: Additional explanatory material is contained in the appendix.

TABLE 22.12-1
INSULATION STANDARDS FOR ELECTRICALLY HEATED DWELLINGS

Component of Thermal Envelope	Maximum Overall Thermal Transmittances, U_o
Roof-Ceiling[a]	0.020
Walls:	
above grade[b]	0.080
below grade[c]	0.100
Floors:	
slab-on-grade[d]	0.100
over unconditioned spaces[e]	0.055

Note a: Roof-ceiling assemblies include attic access panels and skylites.

Note b: Walls include box sills, windows, doors, and those portions of the foundation wall above grade.

Note c: The thermal transmittance value applies to the surface area which extends from grade to the top of the footing. If insulation is to be applied to the exterior of the wall below grade, the insulation shall be a type suitable for this application.

Note d: The thermal transmittance value applies to a surface area which extends from the top of a slab to 48 inches vertically downward or horizontally or a combination thereof with a total dimension of 48 inches.

Note e: Includes unheated crawl spaces, basements, garages and other spaces outside of the thermal envolope.

(2) SYSTEM METHOD. The overall thermal transmittance for any component of an electrically heated dwelling specified in sub. (1) may be exceeded if the calculated heat loss or gain for the entire thermal envelope does not exceed the total heat loss or gain calculated using the maximum overall thermal transmittances for all the components as specified in sub. (1).

Note: Additional explanatory material and examples of some methods which may be used to meet these requirements are contained in Appendices A through C.

History: Cr. Register, July, 1986, No 367, eff. 1-1-87.

ILHR 22.13 Infiltration control for electrically heated dwellings. Provisions for the limitation of infiltration in electrically heated dwellings shall be made in accordance with this section.

(1) GENERAL. Windows and door assemblies and other portions of the thermal envelope shall be constructed and installed to minimize infiltration.

(2) WINDOWS AND DOORS. Manufactured windows and door assemblies which form a part of the thermal envelope of an electrically heated dwelling shall be constructed and installed to limit infiltration.

(a) *Windows.* Except as provided in par. (c), the air infiltration rate for manufactured windows of electricallly heated dwellings may not exceed 0.20 cubic feet per minute per foot of sash crack.

(b) *Sliding doors.* Except as provided in par. (c), the air infiltration rate for manufactured sliding doors of electrically heated dwellings may not exceed 0.25 cubic feet per minute per square foot of door area.

(c) *Exception.* Windows with a maximum infiltration rate of 0.30 cubic feet per minute per foot of sash crack and sliding doors with a maximum infiltration rate of 0.30 cubic feet per minute per square foot of door area may be used in electrically heated dwellings where a blower door test, performed in accordance with sub. (4), indicates that the infiltration rate of the entire thermal envelope does not exceed 4.4 air changes per hour at 50 pascals (Pa) or does not exceed an equivalent leakage area (ELA) of 2 square inches per 100 square feet of above grade thermal envelope at 10 pascals (Pa).

(d) *Swinging doors.* The air infiltration rate for swinging door assemblies of electrically heated dwellings may not exceed 0.35 cubic feet per minute per square foot of door area.

Note: The department will allow the use of windows and doors meeting the requirements of this section when tested in accordance with ASTM E-283, Standard Method of Test for Rate of Air Leakage Through Exterior Curtain Walls and Doors.

(3) EXTERIOR OPENINGS IN THE THERMAL ENVELOPE. (a) *Sealing of openings.* Except as provided in par. (b) or as provided in par. (c), the following openings and all other similar openings in the thermal envelope shall be caulked, gasketed, weatherstripped, tightly packed with fiberglass, or otherwise sealed with a flexible material to limit air infiltration:

Note: Additional explanatory material is contained in Appendix D.

1. At the junction of exterior walls and the roof, including but not limited to the joints between:

a. Double top plates; and

b. The top plate and the siding or exterior finish, where extruded polystyrene is not placed behind the siding or exterior finish.

2. Between exterior walls and floors, including but not limited to the joints between:

a. The subfloor and the exterior header joist;

Note: The header joist is also known as a band joist or a skirt.

b. The top plates of the exterior wall and the header joists of floors placed on wall;

c. The subfloor and bottom plates of exterior walls; and

d. The joints between double top plates or double bottom plates of exterior walls.

3. Between floors and foundation walls, including but not limited to the joints between:

a. The foundation and sill plate and between the sill plate and floor joist header; or

b. The foundation and floor joist header; and

c. Floor joist header and the subfloor.

4. Between exterior frame walls placed on foundations, including but not limited to the joint between foundation and sill plate and the joint between double bottom plates.

5. At openings in exterior walls, including but not limited to the joints between:

a. Window headers and top wall plates;

b. Window headers and plates at the heads of windows and doors;

c. Plates and window sills;

d. Plate and window frame;

e. Separate wall panels;

f. Siding or exterior finish joints at cantilevered floors, bay windows and at soffits; and

g. Siding and foundation where no sheathing is provided behind the siding.

6. At joints around window and door assemblies in the thermal envelope, including but not limited to the joints between:

a. Window and door assemblies and the wall framing;

b. Window and door assemblies and the exterior siding or finish; and

c. Door thresholds and the subfloor.

7. At the joint between the foundation wall and the sill plate or joist header of a floor, or between the foundation wall and the bottom plate of a wall.

8. At penetrations through the thermal envelope at walls, floors and ceilings or insulated roof assemblies, including but not limited to:

a. Piping;

b. Hose bibbs;

c. Plumbing vent stacks;

d. Electrical wiring;

e. Chimney or vent penetrations;

f. Dryer vents;

g. Bathroom vents;

h. Kitchen vents;

i. Telephone wire entrances;

j. Through-the-wall air conditioners;

k. Refrigeration lines;

l. Air vents and inlets; and

m. Recessed light fixtures.

9. Attic access panels in the thermal envelope shall be weatherstripped or otherwise sealed.

10. Air exhaust or intake openings shall be provided with back draft dampers or automatic dampers to limit air leakage.

11. All receptacles, switches or other electric boxes which are set into the vapor barrier or infiltration barrier shall be gasketed or otherwise sealed to limit infiltration. Insulation shall be placed behind all electric boxes and around wires in cavities of the thermal envelope.

12. Fireplaces shall be provided with:

a. Closable metal or glass doors covering the opening of the firebox;

b. A combustion air intake to draw air from the outside of the building directly into the firebox. The air intake shall be at least 6 square inches in area, or more if required by the manufacturers listing or installation instructions. The air intake shall be equipped with an accessible manual or automatic back draft damper; and

c. A flue damper with an accessible control.

(b) *Exception.* The sealing of any or all of the openings as specified in par. (a) 1. through 5. may be omitted if the openings are covered by an infiltration barrier installed as specified in this paragraph.

1. The infiltration barrier shall be installed on the exterior side of the insulation of the thermal envelope.

2. The infiltration barrier shall form a continuous surface over the walls of the building, extending from the bearing points of the roof to the top of the foundation.

3. All seams, joints, tears and punctures shall be sealed.

Note: Infiltration barriers include spun-bonded polyolefin sheets and tongue and groove extruded polystyrene.

(c) *Exception.* The sealing of any or all of the openings specified in par. (a) 1. through 5. may be omitted if a blower door test is performed in accordance with sub. (4) and the test indicates that the infiltration rate of the entire thermal envelope does not exceed 4.4 air changes per hour at 50 pascals (Pa) or does not exceed air equivalent leakage area (ELA) of 2 square inches per 100 square feet of above grade thermal envelope at 10 pascals (Pa).

(4) BLOWER DOOR TESTING PROCEDURE. Blower door tests which are performed to meet the requirements of sub. (2) (c) or (3) (c) shall be performed in accordance with this subsection:

(a) The test shall be performed in accordance with ASTM E-799, "Standard Practice for Measuring Air Leakage by the Fan Pressurization Method".

Note: ASTM is an acronym for the American Society for Testing and Materials. Copies of ASTM Standards may be purchased from the ASTM Publications Sales Department, 1916 Race Street, Philadelphia, PA 19103.

(b) The blower door test may not be conducted when the wind speed exceeds 10 miles per hour (mph).

(c) The results of the test shall be provided to the purchaser.

History: Cr. Register, July, 1986, No. 367, eff. 1-1-87.

Subchapter VI—Heating and Air Conditioning Equipment and Systems

ILHR 22.14 Scope. This subchapter shall apply to all newly constructed conventional and manufactured one- and 2-family dwellings.

History: Cr. Register, July, 1986, No. 367, eff. 1-1-87.

ILHR 22.15 Selection of equipment. The output capacity of the mechanical heating, cooling and air conditioning equipment shall not exceed the calculated heating load and cooling load by more than 15%, except to satisfy the next closest manufacturer's nominal size.

History: Cr. Register, May, 1978, No. 269, eff. 12-1-78; renum. from ILHR 22.08, Register, July, 1986, No. 367, eff. 1-1-87.

ILHR 22.16 Temperature control. At least one thermostat for regulating the temperature of the space shall be provided for each separate system. Thermostats used to control the heating system may also be used to control the cooling system.

Note: Setting back the thermostat during periods of non-use or thermostats equipped with automatic controls which reduce the temperature during periods of non-use, conserve energy.

History: Cr. Register, May, 1978, No. 269, eff. 12-1-78; renum. from ILHR 22.09, Register, July, 1986, No. 367, eff. 1-1-87.

ILHR 22.17 Zone control. Each heating and cooling system shall be provided with an automatic or manually controlled damper or valve to shut off or reduce the heating or cooling to each zone or floor and to each room.

History: Cr. Register, May, 1978, No. 269, eff. 12-1-78; renum. from ILHR 22.10, Register, July, 1986, No. 367, eff. 1-1-87.

ILHR 22.18 Duct and pipe insulation. (1) DUCT INSULATION. All duct systems exposed to unheated spaces shall be insulated with materials having a minimum thermal resistance of R = 5.

(2) PIPE INSULATION. All heating pipes in unheated spaces and all cooling pipes in conditioned spaces shall be insulated with at least one inch of insulation. A vapor barrier on the exposed side of the insulation shall be provided on cooling pipes to prevent condensation. Pipes installed within heating and air conditioning equipment, installed in conditioned spaces, are not required to be insulated.

History: Cr. Register, May, 1978, No. 269, eff. 12-1-78; renum. from ILHR 22.11, Register, July, 1986, No. 367, eff. 1-1-87.

ILHR 22.19 Equipment efficiencies. (1) ELECTRICAL EQUIPMENT. (a) *Air conditioning equipment.* Air conditioning equipment shall have a minimum energy efficiency ratio (EER) of 7.8 or a COP of 2.3.

(b) *Heat pumps.* Heat pumps shall comply with the minimum coefficients of performance set forth in Table 22.19.

TABLE 22.19
MINIMUM COP FOR HEAT PUMPS, HEATING MODE

Source and outdoor temperature (°F)	Minimum COP
Air source - 47 dry bulb/43 wet bulb	2.2
Air source - 17 dry bulb/15 wet bulb	1.2
Water source - 60 entering	2.2

1. The heat pump shall be installed with a control to prevent the supplementary heater from operating when the heating load can be more efficiently satisfied by the heat pump alone.

2. Supplementary heater operation is permitted during transient periods, such as start-ups, following room thermostat set point advance, and during defrost.

Note: A two-stage room thermostat, which controls the supplementary heat on its second stage, will be accepted as meeting this requirement. The cut-on temperature for the compression heating should be higher than the cut-on temperature for the supplementary heat; the cut-off temperature for the compression heating should be higher than the cut-off temperature for the supplementary heat.

(2) COMBUSTION HEATING EQUIPMENT. (a) *General.* Except as provided in par. (b), all gas-fired and oil-fired heating equipment shall have a minimum annual fuel utilization efficiency (AFUE) of 80%. Where a vent damper is provided but not included in the AFUE rating of the equipment, the equipment, without the vent damper, shall have a minimum AFUE of 75.

(b) *Exception.* All gas-fired and oil-fired copper fin and coil type boilers shall meet the minimum energy efficiency standards of ASHRAE 90A-80 "Energy Conservation in New Building Design."

Note: ASHRAE is an acronym for the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. Copies of the ASHRAE standards may be purchased from the ASHRAE Publications Sales Department, 1719 Tullie Circle, N.E., Atlanta, Georgia 30329.

