

Wisconsin Administrative Code

Rules of INDUSTRY, LABOR AND HUMAN RELATIONS UNIFORM DWELLING CODE

Cite the rules in this Code as

(for example)

s. ILHR 20.01, Wis. Adm. Code

INDUSTRY, LABOR AND HUMAN RELATIONS

201 East Washington Avenue

Madison, Wisconsin 53702

608-266-3151

INTRODUCTION

Purpose and Structure

The legislature, by s. 35.93 and ch. 227, Stats., directed the publication of the rules of administrative agencies having rule-making authority in a loose-leaf, continual revision system known as the Wisconsin Administrative Code. The code is kept current by means of new and replacement pages. The pages are issued monthly, together with notices of hearings, notices of proposed rules, emergency rules, new rules, instructions for insertion of new material, and other information relating to administrative rules. This service is called the Wisconsin Administrative Register, and comes to the subscriber after the 10th and the 25th of each month. Code pages are issued to subscribers only with the end of the month Register. The editing and publishing of the Register and Code is done by the Revisor of Statutes Bureau, 411 W. State Capitol, Madison, Wisconsin, 53702. (608-266-7275).

Availability

The complete code and the upkeep service are distributed to the county law libraries; to the libraries of the University of Wisconsin Law School and Marquette University Law School; to the State Historical Society; to the Legislative Reference Bureau and to the State Law Library, and to certain designated public libraries throughout the state.

The sale and distribution of the Register, Code and of its parts is handled by Department of Administration, Document Sales and Distribution, 202 S. Thornton Ave., Madison, Wisconsin 53702. (608-266-3358)

Table of Contents

Each code with more than one chapter will have a table of chapters. After the title of each chapter will be the page numbers on which the chapter begins. Each chapter will have a table of sections. When a chapter has more than 10 sections and is over 10 pages in length the page number which that particular section begins on will be inserted after the title of the section.

History Notes

Each page of the code as it was originally filed and printed pursuant to the 1955 legislation, is dated "1-2-56". A rule which is revised or created subsequent to the original printing date is followed by a history note indicating the date and number of the Register in which it was published and the date on which the revision or creation of the rule became effective. The absence of a history note at the end of a section indicates that the rule has remained unchanged since the original printing in 1956. The date line at the bottom of the page indicates the month in which the page was released. Some common abbreviations used in the history notes are: cr. - created, am. - amend, r. - repeal, recr. - recreate, renum. - renumber, eff. - effective and emerg. - emergency.

In some instances an *entire* chapter has been repealed and recreated or renumbered subsequent to the original printing date. When this occurs a history note has been placed at the beginning of the chapter to contain this information. A separate history note appears after each section indicating the date when the revision became effective.

Index

The index for the complete Wisconsin Administrative Code will be found in the last volume. It will be recompiled, reprinted and distributed annually. Some codes have a separate index prepared by the agency involved. See the Building and Heating Code (chs. ILHR 50-64) for an example.

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SUBCHAPTER I—PURPOSE AND SCOPE

ILHR 20.01 Purpose. The purpose of this code is to establish uniform statewide construction standards and inspection procedures for one- and 2-family dwellings and manufactured buildings for dwellings in accordance with the requirements of ss. 101.60 and 101.70, Stats.

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

ILHR 20.02 Scope. The provisions of chs. ILHR 20 to 25 shall apply to the construction and inspection procedures used for all new one- and 2-family dwellings, manufactured buildings for dwellings and newly constructed community-based residential facilities providing care, treatment and services for 3 to 8 unrelated adults.

(1) **MUNICIPAL ORDINANCES.** (a) No municipality shall adopt an ordinance on any subject falling within the scope of this code including, but not limited to, establishing restrictions on the occupancy of dwellings for any reason other than noncompliance with the provisions of this code as set forth in s. ILHR 20.10 (3). This code does not apply to occupancy requirements occurring after the first occupancy for residential purposes following the final inspection referred to in s. ILHR 20.10 (1) (b) 3.

(b) This code shall not be construed to affect local requirements relating to land use, zoning, fire districts, side, front and rear setback requirements, property line requirements or other similar requirements. This code shall not affect the right of municipalities to establish safety regulations for the protection of the public from hazards at the job site.

(c) Any municipality may, by ordinance, require permits and fees for any construction, additions, alterations or repairs not within the scope of this code.

(d) Any municipality may, by ordinance, adopt the provisions of chs. ILHR 20 to 25 to apply to any additions or alterations to existing dwellings.

(2) **LEGAL RESPONSIBILITY.** The department or the municipality having jurisdiction shall not assume legal responsibility for the design or construction of dwellings.

(3) **RETROACTIVITY.** The provisions of this code are not retroactive.

(4) **INNOVATIVE DWELLINGS.** No part of this code is intended to prohibit or discourage the construction of innovative dwellings such as a dwelling built below ground, a geodesic dome, a concrete house, a fiberglass house or any other nonconventional structure.

(5) **LANDSCAPING.** The scope of this code does not extend to driveways, sidewalks, landscaping and other similar features not having an impact on the dwelling structure.

(6) **LICENSING.** A city, village, town or county may license persons for performing work on a dwelling in which the licensed person has no legal or equitable interest.

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

ILHR 20.03 Effective date. The effective date of ch. ILHR 22 of this code is December 1, 1978. Chapters ILHR 20, 21, 23, 24 and 25 shall become effective 6 months after the date of publication.

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

ILHR 20.04 Applications. (1) **NEW DWELLINGS.** The provisions of this code shall apply to all dwellings and dwelling units, the initial construction of which was commenced on or after the effective date of this code. Additions and alterations to dwellings covered by this code shall comply with the provisions of this code at the time the permit for the addition or alteration is issued.

(2) **RECREATIONAL DWELLINGS.** Recreational dwellings, the initial construction of which was commenced on or after the effective date of this code, shall comply with all structural requirements of this code. The installation of any permanent heating, air conditioning, electrical or plumbing systems shall not be required; however, if such systems are installed, those systems shall comply with the provisions of this code. Any addition or alteration to such recreational dwelling or system therein shall comply with the provisions of the code at the time the permit for the addition or alteration is issued.

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

ILHR 20.05 Exemptions. (1) **EXISTING DWELLINGS.** The provisions of this code shall not apply to dwellings and dwelling units, the construction of which was commenced prior to the effective date of this code, or to additions or alterations to such dwellings.

Note: The provisions of chs. ILHR 20 to 25 may be adopted by a municipality to apply to any additions or alterations to existing dwellings.

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(2) **MULTIFAMILY DWELLINGS.** The provisions of this code shall not apply to residences occupied by 3 or more families living independently or occupied by 2 such families and used also for business purposes.

(3) **REPAIRS.** The provisions of this code do not apply to repairs or maintenance to dwellings or dwelling units, or to electrical, heating, ventilating, air conditioning and other systems installed therein.

(4) **MOVING OF DWELLINGS.** The status of a dwelling, new or existing, shall not be affected by the moving of the dwelling.

(5) **ACCESSORY BUILDINGS.** The provisions of this code do not apply to detached garages or to any accessory building(s) detached from the dwelling.

(6) **FARM BUILDINGS.** The provisions of this code do not apply to the buildings used exclusively for farm operations.

(7) **INDIAN RESERVATIONS.** The provisions of this code do not apply to dwellings located on Indian reservation land held in trust by the United States.

(8) **RECREATIONAL VEHICLES AND MOBILE HOMES.** The provisions of this code do not apply to recreational vehicles or mobile homes, but shall apply to the on-site construction of additions to recreational vehicles and mobile homes.

(9) **HISTORICAL BUILDINGS.** The provisions of this code do not apply to historical buildings designated as such by the federal or state government.

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

SUBCHAPTER II—JURISDICTION

ILHR 20.06 Procedure for municipalities exercising jurisdiction. (1) **MUNICIPAL JURISDICTION.** Pursuant to ss. 101.65 and 101.76, Stats., cities, villages, towns and counties may exercise jurisdiction over the construction and inspection of new dwellings. Municipalities intending to exercise jurisdiction shall adopt the Uniform Dwelling Code in its entirety. No additional standards within the scope of this code shall be adopted by the municipality unless specific approval has been granted by the department pursuant to s. ILHR 20.20. No such municipality shall exercise jurisdiction except in accordance with the following procedure.

(a) *Intent to exercise jurisdiction.* Municipalities intending to exercise jurisdiction shall notify the department, in writing, at least 30 days prior to the date upon which the municipality intends to exercise jurisdiction under this code. The notification of intent shall include a statement by the municipality as to which of the following methods will be used for enforcement:

1. Individual municipal enforcement.
2. Joint municipal enforcement.
3. Contract with certified inspector or independent inspection agency.
4. Contract with another municipality.
5. Contract with the department.

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(b) *Submission of ordinances.* Municipalities intending to exercise jurisdiction shall submit all ordinances adopting the uniform dwelling code to the department at the same time as the notice of intent. The department shall review and make a determination regarding municipal intent to exercise jurisdiction over new dwellings within 15 business days of receipt of the municipal ordinances adopting the uniform dwelling code. A municipality may appeal a determination by the department that an ordinance does not comply with the code. Any appeal shall follow the procedure set out in s. ILHR 20.21 (2).

(c) *Passage of ordinances.* A certified copy of all adopted ordinances and subsequent amendments thereto shall be filed with the department within 30 days after adoption.

Note: Municipalities adopting the model ordinance shall be considered to be in compliance with the provisions of this code and may exercise jurisdiction.

(2) **COUNTY JURISDICTION.** A county ordinance shall apply in any city, village or town which has not enacted ordinances pursuant to this section. No county ordinance may apply until after 30 business days after the effective date of this code unless a municipality within the county informs the department of its intent to have this code administered and enforced by the county. This section shall not be construed to prevent or prohibit any municipality from enacting and administering this code at any time after the effective date of this code. The department shall review and make a determination regarding county jurisdiction over new buildings within 15 business days of receipt of the county ordinances adopting the uniform dwelling code.

(3) **DEPARTMENTAL JURISDICTION.** Pursuant to ss. 101.63 and 101.73, Stats., the department will administer and enforce this code in any municipality which has not adopted, or is not covered by, an ordinance adopted in accordance with this section.

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

SUBCHAPTER III—DEFINITIONS

ILHR 20.07 Definitions. (1) "Accessory building" means a detached building, not used as a dwelling unit but is incidental to that of the main building and which is located on the same lot. Accessory building does not mean farm building.

(2) "Addition" means new construction performed on a dwelling which increases the outside dimensions of the dwelling.

(3) "Allowable stress" means the specified maximum permissible stress of a material expressed in load per unit area.

(4) "Alteration" means a substantial change or modification other than an addition or repair to a dwelling or to systems involved within a dwelling.

(5) "Approved" means an approval by the department or its authorized representative. (Approval is not to be construed as an assumption of any legal responsibility for the design or construction of the dwelling or building component.)

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(6) "Attic" means a space under the roof and above the ceiling of the topmost part of a dwelling.

(7) A "balcony" is a landing or porch projecting from the wall of a building.

(8) "Basement" means that portion of a dwelling between floor and ceiling which is below or partly below and partly above grade but so located that the vertical distance from the grade to the floor below is more than the vertical distance from grade to ceiling.

(9) "Building component" means any subsystem, subassembly or other system designed for use in or as part of a structure, which may include structural, electrical, mechanical, plumbing and fire protection systems and other systems affecting health and safety.

(10) "Building system" means plans, specifications and documentation for a system of manufactured building or for a type or a system of building components, which may include structural, electrical, mechanical, plumbing and variations which are submitted as part of the building system.

(11) "Ceiling height" means the clear vertical distance from the finished floor to the finished ceiling.

(12) "Certified inspector" means a person certified by the department to engage in the administration and enforcement of this code.

(13) A "chimney" is one or more vertical, or nearly so, passageways or flues for the purpose of conveying flue gases to the atmosphere.

(14) "Chimney connector". Same as smoke pipe.

(15) "Closed construction" means any building, building component, assembly or system manufactured in such a manner that it cannot be inspected before installation at the building site without disassembly, damage or destruction.

(16) "Code" means the Wisconsin uniform dwelling code.

(17) "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.

(18) "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.

(19) "Compliance assurance program" means the detailed system documentation and methods of assuring that manufactured dwellings and dwelling components are manufactured, stored, transported, assembled, handled and installed in accordance with this code.

(20) "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.

(21) "Dead load" means the vertical load due to all permanent structural and nonstructural components of the building such as joists, raft-

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ers, sheathing, finishes and construction assemblies such as walls, partitions, floors, ceilings and roofs, and systems.

(22) "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 $(30° + 50°) \div 2 = 40°$; therefore, $65° - 40° = 25$ degree days.

(23) "Department" means the department of industry, labor and human relations.

(24) "Detached building" means any building which is not physically connected to the dwelling.

(25) "Dwelling" means any building, the initial construction of which is commenced on or after the effective date of this code, which contains one or 2 dwelling units.

(26) An "existing dwelling" is a dwelling erected prior to the effective date of this code, one for which a valid building permit exists, or one for which lawful construction has commenced prior to the effective date of this code.

(27) "Dwelling unit" means a structure, or that part of a structure, which is used or intended to be used as a home, residence or sleeping place by one person or by 2 or more persons maintaining a common household, to the exclusion of all others.

(28) "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.

(29) "Exit" means a continuous and unobstructed means of egress to a street, alley or open court and includes intervening doors, doorways, corridors, halls, balconies, ramps, fire escapes, stairways and windows.

(30) "Farm operation" is the planting and cultivating of the soil and growing of farm products substantially all of which have been planted or produced on the farm premises.

Note: According to s. 102.04 (3), Stats., the farm operation includes the management, conserving, improving and maintaining of the premises, tools, equipment improvements and the exchange of labor or services with other farmers; the processing, drying, packing, packaging, freezing, grading, storing, delivery to storage, carrying to market or to a carrier for transportation to market and distributing directly to the consumer; the clearing of such premises and the salvaging of timber and the management and use of wood lots thereon but does not include logging, lumbering and wood-cutting operations unless the operations are conducted as an accessory to other farm operations.

(31) "Farm premises" is defined to be the area which is planted and cultivated. The farm premises does not include greenhouses, structures or other areas unless used principally for the production of food or farm products.

(32) "Farm products" are defined as agricultural, horticultural and arboricultural crops. Animals considered within the definition of agricultural include livestock, bees, poultry, fur-bearing animals, and wildlife or aquatic life.

(33) "Farming" means the operation of a farm premises owned or rented by the operator.

(34) "Firebox" means that part of the fireplace used as the combustion chamber.

(34m) "Floor area" means the area of a room that has a ceiling height of at least 7 feet. Rooms with ceilings less than 7 feet in height are not considered to be floor areas.

(35) "Garage" means an unenclosed or enclosed portion of a dwelling used for storing motorized vehicles.

(36) "Gas appliance" means any furnace or heater, air conditioner, refrigerator, stove having an electrical supply cord, dishwasher, dryer, swimming pool heater, or other similar appliance or device used in a dwelling or dwelling unit which uses a gaseous fuel for operation.

(36m) "Groundfloor" means that level of a dwelling located on a site with a sloping grade and which has its floor line at grade.

(37) "Habitable room" means any room used for sleeping, living or dining purposes, excluding such enclosed places as kitchens, closets, pantries, bath or toilet rooms, hallways, laundries, storage spaces, utility rooms, and similar spaces.

(38) "Hearth" means the floor of the fireplace. The inner part of the hearth is located within the firebox; the outer part of the hearth is located outside of the fireplace.

(39) "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.

(40) "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.

(41) "Independent inspection agency" means any person, firm, association, partnership or corporation certified by the department to perform certified inspections under this code.

(42) "Initial construction" means the date of issuance of the Wisconsin uniform building permit.

(43) "Insignia." See "Wisconsin insignia."

(44) "Installation" means the assembly of a manufactured building on site and the process of affixing a manufactured building to land, a foundation, footing or an existing building.

(45) "Intermittent ignition device" means an ignition device which is actuated only when a gas appliance is in operation.

(46) "Kitchen" means an area used, or designed to be used, for the preparation of food.

(47) "Landing" means the level portion of a stairs located within a flight of stairs or located at the base and foot of a stairs.

(48) "Listed and listing" means equipment or building components which are tested by an independent testing agency and accepted by the department.

(49) "Live load" means the weight superimposed on the floors, roof and structural and nonstructural components of the dwelling through use and by snow, ice or rain.

(50) "Loft" means an upper room or floor which is open to the floor below.

(51) "Manufacture" means the process of making, fabricating, constructing, forming or assembling a product from raw, unfinished, semifinished or finished materials.

(52) (a) "Manufactured building" means any structure or component thereof which is intended for use as a dwelling and:

1. Is of closed construction and fabricated or assembled on site or off site in manufacturing facilities for installation, connection or assembly and installation at the building site; or

2. Is a building of open construction which is made or assembled in manufacturing facilities away from the building site for installation, connection, or assembly and installation on the building site and for which certification is sought by the manufacturer.

(b) The term manufactured building does not include a building of open construction which is not subject to par. (a) 2. A single or double width mobile home is not considered a manufactured building and is not subject to this code.

(53) (a) A "hollow unit" is a masonry unit in which the net cross-sectional area parallel to the bearing face is less than 75% of the gross cross-sectional area.

(b) Masonry units having net cross-sectional areas of 75% or more of the gross cross-sectional area are classified as solid units.

(54) A "multi-wythe wall" is a masonry wall composed of 2 or more wythes of masonry units tied or bonded together.

(55) "Municipality" means any city, village, town or county in this state.

(56) "Open construction" means any building, building component, assembly or system manufactured in such a manner that it can be readily inspected at the building site without disassembly, damage or destruction.

(57) "Owner" means any person having a legal or equitable interest in the dwelling.

(58) "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).

(59) "Pilaster" is a projection of masonry or a filled cell area of masonry for the purpose of bearing concentrated loads or to stiffen the wall against lateral forces.

(60) "Recreational dwelling unit" means a permanent structure occupied occasionally or seasonally solely for recreational purposes and not used as a principal residence.

(61) "Repair" means the act or process of restoring to original soundness, including, but not limited to, redecorating, refinishing, nonstructural repairs, maintenance repairs or replacement of existing fixtures, systems or equipment.

(62) "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.

(63) A "single-wythe wall" is a masonry wall consisting of one unit of thickness.

(64) A "smoke chamber" is that part of a fireplace which acts as a funnel to compress the smoke and gases from the fire so that they will enter the chimney above.

(65) A "smoke pipe" is a connector between the solid or liquid fuel-burning appliance and the chimney.

(66) A "stairway" is one or more flights of steps, and the necessary platforms or landings connecting them, to form a continuous passage from one elevation to another.

(67) "Step(s)" is a unit(s) consisting of one riser and one tread, alone or in series.

(68) A "story" is that portion of a building located above the basement, between the floor and the ceiling.

(69) A "stove" is a nonportable solid-fuel-burning, vented, nonducted heat-producing appliance located in the space that it is intended to heat. This definition does not include cooking appliances.

(70) Stovepipe. Same as smoke pipe.

(71) "Strain" means a change in the physical shape of a material caused by stress.

(72) "Stress" means internal resistance to an external force expressed in load per unit area; stresses acting perpendicular (compression or tension) to the surface, shear stresses acting in the plane of the surface, or bending stresses which cause curving.

(73) "Structural analysis" is a branch of the physical sciences which uses the principles of mechanics in analyzing the impact of loads and forces and their effect on the physical properties of materials in the form of internal stress and strain.

(74) "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.

(75) The "throat" of a fireplace is the slot-like opening above the fire-box through which flames, smoke and other products of combustion pass into the smoke chamber.

(76) "Vent" means a vertical flue or passageway to vent fuel-burning appliances.

(77) A "vent connector" is a connector between a fuel-burning appliance and the chimney or vent.

(78) "Window" means a glazed opening in an exterior wall, including glazed portions of doors, within a conditioned space.

(79) "Wisconsin insignia" means a device or seal approved by the department to certify compliance with this code.

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80; cr. (34m) and (36m), Register, February, 1985, No. 350, eff. 3-1-85.

SUBCHAPTER IV—APPROVAL AND INSPECTION OF ONE- AND 2-FAMILY DWELLINGS

ILHR 20.08 Wisconsin uniform building permit. A Wisconsin uniform building permit shall be obtained from the department or the municipality administering and enforcing this code before any on-site construction within the scope of this code is commenced, except where a permit to start construction has been issued in accordance with s. ILHR 20.09 (5) (b) 2. A Wisconsin uniform building permit shall not be required for repairs.

Note: Section ILHR 20.09 (5) (b) 2. permits the issuance of a footing and foundation permit prior to the issuance of the Wisconsin uniform building permit.

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

ILHR 20.09 Procedures for obtaining uniform building permit. (1) APPLICATION FOR A WISCONSIN UNIFORM BUILDING PERMIT. Application for a Wisconsin uniform building permit shall be on the forms obtained from the department or the municipality administering and enforcing this code. No application shall be accepted that does not contain all the information requested on the form.

Note 1: See appendix for a copy of the Wisconsin uniform building permit and application.

Note 2: Any municipality exercising jurisdiction may require reasonable supplementary information not contained on the Wisconsin building permit application.

(2) FILING OF THE WISCONSIN UNIFORM BUILDING PERMIT APPLICATION. The Wisconsin uniform building permit application shall be filed with the municipality administering and enforcing this code or its authorized representative. The municipality shall promptly forward a copy of all applications to the department. If no municipality administers and Register, February, 1985, No. 350

enforces the code, the application shall be filed with the department or its authorized representative.

Note: Section 101.64, Stats., permits the department to collect and publish data.

(3) FEES. (a) *Municipal fees.* Fees shall be submitted to the municipality at the time the Wisconsin uniform building permit application is filed. The municipality shall, by ordinance, determine fees to cover expenses for plan examination, inspection and the issuance of the Wisconsin uniform building permit. The municipality shall collect and send to the department the fee for the Wisconsin uniform building permit in accordance with s. Ind 69.21.

(b) *Department fees.* Where the department administers and enforces the code, the fees for plan examination, inspection, and the issuance of the Wisconsin uniform building permit, in accordance with s. Ind 69.21, shall be submitted to the department, or its authorized representative, at the time the Wisconsin uniform building permit application is filed.

(4) SUBMISSION OF PLANS. At least 2 sets of plans for all one- and 2-family dwellings shall be submitted to the department, or the municipality administering and enforcing this code, for examination and approval at the time the Wisconsin uniform building permit application is filed. A municipality exercising jurisdiction may require a third set of plans at its option.

(a) *Required building plans.* The required building plans shall be legible and drawn to scale or dimensioned and shall include the following:

1. Plot plan. The plot plan shall show the location of the dwelling and any other buildings, wells and disposal systems on the property with respect to property lines.

2. Floor plans. Floor plans shall be provided for each floor. The size and location of all rooms, doors, windows, structural features, exit passageways and stairs shall be indicated. The location of plumbing fixtures, chimneys, and heating and cooling appliances, and, when requested, a heating distribution layout shall be included.

3. Elevations. The elevations shall contain information on the exterior appearance of the building, indicate the location, size and configuration of doors, windows, roof, chimneys, exterior grade, footings and foundation walls, and include the type of exterior materials.

(b) *Data required.* All required plans submitted for approval shall be accompanied by sufficient data and information to determine if the dwelling will meet the requirements of this code. The data and information for determining compliance with the energy conservation standards shall be submitted on forms provided by the department or other approved forms.