History: Cr. Register, May, 1978, No. 269, eff. 12-1-78; renum. from ILHR 22.12 and r. and recr. (1) (a) and (2), Register, July, 1986, No. 367, eff. 1-1-87.

ILHR 22.20 Electronic ignition and automatic flue dampering. Combustion space heating equipment shall be provided with intermittent ignition devices and automatic flue dampers. Automatic flue dampers may be eliminated where:

(1) Induced draft equipment is used;

(2) Where equipment with a condensing secondary heat exchanger is used;

(3) All combustion air is ducted to the furnace burner from the outside; or

(4) Where combustion equipment is located in an enclosure and provided with combustion air from the outside.

History: Cr. Register, May, 1978, No. 269, eff. 4-1-79; renum. from ILHR 22.13 and am. Register, July, 1986, No. 367, eff. 1-1-87.

Subchapter VII—Buildings Utilizing Solar, Wind Or Other Nondepletable Energy Sources

ILHR 22.21 Scope. This subchapter shall apply to all newly constructed conventional and manufactured one- and 2-family dwellings.

History: Cr. Register, July, 1986, No. 367, eff. 1-1-87.

ILHR 22.22 Innovative designs. (1) DESIGNS UTILIZING NONDEPLETABLE ENERGY SOURCES. Any innovative building or system design, or a design which utilizes solar, geothermal, wind or other nondepletable energy sources will be accepted by the department provided the design utilizes less depletable energy than determined through the accepted practice method or the system design method.

(2) OTHER ALTERNATIVE DESIGNS. Proposed alternative designs may also consider energy savings resulting from orientation of the building on the site; the geometric shape of the building; the aspect ratio (ratio of length to width); the number of stories for a given floor area; the thermal mass of the building; the exterior surface color; shading or reflections from adjacent structures; surrounding surfaces of vegetation; natural ventilation; and wind direction and speed.

History: Cr. Register, May, 1978, No. 269, eff. 12-1-78; renum. from ILHR 22.14, Register, July, 1986, No. 367, eff. 1-1-87.

ILHR 22.23 Documentation. Proposed alternative designs shall be accompanied with an energy analysis comparing the energy utilized by the proposed design with the energy used by a design complying with subch. IV or V.

History: Cr. Register, May, 1978, No. 269, eff. 12-1-78; renum. from ILHR 22.15, Register, July, 1986, No. 367, eff. 1-1-87.

Chapter ILHR 25

PLUMBING AND POTABLE WATER STANDARDS

Note: Chapter Ind 25 was renumbered to be chapter ILHR 25, Register, February, 1985, No. 350, eff. 3-1-85.

Subchapter I — Scope

ILHR 25.01 Scope. All one- and 2-family dwellings shall be provided with potable water and plumbing systems in accordance with the standards listed in this chapter and shall comply with chs. ILHR 82 to 84.

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80; am. Register, February, 1985, No. 350, eff. 3-1-85.

Subchapter II — Potable Water

ILHR 25.02 Public water supply. Each dwelling shall be provided with potable water from a public water supply when available.

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80.

ILHR 25.03 Well water supply. When a public water supply is not available, each dwelling shall be provided with a well(s) approved by the department of natural resources. Water samples from an approved well shall be tested at the state laboratory of hygiene, or a state approved laboratory, at least annually. The water supply shall be tested bacteriologically safe prior to use.

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80.

Subchapter III — Plumbing Systems

ILHR 25.04 Plumbing systems. Every dwelling unit connected to a septic system or public sewer shall be provided with a water closet, a lavatory and a bathtub or shower. Each dwelling unit shall be provided with a kitchen area and every kitchen shall be provided with a sink.

(1) WATER-CONSERVING FIXTURES. Each dwelling shall be provided with the following water-conserving fixtures:

(a) Water closets having a maximum water usage of 4 gallons or less per flush.

(b) Lavatory (washbowl) faucets having a maximum flow rate of 3 gallons per minute (gpm).

Note: This rule is not intended to apply to faucets serving kitchen sinks, laundry tubs or bathtubs.

(c) Showerheads having a maximum flow rate of 3 gallons per minute (gpm).

(2) PROTECTION FROM FREEZING. All plumbing fixtures, and the pipes connecting therewith, shall be properly protected against freezing so that the fixtures will be in proper condition for use at all times.

Note: See ch. ILHR 82 for the design, construction and installation of plumbing systems.

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80.

ILHR 25.05 Water heating equipment. (1) GENERAL. Except as provided by sub. (2), all residential water heaters shall meet the minimum energy efficiency standards of ASHRAE 90A-80, "Energy Conservation in New Building Design."

(2) EXCEPTION. Heat pump water heaters, solar water heaters and tankless water heaters are exempt from the requirements of sub. (1).

Note: ASHRAE is an acronym for the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. Copies of the ASHRAE Standards may be purchased from the ASHRAE Publications Sales Department, 1791 Tullie Circle, N.E., Atlanta, Georgia 30329.

History: Cr. Register, July, 1986, No. 367, eff. 1-1-87.

WHITE WOODS (WESTERN WOODS) (Surfaced dry or surfaced green)					
Select Structural No. 1 & Appearance No. 2 No. 3 Stud	2x4	1550 1300 1050 600 600	1630 1370 1100 630 630	1,100,000 1,100,000 1,000,000 900,000 900,000	Western Wood Products Association
Construction Standard Utility	2x4	775 425 200	810 450 210	900,000 900,000 900,000	(See notes 1 and 3)
Select Structural No. 1 & Appearance No. 2 No. 3 Stud	2x5 and wider	1300 1100 925 550 550	1370 1160 970 580 580	1,100,000 1,100,000 1,000,000 900,000 900,000	

1. When 2-inch lumber is manufactured at a maximum moisture content of 15% (grade marked MC-15) and used in a condition where the moisture content does not exceed 15%, the design values shown for "surfaced dry or surfaced green" lumber may be increased 8% for design value in bending "F_b", and 5% for modulus of elasticity "E".

2. National Lumber Grades Authority is the Canadian rules writing agency responsible for preparation, maintenance and dissemination of a uniform softwood lumber grading rule for all Canadian species.

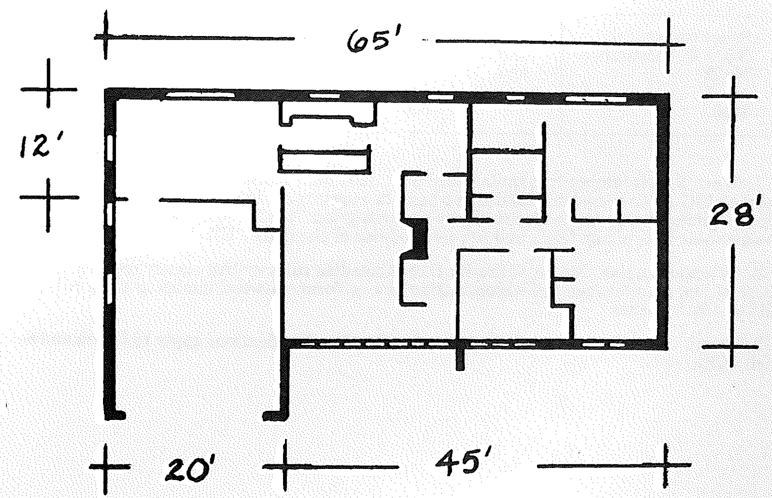
3. Design values for stud grade in 2x5 and wider size classifications apply to 5-inch and 6-inch widths only.

APPENDIX A

CHAPTER ILHR 22

DETERMINING THE LEVEL OF INSULATION

Two methods are outlined for determining the level of insulation, required by section ILHR 22.06 for non-electrically heated dwellings and by section ILHR 22.12 for electrically heated dwellings, using the following sample dwelling:



Sample dwelling: 1,500 square feet (186 lineal feet)

Gross wall area = 8.13 feet × 186 lineal feet = 1,512.18 square feet
Framed wall area = 1,301.69 square feet (20% framing, 80% cavity) (does not include box sill)
Wall window area = 172.67 square feet
Box sill area = 0.81 feet × 186 lineal feet = 150.66 square feet
Gross exposed foundation wall area = 124.62 square feet
Opaque exposed foundation area = 108.97 square feet
Basement window area = 15.65 square feet
Door area = 37.82 square feet
Ceiling area = 1,500 square feet (10% framing, 90% cavity)

METHOD I — COMPONENT METHOD

The component method outlined below can be used with minimum calculations for determining the acceptable level of insulation. The first example shows how to determine the level of insulation for non-electrically heated dwellings. The second example shows how to determine the level of insulation for electrically heated dwellings.

EXAMPLE I — NON-ELECTRICALLY HEATED DWELLING

Problem: Using the component method determine the level of insulation required for the 1,500 square foot dwelling.

Step 1: Determine the percentage window and door area in the wall above the foundation.

$$\text{Percent opening area} = \frac{\text{Window area} + \text{Door area}}{\text{Gross wall area} + \text{Box sill area}} \times 100\%$$

$$= \frac{172.67 \text{ sq. ft.} + 37.82 \text{ sq. ft.}}{1512.18 \text{ sq. ft.} + 150.66 \text{ sq. ft.}} \times 100\%$$

$$= \frac{210.49 \text{ sq. ft.}}{1{,}662.84 \text{ sq. ft.}} \times 100\% = 12.66\%$$

Step 2: Determine level of insulation required for the box sill and sidewalls for the given window and door area from Table A-1.

Using backed aluminum siding, the table shows that an R-11 batt with R-5.27 extruded polystyrene will allow up to 13% window and door area.

Step 3: Determine the percentage window area for the exposed foundation wall.

$$\text{Percent opening area} = \frac{\text{Window area}}{\text{Gross exposed foundation area}} \times 100\%$$

$$= \frac{15.65 \text{ sq. ft.}}{124.62 \text{ sq. ft.}} \times 100\% = 12.6\%$$

Step 4: Determine the amount of exposed foundation wall: If there is 8 inches of wall exposed and the wall height is 8 feet,

$$\text{Percent exposed wall} = \frac{8''/(12'' \text{ per foot})}{8'} \times 100\% = 8.3\%$$

Step 5: Refer to Table A-2 to determine the level of insulation required for the foundation.

Using the requirements for less than 25% exposed foundation wall, the table shows that R-5.27 insulation can be used for up to 24.8% double glazed windows.

Step 6: Select the level of insulation required for the ceiling from Table A-3.

TABLE A-1

WALL INSULATION GUIDE

(Based on U_0 requirements above the foundation wall for non-electrically heated dwellings)

INSULATION TYPE	MAXIMUM PERCENT WINDOW AND DOOR AREA ALLOWABLE FOR INSULATION TYPE U_0 = .12	
	⅝ inch Plywood Siding	Backed Aluminum Siding
R-11 Batt	6.8	8.4
R-11 Batt, R-1.22 Fiberboard	8.7	9.9
R-11 Batt, R-5.27 Extruded Polystyrene	12.4	13.0
R-11 Batt, R-10.54 Extruded Polystyrene	14.9	15.3
R-13 Batt	8.3	9.8
R-13 Batt, R-1.22 Fiberboard	10.3	11.2
R-13 Batt, R-5.27 Extruded Polystyrene	13.1	13.6
R-13 Batt, R-10.54 Extruded Polystyrene	15.3	15.6
R-19 Batt	11.2	12.2
R-19 Batt, R-1.22 Fiberboard	12.3	13.1
R-19 Batt, R-5.27 Extruded Polystyrene	14.7	15.1
R-19 Batt, R-10.54 Extruded Polystyrene	16.3	16.6

Note: The following assumptions were used to derive this table:
1. Door area = 2% of wall and box sill area.
2. Doors are used with a U-value of 0.47.
3. Windows are used with a U-value of 0.56.
4. The insulation type is carried down through the box sill.