(c) *Master plans.* Where a dwelling is intended to be identically and repetitively constructed at different locations, a master plan may be submitted for approval. The plans shall include floor plans, elevations and data as required in par. (a) 2. and 3. If the plans conform to the provisions of the code, an approval and a master plan number shall be issued. The number issued may be used in lieu of submitting building plans for each location. A plot plan shall be submitted for each location at the time of application for the Wisconsin uniform building permit.

(5) **APPROVAL OF PLANS AND ISSUANCE OF PERMITS.** (a) *Plan approval.* If the department, or the municipality administering and enforcing the code, determines that the plans submitted for a one- or 2-family dwelling substantially conform to the provisions of this code and other legal requirements, an approval shall be issued. The plans shall be stamped "conditionally approved" by a certified inspector or certified independent inspection agency. One copy shall be returned to the applicant; one copy shall be retained by the department or the municipality administering and enforcing the code. The conditions of approval shall be indicated by a letter or on the permit. All conditions of the approval shall be met during construction.

(b) *Issuance of permits.* 1. Uniform building permit. The Wisconsin uniform building permit shall be issued if the requirements for filing and fees are satisfied and the plans have been conditionally approved. The permit shall expire 24 months after issuance if construction has not commenced. The municipality issuing the Wisconsin uniform building permit shall send a copy of the application to the department.

2. Permit to start construction of footings and foundation. Construction may begin on footings and foundations prior to the issuance of the Wisconsin uniform building permit where a permit to start construction is obtained. Upon submittal of the application for a permit to start construction, a plot plan, complete footing and foundation information including exterior grading, and a fee, the department or the municipality enforcing this code may issue a permit to start construction of the footings and foundation. The issuance of a permit to start construction shall not influence the approval or denial of the application.

Note: Section 66.036, Stats., prohibits issuance of building permits by counties, cities, towns or villages for structures requiring connection to a private domestic sewerage treatment and disposal system unless such system satisfies all applicable requirements and all necessary permits for such system have been obtained.

(c) *Posting of permit.* The Wisconsin uniform building permit shall be posted in a conspicuous place at the dwelling site.

(6) **DISAPPROVAL OF PLANS AND DENIAL OF PERMITS.** If the department, or the municipality administering and enforcing the code, determines that the Wisconsin uniform building permit application or the plans do not substantially conform to the provisions of this code or other legal requirements are not met, approval shall be denied.

(a) *Denial of application.* A copy of the "denied" application, accompanied by a written statement specifying the reasons for denial, shall be sent to the applicant and to the owner as specified on the Wisconsin uniform building permit application.

(b) *Stamping of plans.* Plans which do not substantially conform to the provisions of the code shall be stamped "not approved." One copy shall be returned to the person applying for the Wisconsin uniform building permit; one copy shall be retained by the department or the municipality administering and enforcing the code.

(c) *Appeals.* The applicant may appeal a denial of the application in accordance with the procedure outlined in s. ILHR 20.21.

(7) **ACTION TO APPROVE OR DENY.** Action to approve or deny a uniform building permit application shall be completed within 10 business days of

receipt of all forms, fees, plans and documents required to process the application.

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80; r. and recr. (7), Register, February, 1985, No. 350, eff. 3-1-85.

ILHR 20.10 Inspections. All inspections, for the purpose of administering and enforcing this code, shall be performed by a certified inspector or certified independent inspection agency.

(1) **REQUIRED INSPECTIONS.** Inspections shall be conducted by the department or the municipality administering and enforcing this code to ascertain whether or not the construction or installations conform to the conditionally approved plans, the Wisconsin uniform building permit application and the provisions of this code and shall notify the permit holder and the owner of any violations to be corrected.

(a) *Inspection notice.* The applicant or an authorized representative shall, in writing or orally, request inspections of the department or the municipality administering and enforcing this code. The department, or the municipality administering and enforcing this code, shall perform the requested inspection within 2 business days after notification, except the final inspection. Construction shall not proceed beyond the point of inspection until the inspection has been completed. Construction may proceed if the inspection has not taken place within 2 business days of the notification, except if otherwise agreed between the applicant and the department or the municipality administering and enforcing the code.

(b) *Inspection types.* The following sequence of inspections shall be performed for the purpose of determining if the work complies with this code:

1. Footing and foundation inspection. The excavation shall be inspected after the placement of forms, shoring and reinforcement, where required, and prior to the placement of footing materials. Where below-grade drain tiles, waterproofing or exterior insulation is required, the foundation shall be inspected prior to backfilling.

2. Rough inspection. A rough inspection shall be performed for each inspection category listed in a. through e. of this section after the rough work is constructed but before it is concealed. All categories of work for rough inspections may be completed before the notice for inspection is provided. The applicant may request one rough inspection or individual rough inspections. A separate fee may be charged for each individual inspection.

a. General construction, including framing.

b. Rough electrical.

c. Rough plumbing.

d. Rough heating, ventilating and air conditioning.

e. Insulation.

3. Final inspection. The dwelling may not be occupied until a final inspection has been made which finds that no violations of this code exist that could reasonably be expected to affect the health and safety of the occupant.

a. The basement portion of the dwelling may be occupied prior to completion of the dwelling, but only if the basement portion to be occupied would otherwise comply with the provisions of this code, particularly those relating to construction of underground dwellings.

(c) *Notice of compliance or noncompliance.* Notice of compliance or noncompliance shall be written on the building permit and posted at the job site. Upon finding of noncompliance, the department or the municipality enforcing this code shall notify the applicant and the owner, in writing, of the violations to be corrected. All cited violations shall be ordered corrected within 30 days after written notification, unless an extension of time is granted pursuant to s. ILHR 20.21.

(3) **VOLUNTARY INSPECTION.** The department or its authorized representative may, at the request of the owner or the lawful occupant, enter and inspect dwellings, subject to the provisions of this code, to ascertain compliance with this code.

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

ILHR 20.11 Suspension or revocation of Wisconsin uniform building permit. The department, or the municipality administering and enforcing this code, may suspend or revoke any Wisconsin uniform building permit where it appears that the permit or approval was obtained through fraud or deceit, where the applicant has willfully refused to correct a violation order or where the inspector is denied access to the premises. No construction shall take place on the dwelling after suspension or revocation of the permit.

(1) Any person aggrieved by a determination made by the municipality exercising jurisdiction may appeal the decision in accordance with s. ILHR 20.21.

(2) Any person aggrieved by a determination made by the department may appeal the decision in accordance with s. ILHR 20.21.

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

SUBCHAPTER V—APPROVAL AND INSPECTION OF MANUFACTURED DWELLINGS AND THEIR COMPONENTS

ILHR 20.12 Scope. This part shall govern the design, manufacture, installation and inspection of manufactured dwellings, manufactured building systems and the components of the building systems displaying the Wisconsin insignia.

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

ILHR 20.13 Manufacture, sale and installation of dwellings. (1) **MANUFACTURE AND SALE.** No manufactured dwelling, manufactured building system or component of the building system subject to this part shall be manufactured for use, sold for initial use or installed in this state unless it is approved by the department and it bears the Wisconsin insignia issued or a state seal or an insignia reciprocally recognized by the department.

(2) **INSTALLATION.** A Wisconsin uniform building permit shall be obtained in accordance with the procedures outlined in s. ILHR 20.09 (1), (2), (3) and (4) (a) 1. before any on-site construction falling within the scope of this code is commenced for a manufactured dwelling. The

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permit shall be issued in accordance with s. ILHR 20.09 (5) (b) 1.

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

ILHR 20.14 Approval procedures. (1) **APPLICATION FOR APPROVAL.** An application for the approval of any manufactured dwelling, building system or component shall be submitted to the department, in the form required by the department, along with the appropriate fees in accordance with s. Ind 69.21. The department shall review and make a determination on an application for approval of a manufactured dwelling within 3 months of receipt of all forms, fees, plans and documents required to complete the review.

(2) **APPROVAL OF BUILDING SYSTEMS AND COMPONENTS.** (a) *Approval of building systems.* 1. Plans and specifications. All plans and specifications shall be submitted to the department according to subpar. a. or b.:

a. Three complete sets of building, structural, mechanical and electrical plans, (including elevations, sections and details), specifications and calculations shall be submitted to the department on behalf of the manufacturer for examination and approval.

b. At least one complete set of building, structural, mechanical and electrical plans, (including elevations, sections and details), specifications and calculations shall be submitted to the department on behalf of a manufacturer by an independent inspection/evaluation agency certified under s. ILHR 26.14. All plans and specifications submitted to the department shall be stamped "conditionally approved" by the independent inspection/evaluation agency.

2. Compliance assurance program. Three sets of the compliance assurance program shall be submitted for examination and approval. The compliance assurance program submitted to the department on behalf of the manufacturer shall meet the standards of the NBS "Model Rules and Regulations" [ILHR 20.24 (3)] or their equivalent as determined by the department.

(b) *Approval of building components.* 1. Plans and specifications. All plans and specifications shall be submitted to the department according to subpar. a. or b.:

a. At least 3 complete sets of plans and specifications for manufactured dwelling building components shall be submitted to the department on behalf of the manufacturer for examination and approval.

b. At least one complete set of plans and specifications for manufactured dwelling building components shall be submitted to the department on behalf of the manufacturer by an independent inspection/evaluation agency certified as required in s. ILHR 26.14. All plans and specifications submitted to the department shall be stamped "conditionally approved" by the independent inspection/evaluation agency.

2. Compliance assurance program. Three sets of the compliance assurance program shall be submitted to the department on behalf of the manufacturer for examination and approval of components. The compliance assurance program shall meet the requirements established by the department or, where applicable, be in the form of the NBS "Model Rules and Regulations" [ILHR 20.24 (3)].

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(3) NOTIFICATION OF APPROVAL OR DENIAL OF PLANS, SPECIFICATIONS AND COMPLIANCE ASSURANCE PROGRAM. (a) *Conditional approval.* If the department determines that the plans, specifications, compliance assurance program and application for approval submitted for such building system or component substantially conform to the provisions of this code, a conditional approval shall be issued. A conditional approval issued by the department shall not constitute an assumption of any liability for the design or construction of the manufactured building.

1. Written notice. The conditional approval shall be in writing and sent to the manufacturer and the person submitting the application for approval. Any noncompliance specified in the conditional approval shall be corrected before the manufacture, sale or installation of the dwelling, building system or component.

2. Stamping of plans, specifications and compliance assurance program. Approved plans, specifications and compliance assurance programs shall be stamped "conditionally approved." At least 2 copies shall be returned to the person designated on the application for approval; one copy shall be retained by the department.

(b) *Denial.* If the department determines that the plans, specifications, compliance assurance program or the application for approval do not substantially conform to the provisions of this code, the application for approval shall be denied.

1. Written notice. The denial shall be in writing and sent to the manufacturer and the person submitting the application for approval. The notice shall state the reasons for denial.

2. Stamping of plans, specifications and compliance assurance program. Plans, specifications and compliance assurance programs shall be stamped "not approved." At least 2 copies shall be returned to the person submitting the application for approval; one copy shall be retained by the department.

(4) EVIDENCE OF APPROVAL. The manufacturer shall keep at each manufacturing plant where such building system or component is manufactured, one set of plans, specifications and compliance assurance program bearing the stamp of conditional approval. The conditionally approved plans, specifications and compliance assurance program shall be available for inspection by an authorized representative of the department during normal working hours.

(5) INSPECTIONS. Manufacturers shall contract with the department or an independent inspection agency to conduct in-plant inspections to assure that the building system and components manufactured are in compliance with the plans, specifications and the compliance assurance program approved by the department. All inspections, for the purpose of administering and enforcing this code, shall be performed by a certified inspector or certified independent inspection agency.

(6) WISCONSIN INSIGNIA. Upon departmental approval of the plans, specifications and compliance assurance program, and satisfactory in-plant inspections of the building system and components, Wisconsin insignias shall be purchased from the department in accordance with the fee established in s. Ind 69.21. A manufacturer shall be entitled to display the Wisconsin insignia on any approved system or component.

(a) *Lost or damaged insignia.* 1. Notification. If Wisconsin insignias become lost or damaged, the department shall be notified immediately, in writing, by the manufacturer or dealer.

2. Return of damaged insignias. If Wisconsin insignias become damaged, the insignia shall be returned to the department with the appropriate fee to obtain a new insignia.

(b) *Affixing Wisconsin insignias.* Each Wisconsin insignia shall be assigned and affixed to a specific manufactured dwelling or component in the manner approved by the department before the dwelling is shipped from the manufacturing plant.

(c) *Insignia records.* 1. Manufacturer's insignia records. The manufacturer shall keep permanent records regarding the handling of all Wisconsin insignias, including construction compliance certificates, indicating the number of Wisconsin insignias which have been affixed to manufactured dwellings or manufactured building components (or groups of components); which Wisconsin insignias have been applied to which manufactured dwelling or manufactured building component; the disposition of any damaged or rejected Wisconsin insignias; and the location and custody of all unused Wisconsin insignias. The records shall be maintained by the manufacturer or by the independent inspection agency for at least 10 years. A copy of the records shall be sent to the department upon request.

2. Construction compliance certificate. Within 30 days after receiving the original Wisconsin insignias from the department, and at the end of each month thereafter, the manufacturer shall submit a construction compliance certificate, in the form determined by the department, for each manufactured dwelling intended for sale, use or installation in the state.

(d) *Unit identification.* Each manufactured dwelling and major transportable section or component shall be assigned a serial number. The serial number shall be located on the manufacturer's data plate.

(e) *Manufacturer's data plate.* The manufacturer's data plate for building systems shall contain the following information, where applicable:

1. Manufacturer's name and address;
2. Date of manufacture;
3. Serial number of unit;
4. Model designation;
5. Identification of type of gas required for appliances and directions for water and drain connections;
6. Identification of date of the codes or standards complied with;
7. State insignia number;
8. Design loads;
9. Special conditions or limitations of unit;
10. Electrical ratings; instructions and warnings on voltage, phase, size and connections of units and grounding requirements.

(7) **RECIPROCITY.** Upon request, the department will make available to any person a list of those states whose dwelling codes are considered equal to the codes established by the department and whose products are accepted reciprocally by Wisconsin.

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

ILHR 20.15 Effect of approval. (1) **RIGHT TO BEAR INSIGNIA.** A manufactured dwelling or building component approved by the department, manufactured and inspected in accordance with this code, shall be entitled to bear the Wisconsin insignia.

(2) **EFFECT OF INSIGNIA.** Manufactured dwellings and manufactured building components bearing the Wisconsin insignia are deemed to comply with this code, except as to installation site requirements, regardless of the provisions of any other ordinance, rule, regulation or requirement.

(3) **RIGHT TO INSTALL.** Manufactured dwellings and components bearing the Wisconsin insignia may be manufactured, offered for sale and shall be entitled to be installed anywhere in Wisconsin where the installation site complies with the other provisions of this code.

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

ILHR 20.16 Suspension and revocation of approval. The department shall suspend or revoke its approval of a manufactured building system or manufactured building component if it determines that the standards for construction or the manufacture and installation of a manufactured building system or manufactured building component do not meet this code or that such standards are not being enforced as required by this code. The procedure for suspension and revocation of approval shall be as follows:

(1) **FILING OF COMPLAINT.** Proceedings to suspend or revoke an approval shall be initiated by the department or an independent inspection agency having a contract with the manufacturer whose approval is sought to be suspended or revoked. Initiation shall be by a signed, written complaint filed with the department. Any alleged violation of the code shall be set forth in the complaint with particular reference to time, place and circumstance.

(2) **INVESTIGATION AND NOTIFICATION.** The department may investigate alleged violations on its own initiative or upon the filing of a complaint. If it is determined that no further action is warranted, the department shall notify the persons affected. If the department determines that there is probable cause, it shall order a hearing and notify the persons affected.

(3) **MAILING.** Unless otherwise provided by law, all orders, notices and other papers may be served by the department by certified mail to the persons affected at their last known address. If the service is refused, service may be made by sheriff without amendment of the original order, notice or other paper.

(4) **RESPONSE.** Upon receipt of notification of hearing from the department, the person charged with noncompliance or nonenforcement may submit to the department a written response within 30 days of the date of service. If the person charged files a timely written response, such person shall thereafter be referred to as the respondent.

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(5) **CONCILIATION AGREEMENT PRIOR TO HEARING.** If the department and the respondent are able to reach agreement on disposition of a complaint prior to hearing, such agreement shall:

(a) Be transmitted in writing to the secretary;

(b) Not be binding upon any party until signed by all parties and accepted by the secretary;

(c) Not be considered a waiver of any defense nor an admission of any fact until accepted by the secretary.

(6) **HEARINGS.** (a) *Subpoenas; witness fees.* Subpoenas shall be signed and issued by the department or the clerk of any court of record. Witness fees and mileage of witnesses subpoenaed on behalf of the department shall be paid at the rate prescribed for witnesses in circuit court.

(b) *Conduct of hearings.* All hearings shall be conducted by persons selected by the department. Persons so designated may administer oaths or affirmations and may grant continuances and adjournments for cause shown. The respondent shall appear in person and may be represented by an attorney-at-law. Witnesses may be examined by persons designated by all parties.

(7) **FINDINGS.** The department shall make findings and enter its order within 14 days of the hearing. Any findings as a result of petition or hearing shall be in writing and shall be binding unless appealed to the secretary.

(8) **APPEAL ARGUMENTS.** Appeal arguments shall be submitted to the department in writing in accordance with ch. 227, Stats., unless otherwise ordered. The department shall review and make a determination on an appeal of notification of suspension or revocation of approval within 45 business days of receipt of the appeal.

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80; am. (8), Register, February, 1985, No. 350, eff. 3-1-85.

ILHR 20.17 Effect of suspension and revocation. (1) **BEARING OF INSIGNIA.** Upon suspension or revocation by the department of the approval of any manufactured dwelling or manufactured building component, no further insignia shall be attached to any dwelling or building component manufactured with respect to which the approval was suspended or revoked. Upon termination of such suspension or revocation, insignias may again be attached to the dwelling or building component manufactured after the date approval is reinstated. Should any dwelling or building component have been manufactured during the period of suspension or revocation, it shall not be entitled to bear the Wisconsin insignia unless the department has inspected, or caused to be inspected, such manufactured dwelling or manufactured building component and is satisfied that all requirements for certification have been met.

(2) **RETURN OF INSIGNIAS.** The manufacturer shall return to the department all insignias allocated for a manufactured dwelling or manufactured building component no later than 30 days from the effective date of any suspension or revocation of the approval by the department. The manufacturer shall also return to the department all insignias which it determines for any reason are no longer needed.

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

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SUBCHAPTER VI—APPROVAL OF MATERIALS

ILHR 20.18 Materials. (1) **ALTERNATE MATERIALS.** No provision in this code is intended to prohibit or prevent the use of any alternate material or method of construction not specifically mentioned in this code. Approval of alternate materials or methods of construction shall be obtained from the department. Requests for approval shall be accompanied by evidence showing that the alternate material or method of construction performs in a manner equal to or superior to the material or method required by the code. The department may require any claims made regarding the equivalent performance of alternate materials or methods to be substantiated by test.

(a) *Tests.* The department may require that the materials, methods, systems, components, or equipment be tested to determine the suitability for the intended use. The department will accept results of tests conducted by a recognized independent testing agency. The cost of testing shall be borne by the person requesting the approval.

1. The test method used to determine the performance shall be one that is a nationally recognized standard.

2. If no nationally recognized standard exists, past performance or recognized engineering analysis may be used to determine suitability.

(2) **UNGRADED OR USED MATERIALS.** Ungraded or used building materials may be used or reused as long as the material possesses the essential properties necessary to achieve the level of performance required by the code for the intended use. The department or the municipality enforcing this code may require tests in accordance with sub.(1) (a).

(3) **MATERIAL APPROVAL PROCESSING TIME.** The department shall review and make a determination on an application for material, equipment or device approval within 30 business days of receipt of all forms, fees, plans and documents required to complete the review.

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

SUBCHAPTER VII—VARIANCES, APPEALS, VIOLATIONS
AND PENALTIES

ILHR 20.19 Individual variance from a specific rule. The department may grant an individual variance to a specific rule only if the granting of such variance does not result in lowering the level of health, safety and welfare established or intended by the specific rule. The department may consider other reasonable criteria in determining whether a variance should be granted including, but not limited to, the effect of granting the variance on statewide and local uniformity.

(1) **APPLICATION FOR VARIANCE.** The applicant shall submit the application for variance to the municipality exercising jurisdiction. Where no municipality exercises jurisdiction, the application shall be submitted to the department. The following items shall be submitted when requesting a variance.

(a) A clear and concise written statement of the specific provisions of this code from which a variance is requested together with a specific
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statement of the procedure and materials to be used if the variance is granted.

(b) A fee to be determined by the department or the municipality exercising jurisdiction. Where the municipality administers and enforces the code, the department may require a fee for the processing of the application in addition to any municipal fee.

(2) **MUNICIPAL RECOMMENDATION.** The municipality administering and enforcing this code shall submit all applications for variance to the department, together with a municipal recommendation concerning whether or not a variance should be granted within 10 days, excluding Saturdays, Sundays and legal holidays, after the receipt of the application. The recommendation of the municipality shall include, but not be limited to, the following items:

(a) What inspections, if any, have actually taken place with regard to the dwelling for which a variance is requested;

(b) Whether or not any correction orders have been issued with regard to the dwelling; and

(c) Whether the granting of the variance would substantially affect the health, safety or welfare of any individual within the municipality.

(3) **DEPARTMENTAL ACTION.** Where a municipality administers and enforces the code, the department shall approve or deny applications for variance and shall mail said notification to the municipality and the applicant within 5 days, excluding Saturdays, Sundays and legal holidays, after receipt of the application for variance and recommendation is received from the municipality. Where the department administers and enforces the code, the department shall approve or deny applications for variance and shall mail said notification to the applicant within 15 days, excluding Saturdays, Sundays and legal holidays, after receipt of the application and fees by the department.

(4) **APPEALS.** Any aggrieved applicant, or the municipality administering and enforcing the code, may appeal the determination of the department in the manner set out in s. 101.02 (6) (e) to (i) and (8), Stats.

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

ILHR 20.20 Municipal variance from the code. Any municipality exercising or intending to exercise jurisdiction under this code may apply to the department for a variance permitting the municipality to adopt an ordinance not in conformance with this code. The department shall review and make a determination on a municipal request to adopt an ordinance not in conformance with this code within 60 business days of receipt of the request.

(1) **APPLICATION FOR VARIANCE.** The department may grant an application only under the following circumstances:

(a) The municipality has demonstrated that the variance is necessary to protect the health, safety or welfare of individuals within the municipality because of specific climate or soil conditions generally existing within the municipality.

(b) The municipality has demonstrated that the granting of the variance, when viewed both individually and in conjunction with other vari-

ances requested by the municipality, does not impair the statewide uniformity of this code.

(2) **DEPARTMENTAL INQUIRY.** Prior to making a determination, the department shall solicit within the municipality and consider the statements of any interested persons as to whether or not said application should be granted.

(3) **APPEALS.** Any municipality aggrieved by the denial of an application may appeal the determination in accordance with the procedure set out in s. 101.02 (6) (e) to (i) and (8), Stats. The department shall review and make a determination on an appeal of denial of a municipal request to adopt an ordinance not in conformance with this code within 60 business days of receipt of the appeal.

(4) **UNIFORMITY.** This section shall be strictly construed in accordance with the goal of promoting statewide uniformity.

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

ILHR 20.21 Appeals of orders, determinations, and for extension of time.