TABLE A-2

EXPOSED FOUNDATION INSULATION NON-ELECTRICALLY HEATED DWELLINGS

Foundation Exposure	Requirement	Insulation Type	Maximum Percent Window Area	
			Single glazed	Double glazed
Less than 25% of foundation exposed	U_0 = .25	R-5.27	10.4	24.8
		R-11 batt	15.5	34.2
		Multi-cell insul. block (R-12.06)	16.0	35.0
More than 25% of foundation exposed	U_0 = .13	R-11 batt	3.9	8.7
		R-13 batt	4.8	10.6
		Multi-cell insul. block (R-12.06)	4.5	9.9
	U_0 = .12	R-11 batt	3.0	6.7
		R-13 batt	3.9	8.5
		Multi-cell insul. block (R-12.06)	3.5	7.8

TABLE A-3

INSULATION LEVELS REQUIRED TO MEET CEILING U VALUES FOR NON-ELECTRICALLY HEATED DWELLINGS

U_0 Value	Insulation	R-Value Required	
		In Cavity	Over Framing
.029	Fiber glass batt	R-38	R-19
	Fiber glass blown	13.6 in. (R-34)	8.1 in. (R-20)
	Rock wool	10.9 in. (R-33)	5.4 in. (R-16)
	Cellulose	9.5 in. (R-35)	4.0 in. (R-15)

Note: The following assumptions are used:
1. Fiber glass blown = R-2.5 per inch
2. Rock wool = R-3.0 per inch
3. Cellulose = R-3.7 per inch

EXAMPLE II — ELECTRICALLY HEATED DWELLING

OPAQUE WALL AND BOX SILL:

Problem: Using the component method, determine the level of insulation required for the walls and box sill of the 1500 square foot dwelling.

Solution #1: Using Tables E-1 and E-2.

Step 1: Determine the composition of the above grade wall by calculating the percent of the area which is made up by windows, doors and foundation.

$$\text{Percent window area} = \frac{\text{Window area + foundation window area}}{\text{Total above grade wall area}} \times 100\%$$

Total above grade wall area =

Gross wall area + box sill area + Gross exposed foundation area

(Note that the total above grade wall area includes the exposed foundation wall area. However, if the basement or crawl space ceiling is insulated instead of the foundation, the exposed foundation area is set equal to zero because it is not a part of the thermal envelope.)

Total above grade wall area = 1512.18 sq. ft. + 150.66 sq. ft. + 124.62 sq. ft. = 1787.46 sq. ft.

$$\text{\% Window area} = \frac{172.67 \text{ sq. ft.} + 15.65 \text{ sq. ft.}}{1787.46 \text{ sq. ft.}} \times 100\% = 10.53\%$$

The %'s of other components are calculated in a similar manner:

$$\text{\% Door area} = \frac{\text{door area}}{\text{Total wall area}} \times 100\% = \frac{37.82 \text{ sq. ft.}}{1787.46 \text{ sq. ft.}} \times 100\% = 2.12\%$$

$$\text{\% Opaque foundation area} = \frac{\text{opaque foundation area}}{\text{total wall area}} \times 100\%$$

$$= \frac{108.97 \text{ sq. ft.}}{1787.46 \text{ sq. ft.}} \times 100\% = 6.10\%$$

$$\%\text{ Frame wall \& box sill area} = \frac{\text{frame wall area} + \text{box sill area}}{\text{total wall area}} \times 100\%$$

$$= \frac{1301.69\text{ sq. ft.} + 150.66}{1787.46\text{ sq. ft.}} \times 100\% = 81.25\%$$

Step #2: Use Tables E-1 to determine the opaque wall and boxsill U-value and Table E-2 to determine the insulation levels for electrically heated dwellings.

Table E-1 was formulated with the following assumptions:

— The doors have R-values of at least R-8 and form 2% or less of the above-foundation wall.

$$\frac{\text{door area}}{\text{gross wall area} + \text{box sill area}} \times 100\%, \text{ in this case } =$$

$$\frac{37.82}{1512.18 + 150.66} \times 100\% = 2\%$$

— Windows with an R-value of at least 2.7 (triple glazed) are used, including the foundation windows.

— The exposed foundation area is insulated to a level of R-10.54.

If these assumptions are not valid for your case, calculate the required U-value as shown in solution #2.

For this example:

% Opaque foundation area = 6%

% Window area = 11%

From Table E-1, the maximum above-foundation wall U-value = 0.044 Btu/hr. sq. ft. °F.

For compliance, insulation materials and framing type should be used which produce a U-value which is less than or equal to the maximum U-value determined from Table E-1, as above. Table E-2 shows the U-values obtainable from different insulation material combinations and framing types.

TABLE E-1

MAXIMUM ABOVE-FOUNDATION WALL U-VALUES FOR ELECTRICALLY HEATED HOMES

PERCENT WINDOW AREA

		5	6	7	8	9	10	11	12	13	14	15	16
	0	.065	.062	.059	.056	.053	.050	.046	.043	.040	.036	.032	.029
	5	.065	.061	.058	.055	.051	.048	.044	.041	.037	.033	.029	.025
	6	.064	.061	.058	.055	.051	.048	.044	.040	.037	.033	.029	.025
PERCENT	7	.064	.061	.058	.054	.051	.047	.044	.040	.036	.032	.029	
	8	.064	.061	.057	.054	.050	.047	.043	.039	.035	.031	.027	
	9	.064	.061	.057	.054	.050	.046	.043	.039	.035	.031	.027	
OPAQUE	10	.064	.060	.057	.053	.050	.046	.042	.038	.034	.030	.026	
	11	.064	.060	.057	.053	.049	.046	.042	.038	.034	.030	.025	
	12	.063	.060	.056	.053	.049	.045	.041	.037	.033	.029	.025	
FOUNDA-	13	.063	.060	.056	.052	.049	.045	.041	.037	.033	.028		
	14	.063	.059	.056	.052	.048	.044	.040	.036	.032	.027		
	15	.063	.059	.055	.052	.048	.044	.040	.036	.031	.027		
TION	16	.063	.059	.055	.051	.047	.043	.039	.035	.031	.026		
	17	.062	.059	.055	.051	.047	.043	.039	.034	.030	.025		
	18	.062	.058	.055	.051	.047	.042	.038	.034	.029			
AREA	19	.062	.058	.054	.050	.046	.042	.037	.033	.028			
	20	.062	.058	.054	.050	.046	.041	.037	.032	.028			
	21	.061	.057	.053	.049	.045	.041	.036	.032	.027			
	22	.061	.057	.053	.049	.045	.040	.036	.031	.026			
	23	.061	.057	.053	.048	.044	.040	.035	.030	.025			
	24	.061	.057	.052	.048	.044	.039	.034	.029				
	25	.060	.056	.052	.048	.043	.038	.034	.029				

TABLE E-2

FRAME WALL & BOX SILL U-VALUES FROM DIFFERENT BUILDING MATERIALS AND METHODS

Insulation Type	2 × 4 FRAMING 16" O.C.[1]	2 × 6 FRAMING 16" O.C.	2 × 6 FRAMING 24" O.C.[2]	Double 2 × 4 or 2 × 8 FRAMING 24" O.C.
R-11 Batt	0.091			
R-11 Batt, R1.22 Fiberboard	0.081			
R-11 Batt, R5.27 Polystyrene	0.060			
R-11 Batt, R10.54 Polystyrene	0.045			
R-11 Batt, R7.21 Isocyanurate	0.054			
R-11 Batt, R14.4 Isocyanurate	0.038			
R-13 Batt	0.083			
R-13 Batt, R1.22 Fiberboard	0.074			
R-13 Batt, R5.27 Polystyrene	0.056			
R-13 Batt, R10.54 Polystyrene	0.043			
R-13 Batt, R7.21 Isocyanurate	0.050			
R-13 Batt, R14.4 Isocyanurate	0.036			
R-19 Batt		0.060	0.058	0.056
R-19 Batt, R1.22 Fiberboard		0.055	0.053	0.052
R-19 Batt, R5.27 Polystyrene		0.044	0.043	0.042
R-19 Batt, R10.54 Polystyrene		0.036	0.035	0.034
R-19 Batt, R7.21 Isocyanurate		0.040	0.039	0.039
R-19 Batt, R14.4 Isocyanurate		0.031	0.030	0.030
Two R-11 Batts				0.053
Two R-11 Batts, R1.22 Fiberboard				0.049
Two R-11 Batts, R5.27 Polystyrene				0.040
Two R-11 Batts, R10.54 Polystyrene				0.033
Two R-11 Batts, R7.21 Isocyanurate				0.037
Two R-11 Batts, R14.4 Isocyanurate				0.029
Two R-13 Batts				0.048
Two R-13 Batts, R1.22 Fiberboard				0.045
Two R-13 Batts, R5.27 Polystyrene				0.037
Two R-13 Batts, R10.54 Polystyrene				0.030
Two R-13 Batts, R7.21 Isocyanurate				0.034
Two R-13 Batts, R14.4 Isocyanurate				0.027

[1] Assumes 20% framing, 80% cavity.

[2] Assumes 17% framing, 83% cavity.

Solution #2: To calculate the required wall U-value without using Tables E-1 and E-2, use the method outlined below:

Step 1: Calculate the above grade wall composition as illustrated in Step 1 of Solution #1.

% Window area = 10.53%

% Door area = 2.12%

% Opaque foundation area = 6.10%

% Opaque wall & box sill area = 82.25%

Step 2: Use the following formula to calculate the maximum allowable U-value for the opaque wall and box sill.

$$\frac{U_o - (U_w \times \%_w) - (U_d \times \%_d) - (U_f \times \%_f)}{\%_{wall}} = U_{wall}$$

Where:

U_o	= Required overall above grade wall U-value, use 0.080 for an electrically heated home
U_w	= The U-value of the windows (= 1/R-value)
$\%_w$	= The fraction of window area calculated in Step 1
U_d	= The U-value of the doors (= 1/R-value)
$\%_d$	= The fraction of door area calculated in Step 1
U_f	= The U-value of the insulated foundation
$\%_f$	= The fraction of exposed foundation calculated in Step 1
$\%_{wall}$	= The fraction of opaque wall and box sill area as calculated in Step 1
U_{wall}	= The maximum U-value of the opaque wall and box sill to be calculated

In our example:

The window R-value = R-2.78	U = 1/2.78 = 0.341
The door R-value = R-8.85	U = 1/8.85 = 0.113
The foundation R-value = R-12.4	U = 1/12.4 = 0.080

$$U_{wall} = \frac{0.080 - (0.341 \times 0.1053) - (0.113 \times 0.0212) - (0.080 \times 0.0610)}{0.8225} = 0.045$$

In this case, the maximum U-value of the opaque wall and box sill is 0.045 Btu/hr. sq. ft. °F. For compliance, the insulation which is installed in the wall and box sill must provide a U-value which is less than or equal to 0.045. Table E-2 shows the U-values obtainable from different insulation materials and framing types.

CEILING:

Problem: Using the component method, determine the level of insulation required for the ceiling of the 1500 sq. ft. dwelling.

Solution #1: Use Table E-3

Table E-3 gives the amount of installed insulation which would be necessary to achieve a required U-value in the ceiling or attic.

Table E-3 was formulated with the following assumptions:

— The loose fill insulation, if used, is installed to provide the following R-values:

Cellulose	R = 3.7/in
Expanded pearlite	R = 2.7/in
Mineral Fiber (rock, slag, or glass)	R = 3.3/in
Polystyrene beads	R = 2.9/in
Fiber glass, blown	R = 2.5/in

— The insulated area is 90% cavity and 10% 2 × 6 framing

— There are no skylights in the ceiling/attic assembly

— The R-value of the ceiling finish materials plus air films is R-1.2

— The attic hatch is insulated to the same level as the rest of the attic floor, if it is a part of the thermal envelope.

If these assumptions are not valid for your case, calculate the required U-value as shown in solution #2.

TABLE E-3

INSULATION LEVELS REQUIRED TO MEET CEILING U_o VALUES

Dwelling Fuel Type	U_o	Insulation Type	Amount Required In Cavity Depth (R-Value)
Electrically Heated	0.020	Fiber glass Batts	R-54
		Cellulose	14.1 in. (R-52)
		Expanded Pearlite	18.6 in. (R-50)
		Mineral Fiber	15.6 in. (R-51)
		Polystyrene Beads	17.5 in. (R-52)
		Blown Fiber glass	20.0 in. (R-50)

Solution #2: To calculate the required ceiling insulation level for ceiling/attic assemblies, use the following method.

Step 1: Calculate the required U-value for the attic floor, U_F, with the following formula.

$$U_F = \frac{U_oA_o - U_sA_s - U_h A_h}{A_F}$$

Where:

U_F = The required U-value for the attic floor

U_o = The overall U-value set by the code, use 0.020 for an electrically heated dwelling

A_o = The overall attic/ceiling area including the attic floor, any skylights and the attic hatch or access panel

U_s = The U-value of the skylights including the frame

A_s = The area of skylights, including the frame (if there are no skylights, set equal to zero)

U_h = The U-value of the attic hatch or access panel

A_h = The area of the attic hatch or access panel (If the hatch is to be insulated to the same level as the attic floor, add the area to the floor area, A_F, and set A_h equal to zero. If the attic hatch or access panel is not a part of the thermal envelope, set A_h equal to zero.)