(1) **APPEALS OF ORDERS AND DETERMINATIONS BY A MUNICIPALITY EXERCISING JURISDICTION.** Appeals of an order or determination of a municipality exercising jurisdiction under this code, including denials of application for permits, shall be made in accordance with the procedure set out in ch. 68, Stats., except as follows:

(a) *Appeals of final determinations by a municipality exercising jurisdiction.* Appeals of final determination by municipalities shall be made to the department after the procedures prescribed in ch. 68, Stats., have been exhausted. All appeals to the department shall be in writing stating the reason for the appeal. All appeals shall be filed with the department within 10 business days of the date the final determination is rendered under ch. 68, Stats. The department shall render a written decision on all appeals within 60 business days of receipt of all calculations and documents necessary to complete the review.

Note: Chapter 68, Stats., provides that municipalities may adopt alternate administrative appeal procedures that provide the same due process rights as ch. 68, Stats. Municipalities having adopted such alternate procedures may follow those alternate procedures.

(2) **APPEALS OF ORDERS AND DETERMINATIONS BY THE DEPARTMENT.** Appeals of an order of the department made pursuant to the provisions of this code, including denials of application for permits, shall be in accordance with the procedure set out in s. 101.02 (6) (e) to (i) and (8), Stats. The department shall review and make a determination on an appeal of an order or determination within 60 business days of receipt of all calculations and documents necessary to complete the review.

(3) **EXTENSIONS OF TIME.** (a) The time for correction of cited orders as set out in s. ILHR 20.10 shall automatically be extended in the event that an appeal of said orders is filed. The extension of time shall extend to the termination of the appeal procedure and for such additional time as the department or municipality administering and enforcing this code may allow.

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(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.

Ind 20.23 Saving and severable clauses. History: Cr. Register, November, 1979, No. 287, eff. 6-1-80; r. under s. 13.93 (2m) (b) 16, Stats., Register, February, 1985, No. 350, eff. 3-1-85.

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.

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(2m) American Society for Testing and Materials (ASTM), 1916 Race Street, Philadelphia, PA 19103, STANDARD SPECIFICATION FOR MORTAR FOR UNIT MASONRY, ASTM Designation C270-82.

(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.

Chapter ILHR 21

CONSTRUCTION STANDARDS

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NOTE: Chapter Ind 21 was renumbered to be chapter ILHR 21, Register, February, 1985, No. 350, eff. 3-1-85.

SUBCHAPTER I—SCOPE

ILHR 21.01 Scope. The provisions of this chapter shall apply to the design and construction of all one- and 2-family dwellings.

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

SUBCHAPTER II—DESIGN CRITERIA

ILHR 21.02 Loads and materials. Every dwelling shall be designed and constructed in accordance with the requirements of this section.

(1) **DESIGN LOAD.** Every dwelling shall be designed and constructed to support the actual dead load, live loads and wind loads acting upon it without exceeding the allowable stresses of the material.

(a) *Dead loads.* Every dwelling shall be designed and constructed to support the actual weight of all components and materials. Earth-sheltered dwellings shall be designed and constructed to support the actual weight of all soil loads.

(b) *Live loads.* 1. Floors and ceilings. Floors and ceilings shall be designed and constructed to support the minimum live loads listed in Table 21.02. The design load shall be applied uniformly over the component area.

TABLE 21.02

Component	Live Load (pounds per sq. ft.)
Floors.....	40
Garage floors	50
Exterior balconies, decks, porches	40
Ceilings (with storage)	20
Ceilings (without storage)	5

2. Snow loads. Roofs shall be designed and constructed to support the minimum snow loads listed on the zone map. The loads shall be assumed to act vertically over the roof area projected upon a horizontal plane.

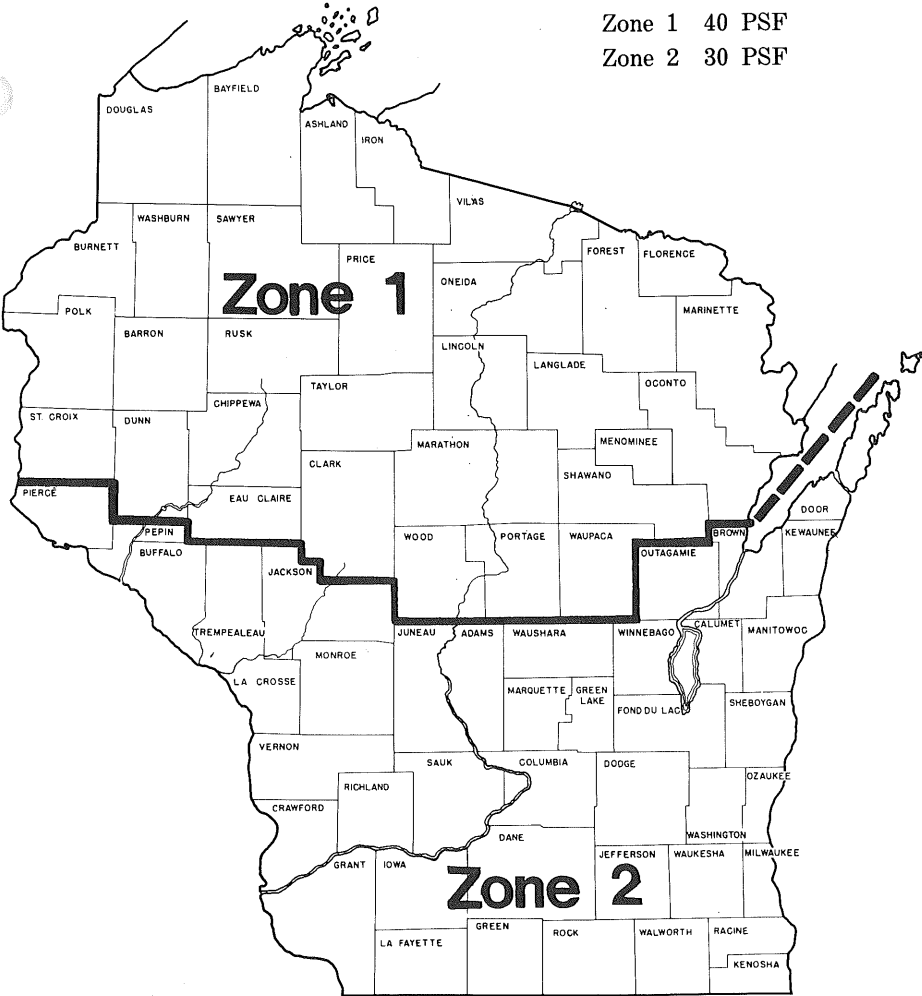
(c) *Wind loads.* Every dwelling shall be designed and constructed to withstand a horizontal and uplift pressure of 20 pounds per square foot acting over the surface area.

(d) *Fasteners.* All building components shall be fastened to withstand the dead load, live load and wind load. Where the effect of the dead load exceeds the wind load effect, the dwelling need not be anchored to the foundation.

Note: See the Appendix for a schedule of fasteners.

Figure 21.02
ZONE MAP FOR ROOF LOADS

ROOF LIVE LOADS
Zone 1 40 PSF
Zone 2 30 PSF



(2) **METHODS OF DESIGN.** All dwellings shall be designed by the method of structural analysis or the method of accepted practice specified in each part of this code.

Note: See ch. NR 116, rules of the department of natural resources, for special requirements relating to buildings located in flood plain zones. Information regarding the elevation of the regional flood may be obtained from the local zoning official.

(3) **STRUCTURAL ANALYSIS STANDARDS.** Structural analysis shall conform to the following nationally recognized standards.

(a) **Wood.** 1. Except as provided in subpar a. and b., structural lumber, glue-laminated timber, timber pilings and fastenings shall be designed in accordance with the "National Design Specification for Wood Construction" and the "Design Values for Wood Construction," a supplement to the National Design Specification for Wood Construction.

a. Section 2.2.5.3. The cumulative effects of short-time loads, such as snow, shall be considered in determining duration of load. For snow load, no greater duration of load factor than 1.05 shall be used.

Note: Subparagraph a. is applicable only when the spacing of the roof rafters exceeds 24 inches on center.

b. Section 4.1.7. The provisions of this section shall also apply to reused lumber. Reused lumber shall be considered to have a duration of load factor of 0.90.

2. Span tables for joists and rafters printed in the appendix or approved by the department may be used in lieu of designing by structural analysis.

Note #1: The department will accept designs and installations in conformance with the following: (1) "Plywood Design Specification" including Supplement No. 1, "Design of Plywood Curved Panels"; Supplement No. 2, "Design of Plywood Beams"; Supplement No. 3, "Design of Flat Plywood Stressed-Skin Panels"; and Supplement No. 4, "Design of Flat Plywood Sandwich Panels"; (2) "Plywood Diaphragm Construction"; (3) Laboratory Report 121, "Plywood Folded Plate Design and Details"; (4) Laboratory Report 93, "Load-Bearing Plywood Sandwich Panels"; and (5) "Fabrication Specifications Plywood-Lumber Components: CP-8, BB-8, SS-8, SP-61, FF-62, PW-61" (above publications available from the American Plywood Association, 1119 A Street, Tacoma, Washington 98401); (6) Design Guide HP-SG-71, "Structural Design Guide for Hardwood Plywood" (available from the Hardwood Plywood Manufacturers Association, 2310 S. Walter Reed Drive, Arlington, Virginia 22206); (7) U.S. Product Standards PS 1-74 for Softwood Plywood Construction and Industrial (available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402); (8) TPI-78, "Design Specification for Metal Plate Connected Wood Trusses" (available from Truss Plate Institute, Inc., 7411 Riggs Road, Hyattsville, Maryland 20783); (9) "Wood Structural Design Data," 1978 edition (available from National Forest Products Association, 1619 Massachusetts Ave. NW, Washington, D.C. 20036).

Note #2: The department will accept plywood treated in accordance with the standards of the American Wood Preservers Association.

(b) **Structural steel.** The design, fabrication and erection of structural steel for buildings shall conform to: AISC, "Specification for Design, Fabrication and Erection of Structural Steel for Buildings" [ILHR 20.24 (1)] and the provisions of the accompanying commentary for this specification.

(c) **Concrete.** Plain, reinforced or prestressed concrete construction shall conform to the following standards:

1. ACI Std. 318, "Building Code Requirements for Reinforced Concrete".

2. ACI Standard 318.1, "Building Code Requirements for Structural Plain Concrete".

Note: The following standards are recognized by the department as being good construction practice: (1) "Commentary on Building Code Requirements for Reinforced Concrete," ACI Report 318; (2) "Recommended Practice for Selecting Proportions for Concrete," ACI Std. 211.1; (3) "Recommended Practice for Selecting Proportions for Structural Lightweight Concrete," ACI Std. 211.2; (4) "Recommended Practice for Hot Weather Concreting," ACI Std. 605; (5) "Recommended Practice for Cold Weather Concreting," ACI Std. 306; (6) "Manual of Standard Practice for Detailing Reinforced Concrete Structures," ACI Std. 315; (7) "Recommended Practice for Evaluation of Compression Test Results of Field Concrete," ACI Std. 214; (8) "Recommended Practice for Measuring, Mixing and Placing Concrete," ACI Std. 614; (9) "Recommended Practice for Concrete Formwork," ACI Std. 347; (10) "Specification for the Design and Construction of Reinforced Concrete Chimneys," ACI Std. 505; (11) "Suggested Design of Joints and Connections in Precast Structural Concrete," ACI Report 512; (12) "Guide for Cellular Concretes Above 50 pcf and for Aggregate Concretes Above 50 pcf with Compressive Strengths Less than 2500 psi," ACI JOURNAL, February 1975 (Copies of above standards may be obtained from American Concrete Institute, P.O. Box 19150, Redford Station, Detroit, Michigan 48219); (13) "Recommended Practices for Welding Reinforcing Steel, Metal Inserts and Connections in Reinforced Concrete Construction," AWS Std. 12.1 (American Welding Society, 2501 NW 7th St., Miami, Florida 33125).

(e) **Masonry.** The design and construction of masonry buildings shall conform to the "Concrete Masonry Handbook" [ILHR 20.24 (5)].

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80; r. and recr. (3) (a), am. (3) (c) and Table 21.02, cr. (3) (c) 2., Register, February, 1985, No. 350, eff. 3-1-85.

ILHR 21.03 Exits, doors and hallways. Exits, doors and hallways shall be constructed as specified in this section.

(1) **EXITS FROM THE FIRST FLOOR.** (a) Every dwelling unit shall be provided with at least 2 exits from the first floor. One of the exits shall discharge to grade. The second exit may discharge to an outside balcony or discharge to grade or discharge into an attached garage provided with an exit door which discharges to grade. An overhead garage door may not be used as an exit door. The 2 required exits from the first floor shall be located as far apart as practical.

(b) Exits from bedrooms shall be in accordance with subds. 1. and 2.: 1. Every bedroom shall have at least one operable window for emergency egress or rescue. The window shall be operable from the inside without the use of separate tools. Where windows are provided as a means of egress or rescue the sill height shall be not more than 44 inches above the floor. An exit door may be used in lieu of an exit window. Where exit doors are provided, the exit shall discharge to an exterior balcony or discharge to grade.

2. All egress or rescue windows from bedrooms shall have a minimum net clear opening of 5.4 square feet. The minimum net clear opening height dimension shall be 24 inches. The minimum net clear opening width dimension shall be 20 inches. If equipped with a screen or storm, it shall be openable from the inside.

(2) **EXITS FROM THE SECOND FLOOR.** At least 2 exits shall be provided from the second floor. One of the exits shall be a stairway or ramp and lead to the first floor or discharge to grade. The second exit may be an exit from a bedroom specified in accordance with sub. (1) (b).

(3) **EXITS ABOVE THE SECOND FLOOR.** At least 2 exits shall be provided for each floor above the second floor. The exits shall be located such that in case any exit is blocked some other exit will still be accessible to the

second floor. The exits shall be stairways or ramps that lead to the second floor or discharge to grade.

(4) **EXITS FROM LOFTS.** (a) At least one stairway exit shall be provided, to the floor below, for a loft exceeding 400 square feet in area.

(b) At least one stairway or ladder exit shall be provided to the floor below for a loft, 400 square feet or less, in area.

(5) **EXITS FROM THE BASEMENT.** (a) Where the entire floor of the basement is below grade, at least one exit shall be provided, unless the basement is used for sleeping. The exit shall be a stairway or ramp which leads to the first floor or discharges to grade.

(b) Where the entire floor of the basement is below grade and the basement is utilized for sleeping, at least two exits shall be provided. The two exits shall not be accessed by the same stairway and shall be in accordance with subds. 1. and 2.

1. One of the exits shall be a stairway which leads to the first floor.

2. The second exit may be a stairway which leads to grade, or a door located at the basement level which leads to grade via an exterior stairs or an outside window which can be opened from the inside without the use of tools. The window shall not be less than 20 inches in width, 24 inches in height and 5.7 square feet in area, with the bottom of the sill located not more than 44 inches above the floor. If a window is provided as the second exit, a window shall be located in each bedroom. If the window is located below grade, an areaway shall be provided. The width of the areaway shall be 1½ times the depth of the areaway. The areaway shall be a minimum of 3 feet measured perpendicular from the wall. The areaway shall be constructed to prevent rainfall flowing into the areaway from entering the bedroom.

(6) **EXITS FROM THE GROUND FLOOR.** (a) At least one exit shall be provided for the ground floor unless the ground floor is used for sleeping. The exit may be a swing door or a sliding glass door which discharges directly to grade or may be a stairway which leads to the first floor.

(b) If the ground floor is used for sleeping, at least two exits shall be provided in accordance with subds. 1. and 2.

1. One of the exits shall discharge to grade via a swing door or sliding glass door.

2. The second exit may be a door which discharges directly to grade or meets the requirements of sub. (5) (b).

(7) **DOORS.** One exterior exit door from a dwelling unit shall be a swing type door at least 3 feet wide by 6 feet 8 inches high. All other exterior exit doors shall be at least 2 feet 8 inches wide by 6 feet 8 inches high. Where double doors are provided, the width of each door leaf shall be at least 2 feet 6 inches. The double doors shall not have an intermediate mullion.

(8) **INTERIOR CIRCULATION.** All passageway doors to at least 50% of the bedrooms, at least one full bathroom, and the common-use areas such as kitchens, dining rooms, living rooms and family rooms shall be at least 2 feet 8 inches wide by 6 feet 8 inches high. Where cased or uncased

openings are provided in lieu of doors, the clear width of the passageway openings shall be at least 2 feet 6 inches wide.

(9) **HALLWAYS.** Hallways shall be at least 3 feet in width except that door hardware, finish trim and heating registers may infringe upon this dimension.

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

ILHR 21.04 Stairs. Every exterior or interior stairs shall conform to the requirements of this section.

(1) **LANDINGS.** (a) *Intermediate landings.* Intermediate landings located in a flight of stairs shall be at least as wide as the stairs and shall measure at least 3 feet in the direction of travel. Trim and handrails may project no more than 3-½ inches into the required width.

(b) *Landings at the top and base of stairs.* A level landing shall be provided at the top and at the foot of every stairs. The landing shall be at least as wide as the stairs and shall measure at least 3 feet in the direction of travel.

(c) *Doors at landings.* Where a door is provided at the head or foot of a stairs, a level landing on each side of the door shall be provided between the door and the stairs, regardless of the door swing.

1. Exception. A landing shall not be required between the door and the head of interior stairs within a dwelling unit, provided the door does not swing over the stairs.

2. Exception. A storm door or screen door shall be permitted to swing over an exterior platform or sidewalk provided the platform or sidewalk is located not more than 8-¼ inches below the door sill and provided the platform has a length at least equal to the width of the door.

(2) **HANDRAILS AND GUARDRAILS.** (a) *Handrails.* Every stairs of more than 3 risers shall be provided with at least one handrail. Handrails shall be provided on all open sides of stairways.

(b) *Guardrails.* All openings between floors, open sides of landings, platforms, balconies or porches which are more than 24 inches above grade or a floor, shall be protected with guardrails.

(c) *Handrail and guardrail details.* 1. Height. Handrails shall be located at least 30 inches, but not more than 34 inches, above the nosing of the treads. Guardrails shall be located at least 36 inches above the upper surface of the floor.

2. Open railings. Open guardrails or handrails shall be provided with intermediate rails or an ornamental pattern to prevent the passage of a sphere with a diameter larger than 9 inches.

3. Clearance. The clearance between the handrail and the wall surface shall be at least 1-½ inches.

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

5. Exterior rails. Exterior handrails and guardrails shall be constructed of metal, decay resistant or pressure treated wood or shall be protected from the weather.

(3) STAIR DETAILS. Stairs shall meet the following requirements:

(a) *Minimum width.* Every stairs shall measure at least 3 feet in width.

(b) *Headroom.* Every stairs shall be provided with a minimum headroom clearance of 6 feet 4 inches. The minimum clearance shall be measured vertically from a line parallel to the nosing of the treads to the ceiling or soffit directly above that line.

(c) *TREADS AND RISERS.* Risers shall not exceed 8 inches in height, measured vertically from tread to tread. Treads shall be at least 9 inches wide, measured horizontally from nosing to nosing. There shall be no variation in uniformity exceeding 3/16-inch in the width of tread or in the height of risers. No flight of stairs shall exceed 12 feet in height unless landings are provided.

(d) *Winders.* Winder steps may be used in stairs where the length of the tread is at least 3 feet and the winder tread measures at least 7 inches in width at a point one foot from the narrow end of the tread.

(e) *Spiral stairs.* Spiral stairs may be used as an exit stairs. The tread shall measure at least 26 inches from the outer edge of the supporting column to the inner edge of the handrail and at least 7 inches in width from nosing to nosing at a point one foot from the narrow end of the tread.

(f) *Ladders.* 1. Design load. Ladders shall be designed to withstand loads of at least 200 pounds.

2. Tread or rungs. a. Minimum tread requirements shall be specified in Table 21.04. Treads less than 9 inches in width shall have open risers. All treads shall be uniform in dimension.

TABLE 21.04

Pitch of Ladder Angle to Horizontal (degrees)	Maximum rise (inches)	Minimum Tread (inches)
41.6 to 48.4	8	9
greater than 48.4 to 55.0	9	8
greater than 55.0 to 61.4	10	7
greater than 61.4 to 67.4	11	6
greater than 67.4 to 71.6	12	5
greater than 71.6 to 75.9	12	4
greater than 75.9 to 80.5	12	3
greater than 80.5 to 90	12	2

b. Rungs may only be used for ladders with a pitch range of 75° to 90°. Rungs shall be at least 1 inch in diameter for metal ladders and 1½ inch for wood ladders. All rungs shall be uniform in dimension.

3. Risers. Risers shall be uniform in height and shall conform with Table 21.04.

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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.

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(3) **COLD-SIDE VENTING.** Cold-side venting of insulation shall be provided at roof/attic, flat-roof/ceiling and sloping-roof/ceiling assemblies. Ventilation shall be provided at the rate of one square foot of free ventilating area for each 300 square feet of area. At least 50% of the vents shall be located at the soffit area.

Note: Example: The venting area required for a 1500 square foot dwelling is 1500 sq. ft. x 1/300 = 5 sq. ft.

(4) **CRAWL SPACE VENTING.** Unheated crawl spaces shall be provided with a concrete slab, roll roofing or plastic film vapor barrier and a minimum of 2 ventilators located at opposite sides of the crawl space. Ventilation shall be provided at the rate of one square foot of free ventilating area for each 1500 square feet of area.

(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.

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) **FIRE-STOPPING 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.

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(3) **DRAFTSTOPPING LOCATIONS.** Draftstopping shall be provided in the following locations:

(a) In floor-ceiling assemblies above and in line with the tenant separation, when tenant separation walls do not extend to the floor sheathing above;

(b) In the attic, mansard, overhang or other concealed roof space above and in line with the tenant separation when tenant separation walls do not extend to the roof sheathing above. Where flat roofs with solid joist construction are used, draftstopping over tenant separation walls is not required; and

(c) At openings around vents, pipes, ducts, chimneys and fireplaces at ceiling and floor levels.

(4) **DRAFTSTOPPING MATERIALS.** Except as provided in sub. (3) (c), draftstopping materials shall be not less than ½-inch gypsumboard, ¾-inch plywood, mineral-based insulation or other approved noncombustible materials.

(5) **FIRE SEPARATION.** Garage space and accessory buildings shall be separated from the dwelling unit in accordance with Table 21.08 and the following requirements:

TABLE 21.08

Distance from Dwelling Wall to the Closest Garage Wall or Accessory Building Wall	Fire-rated Construction
0 to 5 feet	¾-hour
5 to 10 feet with windows in either wall	¾-hour
5 to 10 feet with windows in either wall	No requirements
10 feet or more	No requirements

(a) The garage shall be separated from habitable and nonhabitable areas of the dwelling unit, as well as attics. The vertical separation shall extend from the top of the concrete or masonry foundation to the underside of the roof sheathing or ceiling. The fire-rated construction shall conform with Table 21.08.

1. Exception. Gypsum drywall on the garage side may be untaped provided at least ⅝-inch firecode drywall is used on the garage side and all edges are tightly fitted.

2. Exception. Gypsum drywall on the garage side may be untaped provided at least ½-inch drywall is used on both sides of the wall separating the garage and the dwelling and all edges are tightly fitted.

3. Exception. Two layers of ½-inch drywall on the garage side may be untaped where no drywall is installed on the interior provided all edges are tightly fitted.

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(b) The door and frame assembly between the garage and the dwelling unit shall have a minimum fire rating of 20 minutes. A 1-¾-inch solid core wood or insulated metal door may be installed with a pair of 1-½-inch steel hinges in a 1-7/32-inch minimum thick solid wood frame with a ½-inch thick door stop.

(c) Garage floors shall be constructed of noncombustible materials. The garage floor shall slope toward the exterior garage opening or shall slope to an interior drain.

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

ILHR 21.09 Smoke detectors. Each living unit in one- and 2-family dwellings shall be provided with an approved, listed and labeled smoke detector sensing visible or invisible particles of combustion, installed in the basement of the dwelling and on each floor level except the attic or storage area of each dwelling unit.

Note: Section 50.035 (2), Stats., created by 1983 Wisconsin Act 363 requires the installation of a complete low voltage, interconnected or radio-transmitting smoke detection system in all community-based residential facilities including those having 8 or less beds.

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

ILHR 21.10 Protection against decay and termites. (1) GENERAL. Except as provided in sub. (2), wood used in the following locations shall be pressure treated with preservative, shall be a naturally durable, decay resistant species of lumber and shall be protected against termites:

(a) Wood floor joists closer than 18 inches or wood girders closer than 12 inches to earth;

(b) Sills which rest on concrete or masonry walls or which are less than 8 inches from exposed earth;

(c) Ends of wood girders entering masonry or concrete walls and having clearances of less than ½ inch on the tops, sides and ends;

(d) Wood siding having a clearance of less than 6 inches from the earth;

(e) Wood embedded in earth; and

(f) Bottom plates of load bearing walls in basements.

(2) EXCEPTION. Wood used in basements as furring or finish material or in nonbearing walls need not comply with this section.

(3) IDENTIFICATION. All pressure-treated wood and plywood shall be identified by a quality mark or certificate of inspection of an approved inspection agency which maintains continued supervision, testing and inspection over the quality of the product in accordance with the adopted standards of the American Wood Preservers Bureau specified in s. ILHR 20.24 (2n).

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

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ILHR 21.11 Foam plastic insulation. Foam plastic insulation shall have a flame-spread rating of not more than 75 and a smoke-developed rating of not more than 450.

Note: The department will accept foam plastic insulation tested in accordance with ASTM E-84.

(1) PROTECTION. Foam plastic insulation shall be protected in accordance with the following:

(a) *Walls.* Foam plastic insulation may be used within the cavity of a masonry wall, in cores of masonry units, within the stud space of a wood frame wall, or on the inside of a building surface of a wall or ceiling if the foam plastic insulation is fully protected by a thermal barrier having a finish rating of at least 15 minutes.

(b) *Roofs.* Roof coverings may be applied over foam plastic insulation where the interior of the dwelling is separated from the foam plastic insulation by plywood sheathing at least ½-inch in thickness or other approved material having a minimum 15-minute finish rating.

(c) *Doors.* Foam plastic insulation having a flame-spread rating of 75 or less may be used in doors when the door facing is of metal having a minimum thickness of 0.032-inch aluminum or No. 26 gauge sheet metal.

(2) SPECIFIC APPROVAL. Foam plastic insulation not meeting the requirements of this section may be approved by the department based upon diversified tests which evaluate materials or assemblies representative of actual end use applications.

Note: Approved diversified tests may include, but are not limited to: ASTM E-84 (tunnel test), ASTM E-19 fire test, full-scale corner test, enclosed room corner test and ignition temperature test.

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

SUBCHAPTER III—EXCAVATIONS

ILHR 21.12 Grade. The grade shall slope away from the dwelling to provide drainage away from the dwelling.

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

ILHR 21.13 Excavations adjacent to adjoining property. (1) NOTICE. Any person making or causing an excavation which may affect the lateral soil support of adjoining property or buildings shall provide at least 30 days written notice to all owners of adjoining buildings of the intention to excavate. The notice shall state that adjoining buildings may require permanent protection.

(a) *Exception.* The 30-day time limit for written notification may be waived if such waiver is signed by the owner(s) of the adjoining properties.

(2) RESPONSIBILITY FOR UNDERPINNING AND FOUNDATION EXTENSIONS. (a) *Excavations less than 12 feet in depth.* If the excavation is made to a depth of 12 feet or less below grade, the person making or causing the excavation shall not be responsible for any necessary underpinning or extension of the foundations of any adjoining buildings.

(b) *Excavations greater than 12 feet in depth.* If the excavation is made to a depth in excess of 12 feet below grade, the owner(s) of adjoining

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buildings shall be responsible for any necessary underpinning or extension of the foundations of their buildings to a depth of 12 feet below grade. The person making or causing the excavation shall be responsible for any underpinning or extension of foundations below the depth of 12 feet below grade.

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

ILHR 21.14 Excavations for footings and foundations. (1) EXCAVATIONS BELOW FOOTINGS AND FOUNDATIONS. No excavation shall be made below the footing and foundation unless provisions are taken to prevent the collapse of the footing or foundation.

(2) EXCAVATIONS FOR FOOTINGS. All footings shall be located on undisturbed or compacted soil, free of organic material, unless the footings are reinforced to bridge poor soil conditions.

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

SUBCHAPTER IV—FOOTINGS

ILHR 21.15 Footings. The dwelling shall be supported on a structural system designed to transmit and safely distribute the loads to the soil. The loads for determining the footing size shall include the weight of the live load, roof, walls, floors, pier or column, plus the weight of the structural system and the soil over the footing. Footings shall be sized to not exceed the allowable material stresses. The bearing area shall be at least equal to the area required to transfer the loads to the supporting soil without exceeding the bearing values of the soil.

(1) SIZE. Unless designed by structural analysis, unreinforced concrete footings shall comply with the following requirements:

(a) *Continuous footings.* The minimum width of the footing on each side of the foundation wall shall measure at least 4 inches wider than the wall. The footing depth shall be at least 8 inches nominal. Footings placed in unstable soil shall be formed.

Note: Unstable soil includes soils which are unable to support themselves.

(b) *Column or pier footing.* The minimum width and length of column or pier footings shall measure at least 2 feet by 2 feet. The depth shall measure at least 12 inches nominal. The column shall be so placed as to provide equal projections on each side of the column.

(c) *Trench footings.* Footings poured integrally with the wall may be used when soil conditions permit. The minimum width shall be at least 8 inches nominal.

(d) *Chimney and fireplace footings.* Footing for chimneys or fireplaces shall extend at least 4 inches on each side of the chimney or fireplace. The minimum depth shall measure at least 12 inches nominal.

(e) *Floating slabs.* Any dwelling supported on a floating slab on grade shall be designed through structural analysis.

(2) SOIL-BEARING CAPACITY. No footing or foundation shall be placed on soil with a bearing capacity of less than 2,000 pounds per square foot unless the footing or foundation has been designed through structural

analysis. The soil-bearing values of common soils may be determined through soil identification.

Note: The department will accept the soil-bearing values for the types of soil listed in the following table:

Type of soil	PSF
1. Wet, soft clay; very loose silt; silty clay.....	2,000
2. Loose, fine sand; medium clay; loose sandy clay soils.....	2,000
3. Stiff clay; firm inorganic silt.....	3,000
4. Medium (firm) sand; loose sandy gravel; firm sandy clay soils; hard dry clay	4,000
5. Dense sand and gravel; very compact mixture of clay, sand and gravel	6,000
6. Rock.....	12,000

(a) *Minimum soil-bearing values.* If the soil located directly under a footing or foundation overlies a layer of soil having a smaller allowable bearing value, the smaller soil-bearing value shall be used.

(b) *Unprepared fill material, organic material.* No footing or foundation shall be placed upon unprepared fill material, organic soil, alluvial soil or mud unless the load will be supported. When requested, soil data shall be provided.

Note: The decomposition of organic material in landfill sites established for the disposal of organic wastes may produce odorous, toxic and explosive concentrations of gas which may seep into buildings through storm sewers and similar underground utilities unless provisions are taken to release the gases to the atmosphere.

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

ILHR 21.16 Frost penetration. Footings and foundations, including those for ramps and stoops, shall be placed below the frost penetration level, but in no case less than 48 inches below the ground. Footings shall not be placed over frozen material.

(1) EXCEPTIONS. (a) Floating slabs constructed on grade need not be installed below the minimum frost penetration line provided measures have been taken to prevent frost forces from damaging the structure.

(b) Grade beams need not be installed to the minimum frost penetration line provided measures are taken to prevent frost forces from damaging the structure.

(c) Stoops or ramps need not be installed below the minimum frost penetration level provided measures are taken to prevent frost forces from damaging the structure.

(d) Footings or foundations may bear directly on rock located less than 42 inches below grade. Prior to placement, the rock shall be cleaned of all earth. All clay in the crevices of the rock shall be removed to the level of frost penetration or 1-½ times the width of the rock crevice. Provisions shall be taken at grade to prevent rain water from collecting along the foundation wall of the building.

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

ILHR 21.17 Drain tiles. (1) **WHERE REQUIRED.** Drain tiles or pipe shall be provided around footings located in soils where ground water levels occur above the elevation of the footing.

(a) *Municipalities exercising jurisdiction.* Municipalities exercising jurisdiction under chs. ILHR 20 to 25 may determine the soil types, natural and seasonal groundwater levels for which drain tile is required.

(b) *All other areas.* Drain tiles shall be required whenever a soil test shows evidence of periodic or seasonal saturation at any depth less than 72 inches. When the on-site evaluation shows no evidence of saturation, drain tiles need not be installed. Under all other conditions, drain tiles shall be installed on each side of foundation walls at the footing level.

(2) **MATERIALS AND INSTALLATION REQUIREMENTS.** (a) Drain tiles or pipes used for foundation drainage shall be at least 3 inches inside diameter.

(b) Where individual tiles are used, they shall be laid with 1/8-inch open joints. Joints between the tiles shall be covered with a strip of sheathing paper or asphalt or tar saturated felt.

(c) The tile or pipe shall be placed upon at least 2 inches of washed rock and shall be covered with at least 12 inches of washed rock which meets the following criteria:

1. 90-100% of the rock must pass a 3/4-inch sieve; and

2. 20-25% of the rock must pass a 3/8-inch sieve.

(d) The basement slab shall be placed on at least 4 inches of gravel.

(e) Bleeder tiles shall be provided to connect the exterior footing drain tile to the interior footing tile and shall be placed in the footing such that the tiles are spaced at 8 foot intervals.

(f) The drain tiles or pipe shall be laid at a grade of not less than 1/8 inch per foot leading to the sump pit.

(3) **DRAIN TILE DISCHARGE.** Drain tiles shall be connected to a sump pit. The sump shall discharge to natural grade or be equipped with a pump to discharge water away from the dwelling via surface drainage channels.

(a) *Sumps.* 1. Construction and installation. The sump shall have a rim extending at least one inch above the floor immediately adjacent to the sump, except where the sump is installed in an exterior meter pit. The sump shall have a removable cover of sufficient strength for anticipated loads. The sump shall have a solid bottom.

2. Location. All sumps installed for the purpose of receiving clear water, basement or foundation drainage water shall be located at least 15 feet from any water well.

3. Size. The size of each clear water sump shall be as recommended by the sump pump manufacturer, but shall be not smaller than 18 inches in diameter and 24 inches in depth.

(b) *Sump pump systems.* 1. Pump size. The pump shall have a capacity appropriate for anticipated use.

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2. Discharge piping. Where a sump discharges into a storm building drain or sewer, a free flow check valve shall be installed.

(4) **SUMP DISCHARGE DISPOSAL.** (a) *Storm sewer.* Storm water, surface water, groundwater and clear water wastes shall be drained to a storm sewer where available.

(b) *Other disposal methods.* 1. Where no storm sewer system is available or exists or is not adequate to receive the anticipated load, the storm water, surface water, groundwater and clear water wastes shall be discharged in accordance with local governmental requirements.

2. Where approved by the local governmental authority, storm water, surface water, groundwater and clear water wastes of the properties of one- and 2-family dwellings may be discharged onto flat areas, such as streets or lawns, so long as the water flows away from the buildings and does not create a nuisance.

(c) *Segregation of wastes.* 1. Storm and clear water wastes shall not discharge to any part of a sanitary drain system, nor shall sanitary wastes discharge to any part of a storm or clear water drain system; except the clear water wastes of a refrigerated drinking fountain, water heater relief valve or water softener may discharge to a sanitary drain system.

2. Storm water wastes and clear water wastes shall not be combined until discharging into the storm building drain.

Note: Subsections (3) (a) and (b) and (4) are excerpts from the state uniform plumbing code, s. ILHR 82.36.

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

SUBCHAPTER V—FOUNDATIONS

ILHR 21.18 Foundations. Foundation walls shall be designed and constructed to support the vertical loads of the dwelling, lateral soil pressure, and other loads without exceeding the allowable stresses of the materials of which the foundations are constructed.

(1) **CONCRETE FOUNDATION WALLS.** Unless designed through structural analysis, the minimum thickness of concrete foundation walls shall be determined from Table 21.18-A, but in no case shall the thickness be less than the thickness of the wall it supports.

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TABLE 21.18-A
CONCRETE WALL THICKNESSES

Type of Concrete	Nominal Thickness (inches)	Maximum Height of Unbalanced Fill ¹ for Material of Wall Being Supported (Wood frame - feet)
3000 psi	6	6.5
Unreinforced concrete	8	8
	10	9
	12 ²	10
	14	11.5

¹Unbalanced fill is the difference in elevation between the outside grade and the basement floor.

²The maximum height of unbalanced fill for a 12-inch thick plain concrete wall may be increased to 12 feet provided the wall is constructed of concrete with a minimum compressive value of 6,000 psi at 28 days.

(2) MASONRY FOUNDATION WALLS. Unless designed through structural analysis, the masonry foundation walls shall be constructed in accordance with the following requirements:

(a) *Unreinforced masonry wall; thickness.* The minimum thickness of unreinforced masonry foundation walls shall be determined by Table 21.18-B, but in no case shall the thickness be less than the thickness of the wall it supports.

(b) *Reinforced masonry wall; thickness.* Reinforced masonry walls shall be reinforced in accordance with the requirements of Tables 21.18-C and 21.18-D. In partially reinforced masonry walls, vertical reinforcement shall be provided on each side of any opening, at each wall corner, and at intervals indicated in the tables.

TABLE 21.18-B
MAXIMUM DEPTH BELOW GRADE* (HEIGHT OF FILL) AND THICKNESSES
FOR VARIOUS CONCRETE MASONRY FOUNDATION WALLS WITHOUT
PILASTERS

Wall Construction Nominal Thickness, in., and Type of Unit	Maximum Depth Below Grade, feet, when Walls Support:	
	Frame Construction	Masonry, or Masonry Veneer Construction
Hollow-Load-Bearing:		
8"	5' (6')	6'
10"	6' (7')	7'
12"	7'	7'
Solid Load-Bearing:		
8"	5' (7')	7'
10"	6' (7')	7'
12"	7'	7'

*In well drained sand and gravel soils, the height of the unbalanced fill may be increased to the values shown in parentheses.

TABLE 21.18-C
MAXIMUM DEPTH BELOW GRADE (HEIGHT OF FILL) FOR VARIOUS
CONCRETE MASONRY FOUNDATION WALLS WITH PILASTERS

Wall Construction Nominal Thickness, in., and Type of Unit	Total Ht. of Wall (feet)	Max. Pilaster Spacing o.c. (feet)	Pilaster Size (nominal)	Max. Depth Below Grade (feet)
8-inch Hollow Load-Bearing	7.5	11	16" x 16"	6.5
8-inch Hollow Load-Bearing with Solid Pilasters or Filled Cells of Hollow Units	7.5	20	16" x 16"	6.5

TABLE 21.18-D
MAXIMUM DEPTH BELOW GRADE FOR PARTIALLY REINFORCED
MASONRY WALLS

Wall Construction Nominal Thickness, in., and Type of Unit	Total Height of Wall (feet)	Reinforcement Size and Spacing (feet) Center to Center	Max. Depth Below Grade (feet)
8-inch Hollow Load-Bearing	7.0 to 8.5	#5 bars @ 8'	6.5
		#6 bars @ 8'	7.5
		#7 bars @ 8'	7.5

(3) WOOD FOUNDATIONS. Wood foundations shall be designed and constructed in accordance with the National Forest Products Association standard, "The All-Weather Wood Foundation System, Basic Requirements, Technical Report No. 7" and the following exceptions. The thick-

ness of the foundation wall shall be no less than the thickness of the wall it supports.

(a) *Exceptions.* 1. Section 3.3.1. *Fasteners.* Fasteners shall be of silicon bronze, copper or stainless steel types 304 or 316.

2. Section 6.7. *Plastic film.* Six-mil thick polyethylene sheeting shall be installed over the below-grade portion of exterior basement walls prior to backfilling. Joints in the polyethylene sheeting shall be lapped at least 6 inches and bonded. The top edge of the polyethylene sheeting shall be bonded to the plywood sheathing. A treated lumber or plywood strip shall be attached to the wall to cover the top edge to the polyethylene sheeting. The wood strip shall extend several inches above and below finish grade level to protect the polyethylene from exposure to light and from mechanical damage at or near grade. The joint between the strip and the wall shall be caulked full length prior to fastening the strip to the wall. Alternatively, asbestos-cement board, brick, stucco or other covering may be used in place of the wood strip. The polyethylene sheeting shall extend down to the bottom of the wood footing plate but shall not overlap or extend into the gravel footing.

Note: Additional explanatory information regarding wood foundations can be obtained in "All-Weather Wood Foundation Systems, Design, Fabrication, Installation Manual", published by the National Forest Products Association.

(b) *Materials.* All lumber and plywood shall be pressure treated with preservative and labeled.

Note: The department will accept materials which meet the "Quality control Program for Soft-Wood Lumber, Timber and Plywood Pressure Treated with Water-Borne Preservatives for Ground Contact Use in Residential and Light Commercial Foundations," published by the American Wood Preservers Bureau.

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

SUBCHAPTER VI—FLOORS

ILHR 21.19 Floor design. Floors shall support all dead loads plus the minimum unit live loads as set forth in s. ILHR 21.02. The live loads shall be applied to act vertically and uniformly to each square foot of horizontal floor area.

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

ILHR 21.20 Concrete floors. When concrete floors are provided, the thickness of the concrete shall measure at least 3 inches. In clay soils, a 4-inch thick base course shall be placed in the subgrade consisting of clean graded sand, gravel or crushed stone. The base course may be omitted in sand and gravel soils. Basements shall be provided with a concrete or similar type floor.

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

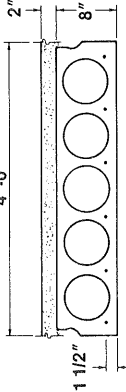
ILHR 21.21 Precast concrete floors. Unless designed through structural analysis, the maximum allowable stress, span or section size for precast concrete floors shall be determined from Table 21.21.

TABLE 21.21

HOLLOW-CORE

4'-0" x 8"
Normal Weight Concrete

Section Properties	Topped	
	Untopped	Topped
A =	215 in. ²	3071 in. ²
I =	1666 in. ⁴	5.29 in. ⁴
Y _b =	4.00 in.	4.71 in.
Y _t =	4.00 in.	580 in. ³
Z _b =	416 in. ³	652 in. ³
Z _t =	416 in. ³	12.00 in.
b _w =	224 plf	323 plf
wt =	56 psf	81 psf
V/S =	1.92 in.	



2"
4'-0"
8"
1 1/2"

$f'_c = 5000 \text{ psi}$
 $f'_{ci} = 3500 \text{ psi}$

Strand Patterns
Producer may vary size and strength (f_{pu}) of strands to achieve value shown in first column.

Safe loads shown include dead load of 10 psf for untopped members and 15 psf for topped members. Remainder is live load.

Capacity of sections of other configurations are similar. For precise values, see local hollow-core manufacturer.

TABLE 21.21 (continued)

4HC8

Table of safe superimposed service load (psf)		Span, ft.																				No Topping			
A _{ps} × f _{pu} kips per ft of width		14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33				
		284	242	207	178	154	134	117	102	89	77	67	59	51											
30-S																									
40-S				285	247	216	189	166	147	130	115	102	90	80	71	63	56	49							
50-S					287	269	241	213	189	169	150	135	120	107	95	85	75	66	59	52	45				
60-S						296	275	260	244	224	205	183	163	146	131	117	105	94	84	76	67				
70-S							284	266	250	236	223	209	190	172	155	139	126	113	102	92	83				

4HC8 + 2

2" Normal Weight Topping

Table of safe superimposed service load (psf)

$A_{ps} \times f_{pu}$ kips per foot of width	Span, ft.																	
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
30-S	260	223	192	166	143	124	107	93	76	61	48							
40-S		269	235	206	181	158	135	115	97	82	67	55	43					
50-S			299	264	234	205	178	154	133	115	98	83	70	58	47			
60-S				284	251	220	193	169	148	129	112	97	83	71	59	49		
70-S					297	280	263	232	205	181	160	141	124	108	94	81	70	

Bold type — Capacity governed by stresses, others governed by flexural or shear strength

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

ILHR 21.22 Wood frame floors. Unless designed through structural analysis, wood frame floors shall comply with the following requirements:

(1) **FLOOR JOISTS.** Wood floor joists shall comply with the requirements of s. ILHR 21.02 (3) (a). The minimum live loads shall be determined from s. ILHR 21.02. Where sill plates are provided, the sill plates shall be fastened to the foundation. Double floor joists shall be provided underneath all bearing walls which are parallel to the floor joists.

(1m) **FLOOR JOISTS RESTING ON MASONRY WALLS.** On masonry walls the floor joists shall rest upon a mortar filled core concrete block or a solid top concrete block or a sill plate. The dimensions of the sill plate shall not be less than 2 inches by 6 inches. The mortar used shall be determined as in s. ILHR 21.26 (3).

(2) **TRUSS JOISTS.** Wood truss joists shall be designed through structural analysis.

(3) **GIRDERS AND BEAMS.** Girders and beams shall be selected from Table 21.22-A.

(a) Wood girders and beams shall be fitted at the post or column. Adjoining ends shall be fastened to each other to transfer horizontal loads across the joint. Beams shall also be fastened to the posts with framing anchors, angle clips, or equivalent.

(b) Where intermediate beams are used, they shall rest on top of the girders; or shall be supported by ledgers or blocks fastened to the sides of the girders; or they may be supported by approved metal hangers into which the ends of the beams shall be fitted.

(4) **BEARING.** The minimum bearing for wood joists and rafters shall be at least 1-½ inches on wood or metal and at least 3 inches on masonry or concrete. Wood beams and girders shall have at least 3 inches of bearing on masonry or concrete. Tail ends of floor joists shall not overlap the beams by more than 8 inches.

(5) **NOTCHING AND BORING.** Notching and boring of beams or girders is prohibited unless determined through structural analysis.

(a) *Notching.* 1. Notches located in the top or bottom of joists shall not exceed 1/6 the depth of the joist nor be located in the middle ½ of the span of the joist.

2. Where joists are notched on the ends, the notch shall not exceed ¼ the depth of the joist.

(b) *Boring.* Holes bored in joists shall be located in the center of the joist. The diameter of the hole shall not exceed ¼ the depth of the joist.

(6) **OVERHANG OF FLOORS.** (a) Floor joists which are at right angles to the supporting wall shall not be cantilevered more than 2 feet over the supporting wall and shall support only the wall and roof above it.

(b) Where floor joists are parallel to the supporting wall, a double floor joist may be used to support lookout joists extending over the wall line below. The double joist shall be located a distance of twice the overhang

from the lower wall. The lookout joists shall be fastened to the double joist with metal hangers.

(7) FLOOR OPENINGS. Trimmers and headers shall be doubled when the span of the header exceeds 4 feet. Headers which span more than 6 feet shall have the ends supported by joist hangers or framing anchors, unless the ends are supported on a partition or beam. Tail joists (joists which frame into headers) more than 8 feet long shall be supported on metal framing anchors or on ledger strips of at least 2 inches by 2 inches nominal.