A_F = The area of the insulated attic floor, equal to the overall attic/ceiling area minus the attic hatch and skylight areas, if any.

Example: For the attic of an electrically heated dwelling with an overall attic area of 1500 sq. ft. The attic hatch is 14″ × 24″ and is to be insulated with two R-19 fiber glass batts, the rest of the attic is to be insulated with blown mineral fiber with an R-value of 3.3/inch. There are two skylights, each 6 square feet with R-values of 1.8.

The R-value of the attic hatch is the sum of the R-values of the batts plus R-2 for the finish materials and air films.

$R = 19 + 19 + 2 = 40$

The U-value of the hatch is $U_h = 1/40 = 0.025$

The U-value of the skylights $U_s = 1/1.8 = 0.56$

The area of the hatch = 2 ft × 1.17 ft = 2.3 sq. ft.

The area of the skylights is 12 square feet

The area of the floor is 1500 − 12 − 2.3 = 1486 sq. ft.

$$U_F = \frac{(0.020)(1500) - (0.56)(12) - (0.025)(2.3)}{1486} = 0.0156$$

Step #2: To calculate the amount of insulation needed over the framing and cavity areas, d, of the attic floor use the following formula:

$$d = \frac{1}{U_F\,(R/in)} - \frac{(RW/in)\,h}{(\%C)(RW/in) + (\%W)(R/in)} - \frac{Rfin + h}{(R/in)}$$

Where:

d	=	depth of insulation at cavity in inches
U_F	=	required U-value of floor calculated in Step #1
R/in	=	R-value per inch of insulating material obtained from manufacturer or Table A-4
h	=	height of framing, 5-1/2″ for 2 × 6 framing or 7-1/4″ for 2 × 8 framing, for example.
%C	=	fraction of floor which is cavity (usually assume 0.9)
%W	=	fraction of floor which is framing (usually assume 0.1)

RW/in = R-value per inch of wood framing (usually assume 1.25 R/inch)

R_{fin} = R-value of interior ceiling finish materials, including air films (usually assume R-1.2)

$$d = \frac{1}{(0.0156)(3.3)} - \frac{(1.25)(5.5)}{(0.9)(1.25)+(0.1)(3.3)} - \frac{1.2}{3.3} + 5.5 = 19.59 \text{ inches}$$

The floor of the attic is to be covered with insulation so that the depth in the cavities is equal to 19.59 inches.

METHOD II — SYSTEM DESIGN METHOD

The system design method is the more complex method of determining the level of insulation required by the code. This procedure may be used when it becomes necessary to combine various materials to comply with the code. If the window area is increased and the same wall insulation is used, the wall section will not meet the requirements of section ILHR 22.06 or 22.12 (1) (6), but the system design method can be used by adding extra insulation elsewhere.

Problem: Using the system design method, increase the opening area to 15% and determine compliance by adding extra insulation to the walls and ceiling.

Step 1: Determine the inside and outside design temperatures from Tables 22.04-A or 22.10A, and 22.04-B.

Inside temperature = 70° F
Outside temperature = -20° F
$\Delta T = T_{inside} - T_{outside} = 70 - (-20) = 90°$ F.

Note: Degree days may be used for system design instead of design temperatures:

Zone 1, 9,000 degree days
Zone 2, 8,000 degree days
Zone 3, 7,500 degree days
Zone 4, 7,000 degree days

Step 2: Using section ILHR 22.06 or 22.12, determine the insulation values for the exterior walls above grade and the roof/ceiling for Phase I.

Exposed exterior walls above grade; $U_o = .15$
Roof/ceiling; $U_o = .033$

Step 3: Fill in the worksheet to determine requirements for building enclosure heat loss.

Step 4: Select the levels of insulation to be used and determine the U values for the ceiling, wall, box sill and foundation (shown in Figure A-1). Fill in the building enclosure worksheet.

Step 5: If the total heat loss determined through the system design method is within one percent or is less than the heat loss determined through the code requirements, the code has been satisfied.

R-VALUE DETERMINATION BY COMPONENT

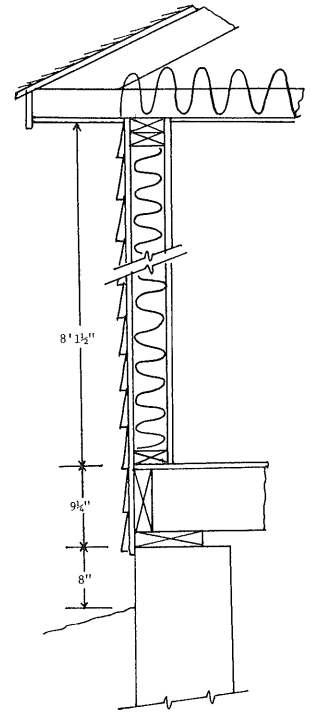


Figure A-1

Ceiling	Cavity R	Joist R
Top surface	.17	.17
Insulation	38.0	19.0
Wood	—	6.88
½" gyp. wall board	.45	.45
Bottom surface	.61	.61
	39.23	27.11
	(U=.025)	(U=.037)

Wall	Cavity R	Stud R
Outside surface	.17	.17
⅝" ext. siding	.77	.77
Rigid insulation	—	—
Insulation	11.00	—
Wood stud	—	4.38
½" gyp. wall board	.45	.45
Inside surface	.68	.68
	13.07	6.45
	(U=.070)	(U=.13)

Box sill	R
Outside surface	.17
⅝" ext. siding	.77
Rigid insulation	—
Insulation	11.00
1½" wood	1.88
Inside surface	.68
	14.50
	(U=.064)

Foundation	R
Outside surface	.17
8" concrete	.64
Inside surface	.68
Rigid insulation	5.27
	6.76
	(U=.15)

WORKSHEET FOR SYSTEM DESIGN ANALYSIS

	CODE REQUIREMENTS			
Component	U_o Reqd.	Area	ΔT	Heat Loss
Walls				
Above grade	.15	1512.18	90	20,414.4
Box sill	.15	150.66	70	1,581.9
Foundation	.15	124.62	70	1,308.5
Roof/Ceiling	.033	1500.00	90	4,455.0
Floor				
Over unheated spaces				
Slab-on-grade				
			TOTAL	27,759.9

SYSTEM DESIGN ALTERNATIVE

Component	U	Area	△T	Heat Loss
Walls				
Cavity	.070	1010.20	90	6,364.3
Solid	.13	252.60	90	2,955.4
Box sill	.064	150.66	70	675.0
Foundation	.15	108.97	70	1,114.2
Roof/Ceiling				
Cavity	.025	1350.00	90	3,037.5
Solid	.037	150.00	90	499.5
Floor				
Over unheated spaces				
Slab-on-grade				
Windows	.56	211.61	90	10,665.1
Doors	.31	37.82	90	1,055.2
Basement windows	1.13	15.65	70	1,237.9
			TOTAL	27,634.1

WORKSHEET FOR SYSTEM DESIGN ANALYSIS

CODE REQUIREMENTS

Component	U_O Reqd.	Area	△T	Heat Loss
Walls				
Above grade				
Box sill				
Foundation				
Roof/Ceiling				
Floor				
Over unheated spaces				
Slab-on-grade				
			TOTAL	

SYSTEM DESIGN ALTERNATIVE

Component	U	Area	△T	Heat Loss
Walls				
Cavity				
Solid				
Box sill				
Foundation				
Roof/Ceiling				
Cavity				
Solid				
Floor				
Over unheated spaces				
Slab-on-grade				
Windows				
Doors				
Basement windows				
			TOTAL	

TABLE A-4

COMMON CONSTRUCTION MATERIAL R-VALUES*

Material	Description	Density (lb per cu ft)	Per inch thickness R-Value	For thickness listed R-Value
BUILDING BOARD Boards, panels, subflooring, sheathing, woodbased panel products	Asbestos-cement board	120	0.25	—
	Asbestos-cement board ⅛ in.	120	—	0.03
	Asbestos-cement board ¼ in.	120	—	0.06
	Gypsum or plaster board ⅜ in.	50	—	0.32
	Gypsum or plaster board ½ in.	50	—	0.45
	Plywood	34	1.25	—
	Plywood ¼ in.	34	—	0.31
	Plywood ⅜ in.	34	—	0.47
	Plywood ½ in.	34	—	0.62
	Plywood or wood panels ¾ in.	34	—	0.93
	Insulating board			
	Sheathing, reg. density ½ in.	18	—	1.32
	25/32 in.	18	—	2.06
	Sheathing, intermediate density ½ in.	22	—	1.22
	Nail-base sheathing ½ in.	25	—	1.14
	Shingle backer ⅜ in.	18	—	0.94
	Shingle backer 5/16 in.	18	—	0.78
	Sound deadening board ½ in.	15	—	1.35
	Tile and lay-in panels, plain or acoustic	18	2.50	—
	½ in.	18	—	1.25
	¾ in.	18	—	1.89
	Laminated paperboard	30	2.00	—
	Homogeneous board from repulped paper	30	2.00	—
	Hardboard			
	Medium density siding 7/16 in.	40	—	0.67
	Other medium density	50	1.37	—
	High density, underlay	55	1.22	—
	High density std. tempered	63	1.00	—

Material	Description	Density (lb per cu ft)	Per inch thickness R-Value	For thickness listed R-Value
	Particleboard			
	Low density	37	1.85	—
	Medium density	50	1.06	—
	High density	62.5	0.85	—
	Underlayment ⅝ in.	40	—	0.82
	Wood subfloor ¾ in.	—	—	0.94
BUILDING PAPER	Vapor-permeable felt	—	—	0.06
	Vapor-seal, 2 layers of mopped 15 lb. felt	—	—	0.12
	Vapor-seal, plastic film	—	—	Negl.
ROOF INSULATION	Preformed, for use above deck			
	Approximately ½ in.	—	—	1.39
	Approximately 1 in.	—	—	2.78
	Approximately 1½ in	—	—	4.17
	Approximately 2 in.	—	—	5.56
	Approximately 2½ in.	—	—	6.67
	Approximately 3 in.	—	—	8.33
	Cellular glass	9	2.50	—
MASONRY MATERIALS Concrete	Cement mortar	116	0.20	—
	Gypsum-fiber concrete 87½% gypsum, 12½% wood chips	51	0.60	—
	Lightweight aggregates	120	0.19	—
	including expanded shale,	100	0.28	—
	clay or slate, expanded	80	0.40	—
	slags; cinders; pumice;	60	0.59	—
	vermiculite; also cellular	40	0.86	—
	concretes	30	1.11	—
		20	1.43	—
	Perlite	40	1.08	—
		30	1.41	—
		20	2.00	—
	Sand and gravel or stone aggregate (oven dried)	140	0.11	—
	Sand and gravel or stone aggregate (not dried)	140	0.08	—
	Stucco	116	0.20	—
MASONRY UNITS	Brick, common	120	0.20	—
	Brick, face	130	0.11	—
	Clay tile, hollow:			
	1 cell deep 3 in.	—	—	0.80
	1 cell deep 4 in.	—	—	1.11
	2 cells deep 6 in.	—	—	1.52
	2 cells deep 8 in.	—	—	1.85
	2 cells deep 10 in.	—	—	2.22
	3 cells deep 12 in.	—	—	2.50
	Concrete blocks, 3 oval core:			
	Sand & gravel aggregate 4 in.	—	—	0.71
	8 in.	—	—	1.11
	12 in.	—	—	1.28
	Cinder aggregate 3 in.	—	—	0.86
	4 in.	—	—	1.11
	8 in.	—	—	1.72
	12 in.	—	—	1.89
	Lightweight 3 in.	—	—	1.27
	aggregate(expanded 4 in.	—	—	1.50
	shale, clay, slate 8 in.	—	—	2.00
	or slag; pumice) 12 in.	—	—	2.27
	Concrete blocks, rectangular core			
	Sand & gravel aggregate			