TABLE 21.22-A
MINIMUM SIZES FOR BEAMS AND GIRDERS OF STEEL OR WOOD

Column Spacing	Roof/Ceiling and One Floor				Roof/Ceiling + One Floor/Ceiling + One Floor			
	Wood Beams ¹ (in., nominal)		A 36 Steel Beams ²		Wood Beams ¹ (in., nominal)		A 36 Steel Beams ²	
	Zone 2	Zone 1	Zone 2	Zone 1	Zone 2	Zone 1	Zone 2	Zone 1
24 ft. wide house:								
8 ft.	8x10	10x10	—	—	8x12	10x12	—	—
	6x12	6x12	—	—	6x14	8x14	—	—
10 ft.	8x12	10x12	—	—	10x14	10x14	—	—
	6x14	8x14	M 10x9	M 10x9	8x16	8x16	M 12x11.8	M 12x11.8
12 ft.	12x12	10x14	W 6x12	W 8x10	14x14	14x14	W 8x15	W 8x15
	10x14	8x16	W 10x11.5	M 12x11.8	10x16	12x16	W 12x16.5	W 12x16.5
15 ft.	—	—	S 7x15.3	W 8x15	—	—	S 8x23	W 8x20
	—	—	W 12x16.5	W 12x16.5	—	—	W 12x22	W 14x22
	—	—	W 10x17	W 6x25	—	—	W 8x28	W 8x31
26 ft. wide house:								
8 ft.	10x10	10x10	—	—	10x12	10x12	—	—
	6x12	8x12	—	—	8x14	8x14	—	—
10 ft.	10x12	10x12	—	—	10x14	12x14	—	—
	8x14	8x14	M 10x9	S 6x17.25	8x16	8x16	M 12x11.8	W 12x14
12 ft.	10x14	10x14	W 8x10	W 8x13	14x14	12x16	W 8x15	W 8x17
	8x16	8x16	M 12x11.8	M 12x11.8	12x16	10x18	W 12x16.5	W 10x19
15 ft.	—	—	W 8x15	W 6x20	—	—	W 8x20	W 8x24
	—	—	W 12x16.5	W 10x19	—	—	W 14x22	W 14x22
	—	—	W 8x20	W 8x24	—	—	W 8x31	W 8x35
28 ft. wide house:								
8 ft.	10x10	8x12	—	—	10x12	10x12	—	—
	8x12	4x16	—	—	8x14	8x14	—	—
10 ft.	10x12	12x12	S 6x17.25	W 10x11.5	12x14	12x14	—	—
	8x14	8x14	W 8x13	W 8x13	10x16	10x16	W 12x14	W 12x14
12 ft.	10x14	12x14	M 12x11.8	W 12x14	12x16	12x16	W 8x17	W 10x15
	8x16	10x16	W 8x15	W 8x17	10x18	10x18	W 10x19	M 14x17.2
	—	—	—	—	—	—	W 8x24	W 8x24

Column Spacing	Roof/Ceiling and One Floor				Roof/Ceiling + One Floor/Ceiling + One Floor			
	Wood Beams ¹ (in., nominal)		A 36 Steel Beams ²		Wood Beams ¹ (in., nominal)		A 36 Steel Beams ²	
	Zone 2	Zone 1	Zone 2	Zone 1	Zone 2	Zone 1	Zone 2	Zone 1
28 ft. wide house (cont)								
15 ft.	—	—	W 10x19 W 8x24	M 14x17.2 W 8x24	—	—	W 14x22 W 8x35	W 14x26 W 8x35
30 ft. wide house:								
8 ft.	10x10	8x12	—	—	10x12	12x12	—	—
	8x12	6x14	—	—	8x14	8x14	—	—
10 ft.	10x12	12x12	—	—	12x14	12x14	—	—
	8x14	10x14	W 8x13	W 10x11.5	10x16	10x16	W 12x14	W 12x14
12 ft.	12x14	12x14	W 12x14	W 12x14	12x16	14x16	W 10x15	S 8x18.4
	8x16	10x16	W 8x17	W 10x17	10x18	12x18	M 14x17.2	M 14x17.2
15 ft.	—	—	M 14x17.2 W 8x24	W 10x21 W 8x28	—	—	W 8x24	W 8x24
	—	—	—	—	—	—	W 14x26	W 14x26
	—	—	—	—	—	—	W 8x35	W 10x33
32 ft. wide house:								
8 ft.	8x12	6x14	—	—	12x12	12x12	—	—
	6x14	12x12	—	—	8x14	10x14	—	—
10 ft.	12x12	10x14	W 10x11.5	W 10x11.5	12x14	14x14	W 12x14	W 12x16.5
	8x14	10x14	W 8x13	W 6x16	10x16	10x16	S 8x18.4	W 10x17
12 ft.	12x14	14x14	W 12x14	W 12x14	14x16	14x16	W 14x17.2	W 12x22
	10x16	10x16	W 10x15	W 10x17	12x18	12x18	W 8x24	W 8x28
15 ft.	—	—	M 14x17.2 W 8x24	W 12x22 W 8x28	—	—	W 14x26	W 14x26
	—	—	—	—	—	—	W 12x27	W 12x27

¹This table is based upon wood with a fiber bending stress of 1,000 psi. Two acceptable wood beam selections are listed for each loading condition.

²Two acceptable steel beam selections are listed for each loading condition. The first entry is the most economical selection based upon beam weight.

(8) FLOOR SHEATHING, BOARDS AND PLANKS. (a) *Plywood sheathing.* Plywood sheathing used for floors shall be limited to the allowable loads and spans shown in Table 21.22-B.

(b) *Plywood underlayment.* Plywood underlayment shall be installed in accordance with Table 21.22-C.

(c) *Floor boards.* Where wood boards are used for floor sheathing, the boards shall comply with the minimum thicknesses shown in Table 21.22-D.

(d) *Planks.* Planks shall be tongue and groove or splined and at least 2 inches, nominal, in thickness. Planks shall terminate over beams unless the joints are end matched. The planks shall be laid so that no continuous line of joints will occur except at points of support. Planks shall be nailed to each beam.

(9) BRIDGING. Bridging shall be provided at intervals not exceeding 8 feet.

TABLE 21.22-B

ALLOWABLE LOADS AND SPANS FOR PLYWOOD FLOOR AND ROOF SHEATHING CONTINUOUS OVER TWO OR MORE SPANS AND FACE GRAIN PERPENDICULAR TO SUPPORTS¹

Panel Identification	Plywood Thickness	Roof ²				Floor Maximum
		Maximum Span (in inches)		Load (in pounds per square foot)		
		Edges Blocked	Edges Un-blocked	Total Load	Live Load	Span ⁴ (in inches)
Index ³	(in inches)					
12/0	5/16	12	12	155	150	0
16/0	5/16, 3/8	16	16	95	75	0
20/0	5/16, 3/8	20	20	75	65	0
24/0	3/8	24	20	65	50	0
24/0	1/2	24	24	65	50	0
30/12	5/8	30	26	70	50	12 ⁵
32/16	1/2, 5/8	32	28	55	40	16 ⁷
36/16	3/4	36	30	55	50	16 ⁷
42/20	5/8, 3/4, 7/8	42	32	40 ⁶	35	20 ⁷
48/24	3/4, 7/8	48	36	40 ⁶	35	24

¹These values apply to C-D, C-C, and structural I and II grades only. Spans shall be limited to values shown because of possible effect of concentrated loads.

²Uniform load deflection limitation: 1/180th of the span under live load plus dead load, 1/240th under live load only. Edges may be locked with lumber or other approved type of edge support.

³Identification index appears on all panels in the construction grades listed in footnote 1.

⁴Plywood edges shall have approved tongue and groove joints or shall be supported with blocking, unless 1/4-inch minimum thickness underlayment is installed or finish floor is 25/32-inch wood strip. Allowable uniform load based on deflection of 1/360 of span is 165 pounds per square foot.

⁵May be 16 inches if 25/32-inch wood strip flooring is installed at right angles to joists.

⁶For roof live load of 40 pounds per square foot or total load of 55 pounds per square foot, decrease spans by 13% or use panel with next greater identification index.

⁷May be 24 inches if 25/32-inch wood strip flooring is installed at right angles to joists.

TABLE 21.22-C
MINIMUM THICKNESS FOR PLYWOOD COMBINATION SUBFLOOR
UNDERLAYMENT PLYWOOD CONTINUOUS OVER TWO OR MORE SPANS
AND FACE GRAIN PERPENDICULAR TO SUPPORTS

Plywood Grade	Plywood Species Group	Maximum Support Spacing ¹			
		16" o.c. ^{2,3}	20" o.c. ^{2,3}	24" o.c. ²	48" o.c. ²
		Panel thickness (inch)	Panel thickness (inch)	Panel thickness (inch)	Panel thickness (inch)
Underlayment	1	1/2	5/8 ⁴	3/4 ⁴	--
C-C plugged	2 & 3	5/8 ⁴	3/4 ⁴	7/8 ⁴	--
Sanded exterior type	4	3/4 ⁴	7/8 ⁴	1 ⁴	--
2-4-1	1, 2 & 3	All panel groups have equal properties			1-1/8
		Panel Index	Panel Index	Panel Index	Panel Index
Sturdi-I-Floor ⁵	1, 2, 3 & 4	16" o.c.	20" o.c.	24" o.c.	48" o.c.

¹Spans shall be limited to values shown, based on possible effect of concentrated loads.

²Underlayment, C-C plugged, sanded exterior type: allowable uniform load based on deflection of L/360 span for spans 24 inches or less is 125 psf; and for spans 48 inches, 65 psf.

³If a 25/32-inch wood finish floor is laid perpendicular to supports, thicknesses shown for 16-inch and 20-inch spans may be used for 24-inch span.

⁴Except for 1/2-inch, underlayment grade and C-C plugged panels may be of nominal thickness 1/32-inch less than the nominal thicknesses shown when marked with the reduced thickness.

⁵The department will accept subfloor underlayment panels such as sturdi-i-floor which meet the requirements of APA manufacturing specification for sturdi-i-floor panels.

TABLE 21.22-D
MINIMUM THICKNESS OF FLOOR BOARDS

Joist Spacing (inches)	Minimum Net Thickness (inches)	
	Perpendicular to Joist	Diagonal to Joist
24	11/16	3/4
16	5/8	5/8

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

SUBCHAPTER VII—WALLS

ILHR 21.23 Wall design. (1) **LIVE AND DEAD LOADS.** All walls shall support all superimposed vertical dead loads and live loads from floors and roofs.

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(2) **HORIZONTAL WIND LOAD.** Walls shall be designed to withstand a horizontal wind pressure of at least 20 pounds per square foot applied to the vertical projection of that portion of the dwelling above grade. No wind load reduction shall be permitted for the shielding effect of other buildings.

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

ILHR 21.24 Exterior covering. The exterior walls shall be faced with a weather-resistant covering.

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

ILHR 21.25 Wood frame walls. Unless designed through structural analysis, wood frame walls shall comply with the following requirements.

(1) **STUD SIZE AND SPACING.** (a) *Studs.* Wood studs shall comply with the size and spacing requirements indicated in Table 21.25-A. Studs in the exterior walls shall be placed with the wide faces perpendicular to the plane of the wall.

(b) *Corner posts.* Posts or multiple studs shall be provided at the corners of the walls.

(c) *Wood posts or columns.* Posts and columns shall be anchored to resist loads.

TABLE 21.25-A
MAXIMUM SPACING AND HEIGHT OF STUDS

Size	Grade	Max. Height (feet)	Spacing (inches)			
			Supporting roof and ceiling only	Supporting one floor, roof and ceiling	Supporting two floors, roof and ceiling	Interior and non-load-bearing
2x3	Standard & better	8	16	N/P	N/P	24
2x4 or larger	Utility	8	24	16	12	24
2x4	Standard & better	12	24	24	12	24
2x6 or larger	No. 3 & better	18	24	24	16	24

N/P = Not permitted.

Note: A 3-story frame house with walls constructed of 2 x 4 studs would require a 12-inch stud spacing on the lowest level, a 16-inch stud spacing on the intermediate level, and a 24-inch stud spacing on the upper level.

(d) *Bracing.* Exterior walls shall be braced at the corners.

1. Nominal 1 inch by 4 inch continuous diagonal members set into the face of the studs at an angle between 45° and 60°; or

2. Four feet by 8 feet plywood sheathing panels not less than 5/16 inch thick for 16-inch stud spacing and not less than 3/8 inch thick for 24-inch stud spacing; or

3. Preformed metal T-bracing not less than 22 gage (.0296 inches) thick and 1 1/4 inch wide; or

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4. Other approved wind bracing materials.

Note: See Appendix for acceptable nailing schedule.

(2) TOP PLATES. Studs at bearing walls shall be capped with double top plates. End joints in double top plates shall be offset at least 48 inches. Double top plates shall be overlapped at the corners and at intersections with partitions. The plate immediately above the stud shall be broken directly over the stud.

(a) *Exceptions.* 1. A single top plate may be used in lieu of a double top plate where the rafter is located directly over the stud and the plate is securely tied at the end joints, corners and intersecting walls. Single top plates shall be broken directly over the stud.

2. A continuous header, consisting of two 2-inch members set on edge, may be used in lieu of a double plate if tied to the adjacent wall.

(3) WALL OPENINGS. Where doors or windows occur, headers shall be used to carry the load across the opening.

(a) *Header size.* The size of headers shall be determined in accordance with the spans and loading conditions listed in tables 21.25-B, 21.25-C and 21.25-D.

(b) *Header support.* The ends of the header shall be supported on the stud and fastened to a single stud when the span is not more than 3 feet. A second stud shall be provided on each side of the header in load-bearing walls exceeding 3 feet in width. Where the opening in load-bearing walls exceeds 6 feet in width, the end of the header shall be supported directly on at least 2 studs (shoulder stud) and an additional stud shall be provided and fastened to the end of header.

(c) *Flashing.* Unless sealed or caulked, flashing shall be provided at the top and sides of all exterior window and door openings.

(4) NOTCHING. Notching and boring of columns or posts is prohibited unless designed through structural analysis. Studs shall not be cut or bored more than 1/3 the depth of the stud, unless the stud is reinforced.

(5) PARTITIONS. Load-bearing partitions shall be placed over beams, girders, or other load-bearing partitions. Load-bearing partitions running at right angles to the joists shall not be offset from the main girder or walls more than the depth of the joist unless the joists are designed to carry the load.

(6) WALL SHEATHING. Exposed plywood panel siding and plywood wall sheathing shall conform to the requirements shown in Table 21.25-E.

TABLE 21.25-B

ALLOWABLE SPANS (FEET) FOR HEADERS SUPPORTING
ROOF/CEILING ASSEMBLIES*

House Width (feet)	Header Members									
	Two 2 x 4s		Two 2 x 6s		Two 2 x 8s		Two 2 x 10s		Two 2 x 12s	
	Zone 2/Zone 1		Zone 2/Zone 1		Zone 2/Zone 1		Zone 2/Zone 1		Zone 2/Zone 1	
24	2.5	2.5	4	4	5	5	7	6	9	8
26	2.5	2	4	3	5	5	7	6	8	7
28	2.5	2	4	3	4	5	6	6	8	7
30	2.5	2	4	3	4	5	6	6	8	7
32	2	2	3	3	4	5	6	5	7	7

TABLE 21.25-C

ALLOWABLE SPANS (FEET) FOR HEADERS SUPPORTING ONE FLOOR*

House Width (feet)	Header Members				
	Two 2 x 4s	Two 2 x 6s	Two 2 x 8s	Two 2 x 10s	Two 2 x 12s
24	2.5	4	5	6	8
26	2.5	3	5	6	8
28	2	3	5	6	7
30	2	3	4	6	7
32	2	3	4	5	7

TABLE 21.25-D

ALLOWABLE SPANS (FEET) FOR HEADERS SUPPORTING ONE FLOOR
AND ROOF/CEILING ASSEMBLY*

House Width (feet)	Header Members									
	Two 2 x 4s		Two 2 x 6s		Two 2 x 8s		Two 2 x 10s		Two 2 x 12s	
	Zone 2/Zone 1		Zone 2/Zone 1		Zone 2/Zone 1		Zone 2/Zone 1		Zone 2/Zone 1	
24	1.5	1.5	3	2.5	4	3	5	4	6	5
26	1.5	1.5	2.5	2.5	3	3	4	4	5	5
28	1.5	1.5	2.5	2.5	3	3	4	4	5	5
30	1.5	1.5	2.5	2.5	3	3	4	4	5	5
32	1.5	1.5	2.5	2	3	3	4	4	5	5

*These tables are based on wood with a fiber bending stress of 1,000. For other species with different fiber bending stresses, multiply the span by the ratio of the actual bending stress to 1,000. Example: The allowable roof/ceiling span for a 28-foot wide house in zone 2, using two 2 x 8 header members with a 1400 psi bending stress, is 4 ft. x 1400/1000 = 5.6 feet.

TABLE 21.25-E
EXPOSED PLYWOOD PANEL SIDING

Minimum Thickness ¹	Minimum No. of Plys	Stud Spacing (Inches) Plywood Siding Applied Direct to Studs or Over Sheathing
3/8"	3	16 ²
1/2"	4	24

¹Thickness of grooved panels is measured at bottom of grooves.
²May be 24 inches if plywood siding applied with face grain perpendicular to studs or over one of the following: (a) one-inch board sheathing; (b) 1/2-inch plywood sheathing; (c) 3/8-inch plywood sheathing with face grain of sheathing perpendicular to studs.
History: Cr. Register, November, 1979, No. 287, eff. 6-1-80; cr. (1) (d) and am. (3) (b), Register, February, 1985, No. 350, eff. 3-1-85.

ILHR 21.26 Masonry walls. Masonry walls shall be constructed in accordance with the requirements of this section.

(1) COLD WEATHER WORK. In cold weather, provisions shall be taken to prevent masonry from being damaged by freezing.

Note: It will be the practice of the department to accept performance with "Recommended Practices for Cold Weather Masonry Construction," available from International Masonry Institute, 823 15th Street NW, Washington, D.C. 20005.

(2) MASONRY UNITS. All masonry units shall be free from physical defects which interfere with laying of the unit and impair the compressive strength of the unit.

(3) TYPES OF MORTAR. The type of masonry mortar to be used for various kinds of masonry work shall be determined from Table 21.26-A. The mortar shall conform to the property requirements of Table 21.26-B1 and to the requirements of ASTM C-270 or shall be mixed in accordance with the proportions specified in Table 21.26-B.

(a) Surface bond mortars. Surface bond mortars for masonry walls shall be mixed in accordance with the proportions specified on the bag.

(4) MORTAR COMPONENTS. Mortar components shall comply with the following requirements:

(a) Water. Water shall be clean and free of deleterious amounts of acids, alkalies, or organic materials.

(b) Admixtures or mortar colors. Admixtures or mortar colors shall not be added to the mortar unless the resulting mortar conforms to the requirements of the mortar specifications. Only calcium chloride may be used as an accelerant and shall be limited to 2% by weight of the cement used. Calcium chloride may not be used for any other purpose. Only mineral oxide may be used as mortar color and shall not exceed 10% by weight of the cement used.

(c) Mixing. Mortar shall be mixed for at least 3 minutes after all ingredients have been added with the maximum amount of water to produce a workable consistency. Mortars that have stiffened due to water evaporation shall be retempered by adding water as frequently as needed to re-

store the required consistency. Mortars shall be used and placed in final position within 2-½ hours after mixing.

Note: To ensure proper mortar mixing, machine mixing is recommended.

TABLE 21.26-A

TYPES OF MORTAR FOR VARIOUS KINDS OF MASONRY

Kind of Masonry	Types of Mortar
Foundations:	
Footings	M, S
Walls of solid units	M, S, N
Walls of hollow units	M, S
Hollow walls	M, S
Masonry other than foundation masonry:	
Piers of solid masonry	M, S, N
Piers of hollow units	M, S
Walls of solid masonry	M, S, N, O
Walls of solid masonry not less than 12 in. thick or more than 35 ft. in height, supported laterally at intervals not exceeding 12 times the wall thickness	M, S, N, O
Walls of hollow units; load-bearing or exterior, and hollow walls 12 in. or more in thickness	M, S, N
Hollow walls, less than 12 in. thick	M, S, N
Linings of existing masonry, either above or below grade	M, S
Masonry other than above	M, S, N

TABLE 21.26-B

MORTAR SPECIFICATIONS BY PROPORTION¹

Mortar Type, ASTM C 270	Parts by Volume			Sand, Damp Loose Volume
	Portland Cement	Masonry Cement	Hydrated Lime	
M	1	--	1/4	Not less than 2-1/4
	1	1 (Type II)	--	
S	1	--	1/4 to 1/2	and not more than 3 times the sum of
	1/2	1 (Type II)	--	
N ²	1	--	1/2 to 1-1/4	the volumes of the cements and lime.
	--	1 (Type II)	--	

¹All cements are one cubic foot per sack; lime equals 1-1/4 cubic foot per sack.

²Limited to walls with a maximum depth of 5 feet below grade.

TABLE 21.26-B1

MORTAR PROPERTY REQUIREMENTS

Mortar Type	Compressive Strength Min. (psi)	Water Retention Min. (%)	Air Content Max. (%)
M	2,500	75	18
S	1,800	75	18
N	750	75	18

(d) *Cementitious material.* Cementitious material shall conform to the standards approved by the department.

Note: The department will accept cementitious material conforming to the following standards: ASTM C91, Masonry Cement; ASTM C150, Portland Cement; ASTM C595, Portland Blast-Furnace Slag Cement; ASTM C207, Hydrated Lime for Masonry Purposes; and ASTM C5, Quick Lime for Structural Purposes.

(e) *Aggregates.* Aggregates for use in masonry mortar shall consist of natural sand or manufactured sand and shall be graded.

Note: The department will accept aggregates in accordance with ASTM C144.

(5) CAVITY WALL. (a) *Corbeling.* Cavity wall construction may be supported on an 8-inch foundation wall provided the 8-inch wall is corbeled with solid masonry to the width of the cavity wall. Individual corbels shall not exceed 2 inches nor more than one-third the height of each corbeled unit.

(b) *Projections.* The projection of a wall beyond the edge of a supporting member other than masonry, such as a shelf angle or edge of a beam, shall not exceed 1-1/4 inches, unless at least 3/4 the mass of the wythe of masonry involved is located directly over the load-carrying member.

(c) *Flashing.* In exterior hollow walls exposed to the weather, flashing shall be installed at the bottom of the cavity so as to drain any water

outward. Open vertical joints or weep holes of 3/8-inch minimum diameter shall be provided in the facing just above the flashing at a horizontal spacing not exceeding 3 feet.

(6) OPENINGS AND LINTELS. (a) *Openings.* The masonry above openings shall be supported. The bearing length of structural elements which support the masonry above the opening shall be not less than 4 inches.

(b) *Lintels.* Unless designed through structural analysis, lintels shall be provided in accordance with Table 21.26-C.

TABLE 21.26-C

ALLOWABLE SPANS FOR LINTELS SUPPORTING MASONRY VENEER

Size of Steel Angle ^{1, 3}	No Story Above	One Story Above	Two Stories Above	No. of 1/2" or Equivalent Re- inforcing Bars ²
L 3 x 3 x 1/4	6' - 0"	3' - 6"	3' - 0"	1
L 4 x 3 x 1/4	8' - 0"	5' - 0"	3' - 0"	1
L 6 x 3-1/2 x 1/4	14' - 0"	8' - 0"	3' - 6"	2
2 - L 6 x 3-1/4 x 1/4	20' - 0"	11' - 0"	5' - 0"	4

¹Long leg of the angle shall be placed in a vertical position.