Material	Description	Density (lb per cu ft)	Per inch thickness R-Value	For thickness listed R-Value
	2 core, 8″ 36 lb	—	—	1.04
	Same with filled cores	—	—	1.93
	Lightweight aggregate (expanded shale, clay, slate or slag, pumice):			
	3 core, 6″ 19 lb	— —	1.65	
	Same with filled cores	— —	2.99	
	2 core, 8″ 24 lb	— —	2.18	
	Same with filled cores	— —	5.03	
	3 core, 12″ 38 lb	— —	2.48	
	Same with filled cores	— —	5.82	
	Stone, lime or sand	—	0.08	—
	Gypsum partition tile:			
	3 x 12 x 30 in. solid	—	—	1.26
	3 x 12 x 30 in. 4-cell	—	—	1.35
	4 x 12 x 30 in. 3-cell	—	—	1.67
PLASTERING MATERIALS	Cement plaster, sand aggregate	116	0.20	—
	Sand aggregate ¾ in.	—	—	0.08
	Sand aggregate ¾ in.	—	—	0.15
	Gypsum plaster:			
	Lightweight aggregate ½ in.	45	—	0.32
	Lightweight aggregate ⅝ in.	45	—	0.39
	Lightweight aggregate on metal lath ¾ in.	—	—	0.47
	Perlite aggregate	45	0.67	—
	Sand aggregate	105	0.18	—
	Sand aggregate ½ in.	105	—	0.09
	Sand aggregate ⅝ in.	105	—	0.11
	Sand aggregate on metal lath ¾ in	—	—	0.1
	Vermiculite aggregate	45	0.59	—
ROOFING	Asbestos-cement shingles	120	—	0.21
	Asphalt roll roofing	70	—	0.15
	Asphalt shingles	70	—	0.44
	Built-up roofing ⅜ in	70	—	0.33
	Slate ½ in.	—	—	0.05
	Wood shingles, plain plastic film faced	— —	0.94	
SIDING MATERIALS (On flat surface)	Shingles:			
	Asbestos-cement	120	—	0.21
	Wood, 16″, 7½″ exposure	—	—	0.87
	Wood, double, 16″, 12″ exposure	—	—	1.19
	Wood, plus insulating backer board 5/16 in.	—	—	1.40
	Siding:			
	Asbestos-cement, ¼″ lapped	—	—	0.21
	Asphalt roll siding	—	—	0.15
	Asphalt insulating siding (½″ bd.)	—	—	1.46
	Wood drop 1 x 8″	—	—	0.79
	Wood bevel, ½″ x 8″ lapped	—	—	0.81

Material	Description	Density (lb per cu ft)	Per inch thickness R-Value	For thickness listed R-Value
	Wood bevel, ¾ x 10" lapped	—	—	1.05
	Wood plywood ⅜" lapped	—	—	0.59
	Aluminum or steel, over sheathing, hollow-backed	—	—	0.61
	Insulating-board backed nominal ⅜"	—	—	1.82
	Insulating-board backed nominal ⅜" foil backed	—	—	2.96
	Architectural glass	—	—	0.10
FINISH FLOORING MATERIALS	Carpet and fibrous pad	—	—	2.08
	Carpet and rubber pad	—	—	1.23
	Cork tile ⅛ in.	—	—	0.28
	Terrazzo 1 in.	—	—	0.08
	Tile-asphalt, linoleum, vinyl, rubber	—	—	0.05
	Wood, hardwood finish ¾ in.	—	—	0.08
INSULATING MATERIALS Blanket and batt	Mineral fiber, fibrous form processed from rock, slag or glass			
	Approx. 2 to 2¾" ... Note 1	—	—	7
	Approx. 3 to 3½" ... Note 1	—	—	11
	Approx. 5¼ to 6½" Note 1	—	—	19
Board and Slabs	Cellular glass	9	2.50	—
	Glass fiber, organic bonded	4-9	4.00	—
	Expanded rubber (rigid)	4.5	4.55	—
	Expanded polystyrene extruded, plain	1.8	4.00	—
	Expanded polystyrene extruded (R-12 exp.)	2.2	5.00	—
	Expanded polystyrene extruded (R-12 exp.) (Thickness 1" and greater)	3.5	5.26	—
	Expanded polystyrene, molded beads	1.0	3.57	—
	Expanded polyurethane (R-11 exp.)	1.5	6.25	—
	Mineral fiber with resin binder	15	3.45	—
	Mineral fiberboard wet felted			
	Core or roof insulation	16-17	2.94	—
	Acoustical tile	18	2.86	—
	Acoustical tile	21	2.70	—
	Mineral fiberboard wet molded			
	Acoustical tile	23	2.38	—
	Wood or cane fiberboard			
	Acoustical tile ½ in.	—	—	1.25
	Acoustical tile ¾ in.	—	—	1.89
	Interior finish (plank, tile)	15	2.86	—
	Insulating roof deck			
	Approximately 1½ in.	—	—	4.17
	Approximately 2 in.	—	—	5.56
	Approximately 3 in.	—	—	8.33
	Wood shredded (cemented in preformed slabs)	22	1.67	—
	Foil faced, glass fiber — reinforced cellular polyisocyanurate	2	7.04	—
	Nominal 0.5 in.	2	—	3.6
	Nominal 1.0 in.	2	—	7.2
	Nominal 2.0 in.	2	—	14.4

Material	Description	Density (lb per cu ft)	Per inch thickness R-Value	For thickness listed R-Value
Loose Fill	Cellulose insulation (milled paper or wood pulp)	2.5-3	3.70	—
	Sawdust or shavings	0.8-1.5	2.22	—
	Wood fiber, softwoods	2.0-3.5	3.33	—
	Perlite, expanded	5.0-8.0	2.70	—
	Mineral fiber (rock, slag or glass):			
	Approximately 3" Note 1	8-15	—	9
	Approximately 4½" Note 1	8-15	—	13
	Approximately 6¼" Note 1	8-15	—	19
	Approximately 7¼" Note 1	8-15	—	24
	Silica aerogel	7.6	5.88	—
	Vermiculite (expanded)	7.0-8.2	2.13	—
		4.0-6.0	2.27	—
WOODS	Maples, oak and similar hardwoods	45	0.91	—
	Fir, pine, and similar softwoods	32	1.25	—
	Fir, pine, and similar softwoods ¾ in.	32	—	0.94
	1½ in.	32	—	1.89
	2½ in.	32	—	3.12
	3½ in.	32	—	4.35

Note 1: R-value varies with fiber diameter. Insulation is produced by different densities; therefore, there is a wide variation in thickness for the same R-value between various manufacturers. (See Batt and Loose Fill Insulation.)

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TABLE A-5

COEFFICIENTS OF TRANSMISSION (U) OF WINDOWS, SKYLIGHTS, AND LIGHT TRANSMITTING PARTITIONS*

(These values are for heat transfer from air to air.)
Btu per (hr) (sq ft) (F Deg)

PART A
VERTICAL PANELS (EXTERIOR WINDOWS, SLIDING PATIO DOORS AND PARTITIONS) — FLAT GLASS, GLASS BLOCK AND PLASTIC SHEET

Description	Exterior[1] Winter	Exterior[1] Summer	Interior
Flat Glass			
single glass	1.13	1.06	0.73
insulating glass—double[2]			
3/16 in. air space	0.69	0.64	0.51
¼ in. air space	0.65	0.61	0.49
½ in. air space	0.58	0.56	0.46
½ in. air space, low emissivity coating[3]			
emissivity = 0.20	0.38	0.36	0.32
emissivity = 0.40	0.45	0.44	0.38
emissivity = 0.60	0.52	0.50	0.42
insulating glass—triple[2]			
¼ in. air spaces	0.47	0.45	0.38
½ in. air spaces	0.36	0.35	0.30
storm windows			
1 in.-4 in. air space	0.56	0.54	0.44
Glass Block[4]			
6 x 6 x 4 in. thick	0.60	0.57	0.46
8 x 8 x 4 in. thick	0.56	0.54	0.44
—with cavity divider	0.48	0.46	0.38
12 x 12 x 4 in. thick	0.52	0.50	0.41
—with cavity divider	0.44	0.42	0.36
12 x 12 x 2 in. thick	0.60	0.57	0.46
Single Plastic Sheet	1.09	1.00	0.70

[1]See Part C for adjustment for various window and sliding patio door types.
[2]Double and triple refer to the number of lights of glass.
[3]Coating on either glass surface facing air space; all other glass surfaces uncoated.
[4]Dimensions are nominal.

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PART B
HORIZONTAL PANELS (SKYLIGHTS) FLAT GLASS, GLASS BLOCK AND PLASTIC BUBBLES

Description	Exterior[1] Winter[5]	Exterior[1] Summer[6]	Interior[5]
Flat Glass			
single glass	1.22	0.83	0.96
insulating glass—double[2]			
3/16 in. air space	0.75	0.49	0.62
¼ in. air space	0.70	0.46	0.59
½ in. air space	0.66	0.44	0.56
½ in. air space, low emissivity coating[3]			
emissivity = 0.20	0.46	0.31	0.39
emissivity = 0.40	0.53	0.36	0.45
emissivity = 0.60	0.60	0.40	0.50
Glass Block[4]			
11 x 11 x 3 in. thick with cavity divider	0.53	0.35	0.44
12 x 12 x 4 in. thick with cavity divider	0.51	0.34	0.42
Plastic Bubbles[7]			
single walled	1.15	0.80	—
double walled	0.70	0.46	—

[5]For heat flow up.
[6]For heat flow down.
[7]Based on area of opening, not total surface area.

(See following page for Part C of this table.)

PART C
ADJUSTMENT FACTORS FOR VARIOUS WINDOW AND SLIDING PATIO DOOR TYPES
(Multiply U values in Parts A and B by these factors)

Description	Single Glass	Double or Triple Glass	Storm Windows
Windows			
All Glass[8]	1.00	1.00	1.00
Wood Sash—80% Glass	0.90	0.95	0.90
Wood Sash—60% Glass	0.80	0.85	0.80
Metal Sash—80% Glass	1.00	1.20	1.20[9]
Sliding Patio Doors			
Wood Frame	0.95	1.00	—
Metal Frame	1.00	1.10	—

[8]Refers to windows with negligible opaque area.
[9]Value becomes 1.00 when storm sash is separated from prime window by a thermal break.

TABLE A-6

COEFFICIENTS OF TRANSMISSION (U) FOR SLAB DOORS*
Btu per (hr) (sq ft) (F Deg)

Thickness[1]	Winter: Solid Wood, No Storm Door	Winter: With Storm Door Wood	Winter: With Storm Door Metal	Summer, No Storm Door
1 in.	0.64	0.30	0.39	0.61
1¼ in.	0.55	0.28	0.34	0.53
1½ in.	0.49	0.27	0.33	0.47
2 in.	0.43	0.24	0.29	0.42
	Steel Door			
1¾ in.				
A[3]	0.59	—	—	0.58
B[4]	0.19	—	—	0.18
C[5]	0.47	—	—	0.46

[1]Nominal thickness.

[2]Values for wood storm doors are for approximately 50% glass; for metal storm doors values apply for any percent of glass.

[3]A = Mineral fiber core (2 lb/cu ft).

[4]B = Solid urethane foam core with thermal break.

[5]C = Solid polystyrene core with thermal break.

Note: Hollow core doors 1⅜ in. thick - R = 2.17; U = 0.46
1¾ in. thick - R = 2.22; U = 0.45

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APPENDIX B

FORMULA FOR DETERMINING THE OVERALL U_o OF THE WALL

$$U_o = \frac{U_{cav}A_{cav} + U_{sol}A_{sol} + U_{win}A_{win} + U_{door}A_{door} + U_{box}A_{box} + U_{found}A_{found}}{A_o}$$

Where:

U_o	=	Overall thermal transmittance of gross wall area
A_o	=	Gross area of exterior walls
U_{cav}	=	Thermal transmittance of cavity area (usually assume 80%)
A_{cav}	=	Area between wall framing where insulation may be placed
U_{sol}	=	Thermal transmittance of wood framing area
A_{sol}	=	Area of wood framing (usually assume 20%)
U_{box}	=	Thermal transmittance of box sill area
A_{box}	=	Area of box sill
U_{found}	=	Thermal transmittance of foundation area
A_{found}	=	Area of above grade exposed concrete
U_{win}	=	Thermal transmittance of window
A_{win}	=	Total glass area
U_{door}	=	Thermal transmittance of door
A_{door}	=	Total door area

FORMULA FOR DETERMINING THE OVERALL U_o OF THE CEILING

$$U_o = \frac{U_{cav}A_{cav} + U_{sol}A_{sol} + U_{skylight}A_{skylight}}{A_o}$$

Where:

U_o	=	Overall thermal transmittance of gross roof/ceiling
A_o	=	Gross area of roof/ceiling assembly
U_{cav}	=	Thermal transmittance of cavity area
A_{cav}	=	Area between wood framing
U_{sol}	=	Thermal transmittance of framing
A_{sol}	=	Area of wood framing (usually assume 10%)
$U_{skylight}$	=	Thermal transmittance of skylight elements
$A_{skylight}$	=	Area of skylight (including frame)

APPENDIX C

INSULATION, EQUIPMENT AND CONDENSATION CONTROL

This appendix is a guide for the proper installation of insulation. The preceding appendices indicated the required amounts and types of insulation necessary to provide the various thermal resistance values for the building envelope. In order to attain the resistance values specified, it is important that the insulation be properly installed. This appendix includes types of materials currently available and common application practices.

Condensation control should be provided in the form of vapor barriers and thermal breaks. Vapor barriers should be installed on the warm side (area heated in winter) of all walls, ceilings, and insulated floors. All metal window, skylight, and door frames should contain a thermal break.

Insulation is manufactured in many forms and types. The most commonly used materials in residential construction are batts and blankets, rigid insulation, reflective insulation, loose fill, and sprayed insulation. The following is a list of types of materials and the federal specifications governing their characteristics.

Cork board	FS HH-I-561
Cellular glass	FS HH-I-551
Duct insulation	FS HH-I-558b
Expanded polystyrene insulation board	FS HH-I-524
Fiberboard	FS LLL-I-535 or ASTM C-208 Class C
Insulation board (urethane)*	FS HH-I-530
Insulation, thermal (perlite)	FS HH-I-574
Mineral fiber, pneumatic or poured	FS HH-I-1030A
Mineral fiber, insulation blanket	FS HH-I-521E
Perlite	FS HH-I-526a
Perimeter insulation	FS HH-I-524a Type II
	FS HH-I-558b Form A, Class 1 or 2
Reflective, thermal	FS HH-I-1552
Structural fiberboard insulation roof deck	AIMA IB Spec. No. 1
Cellulose; vegetable or wood fiber	FS HH-I-515b-25
Vermiculite	FS HH-I-585
Vermiculite, water repellent loose fill	FHA UM-30
Mineral fiber, roof insulation	HH-I-526c

BATTS AND BLANKETS

These materials are usually identified on the package and on the vapor barrier facing with their "R" values. Under the federal specifications, there are 3 standard products identified as R-7, R-11, and R-19. These values are based on the insulation value of the mass. Some manufacturers offer other products such as R-8, R-13 and R-22. The specific thickness of insulation required for a specific "R" value may vary from one manufacturer to another due to differences in base materials and manufacturing processes.

General Guidelines

1. Install insulation so the vapor barrier faces the interior of the dwelling.
2. Vapor barriers should not be left exposed.
3. Insulate all voids of the building envelope including small spaces, gaps, around receptacles, pipes, etc.
4. Place insulation on the cold side of pipes and ducts (see Fig. 4). Insulation is not required for supply and return air ducts in heated basements and cellars.

Ceilings

There is a variety of methods for installing blanket insulation in ceilings.

1. Fastening from below (Fig. 1b).
2. Installing unfaced (without a vapor barrier), friction-fit blankets (Fig. 2).
3. Laying the insulation in from above when the ceiling finish material is in place (Fig. 1a).

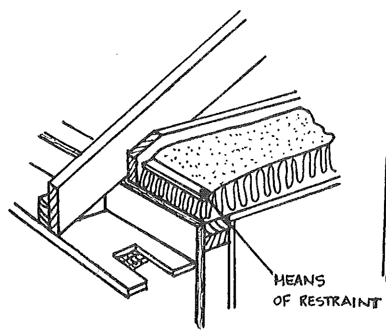


Fig. 1a

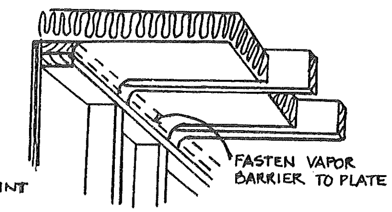


Fig. 1b

Fasten flanges to the inside of ceiling joists as shown in Fig. 1b. Extend the insulation entirely across the top plate, keeping the blanket as close to the plate as possible. Fasten vapor barrier to plate. When eave vents are used, the insulation should not block air movement from eave to space above insulation (Fig. 1a).

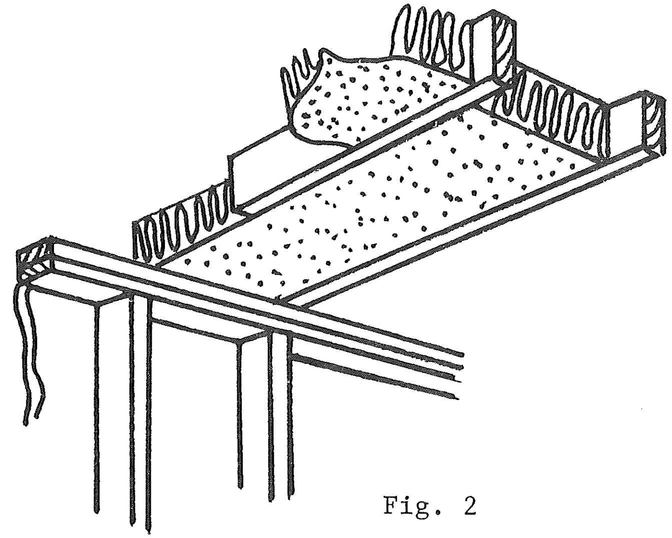


Fig. 2

Insert friction-fit blankets between ceiling joists (Fig. 2). Allow insulation to overlap the top plate of the exterior wall, but not enough to block eave ventilation. The insulation should be in contact with the top of the plate to avoid heat loss and air infiltration beneath the insulation. The required vapor barrier is not shown.

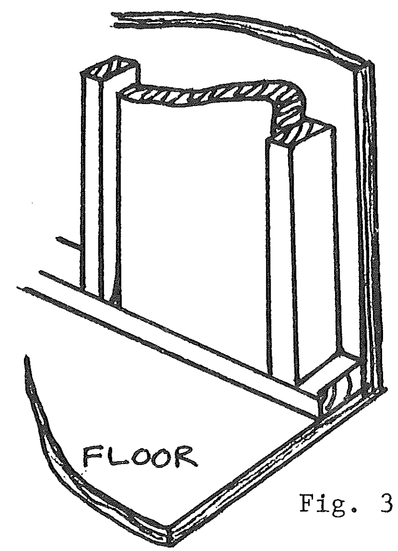


Fig. 3

Insert blankets into stud spaces. Working from the top down, space fasteners per manufacturers recommendations, fitting flanges tightly against face of stud (Fig. 3). Cut blankets slightly over length and fasten the vapor barrier to the top and bottom plates.

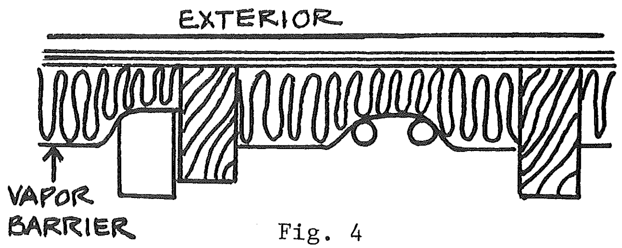


Fig. 4

Insert insulation behind (cold side in winter) pipes, ducts, and electrical boxes (Fig. 4).

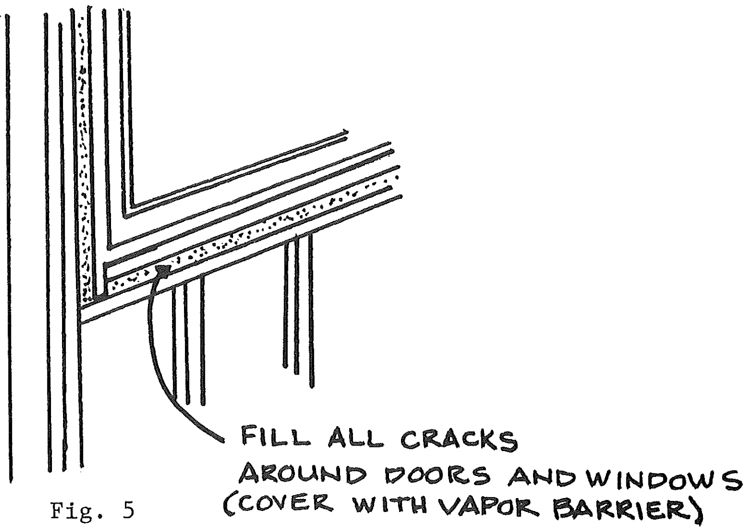


Fig. 5

Fill small spaces between rough framing and door and window heads, jambs and sills with pieces of insulation (Fig. 5).

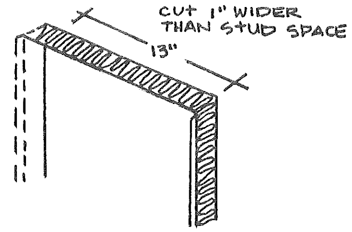


Fig. 6a

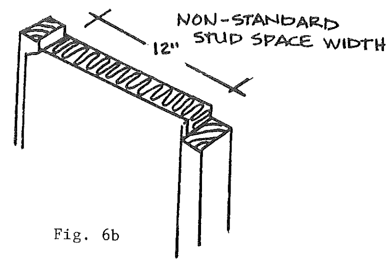


Fig. 6b

Insulate nonstandard-width stud or joist spaces by cutting the insulation and vapor barrier an inch or so wider than the space to be filled (Fig. 6a). Pull the vapor barrier on the cut side to the other stud, compressing the insulation behind it, and fasten through vapor barrier to stud face (Fig. 6b). Unfaced blankets are cut slightly oversize and fitted into place.

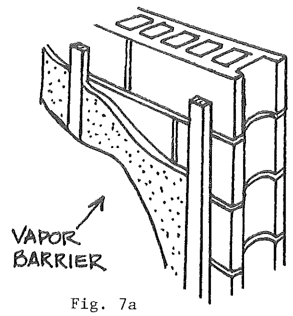


Fig. 7a

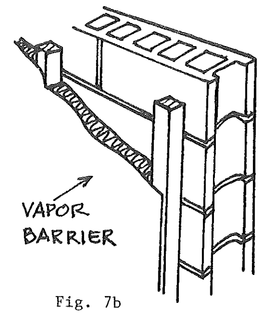


Fig. 7b

Masonry walls may be insulated by inserting insulation between furring strips spaced at 16 or 24 inches o.c. (Fig. 7a and 7b). It is recommended to apply the vapor barrier to the inside surface.

Floor and Crawl Spaces

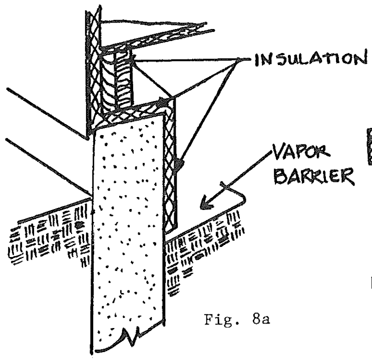


Fig. 8a

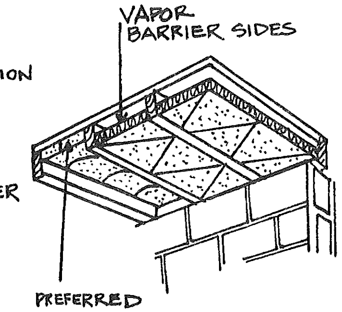


Fig. 8b

Floors over crawl spaces (Fig. 8a) should be insulated either by insulating the foundation walls or by placing insulation on or between the joists. Insulation should be securely fastened. In all cases, the vapor barrier side of the insulation should face the floor above; that is, be adjacent to the warm side in winter. A vapor barrier should be used to cover the ground.

Dropped Soffits

Insulation of dropped soffits over kitchen cabinets, bathtubs, showers, or similar areas, need special attention when they are exposed to the attic. If the dropped soffit is framed before ceiling finish material is applied, a "board" (plywood, hardboard, gypsumboard, etc.) should be installed over the cavity to support insulation.