²Depth of reinforced lintels shall be not less than 8 inches and all cells of hollow masonry lintels shall be grouted solid. Reinforcing bars shall extend not less than 8 inches into the support.

³Steel members indicated are adequate typical examples; other steel members meeting structural design requirements may be used.

(7) MASONRY VENEERS. (a) *Veneer over frame construction.* 1. Masonry veneers may be corbeled over the foundation wall, but the corbeling shall not exceed one inch.

2. An air space shall be provided between the veneer and the sheathing.

3. Where no brick ledge is formed in the foundation wall, a 30-pound asphalt-saturated felt or corrosion-resistant metal base flashing shall extend over the top of the foundation wall from the outside face of the wall and shall extend at least 6 inches up on the wood sheathing under the building paper or water-resistant sheathing.

4. Weepholes shall be provided at the bottom masonry course at intervals of approximately 4 feet.

(b) *Veneer over masonry back-up.* A 30-pound asphalt-saturated felt or corrosion-resistant metal base flashing at the bottom of the veneer shall extend over the top of the foundation and up at least 6 inches and be embedded in the back-up course. Weepholes, at approximately every 3 feet, shall be provided.

(8) VENEER ANCHORAGE. All veneers, supports and attachments shall be mechanically or adhesively anchored.

(a) *Mechanical anchorage.* All anchors shall be corrosion-resistant.

1. Conventional size veneer (one square foot or less) shall be securely attached to its backing by anchors the equivalent of No. 22 U.S. gauge corrugated sheet steel $\frac{3}{8}$ -inch wide with at least one such tie located in every 2 square feet of wall. Ties shall be embedded 2 inches in a masonry joint and nailed to the framing with an 8d nail.

2. Large size veneer (greater than one square foot) shall be securely attached with anchors the equivalent of not less than $\frac{1}{4}$ -inch diameter bolts in accordance with either of the following:

a. Each unit individually anchored to the supporting framework with at least 3 anchors.

b. Individual units doweled to each other at all horizontal joints and anchored to the backing at all horizontal and vertical joints so that one anchor is provided for every 6 square feet of wall surface.

(b) *Adhesive anchorage.* Veneer may be cemented to a masonry or concrete wall or to exterior portland cement plaster in high rib galvanized metal lath with an adhesive, provided that the bond is sufficient to withstand a shearing stress of 50 psi after curing for 28 days.

(9) **BEARING.** (a) *Concentrated loads.* Beams, girders, trusses, joists and other members producing concentrated loads shall bear a minimum of 3 inches on one of the following:

1. Concrete beam. The equivalent of a nominally reinforced 2,500 psi concrete beam 8 inches in height.

2. Solid masonry. At least 8 inches in height of masonry composed of solid masonry units with all voids and joints completely filled with mortar.

3. Metal plate. A metal plate of sufficient thickness and size to distribute the load to masonry units. For piers and columns, the bearing plate shall not exceed 60% of the cross-sectional area of the pier or column and the resultant reaction of all vertical and horizontal loads shall fall within the middle third of the member.

4. Bond beam. The bond beam shall be the equivalent of not less than an 8-inch lintel (bond beam) block with 2 No. 4 bars embedded in high strength mortar fill or equivalent. The loads shall bear on the fill.

(b) *Continuous loads.* Joists, trusses and beams other than wood, spaced 4 feet or more on center and 40 feet in length, slabs or other members causing continuous loads shall be transmitted to masonry with a minimum bearing of 3 inches upon solid masonry at least 2- $\frac{1}{2}$ inches in height, or as indicated for concentrated loads.

(c) *Stack bond walls.* Concentrated loads shall be distributed into masonry laid in stack bond by a concrete beam or bond beam [as defined in (a)]. For masonry of solid units, 2 additional rows of a continuous tie assembly may be used instead of a concrete beam or bond beam.

(d) *Support of wood floor members.* Where a wood structural member is buried in masonry for support, it shall be firecut or a self-releasing device shall be used. Where the end of a wood structural member is built into an exterior wall, a $\frac{1}{2}$ -inch air space shall be provided at the sides, top and end of such member.

(10) **BONDING.** Unless designed through structural analysis, all masonry walls shall be bonded as follows:

(a) *Single-wythe walls.* Masonry units in single-wythe walls shall be lapped at least 2 inches or one-third the height of the masonry unit, whichever is greater, or through the use of continuous tie assemblies spaced at 16-inch vertical intervals.

(b) *Multi-wythe walls.* Adjacent wythes shall be bonded with continuous tie assemblies spaced at vertical intervals not exceeding 16 inches; or individual ties of at least $\frac{3}{16}$ -inch diameter for each 4- $\frac{1}{2}$ square feet of wall area, spaced at a maximum vertical distance of 18 inches and a maximum horizontal distance of 36 inches; or bonded with a full course of masonry headers every seventh course. The clear distance between bond courses shall not exceed 16 inches for solid masonry units and 24 inches for hollow masonry units. Hollow walls shall not be bonded with headers.

(11) **BOLTS AND ANCHORS.** The allowable shear on steel bolts and anchors shall not exceed the values given in Table 21.26.

TABLE 21.26
ALLOWABLE SHEAR ON BOLTS AND ANCHORS

Bolt or Anchor Diameter (inches)	Embedment ¹ (inches)	Allowable Shear (pounds)
1/4	4	270
3/8	4	410
1/2	4	550
5/8	4	750
3/4	5	1100
7/8	6	1500
1	7	1850
1-1/8	8	2250

¹ Bolts and anchors shall be solidly embedded in mortar or grout.

(12) JOINTS. (a) The maximum thickness of a mortar joint shall be 1/2 inch.

(b) Except for head joints used for weepholes and ventilation, solid masonry units shall be laid to achieve full head and bed joints.

(c) Hollow masonry units shall be laid with full head joints and full bed joints under the full bearing areas of the face shells and under webs where the adjacent cells are to be filled with grout.

(13) CLEANING. Chemical cleaning agents shall be prevented from harming the metal reinforcement of structural components and shall not be of a strength which will adversely affect the mortar.

(14) DAMPPROOFING. Masonry foundation walls of basements in clay-type soils shall be made dampproof by the application to the exterior surfaces of a continuous coat of at least 3/4-inch thick portland cement and sand coat mortar, or a type M mortar troweled smooth. Surface bonding material, 1/4-inch thick, applied to the exterior surfaces, may also be used.

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80; am. (3) and cr. Table 21.26-B1 Register, February, 1985, No. 350, eff. 3-1-85.

SUBCHAPTER VIII—ROOF AND CEILINGS

ILHR 21.27 Roof design. (1) *Roof loads.* Roof and roof/ceiling assemblies shall support all dead loads plus the minimum live loads as set forth in s. ILHR 21.02.

(2) UPLIFT AND SUCTION FORCES. Roofs shall withstand a pressure of at least 20 pounds per square foot acting upward normal to the roof surface. Roof overhangs, eaves, canopies and cornices shall withstand an upward wind pressure of at least 20 pounds per square foot applied to the entire exposed area.

(a) *Anchorage.* Roofs shall be anchored to walls and columns to resist uplift.

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(b) *Stress increase.* All stresses may be increased by a maximum of one third for wind forces.

(3) WATER. All roofs shall be designed and constructed to assure drainage of water.

(a) *Roofing.* Roofing shall be installed to shed water. Underlayment shall be provided under shingles. Fasteners shall be corrosion-resistant.

(b) *Eave protection for shingles and shakes.* Sheet metal, asphalt-impregnated felt paper or similar eave protection shall be provided on roof slopes of less than 4:12 (18.4°), extending from the edge of the roof a minimum distance of 2 feet 6 inches up the roof slope to a line not less than 12 inches inside the inner face of the exterior wall; except over unheated garages or porches.

(4) FLASHING. Flashings shall be installed at the junction of chimneys and roofs, in all valleys, and around all roof openings.

(a) *Valley flashing.* 1. Open valleys. Open valleys shall be flashed with at least No. 28 gauge galvanized, corrosion-resistant sheet metal, 16 inches wide, or a layer of at least 50-pound roll roofing, 16 inches wide, placed over a layer of 15-pound roofing underlayment. Flashing sections shall be overlapped by at least 4 inches.

2. Closed valleys. Where shingles are laced or woven over the valley, the valley shall be flashed with at least one layer of 50-pound roofing, at least 20 inches wide, over the layer of 15-pound roofing underlayment.

(b) *Chimney flashing.* 1. Chimney crickets shall be installed where the upper side of a chimney is more than 30 inches wide on a sloping roof. The intersection of the cricket and the chimney shall be flashed and counter-flashed to a height of at least 4 inches.

2. Chimneys not exceeding 30 inches wide shall be flashed and counter-flashed to a height of at least 6 inches.

3. Chimney sides shall be flashed to a height of at least 4 inches.

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

ILHR 21.28 Roof and ceiling wood framing. Unless designed through structural analysis, wood rafters and ceiling joists, and components, shall comply with the requirements of s. ILHR 21.02 (3).

(1) ROOF RAFTERS. Where rafters meet to form a ridge, the rafters shall be placed directly opposite and secured to each other or to a ridge board one inch, nominal, in thickness. Where rafters are offset more than the thickness of the rafter, a ridge board 2 inches, nominal, in thickness shall be used.

(2) ANCHORAGE. Roofs shall be anchored to resist horizontal thrust and uplift. Provisions shall be taken to absorb the horizontal thrust produced by the sloping roof, rafters or beams through collar ties installed in the upper third of the roof rafters on every third pair of rafters; or through the use of cross ties connecting beams; or through the use of metal straps or metal plates located at the ridge which tie the roof beams together. Rafters shall be notched to fit the exterior wall plate and fastened to the wall.

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(3) **CEILING JOISTS.** Ceiling joists shall be nailed to exterior walls and to the ends of rafters. Where joining over interior partitions, they shall be nailed to the plate or to each other. Where ceiling joists are placed at right angles to the rafters, as in flat or hip roofs, the lookout joist or ties shall be fastened to the parallel ceiling joists or rafters.

(4) **VALLEY AND HIP RAFTERS; LADDERS.** (a) *Valley rafters.* Where no bearing is provided under valley rafters at the intersection of 2 roof areas, the valley rafters shall be doubled in thickness and shall be at least 2 inches deeper than the required common rafter to permit full bearing at the beveled end. Where ridges are provided at different elevations, care should be taken to provide vertical support for the interior end of the lower ridge board.

(b) *Hip rafters.* Where no bearing is provided under hip rafters, the hip rafters shall be of the same thickness as common rafters and shall be at least 2 inches deeper to permit full contact with the jack rafter.

(c) *Ladders.* Overhangs at gable end walls shall be provided with ladders (rafters which extend over the wall) which are fastened to the wall and to the first rafter parallel to the gable end wall.

(5) **TRUSSED RAFTERS AND TRUSSES.** Trussed rafters and prefabricated trusses shall be designed through structural analysis. Truss members shall not be cut, bored or notched unless designed through structural analysis.

(6) **NOTCHING AND BORING.** Notching and boring of beams or girders is prohibited unless determined through structural analysis.

(a) *Notching.* 1. Notches located in the top or bottom of joists shall not exceed 1/6 the depth of the joist nor be located in the middle third of the span of the joist.

2. Where joists are notched on the ends, the notch shall not exceed ¼ the depth of the joist.

(b) *Boring.* Holes bored in joists shall be located in the center of the joist. The diameter of the hole shall not exceed one third the depth of the joist.

(7) **ROOF SHEATHING, BOARDS AND PLANKING.** (a) *Plywood sheathing.* Plywood sheathing shall be grade marked and stamped and limited to the allowable loads and spans indicated in tables 21.22-B and 21.28-A.

(b) *Roof boards.* Roof boards shall comply with the minimum thicknesses shown in Table 21.28-B.

(c) *Roof planks.* Roof planks shall be tongue and groove or splined and at least 2 inches, nominal, in thickness. Planks shall terminate over beams unless the joints are end matched. The planks shall be laid so that no continuous line of joints will occur except at points of support. Planks shall be nailed or fastened to each beam.

TABLE 21.28-A

ALLOWABLE LOADS AND SPANS FOR PLYWOOD ROOF SHEATHING
CONTINUOUS OVER TWO OR MORE SPANS AND FACE GRAIN PARALLEL
TO SUPPORTS¹

Species	Thickness (inches)	No. of Plies	Span (inches)	Total Load (psf)	Live Load (psf)
Structural I	1/2	4	24	35	25
	1/2	5	24	55	40
Other grades	1/2	5	24	30	25
covered in	5/8	4	24	40	30
PS-1	5/8	5	24	60	45

¹Uniform load deflection limitations: 1/180 of span under live load plus dead load, 1/240 under live load only. Edges shall be blocked with lumber or other approved type of edge supports.

TABLE 21.28-B

MINIMUM THICKNESS OF ROOF BOARDS

Rafter Spacing (inches)	Minimum Net Thickness (Inches)	
	Solid Sheathing	Spaced Sheathing
24	5/8	3/4

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

SUBCHAPTER IX—FIREPLACE REQUIREMENTS

ILHR 21.29 Masonry fireplaces. Masonry fireplaces shall be constructed of masonry, stone or concrete and shall be provided with masonry chimneys. Masonry fireplaces shall be supported on foundations of concrete or masonry. Structural walls shall be at least 8 inches thick. Masonry fireplaces shall conform to the following requirements:

(1) **FLUE SIZE.** The fireplace flue size shall be based on the type of flue and the fireplace opening indicated in Table 21.29.

TABLE 21.29

MINIMUM FLUE SIZE FOR MASONRY FIREPLACES

Type of Flue	Minimum Cross-Sectional Area
Round	1 1/2 of fireplace opening but not less than 75 square inches.
Square or rectangular	1 1/10 of fireplace opening but not less than 75 square inches.

(2) **TERMINATION OF CHIMNEY.** Masonry fireplace chimneys shall extend at least 3 feet above the highest point where the chimney passes through the roof and at least 2 feet higher than any portion of the dwelling within 10 feet of the chimney.

(3) **FIREBOX MATERIALS.** The firebox shall be of the preformed metal type, at least 1/4-inch thick, or listed by a nationally recognized laboratory; or shall be lined with firebrick, at least 2 inches thick and laid in thin joints of refractory cement. The back and sidewalls of the firebox, including the lining, shall be at least 8 inches nominally thick masonry, at least 4 inches of which shall be solid.

(4) **LINTEL.** Masonry over the fireplace opening shall be supported by a lintel of steel or masonry.

(5) **DUCTS.** Warm-air circulating ducts shall be constructed of masonry or metal.

(6) **HEARTH.** Where the fireplace hearth is an integral part of the floor, there shall be a minimum of 4 inches of reinforced concrete under the hearth surface. The minimum dimensions of the hearth shall be based on the size of the fireplace opening as specified in Table 21.29-1.

TABLE 21.29-1
HEARTH DIMENSIONS

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

(7) **DAMPERS.** Dampers shall be made of cast iron or at least No. 12 gauge sheet metal. The area of the damper opening shall be at least 90% of the required flue area when in the open position.

(8) **HOODS.** Metal hoods, used in lieu of a masonry smoke chamber, shall be constructed of at least No. 19 gauge corrosion-resistant metal with all seams and connections of smokeproof construction. The hood shall be sloped at an angle of 45° or less from the vertical and shall extend horizontally at least 6 inches beyond the firebox limits. Metal hoods shall be kept a minimum of 18 inches from the combustible materials unless approved for reduced clearances.

Note: The department will accept dampers and hoods listed by nationally recognized laboratories.

(9) **FLUE LINERS.** Masonry chimneys shall be provided with fireclay flue liners of at least 3/4-inch thickness, vitrified clay sewer pipe or material that will resist corrosion, softening or cracking from flue gases at temperatures up to 1800°F. Flue liners shall start at the top of the fireplace throat and extend to a point at least 4 inches above the top of the enclosing masonry walls. The nominal thickness of the masonry chimney wall shall be at least 4 inches. Flue liners shall be laid in a full mortar bed and each individual flue shall be wrapped and laterally supported by at least 4 inches of masonry. Firebrick material may be used in lieu of flue liners in the throat of the fireplace.

Note: Mortar means refractory cement.

(10) **CLEANOUT OPENINGS.** Fireplaces with ash dumps shall be provided with cleanout openings at the base. Doors and frames of the opening shall be made of ferrous materials.

(11) **MANTEL SHELVES AND COMBUSTIBLE TRIM.** Woodwork or other combustible materials shall not be placed within 6 inches of the fireplace opening. Combustible materials located within 12 inches of the fireplace opening shall not project perpendicularly more than 1/4-inch for each inch distance from the opening.

(12) **CHIMNEY CAPS.** Precast or cast-in-place concrete caps shall have a minimum thickness of 2 inches. A minimum of a 1/4-inch mortar joint shall be used between flues and caps and shall be caulked or sealed.

(13) **FRAMING AROUND FIREPLACES.** Combustible materials located near fireplaces shall be installed in accordance with s. ILHR 21.30 (9).

(14) **CORBELING.** Unless designed through structural analysis, masonry chimneys shall not be corbeled from a wall more than 6 inches nor shall a masonry chimney be corbeled from a wall less than 12 inches in nominal thickness unless it projects equally on each side of the wall. The corbeling shall not exceed one-inch projection for each brick course.

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

ILHR 21.30 Masonry chimneys. Masonry chimneys shall conform to the following provisions:

(1) **MATERIALS.** No masonry chimney shall rest upon wood. The foundation shall be designed and built in conformity with the requirements for foundations. Masonry chimney walls shall be at least 4 inches in nom-

inal thickness. Hollow cored masonry units may be used to meet the 4 inch nominal thickness requirement.

(2) **FLUE SIZE.** Chimney flues for appliances shall be at least equal in area to that of the area of the connector from the appliance.

(3) **MULTIPLE FLUE SEPARATION.** When more than one flue is contained in the same chimney, a masonry separation of at least 4 inches nominal in thickness shall be provided between the individual flues. The joints of adjacent flue linings shall be staggered by at least 7 inches.

(4) **CORBELING.** Unless designed through structural analysis, masonry chimneys shall not be corbeled from a wall more than 6 inches nor shall a masonry chimney be corbeled from a wall less than 12 inches in nominal thickness unless it projects equally on each side of the wall. The corbeling shall not exceed one-inch projection for each brick course.

(5) **INLETS.** Inlets to masonry chimneys shall enter the side and be provided with thimbles. Thimbles shall be at least No. 24 manufacturer's standard gauge (0.024 inch) or 3/8-inch thick, refractory material. Each chimney shall have an inlet installed at the time of construction.

(6) **CLEAN-OUT OPENING.** Every masonry chimney shall be provided with a clean-out opening at the base. Such openings shall be equipped with metal doors and frames arranged to remain closed when not in use. Clean-out openings shall be located below the lowest inlet to the flue.

(7) **FLUE LINERS.** (a) Masonry chimneys shall be lined with fireclay flue lining at least 3/8-inch thick, vitrified clay, sewer pipe or with material that will resist corrosion, softening or cracking from flue gases at temperatures up to 1800° F. Flue liners shall commence at the chimney footing.

(b) All flue liners shall be laid in a full mortar bed.

(c) Variations in inside and outside dimensions shall not exceed 1/4-inch for clay flue liners.

(8) **CHIMNEY CAPS.** Precast or cast-in-place concrete caps shall have a minimum thickness of 2 inches. A minimum of a 1/4-inch mortar joint shall be used between flues and caps and shall be caulked or sealed.

Note: Mortar means refractory cement.

(9) **CLEARANCE TO COMBUSTIBLES.** (a) The minimum clearance between masonry chimneys and combustible materials shall be 2 inches for interior chimneys and 1/2 inch for chimneys located at the exterior wall.

(b) The clearance between the masonry chimney and combustible flooring and trim shall be at least 1/2 inch.

(c) Ends of wood girders may be supported on a corbeled shelf of a masonry chimney provided there is at least 8 inches of solid masonry between the ends of the girder and the flue liner.

(d) Combustible lath, combustible furring or combustible plaster grounds shall not be placed closer than 1-1/2 inches from the masonry. This requirement shall not:

1. Prevent plastering directly on the masonry or on metal lath or on metal furring or

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 3/8-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 6 or Greater	8	16
	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.

TABLE R-1
FLAT OR SLOPED RAFTERS
Supporting Drywall Ceiling
(Flat roof or cathedral ceiling with no attic space)
Live Load - 20 lb. per sq. ft.

DESIGN CRITERIA:
Strength - 15 lbs. per sq. ft. dead load plus 20
lbs. per sq. ft. live load determines required
fiber stress.
Deflection - For 20 lbs. per sq. ft. live load.
Limited to span in inches divided by 240.

RAFTER SIZE SPACING (IN)	Extreme Fiber Stress in Bending, "F _b " (psi).											
	300	400	500	600	700	800	900	1000	1100	1200	1300	
12.0	6-7	7-7	8-6	9-4	10-0	10-9	11-5	12-0	12-7	13-2	13-8	
	0.12	0.19	0.26	0.35	0.44	0.54	0.64	0.75	0.86	0.98	1.11	
	6-2	7-1	7-11	8-8	9-5	10-0	10-8	11-3	11-9	12-4	12-10	
	0.12	0.18	0.25	0.33	0.41	0.50	0.60	0.70	0.81	0.92	1.04	
2x6	5-8	6-7	7-4	8-1	8-8	9-4	9-10	10-5	10-11	11-5	11-10	
	0.11	0.16	0.23	0.30	0.38	0.46	0.55	0.65	0.75	0.85	0.96	
	5-2	6-0	6-9	7-4	7-11	8-6	9-0	9-6	9-11	10-5	10-10	
	0.10	0.15	0.21	0.27	0.35	0.42	0.51	0.59	0.68	0.78	0.88	
24.0	4-8	5-4	6-0	6-7	7-1	7-7	8-1	8-6	8-11	9-4	9-8	
	0.09	0.13	0.19	0.25	0.31	0.38	0.45	0.53	0.61	0.70	0.78	
	8-8	10-0	11-2	12-3	13-3	14-2	15-0	15-10	16-7	17-4	18-0	
	0.12	0.19	0.26	0.35	0.44	0.54	0.64	0.75	0.86	0.98	1.11	
13.7	8-1	9-4	10-6	11-6	12-5	13-3	14-0	14-10	15-6	16-3	16-10	
	0.12	0.18	0.25	0.33	0.41	0.50	0.60	0.70	0.81	0.92	1.04	
	7-6	8-8	9-8	10-7	11-6	12-3	13-0	13-8	14-4	15-0	15-7	
	0.11	0.16	0.23	0.30	0.38	0.46	0.55	0.65	0.75	0.85	0.96	
2x8	6-10	7-11	8-10	9-8	10-6	11-2	11-10	12-6	13-1	13-8	14-3	
	0.10	0.15	0.21	0.27	0.35	0.42	0.51	0.59	0.68	0.78	0.88	
	6-2	7-1	7-11	8-8	9-4	10-0	10-7	11-2	11-9	12-3	12-9	
	0.09	0.13	0.19	0.25	0.31	0.38	0.45	0.53	0.61	0.70	0.78	

12.0	11-1	12-9	14-3	15-8	16-11	18-1	19-2	20-2	21-2	22-1	23-0	
	0.12	0.19	0.26	0.35	0.44	0.54	0.64	0.75	0.86	0.98	1.11	
	10-4	11-11	13-4	14-8	15-10	16-11	17-11	18-11	19-10	20-8	21-6	
	0.12	0.18	0.25	0.33	0.41	0.50	0.60	0.70	0.81	0.92	1.04	
2x10	9-7	11-1	12-4	13-6	14-8	15-8	16-7	17-6	18-4	19-2	19-11	
	0.11	0.16	0.23	0.30	0.38	0.46	0.55	0.65	0.75	0.85	0.96	
	8-9	10-1	11-3	12-4	13-4	14-3	15-2	15-11	16-9	17-6	18-2	
	0.10	0.15	0.21	0.27	0.35	0.42	0.51	0.59	0.68	0.78	0.88	
24.0	7-10	9-0	10-1	11-1	11-11	12-9	13-6	14-3	15-0	15-8	16-3	
	0.09	0.13	0.19	0.25	0.31	0.38	0.45	0.53	0.61	0.70	0.78	
	13-5	15-6	17-4	19-0	20-6	21-11	23-3	24-7	25-9	26-11	28-0	
	0.12	0.19	0.26	0.35	0.44	0.54	0.64	0.75	0.86	0.98	1.11	
13.7	12-7	14-6	16-3	17-9	19-3	20-6	21-9	23-0	24-1	25-2	26-2	
	0.12	0.18	0.25	0.33	0.41	0.50	0.60	0.70	0.81	0.92	1.04	
	11-8	13-5	15-0	16-6	17-9	19-0	20-2	21-3	22-4	23-3	24-3	
	0.11	0.16	0.23	0.30	0.38	0.46	0.55	0.65	0.75	0.85	0.96	
2x12	10-8	12-3	13-9	15-0	16-3	17-4	18-5	19-5	20-4	21-3	22-2	
	0.10	0.15	0.21	0.27	0.35	0.42	0.51	0.59	0.68	0.78	0.88	
	9-6	11-0	12-3	13-5	14-6	15-6	16-6	17-4	18-2	19-0	19-10	
	0.09	0.13	0.19	0.25	0.31	0.38	0.45	0.53	0.61	0.70	0.78	

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-1 (cont.)