In multiple dwellings with back-to-back kitchens or baths, it is necessary to extend ceiling finish material over dropped soffits to the party wall to avoid loss of acoustical control and to provide adequate fire stops.

Rigid Insulation

Rigid insulation is available in various sizes and thicknesses made of polystyrene, polyurethane, cork, cellular glass, mineral fiber (glass or rock wool), perlite, wood fiberboard, etc. They are used as insulation for masonry construction, as perimeter insulations around concrete slabs, as exterior sheathing under the weather barrier, as rigid insulations on top of roof decks, and other applications. Rigid insulations, such as polystyrene and polyurethane, are vapor barriers and, in most applications, will not require the installation of a separate barrier.

Installation Procedures

Masonry walls: Rigid insulations are applied to either face of a masonry wall(Fig. 9a and 9c) or are used as a cavity insulation between two wythes of masonry (Fig. 9b). When applied to the face of masonry walls, they are generally installed with adhesive and/or mechanical fasteners. The manufacturer's recommendation should be followed.

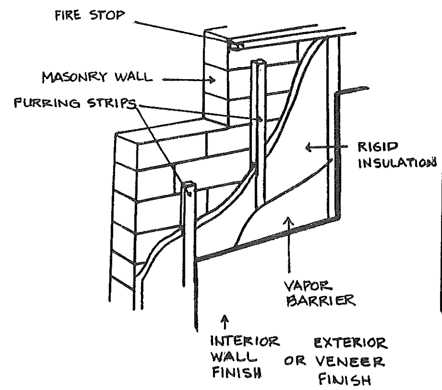


Fig. 9a

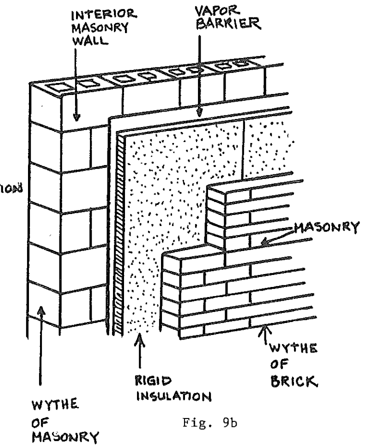


Fig. 9b

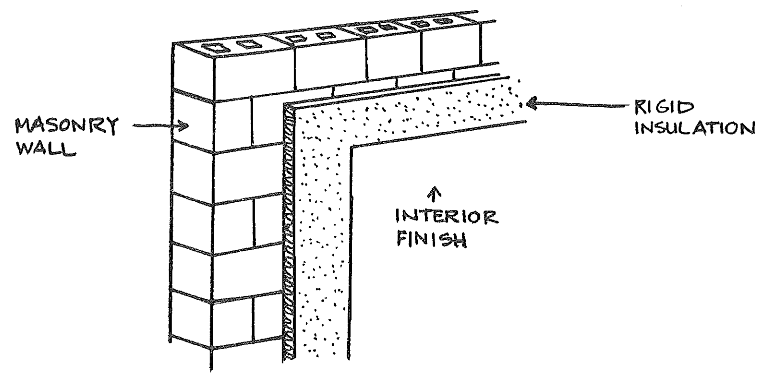


Fig. 9c

Frame Construction: When rigid insulation is used with frame construction (Fig. 10), it is usually applied as sheathing to the outside of the framing, and mechanically attached with nails to wood studs or to metal studs with screws or clips or other approved methods.

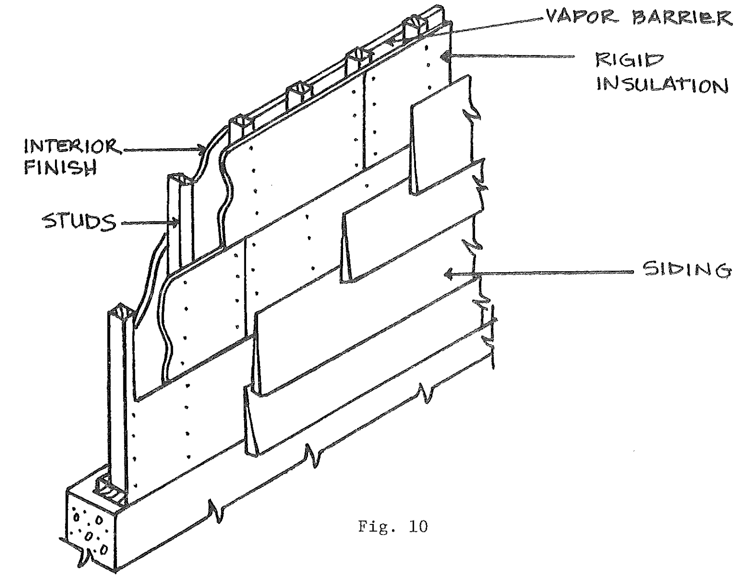


Fig. 10

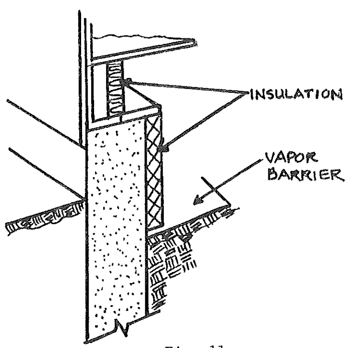


Fig. 11a

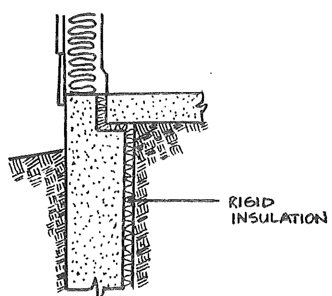


Fig. 11b

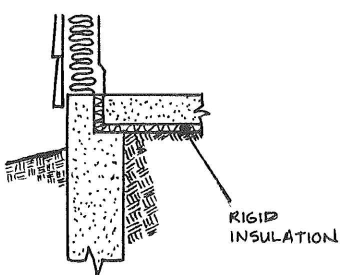


Fig. 11c

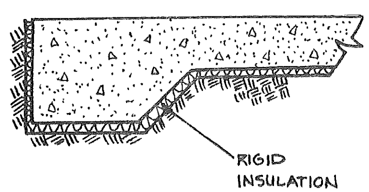


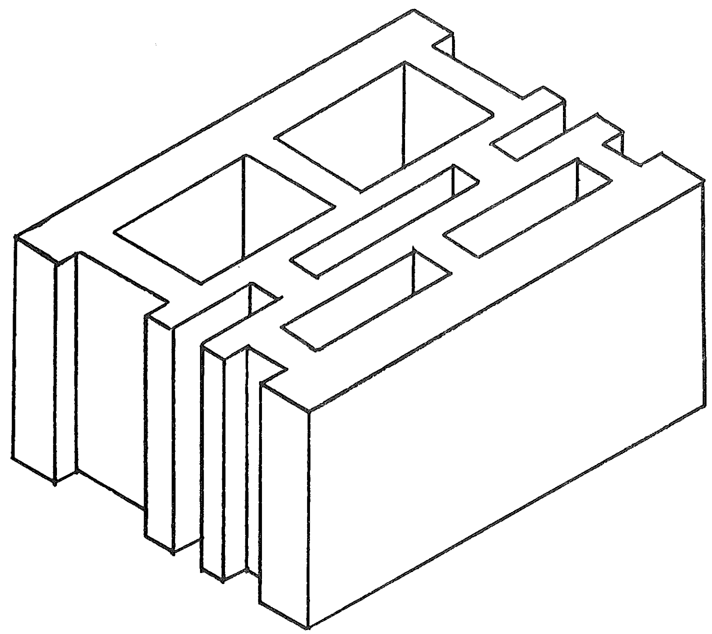
Fig. 11d

Roof Insulation: Roof insulation boards are usually installed with an approved adhesive, hot asphalt, or may be nailed to the roof sheathing. The manufacturer's instructions should be followed.

Slab-on-Grade: Rigid insulation is frequently used as insulation around the perimeter of concrete slabs-on-grade (Fig. 11b, c, d) and also may be used on the inside of foundation walls adjacent to heated crawl spaces, basements or cellars (Fig. 11a). Installation is usually accomplished with adhesive and/or mechanical fasteners. Perimeter insulation should be installed against the foundation wall or extended into the interior of the building to a distance equal to the design frost line (Fig. 11b, c and d). Where the slab bears on the foundation ledge, the insulation should be a load-bearing type.

INSULATED CONCRETE BLOCK

Concrete block manufacturers are currently producing several types of multi-celled block with improved insulating values. The thermal resistance of the block will vary depending upon the types of insulation used and the configuration of the cells. An example of a typical multi-celled block is shown below.



LOOSE FILL INSULATION

Materials of this type are those made from mineral fibers (rock or glass), cellulose materials (wood fibers or shredded paper), or other manufactured products that can easily be poured.

BLOWN ATTIC INSULATION

There are several factors pertaining to blown attic insulation that can cause differences in its installed thermal resistance value (R). For a given manufacturer's insulation, the installed thermal resistance (R) value depends on thickness and weight of insulating material applied per square foot. Federal specification HH-I-1030A for insulation requires that each bag of insulation be labeled to show the minimum thickness, the maximum net coverage, and the minimum weight of (that particular) insulation material required per square foot to produce resistance values of R-30, 22, 19, and 11. A bag label example for blown insulation is shown in Fig. 12.

The number of bags of blown insulation required to provide a given R-value to insulate an attic of a given size may be calculated from data provided by the manufacturer. If only the thickness of blown attic insulation is specified, and the density or number of bags is not, the desired or assumed thermal resistance (R) value may not be achieved. The important characteristic is weight per square foot. Thickness is the minimum thickness, not the average thickness experienced in the field.

Adequate baffling of the vent opening or insulation blocking should be provided so as to deflect the incoming air above the surface of the installed blown or poured insulation. Baffles should be made of durable material securely fastened. Baffles should be in place at the time of framing inspection.

Three blown insulations that provide R-19 are:

Material	Minimum Thickness	Maximum Net Coverage/Bag	Bags/1000 Sq. Ft.
Cellulose	5⅛"	59 sq. ft. (40 lb. bag)	17
Glass fiber	8¾"	51 sq. ft. (24 lb. bag)	20
Rock wool	6½"	26 sq. ft. (27 lb. bag)	38

Bag Label Example: The manufacturer recommends these maximum coverages at these minimum thicknesses to provide the levels of installed insulation resistance (R) values shown:

(Based on 25-pound nominal weight bag)

R-Value	Minimum Thickness	Minimum Weight per Sq. Ft.	Bags per 1000 Sq. Ft.	Maximum Net Coverage per Bag
To obtain an insulation resistance R of:	Installed insulation should not be less than:	The weight per sq. ft. of installed insulation should be not less than:	Number of bags per 1000 sq. ft. of net area should not be less than:	Contents of this bag should not cover more than:
R-30	13¾ in. thick	0.768 lbs. per sq. ft.	30	33 sq. ft.
R-22	10 in. thick	0.558 lbs. per sq. ft.	22	45 sq. ft.
R-19	8¾ in. thick	0.489 lbs. per sq. ft.	20	51 sq. ft.
R-11	5 in. thick	0.279 lbs. per sq. ft.	11	90 sq. ft.

Weight contents: not less than 24 lbs.

R-values are determined in accordance with ASTM C-687 and C-236

Fig. 12

REFLECTIVE INSULATION

Reflective insulation is composed of aluminum foil in one or more layers either plain or laminated to one or both sides of kraft paper for structural strength. The insulation value for reflective air spaces, which this type of insulation provides, varies widely depending on the direction of heat flow. They are much more efficient when the heat flow is *down.* Reflective insulations which comply with the requirements when used in a floor, may not be satisfactory in ceilings or walls, where the heat flow is upward and horizontal, respectively. Reflective insulations are effective in controlling radiant heat energy when installed so that they face an air space. Insulation should be installed in such a manner that it is continuous, without holes or tears.

SPRAYED INSULATION

There are several types of insulation which are sprayed against the surface of the building materials or in cavities. Some of these are cellulose with binder, mineral wool with binder, and cellular foams. They may be sprayed directly on concrete, masonry, wood, plastic, or metal panels or may be sprayed between the framing members. Manufacturer's recommended instructions should be followed. To determine that the proper thickness is installed, either refer to the plans and specifications, or request a certification from the supplier that the insulation installed provides the required "R" value.