RAFTERS: Spans are measured along the horizontal projection and loads are considered as applied on the horizontal projection.

Extreme Fiber Stress in Bending, "F _b " (psi).												RAFTER SPACING SIZE (IN)
1400	1500	1600	1700	1800	1900	2000	2100	2200	2400	2700		
14-2 1.24	14-8 1.37	15-2 1.51	15-8 1.66	16-1 1.81	16-7 1.96	17-0 2.12	17-5 2.28	17-10 2.44			12.0	
13-3 1.16	13-9 1.29	14-2 1.42	14-8 1.55	15-1 1.69	15-6 1.83	15-11 1.98	16-3 2.13	16-8 2.28	17-5 2.60		13.7	
12-4 1.07	12-9 1.19	13-2 1.31	13-7 1.44	13-11 1.56	14-4 1.70	14-8 1.83	15-1 1.97	15-5 2.11	16-1 2.41		16.0	
11-3 0.98	11-7 1.09	12-0 1.20	12-4 1.31	12-9 1.43	13-1 1.55	13-5 1.67	13-9 1.80	14-1 1.93	14-8 2.20		19.2	
10-0 0.88	10-5 0.97	10-9 1.07	11-1 1.17	11-5 1.28	11-8 1.39	12-0 1.50	12-4 1.61	12-7 1.73	13-2 1.97	13-11 2.35	24.0	
18-9 1.24	19-5 1.37	20-0 1.51	20-8 1.66	21-3 1.81	21-10 1.96	22-4 2.12	22-11 2.28	23-6 2.44			12.0	
17-6 1.16	18-2 1.29	18-9 1.42	19-4 1.55	19-10 1.69	20-5 1.83	20-11 1.98	21-5 2.13	21-11 2.28	22-11 2.60		13.7	
16-3 1.07	16-9 1.19	17-4 1.31	17-10 1.44	18-5 1.56	18-11 1.70	19-5 1.83	19-10 1.97	20-4 2.11	21-3 2.41		16.0	
14-10 0.98	15-4 1.09	15-10 1.20	16-4 1.31	16-9 1.43	17-3 1.55	17-8 1.67	18-2 1.80	18-7 1.93	19-5 2.20		19.2	
13-3 0.88	13-8 0.97	14-2 1.07	14-7 1.17	15-0 1.28	15-5 1.39	15-10 1.50	16-3 1.61	16-7 1.73	17-4 1.97	18-5 2.35	24.0	

23-11 1.24	24-9 1.37	25-6 1.51	26-4 1.66	27-1 1.81	27-10 1.96	28-7 2.12	29-3 2.28	29-11 2.44				12.0
22-4 1.16	23-2 1.29	23-11 1.42	24-7 1.55	25-4 1.69	26-0 1.83	26-8 1.98	27-4 2.13	28-0 2.28	28-0 2.43	29-3 2.60		13.7
20-8 1.07	21-5 1.19	22-1 1.31	22-10 1.44	23-5 1.56	24-1 1.70	24-9 1.83	25-4 1.97	25-11 2.11	27-1 2.41			16.0
18-11 0.98	19-7 1.09	20-2 1.20	20-10 1.31	21-5 1.43	22-0 1.55	22-7 1.67	23-2 1.80	23-8 1.93	24-9 2.08			19.2
16-11 0.88	17-6 0.97	18-1 1.07	18-7 1.17	19-2 1.28	19-8 1.39	20-2 1.50	20-8 1.61	21-2 1.73	22-1 1.88	23-5 2.03	23-5 2.35	24.0
29-1 1.24	30-1 1.37	31-1 1.51	32-0 1.66	32-11 1.81	33-10 1.96	34-9 2.12	35-7 2.28	36-5 2.44				12.0
27-2 1.16	28-2 1.29	29-1 1.42	29-11 1.55	30-10 1.69	31-8 1.83	32-6 1.98	33-3 2.13	34-1 2.28	35-7 2.43	35-7 2.60		13.7
25-2 1.07	26-0 1.19	26-11 1.31	27-9 1.44	28-6 1.56	29-4 1.70	30-1 1.83	30-10 1.97	31-6 2.11	32-11 2.26			16.0
23-0 0.98	23-9 1.09	24-7 1.20	25-4 1.31	26-0 1.43	26-9 1.55	27-5 1.67	28-2 1.80	28-9 1.93	30-1 2.08	30-1 2.23		19.2
20-6 0.88	21-3 0.97	21-11 1.07	22-8 1.17	23-3 1.28	23-11 1.39	24-7 1.50	25-2 1.61	25-9 1.73	26-11 1.88	26-11 2.03	28-6 2.35	24.0

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-4
FLAT OR SLOPED RAFTERS
Supporting Plaster Ceiling
(Flat roof or cathedral ceiling with no attic space)
Live Load - 20 lb. per sq. ft.

DESIGN CRITERIA:
Strength - 15 lbs. per sq. ft. dead load plus 20
lbs. per sq. ft. live load determines required
fiber stress.
Deflection - For 20 lbs. per sq. ft. live load.
Limited to span in inches divided by 360.

RAFTER SIZE SPACING (IN)	Extreme Fiber Stress in Bending, "F _b " (psi).									
	300	400	500	600	700	800	900	1000	1100	1200
2x6	12.0	6.7 0.18	7.7 0.28	8.6 0.40	9.4 0.52	10.0 0.66	10.9 0.80	11.5 0.96	12.0 1.12	12.7 1.29
	13.7	6.2 0.17	7.1 0.27	7.11 0.37	8.8 0.49	9.5 0.61	10.0 0.75	10.8 0.90	11.3 1.05	11.9 1.21
	16.0	5.8 0.16	6.7 0.25	7.4 0.34	8.1 0.45	8.8 0.57	9.4 0.70	9.10 0.83	10.5 0.97	11.5 1.12
	19.2	5.2 0.15	6.0 0.22	6.9 0.31	7.4 0.41	7.11 0.52	8.6 0.63	9.0 0.76	9.11 1.02	10.5 1.17
2x8	24.0	4.8 0.13	5.4 0.20	6.0 0.28	6.7 0.37	7.1 0.46	7.7 0.57	8.1 0.68	8.11 0.92	9.4 1.04
	12.0	8.8 0.18	10.0 0.28	11.2 0.40	12.3 0.52	13.3 0.66	14.2 0.80	15.0 0.96	15.10 1.12	16.7 1.29
	13.7	8.1 0.17	9.4 0.27	10.6 0.37	11.6 0.49	12.5 0.61	13.3 0.75	14.0 0.90	14.10 1.05	15.6 1.21
	16.0	7.6 0.16	8.8 0.25	9.8 0.34	10.7 0.45	11.6 0.57	12.3 0.70	13.0 0.83	13.8 0.97	14.4 1.12
2x10	19.2	6.10 0.15	7.11 0.22	8.10 0.31	9.8 0.41	10.6 0.52	11.2 0.63	11.10 0.76	12.6 0.89	13.1 1.02
	24.0	6.2 0.13	7.1 0.20	7.11 0.28	8.8 0.37	9.4 0.46	10.0 0.57	10.7 0.68	11.2 0.79	11.9 0.92
										12.3 1.04

2x10	12.0	11.1 0.18	12.9 0.28	14.3 0.40	15.8 0.52	16.11 0.66	18.1 0.80	19.2 0.96	20.2 1.12	21.2 1.29	22.1 1.48
	13.7	10.4 0.17	11.1 0.27	13.4 0.37	14.8 0.49	15.10 0.61	16.11 0.75	17.11 0.90	18.11 1.05	19.10 1.21	20.8 1.38
	16.0	9.7 0.16	11.1 0.25	12.4 0.34	13.6 0.45	14.8 0.57	15.8 0.70	16.7 0.83	17.6 0.97	18.4 1.12	19.2 1.28
	19.2	8.9 0.15	10.1 0.22	11.3 0.31	12.4 0.41	13.4 0.52	14.3 0.63	15.2 0.76	15.11 0.89	16.9 1.02	17.6 1.17
2x12	24.0	7.10 0.13	9.0 0.20	10.1 0.28	11.1 0.37	11.11 0.46	12.9 0.57	13.6 0.68	14.3 0.79	15.0 0.92	15.8 1.04
	12.0	13.5 0.18	15.6 0.28	17.4 0.40	19.0 0.52	20.6 0.66	21.11 0.80	23.3 0.96	24.7 1.12	25.9 1.29	26.11 1.48
	13.7	12.7 0.17	14.6 0.27	16.3 0.37	17.9 0.49	19.3 0.61	20.6 0.75	21.9 0.90	23.0 1.05	24.1 1.21	25.2 1.38
	16.0	11.8 0.16	13.5 0.25	15.0 0.34	16.6 0.45	17.9 0.57	19.0 0.70	20.2 0.83	21.3 0.97	22.4 1.12	23.3 1.28
2x12	19.2	10.8 0.15	12.3 0.22	13.9 0.31	15.0 0.41	16.3 0.52	17.4 0.63	18.5 0.76	19.5 0.89	20.4 1.02	21.3 1.17
	24.0	9.6 0.13	11.0 0.20	12.3 0.28	13.5 0.37	14.6 0.46	15.6 0.57	16.6 0.68	17.4 0.79	18.2 0.92	19.0 1.04

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-4 (cont.)

RAFTERS: Spans are measured along the horizontal projection and loads are considered as applied on the horizontal projection.

Extreme Fiber Stress in Bending, "F _b " (psi).										RAFTER SPACING SIZE (IN) (IN)
1300	1400	1500	1600	1700	1800	1900	2000	2100		
13.8 1.66	14.2 1.86	14.8 2.06	15.2 2.27	15.8 2.49					12.0	
12.10 1.56	13.3 1.74	13.9 1.93	14.2 2.12	14.8 2.33	15.1 2.54				13.7	
11.10 1.44	12.4 1.61	12.9 1.79	13.2 1.97	13.7 2.15	13.11 2.35	14.4 2.55			16.0	
10.10 1.32	11.3 1.47	11.7 1.63	12.0 1.80	12.4 1.97	12.9 2.14	13.1 2.32	13.5 2.51		19.2	
9.8 1.18	10.0 1.31	10.5 1.46	10.9 1.61	11.1 1.76	11.5 1.92	11.8 2.08	12.0 2.24	12.4 2.41	24.0	
18.0 1.66	18.9 1.86	19.5 2.06	20.0 2.27	20.8 2.49					12.0	
16.10 1.56	17.6 1.74	18.2 1.93	18.9 2.12	19.4 2.33	19.10 2.54				13.7	
15.7 1.44	16.3 1.61	16.9 1.79	17.4 1.97	17.10 2.15	18.5 2.35	18.11 2.55			16.0	
14.3 1.32	14.10 1.47	15.4 1.63	15.10 1.80	16.4 1.97	16.9 2.14	17.3 2.32	17.8 2.51		19.2	
12.9 1.18	13.3 1.31	13.8 1.46	14.2 1.61	14.7 1.76	15.0 1.92	15.5 2.08	15.10 2.24	16.3 2.41	24.0	

23.0 1.66	23.11 1.86	24.9 2.06	25.6 2.27	26.4 2.49						12.0
21.6 1.56	22.4 1.74	23.2 1.93	23.11 2.12	24.7 2.33	25.4 2.54					13.7
19.11 1.44	20.8 1.61	21.5 1.79	22.1 1.97	22.10 2.15	23.5 2.35	24.1 2.55				16.0
18.2 1.32	18.11 1.47	19.7 1.63	20.2 1.80	20.10 1.97	21.5 2.14	22.0 2.32	22.7 2.51			19.2
16.3 1.18	16.11 1.31	17.6 1.46	18.1 1.61	18.7 1.76	19.2 1.92	19.8 2.08	20.2 2.24	20.8 2.41		24.0
28.0 1.66	29.1 1.86	30.1 2.06	31.1 2.27	32.0 2.49						12.0
26.2 1.56	27.2 1.74	28.2 1.93	29.1 2.12	29.11 2.33	30.10 2.54					13.7
24.3 1.44	25.2 1.61	26.0 1.79	26.11 1.97	27.9 2.15	28.6 2.35	29.4 2.55				16.0
22.2 1.32	23.0 1.47	23.9 1.63	24.7 1.80	25.4 1.97	26.0 2.14	26.9 2.32	27.5 2.51			19.2
19.10 1.18	20.6 1.31	21.3 1.46	21.11 1.61	22.8 1.76	23.3 1.92	23.11 2.08	24.7 2.24	25.2 2.41		24.0

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

Chapter ILHR 22

ENERGY CONSERVATION

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ILHR 22.01 Scope (p. 71)	ILHR 22.10	Zone control (p. 78)
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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) **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 $(30° + 50°) \div 2 = 40°$; therefore, $65° - 40° = 25$ degree days.

(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.

(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.

(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.

(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.

SUBCHAPTER III—DESIGN CRITERIA

ILHR 22.04 Indoor and outdoor temperatures. The indoor temperatures listed in Table 22.04-A and the outdoor temperatures listed in Table

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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.

TABLE 22.04-A
INDOOR DESIGN TEMPERATURES

Season	Temperature
Winter	70° F
Summer	78° F

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

ILHR 22.05 Moisture control. (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.** Ventilation above the ceiling/attic insulation shall be required. The free ventilating area shall be at least 1/300 of the horizontal area.

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

SUBCHAPTER IV—BUILDING ENVELOPE

ILHR 22.06 Insulation standards. The exterior envelope of the building shall be insulated to meet the requirements of this part. More stringent overall thermal transmittance (U_o values) will be phased in at time intervals as specified for the designated building components.

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, through the promulgation of an emergency rule. When the office of state planning and energy certifies that such shortages have been remedied, the department will act to reinstate the requirements of s. ILHR 22.06.

(1) **SLAB-ON-GRADE.** The overall thermal transmittance (U_o 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.

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(2) FLOORS OVER UNHEATED AREAS. The overall thermal transmittance (U_o 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.

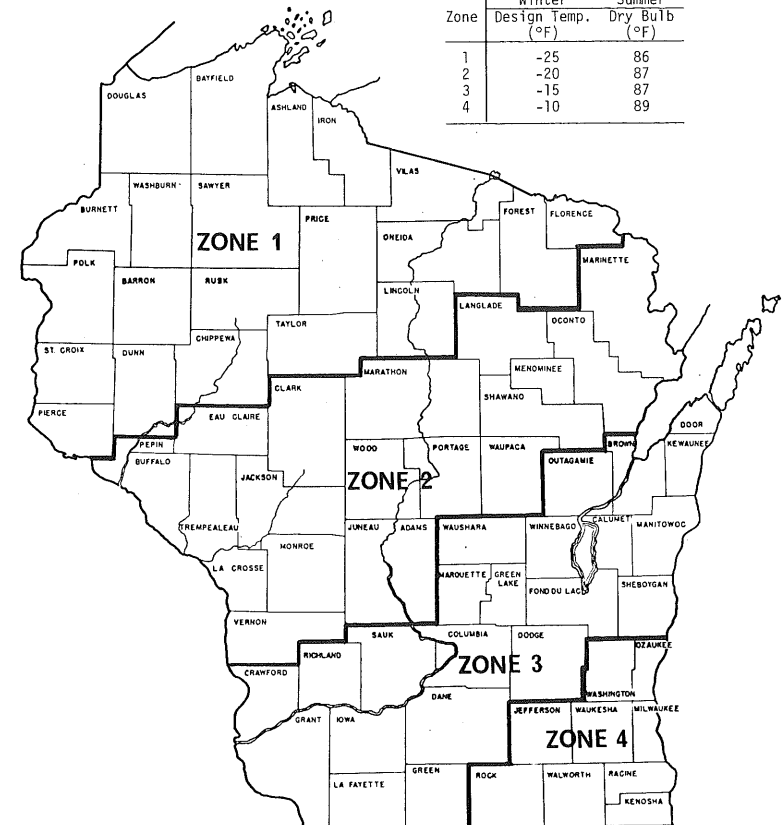
(4) BOX SILL. The box sill area shall be insulated to the same level as the wall.

(5a) ROOF/CEILINGS (effective April 1, 1979). The overall thermal transmittance (U_o value) through roof/ceiling assemblies shall not exceed .029 Btu per (hour) (square foot) (degree F).

(6a) EXTERIOR WALLS (effective April 1, 1979). The exposed exterior walls above grade shall be insulated in accordance with (a) or (b) and (c).

TABLE 22.04-B
OUTDOOR DESIGN CONDITIONS

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



(a) *Exposed exterior walls above grade.* The overall thermal transmittance (U_o value) through exposed exterior walls above grade shall not exceed .14 Btu per (hour) (square foot) (degree F).

(b) *Exterior walls above foundation wall.* The overall thermal transmittance (U_o value) through exterior walls above the foundation wall shall not exceed .13 Btu per (hour) (square foot) (degree F).

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

1. If 25% or less of the foundation wall is exposed, $U_o = .25$ 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 .13 Btu per (hour) (square foot) (degree F).

Note: Section ILHR 22.06 (6a) will be repealed effective March 31, 1980.

(6b) **EXTERIOR WALLS** (effective April 1, 1980). The exposed exterior walls above grade shall be insulated in accordance with (a) or (b) and (c).

(a) *Exposed exterior walls above grade.* The overall thermal transmittance (U_o 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 transmittance (U_o 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_o values:

1. If 25% or less of the foundation wall is exposed, $U_o = .25$ 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** (effective April 1, 1979). A thermal transmittance (U_o 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 (1) through (8) of this section.

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

(10) **ACCURACY OF CALCULATIONS.** The thermal transmittance (U_o) 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_o 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.

ILHR 22.07 Air leakage. (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.

SUBCHAPTER V—HEATING AND AIR CONDITIONING EQUIPMENT AND SYSTEMS

ILHR 22.08 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.

ILHR 22.09 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.

ILHR 22.10 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.

ILHR 22.11 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.

ILHR 22.12 Equipment efficiencies. (1) **ELECTRICAL EQUIPMENT.** (a) *Air conditioning equipment.* Air conditioning equipment shall have a minimum energy efficiency ratio (EER) of 6.1 (COP of 1.8).

(b) *Heat pumps.* Heat pumps shall comply with the minimum coefficients of performance set forth in Table 22.12.

TABLE 22.12
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.** All gas-fired and oil-fired heating equipment shall have a minimum combustion efficiency of 75% at maximum rated output.

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

ILHR 22.13 Electronic ignition and automatic flue dampering (effective April 1, 1979). Combustion space-heating equipment shall be provided with electronic ignition and automatic flue dampering, except sealed combustion equipment or equipment located in enclosures and provided

with combustion air need not be provided with automatic flue dampering.

History: Cr. Register, May, 1978, No. 269, eff. 4-1-79.

SUBCHAPTER VI—BUILDINGS UTILIZING SOLAR, WIND OR OTHER NONDEPLETABLE ENERGY SOURCES

ILHR 22.14 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.

ILHR 22.15 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 Subchapter IV.

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

Chapter ILHR 23

HEATING, VENTILATING AND AIR CONDITIONING
STANDARDS

Subchapter I Scope	ILHR 23.10 Piping (p. 100)
ILHR 23.01 Scope (p. 81)	Subchapter V Chimneys and Vents
Subchapter II Design	ILHR 23.11 General requirements (p. 101)
ILHR 23.02 Design (p. 81)	ILHR 23.12 Masonry chimneys (p. 101)
Subchapter III Heating Equipment	ILHR 23.13 Factory-built chimneys or vents (p. 103)
ILHR 23.03 Selection of equipment (p. 82)	ILHR 23.14 Gas vents (p. 103)
ILHR 23.04 Types of equipment (p. 82)	ILHR 23.15 Chimney connectors, smoke pipes and stovepipes (p. 103)
ILHR 23.045 Solid fuel burning appliances (p. 91)	Subchapter VI Fuel Supply Systems
ILHR 23.05 Safety controls (p. 97)	ILHR 23.16 Fuel storage (p. 105)
ILHR 23.06 Combustion air (p. 97)	Subchapter VII Equipment Location and Operation
Subchapter IV Delivery Systems	ILHR 23.17 Equipment location (p. 106)
ILHR 23.07 Air distribution systems (p. 98)	ILHR 23.18 Operation (p. 107)
ILHR 23.08 Ductwork (p. 98)	
ILHR 23.09 Dampers, registers and grilles (p. 100)	

Note: Chapter Ind 23 was renumbered to be chapter ILHR 23, Register, February, 1985, No. 350, eff. 3-1-85.

SUBCHAPTER I—SCOPE

ILHR 23.01 Scope. The provisions of this chapter shall apply to the design, installation and construction of all heating, ventilating and air conditioning systems in dwellings covered by this code.

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

SUBCHAPTER II—DESIGN

ILHR 23.02 Design. Every dwelling shall be equipped with a heating system designed in accordance with this section. Heating equipment requirements may be waived for recreational dwellings used only during the non-heating season. Where a cooling system is provided, the cooling requirements of this section shall be met.

(1) **HEATING AND COOLING SYSTEM DESIGN.** Indoor and outdoor design temperatures shall be selected from s. ILHR 22.04. The heating and cooling systems shall be designed to maintain the indoor design temperature at outdoor design conditions. When requested, room-by-room heat loss and heat gain calculations shall be furnished.

(2) **DISTRIBUTION SYSTEMS.** Distribution systems shall be sized and located to satisfy the heating and cooling loads of each conditioned space. When requested, a layout of the distribution system shall be furnished to show that the system meets the requirements of this code.

(3) **VENTILATION.** Habitable rooms without openable windows shall be provided with a mechanical ventilation system producing one air change per hour. All required exhaust vents shall terminate outside the struc-

ture. Ductless recirculating fans may be used if approved by the department.