TYPICAL INSULATION THICKNESSES AND VALUES

Insulation	Approximate R-Value	Thickness
Fiber glass	11	3½"
Fiber glass	13	3⅝"
Fiber glass	19	6"
Fiber glass	30	8"
Fiber glass	38	12"
Extruded Polystyrene Foam	5.4	1"
Extruded Polystyrene Foam	10.8	2"

VAPOR BARRIERS

Vapor barriers are used in conjunction with insulation to decrease the chance of moisture condensation inside the building insulation. Vapor barriers are placed on the side of the wall, ceiling or floor that is warm in winter. For equal vapor pressures, moisture vapor penetration through holes or tears in the insulation vapor barrier is proportional to the size of the opening. Holes or tears should be repaired. A snug fit of blanket flanges against the framing is necessary to prevent moisture from bypassing the vapor barrier.

EQUIPMENT

The installation of the heating system can contribute to inefficiencies. A furnace which is oversized by a factor of 2 will require 8 to 10% more fuel than a furnace of correct size. An installation that has uninsulated ducts passing through an unheated crawl or attic space will lose about 1.5 Btu per hour per square foot of duct per degree of temperature differential between duct air and outside air. This can amount to 40% of a furnace output under mild conditions. Undersized ducting will reduce the amount of circulating air and will affect the capacity of the furnace, but will normally have little effect upon its efficiency. Atmospheric combustion equipment that draws its combustion and stack-dilution air from the heated space will require up to 8% more fuel in a season to heat the required makeup air than sealed combustion equipment. Stack heat recovery devices can recover from about 4% at 450° F to 8% at 800° F.

The appliance manufacturer should be consulted when retrofitting the appliance with combustion air to assure that the appliance warranty is not affected.

Effect of Sizing Limitation on Equipment

Using the example on system design illustrated in Appendix A, an analysis was made to see what impact or problem the proposal for limiting the size of equipment to 15% above the design losses would have.

Example:

Total construction loss	27,760 Btu/hour
One air change per hour:	
Inside volume = 12,188 cu. ft. Q = (12,188) (90) (.018) = 19,744 Btu/hour	
Total infiltration loss	19,744 Btu/hour
	47,504 Btu/hour

Maximum furnace size:

47,504 Btu/hour + 47,504 (.15) Btu/hour = 54,630 Btu/hour

COMBUSTION AIR FOR FIREPLACES

It is recommended that combustion air from the exterior be provided for all fireplaces. Masonry fireplaces can be made more energy efficient with combustion air terminating in the fireplace. The opening of the fireplace should be equipped with a door and the combustion air duct with a damper and a louver to minimize air leakage during periods of nonuse.

CONDENSATION CONTROL

Air Infiltration

The department will accept infiltration losses determined by the air crack method or an overall value of ½ air change per hour.

The department will accept the use of engineered top-side moisture vent systems.

Relative Humidity

Winter: During the winter it is desirable to have humidity in the air in order to prevent the nostrils from becoming dry, furniture from cracking, etc. However, from an energy standpoint, it is desirable to keep the relative humidity low; the trade-off is at about 30%.

Summer: During the summer it is desirable to reduce the level of relative humidity in the building in relationship to the outside relative hu-

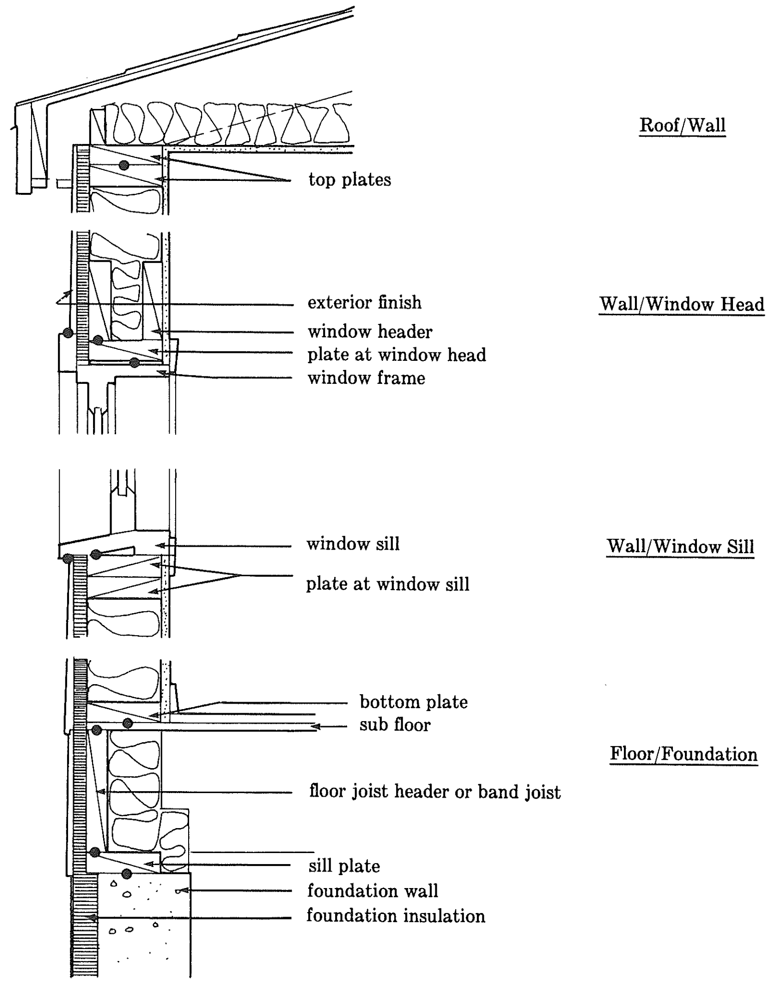
midity. The relative humidity should be kept as high as possible in order to conserve energy, but low enough for comfort. The relative humidity should be kept above 55%, but less than 60%.

APPENDIX D

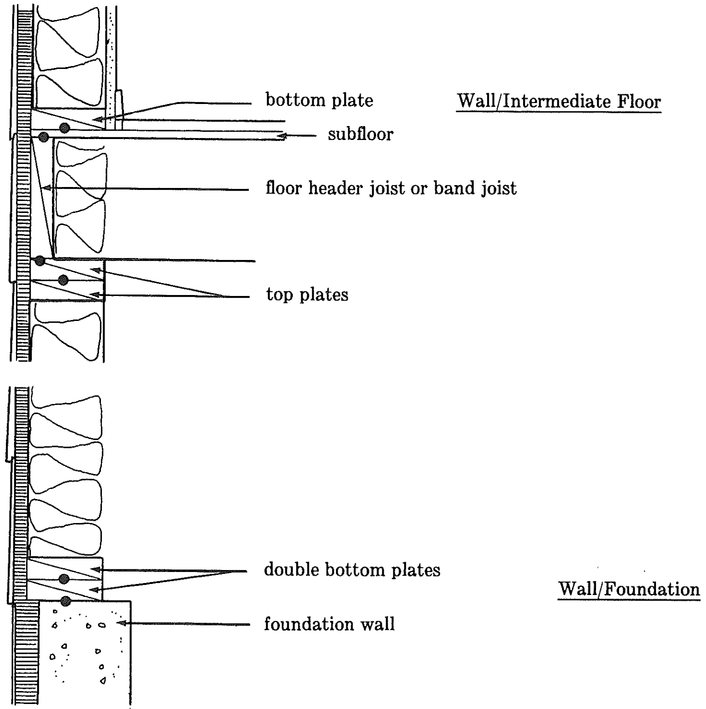
ILLUSTRATIONS OF EXTERIOR OPENINGS IN THE THERMAL ENVELOPE

The following illustrations show some exterior openings in the thermal envelope which may be sealed to control infiltration. A detailed list of sealing requirements for electrically heated homes is given in s. ILHR 22.13 (3).

ILHR 22.13 Infiltration Control for Electrically Heated Homes



ILHR 22.13 Infiltration Control for Electrically Heated Homes (continued)

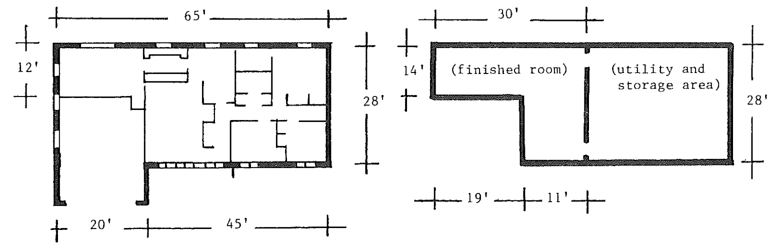


APPENDIX E

CALCULATION OF VENTILATION REQUIREMENTS

The following examples show one way to calculate the cubic feet per minute (CFM) ventilation capacity necessary to meet the requirements of s. ILHR 22.11 (4) for electrically heated homes, and how to calculate the number of air changes delivered by a system.

Example problem #1: Calculate the minimum necessary CFM ventilating capacity for the sample dwelling. The thermal envelope of the sample dwelling encloses the following areas, excluding the garage:



FIRST FLOOR BASEMENT LEVEL

Step #1: Calculate the volume of air contained in the living space

FIRST STORY

The first story interior has 1556 square feet of floor area and 8 foot ceilings. The first floor volume is the floor area multiplied by the ceiling height:

Volume = 1556 sq. ft. × 8 ft. = 12,448 cu. ft.

Next, calculate the volumes (= length × width × height) of spaces which are not living spaces.

Closets	1050 cu. ft.
Utility Room	308 cu. ft.
Vanity in Bath	14 cu. ft.
Storage cabinets	58 cu. ft.
Book shelves	22 cu. ft.
Kitchen cabinets	176 cu. ft.
China cabinets	24 cu. ft.
Fire place	112 cu. ft.
Interior walls	399 cu. ft.
TOTAL	2163 cu. ft.

Subtracting these volumes from the first floor volume gives the volume to be ventilated.

12,448 cu. ft. − 2163 cu. ft. = 10,285 cu. ft.

BASEMENT

The basement has one habitable room which must be ventilated. The room is 575 square feet, the ceiling height is 8 feet.

Volume = 575 sq. ft. × 8 ft. = 4600 cu. ft.

The total living space volume is the sum of the volumes on each story.

Total volume = 10,285 cu. ft. + 4600 cu. ft. = 14,885 cu. ft.

This is the volume of the air which must be exhausted to provide one air change to the living space.

Step #2: Calculate the required CFM capacity.

Use the following formula:

$$CFM = \frac{V \times ach}{60}$$

Where:

CFM = the required exhaust capacity in cubic feet per minute.

V = the volume of air in the space to be ventilated, in cubic feet.

ach = the desired number of air changes per hour. Section ILHR 22.11 (4) requires a minimum of 0.5 air changes per hour for electrically heated homes.

In this case:

$$CFM = \frac{14{,}885 \text{ cu. ft.} \times 0.5 \text{ ach}}{60} = 124 \text{ CFM}$$

A fan or fans with a total effective exhaust capacity of 124 CFM or more would provide 0.5 air changes per hour. The effective capacity is the amount of ventilation actually delivered by the installed system, taking into account any resistance to air flow due to duct work.

Example problem #2: Calculate the number of air changes per hour (ach) which are delivered by an installed ventilation system. If two bathroom fans, each with an effective exhaust rate of 50 cfm, and a

kitchen fan with an effective exhaust rate of 200 cfm are installed in the sample dwelling, how may air changes per hour is the system capable of providing?

Step #1: Calculate the volume of the living space as in step #1 of Example #1. The volume of the living space is 14,885 cubic feet.

Step #2: Calculate the capacity in air changes per hour with the following formula:

$$ach = \frac{CFM \times 60}{V}$$

Where:

ach = the number of air changes per hour that the system is capable of providing.

CFM = the total effective exhaust capacity of the system, in cubic feet per minute.

V = the volume of the space which is ventilated, in cubic feet.

In this case, CFM equals the total effective capacity of the three fans in the kitchen and baths:

CFM = 200 + 50 + 50 = 300 CFM

$$ach = \frac{300 \times 60}{14{,}885} = 1.2 \text{ air changes per hour.}$$

The ventilation system is capable of providing 1.2 air changes per hour to the living space.

INDEX

See also first page of each chapter for listing of section headings.

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