Note: The department will accept designs which meet the Air Conditioning Contractors of America manual; the Mechanical Contractors Association manual; and the Sheet Metal and Air Conditioning Contractors National Association standards for heating and air conditioning systems for one- and 2-family dwellings.

(4) CONTROLS. The temperature rise through the equipment shall not exceed 100° F unless listed. Controls shall be provided to maintain the inside temperature. Where forced, warm-air systems are used, controls shall be installed to control air movement.

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

SUBCHAPTER III—HEATING EQUIPMENT

ILHR 23.03 Selection of equipment. All heating and central cooling equipment shall be selected on the basis of air-handling capacity, pumping capacity, and thermal capacity to handle the calculated design heating or cooling load.

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

ILHR 23.04 Types of equipment. Heating and cooling appliances shall be listed by a recognized testing agency. The clearances in tables 23.04-A and 23.04-B shall apply unless otherwise shown on listed appliances.

TABLE 23.04-A
STANDARD INSTALLATION CLEARANCES (INCHES) FOR HEAT-PRODUCING APPLIANCES

Residential Type Appliances for Installation in Rooms Which are Large (See Note 2)	Appliance ¹				
	Above Top of Casing or Appliance	From Top and Sides of Warm- Air Bonnet or Plenum	From Front See Note 3	From Back	From Sides
Boilers and Water Heaters Steam Boilers - 15 psi Water Boilers - 250° F Water Heaters - 200° F All Water Walls or Jacketed	Automatic Oil	—	24	6	6
	Comb. Gas-Oil	—	18	6	6
	Automatic Gas	—	48	6	6
	Solid Electric	—	18	6	6
Furnaces - Central Gravity, Upflow, Downflow, Horizontal and Duct, Warm-Air - 250° F	Automatic Oil	6 ⁴	24	6	6
	Comb. Gas-Oil	6 ⁴	18	6	6
	Automatic Gas	18 ⁵	48	18	18
	Solid Electric	6 ⁴	18	6	6
Furnaces - Floor For Mounting in Combustible Floors	Automatic Oil	—	12	12	12
	Comb. Gas-Oil	—	12	12	12
	Automatic Gas	—	12	12	12
Heat Exchanger Steam - 15 psi Max. Hot Water - 250° F Max.	—	1	1	1	1
Room Heaters Circulating Type Vented or Unvented Radiant or Other Type Vented or Unvented	Oil or Solid	—	24	12	12
	Gas	36	24	12	12
	Oil or Solid	36	36	36	36
	Gas	36	36	18	18
Radiators Steam or Hot Water	Gas with dbl metal or ceramic back	36	36	12	18
	Gas	36	6	6	6

TABLE 23.04-A (CONTINUED)

Residential Type Appliances for Installation in Rooms Which are Large (See Note 2)	Appliance ¹				
	Above Top of Casing or Appliance See Note 6		From Top and Sides of Warm- Air Bonnet or Plenum	From Front See Note 3	From Back
	See Note 6	See Note 6			
Ranges - Cooking Stoves Vented or Unvented	Oil	30	—	—	9
	Gas	30	—	—	6
	Solid - Clay lined firepot	30	—	—	24
	Solid - Un- lined firepot	30	—	—	36
	Electric	30	—	—	6
Clothes Dryers	Gas	6	—	24	6
Listed Types	Electric	6	—	24	0
Incinerators	—	36	—	48	36
Residential Types	—	—	—	—	—

¹Standard clearances may be reduced by affording protection to combustible material in accordance with Table 23.04-B.

²Rooms which are large in comparison to the size of the appliance are those having a volume equal to at least 12 times the total volume of a furnace and at least 16 times the total volume of a boiler. If the actual ceiling height of a room is greater than 8 feet, the volume of a room should be figured on the basis of a ceiling height of 8 feet.

³The minimum dimension should be that necessary for servicing the appliance including access for cleaning and normal care, tube removal, etc.

⁴For a listed oil, combination gas-oil, gas, or electric furnace this dimension may be 2 inches if the furnace limit control cannot be set higher than 250° F or this dimension may be one inch if the limit control cannot be set higher than 200° F.

⁵The dimension may be 6 inches for an automatically stoker-fired forced warm-air furnace equipped with 250° F limit control and with barometric draft control operated by draft intensity and permanently set to limit draft to a maximum intensity of 0.13 in. water gauge.

⁶To combustible material or metal cabinets. If the underside of such combustible material or metal cabinet is protected with asbestos millboard at least 1/4-inch thick covered with sheet metal of not less than No. 28 gauge, the distance may be not less than 24 inches.

⁷Clearance above charging door should be not less than 48 inches.

TABLE 23.04-B
CLEARANCES, INCHES, WITH SPECIFIED FORMS OF PROTECTION^{1,2}

Type of Protection Applied to the combustible material unless otherwise specified and covering all surfaces within the distance specified as the required clearance with no protection. Thicknesses are minimum.	Where required clearance with no protection is											
	36 inches		18 inches		12 inches		9 inches		6 inches		Chimney or Vent Con- nector	Chimney or Vent Con- nector
	Above	Sides & Rear	Above	Sides & Rear	Above	Sides & Rear	Above	Sides & Rear	Above	Sides & Rear		
(a) 1/4-in. asbestos millboard spaced out 1 in.	30	18	15	9	9	6	6	6	3	2	3	3
(b) 0.013 in. (28 gage) sheet metal on 1/4-in. asbestos millboard	24	18	12	9	9	6	4	4	3	2	2	2
(c) 0.013 in. (28 gage) sheet metal spaced out 1 in.	18	12	9	6	6	4	4	4	2	2	2	2
(d) 0.013 in. (28 gage) sheet metal on 1/4-in. asbestos millboard spaced out 1 in.	18	12	9	6	6	4	4	4	2	2	2	2
(e) 1-1/2 in. asbestos cement covering on heating appliance	18	12	9	6	6	4	4	4	2	1	6	6
(f) 1/2-in. asbestos millboard on 1 in. mineral fiber bats reinforced with wire mesh or equivalent	18	12	6	6	4	4	4	4	2	2	2	2
(g) 0.027 in. (22 gage) sheet metal on 1 in. mineral fiber bats reinforced with wire or equivalent	18	12	4	3	2	2	2	2	2	2	2	2
(h) 1/2-in. asbestos millboard	36	36	18	18	12	12	9	4	4	4	4	4
(i) 1/4-in. cellular asbestos	36	36	18	18	12	12	9	3	3	3	3	3

¹Except for the protection described in (e), all clearances should be measured from the outer surface of the appliance to the combustible material disregarding any intervening protection applied to the combustible material.

²Asbestos millboard referred to above is a different material from asbestos cement board. It is not intended that asbestos cement board be used in complying with these requirements when asbestos millboard is specified.

(1) **FURNACES.** The input and output capacity of furnaces shall be listed on the nameplate. All nameplates shall show evidence that the equipment has been listed by a recognized testing laboratory.

(a) *Fuel supply.* Furnaces shall be fired with the fuel for which they have been approved, except as provided in (1) (d) of this section. Fuels shall be supplied to the furnace in the volume and at the pressure required on the label.

(b) *Unvented furnaces and space heaters.* The use of unvented furnaces and space heaters fueled by natural gas, kerosene, alcohol or other fuel shall be prohibited due to concerns about oxygen depletion; contamination from carbon monoxide, carbon dioxide, nitrogen dioxide, formaldehyde and other combustion related contaminants; and water vapor buildups.

(c) *Vented wall furnaces.* Vented wall furnaces shall not be equipped with duct extensions beyond the vertical and horizontal limits of the enclosure unless listed. Vented wall furnaces shall be located to prevent the restriction of air circulation by doors, projections, or other openings. Vented wall furnaces shall be provided with combustion air.

(d) *Conversion burners.* Conversion burners shall be listed by a recognized testing laboratory. The existing equipment shall be reconditioned and defective parts replaced before a conversion burner is installed. Conversion burners shall be installed in accordance with the installation instructions.

(e) *Location.* No furnace shall be placed in a bedroom, bathroom, closet or garage unless listed for such installation.

(2) **HEAT PUMP APPLIANCES.** (a) *Size.* Heat pump appliances shall be sized to provide control of the wet and dry bulb temperatures during cooling and maximum performance during heating. The heating balance point shall be considered to determine the outdoor temperature at which the heat pump must operate 100% of the time to offset the dwelling heat loss.

(b) *Auxiliary heaters.* Provisions for auxiliary heat to supplement the heat pump at outdoor temperatures below the balance point shall be provided. Auxiliary heaters shall be sized so that the heat pump auxiliary will offset the dwelling heat loss down to the heating design temperature.

(3) **BOILERS.** Boilers shall comply with ch. ILHR 41-42, Boiler and Pressure Vessel Code, ss. ILHR 41.10 and ILHR 41.50 through 41.53.

Note: The department will accept equipment listed by the American Society of Mechanical Engineers, Underwriters' Laboratories, and the American Gas Association.

(4) **SOLID-FUEL-BURNING APPLIANCES.** Solid-fuel-burning appliances shall comply with the following requirements:

(a) *Floor protection.* Stoves may be installed on combustible floors provided the floor is protected with a material such as 24-gauge or thicker sheet metal, 1/4-inch or thicker asbestos millboard covered with 24-gauge sheet metal, 4-inch hollow bricks, or 4 inches of stone or concrete, or equivalent. Such protection shall extend beneath the stove, at least 12 inches beyond all sides and at least 18 inches beyond sides having a door

or other similar opening. Stoves shall have a clearance of at least 4 inches to the floor.

(b) *Chimneys.* Wood-burning appliances shall be connected to a masonry chimney with a flue liner or an all-fuel, residential type factory-built chimney. Wood-burning equipment shall not be connected to a flue serving a fireplace or other equipment. The chimney shall be designed to create a natural draft to carry away the products of combustion or provision shall be made for mechanically maintaining constant updraft during equipment operation. A cleanout opening shall be provided. A listed multi-fuel appliance may be vented into a single flue.

(c) *Chimney connector or stovepipe.* The chimney connector or stovepipe shall comply with Table 23.15-A.

(d) *Damper.* A manual cast iron damper to control the draft shall be provided in the chimney connector next to the appliance.

(e) *Supplemental units.* Supplemental wood-burning units connected to a furnace shall be connected to the warm air side of the furnace in accordance with illustrations 23.01-A, 23.01-B or 23.01-C.

1. Return air duct. The area of the return air duct shall be at least equal to the area of the warm air supply duct. The return air duct shall be of the same material as specified for supply air ducts.

2. Blower. The blower on the furnace shall maintain the manufacturer's specifications for CFM and static pressure when the supplemental unit is in operation.

3. Outside air intake. The outside air intake shall be connected to the cold air return plenum of the furnace. A volume damper shall be placed in the duct for the fresh air intake.

4. Thermostat. The thermostat control on the supplemental heating unit shall activate the blower motor at a temperature between 100° and 120° F.

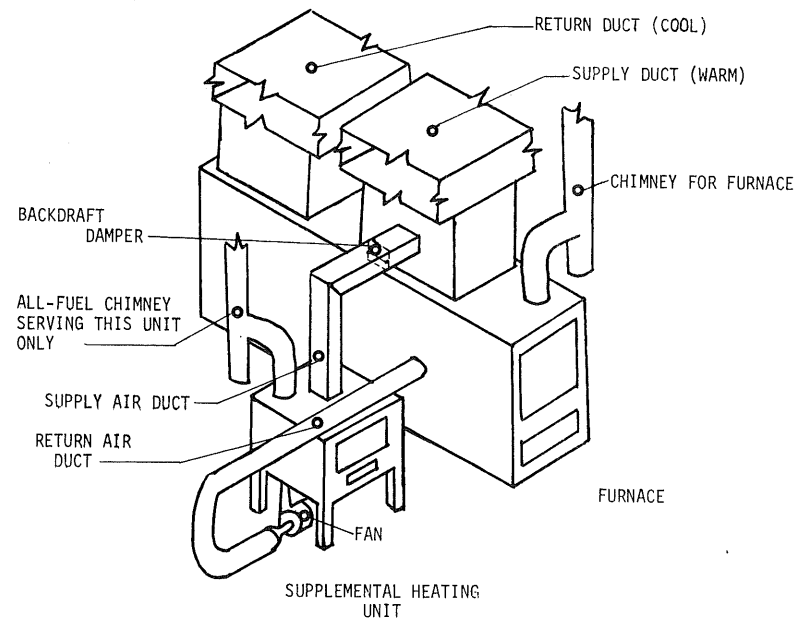


FIGURE 23.01-A

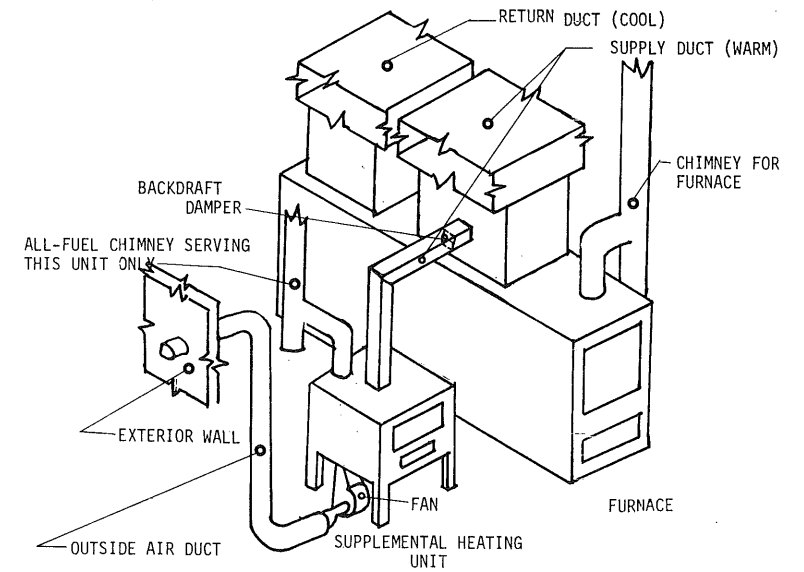


FIGURE 23.01-B

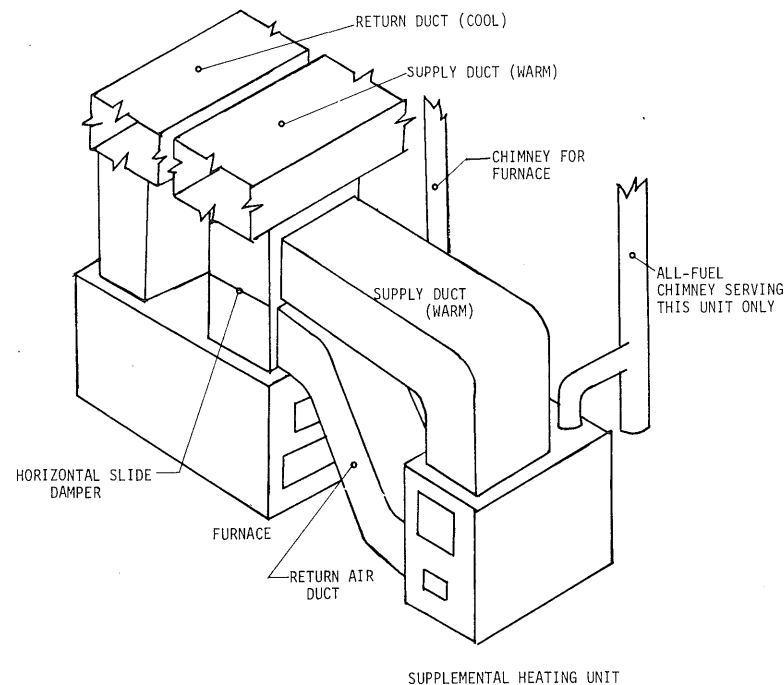


FIGURE 23.01-C

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80; r. and recr. (1) (b), and am. (4) (b), Register, February, 1985, No. 350, eff. 3-1-85; correction in (3) made under s. 13.93 (2m) (b) 7, Stats., Register, February, 1985, No. 350.

ILHR 23.045 Solid fuel burning appliances. (1) **GENERAL.** Solid fuel-burning appliances shall be installed as specified in this section. The installations shall also be in accordance with the appliance manufacturer's installation instructions if the manufacturer specifies the use of increased protection or greater clearances than those specified in this section.

(2) **LOCATION OF APPLIANCES.** (a) *Servicing.* Every appliance shall be located to permit access to the appliance. Sufficient clearance shall be maintained around the equipment to permit cleaning of surfaces; the replacement of air filters, blowers, motors, controls and chimney connectors; the lubrication and servicing of moving parts; and the adjustment and servicing of stokers and appliance components.

(b) *Combustion Air.* Solid fuel-burning appliances shall not be installed in spaces where the volume of the room (measured in cubic feet) is less than 1/20th of the maximum input BTU rating of the appliance, unless combustion air is provided by one of the following methods:

1. Air from inside the dwelling. The openings shall be provided to the equipment enclosure. One opening shall be located within 12 inches from the floor and one opening shall be located within 24 inches from the top of the room. Each opening shall provide a minimum area of one square inch per 1,000 BTU per hour input.

2. Air from outside the dwelling. Two openings shall be provided to the equipment enclosure. One opening shall be located within 12 inches from the floor and one opening shall be located within 24 inches from the top of the room. Each opening shall provide a minimum area of one square inch per 4,000 BTU per hour input.

3. Combustion air openings. Openings required for combustion air to solid fuel-burning appliances shall be in addition to openings required for other appliances.

Note: Wood has a value of 8,600 BTU per pound.

(3) **CHIMNEYS.** (a) Solid fuel-burning appliances shall be connected to one of the following types of chimneys:

1. Factory-built chimneys or vents. A listed residential type and building heating appliance chimney or "building heating appliance only" chimney may be used with solid fuel-burning appliances where the flue gas temperature does not exceed 1,000°F continuously, and does not exceed 1,400°F for infrequent brief periods of forced firing.

2. Masonry chimneys. Masonry chimneys shall be constructed as specified in s. ILHR 21.30.

(4) **CHIMNEY CONNECTORS.** (a) All solid fuel-burning appliances shall be connected to chimneys with factory-built chimney material, Type L vent material or steel pipe with minimum thicknesses as specified in Table 23.045-A.

TABLE 23.045-A
METAL THICKNESS FOR PIPE CONNECTORS

Diameter of Connector (inches)	Galvanized Sheet Gage No.	Minimum Thickness Inches
6 to 10	24	.023
over 10 to 16	22	.029
over 16	16	.056

(b) The required clearance to combustibles for chimney connectors shall be 18 inches. This clearance can be reduced in accordance with Table 23.045-D. The specified protection shall be applied to and cover all combustible material as specified in Figure 23.045.

(c) Connectors and chimneys for solid fuel-burning appliances shall be designed, located and installed to permit ready access for internal inspection and cleaning. —

(d) 1. Chimney connectors shall have no more than two 90° elbows.

2. The horizontal length shall not exceed 75% of the total vertical height of the entire venting system measured from the appliance outlet.

3. The connector shall maintain a rise of at least ¼ inch per foot from the appliance outlet to the chimney inlet.

4. Connectors shall be securely supported and joints fastened with a minimum of 3 sheet metal screws or rivets.

5. Appliances used mainly for wood burning shall have the joints assembled so that the crimped end points towards the stove. Appliances burning coal shall have the joints assembled so that the crimped end points away from the appliance.

6. A connector to a masonry chimney shall extend through the wall to the innerface of the liner but not beyond.

7. The effective area of the connector shall not be less than the area of the appliance flue collar.

(e) No chimney connectors may pass through any floor, ceiling, window, door or combustible wall nor be concealed in any closet, attic or similar space. A connector may pass through a combustible wall if the connector is guarded at the point of passage by one of the following methods:

1. Metal ventilated thimble not less than 12 inches larger in diameter than the connector.

2. All combustible material in the wall is cut away from the connector a sufficient distance to provide the required 18-inch clearance. Any material used to close up such openings shall be noncombustible.

(f) A manual, cast iron damper to control draft shall be provided in the chimney connector. The damper shall not obstruct more than 80% of the connector area. Listed solid-fuel appliances whose listing prohibits the

use of manual dampers in the connector shall not require a manual damper to be installed.

(5) MOUNTING ON FLOORS. (a) Appliances shall be placed on surfaces as described in Table 23.045-B. Solid fuel-burning appliances listed specifically for installation on a floor constructed of combustible material may be installed in accordance with the terms of the listing and the manufacturer's instructions.

TABLE 23.045-B
FLOOR MOUNTINGS FOR
SOLID FUEL-BURNING APPLIANCES

Kind of Appliance	Allowed Mounting
(1) All forced air and gravity furnaces, steam and water boilers.	
(2) Residential-type ranges, fireplace stoves, room heaters and combination fireplace stove/room heaters, having less than 2 inches of ventilated open space beneath the fire chamber or base of the unit.	Floors of fire-resistive construction with noncombustible water heaters, fireplace flooring and surface finish, or fire-resistive arches or slabs. These constructions shall have no combustible material against the underside. Such construction shall extend at least 18 inches beyond the appliance on all sides. These appliances shall not be placed on combustible floors.
(3) Residential-type ranges, water heaters, fireplace stoves, room heaters and combination fireplace stove/room heaters having legs or pedestals providing 2 to 6 inches of ventilated open space beneath the fire chamber or base of the heater.	On combustible floors when such floors are protected by 4 inches of hollow masonry, laid to provide air circulation through the masonry layer. Such masonry shall be covered with 24 gage sheet metal. The required floor protection shall extend at least 18 inches on all sides of the appliance. Noncombustible floors shall extend at least 18 inches on all sides of the appliance.
(4) Residential-type ranges, water heaters, fireplace stoves, room heaters and combination fireplace stove/room heaters having legs or pedestals providing over 6 inches of ventilated open space beneath the fire chamber or base of the covered heater.	On combustible floors, when such floors are protected by closely spaced masonry units of brick, concrete or stone, which provide at least 2 inches of thickness, such masonry shall be covered by or placed over a sheet of 24 gage steel. The required floor protection shall extend at least 18 inches on all sides of the appliance. Noncombustible floors shall extend at least 18 inches on all sides of the appliance.

(6) CLEARANCES (a) Solid fuel-burning equipment shall be installed with clearances not less than specified in Table 23.045-C.

(b) 1. Listed appliances exception. Listed appliances may be installed with clearances other than that specified by Table 23.045-C if installed in accordance with the terms of their listing and the manufacturer's instructions.

2. Clearance with protection exception. Chimney and vent connectors may be installed with reduced clearances provided the combustible material is protected as described in Table 23.045-D. The specified protection shall be applied to and cover all combustible material as specified in Figure 23.045.

TABLE 23.045-C
STANDARD CLEARANCES FOR
SOLID FUEL-BURNING APPLIANCES

Type of Appliance	Above Top of Cas- ing or Appliance. Above Top and Sides of Furnace Plenum or Bonnet (inches)	Minimum Standard Clearances (inches)		
		From Front	From Back	From Sides
<u>Residential Appliances</u>				
Steam Boilers - 15 psi	6	48	6	6
Water Boilers - 250° F max.				
Water Boilers - 200° F max.				
All Water Walled or Jacketed				
<u>Furnaces</u>				
Gravity and Forced Air	18	48	18	18
<u>Room Heaters, Fireplace Stoves,</u>				
<u>Combinations</u>	36	36	36	36
			Firing Side	Opp. Side
<u>Ranges</u>				
Lined Firechamber	30	36	24	18
Unlined Firechamber	30	36	36	18

TABLE 23.045-D
CONNECTOR CLEARANCES WITH SPECIFIED
FORMS OF PROTECTION ^{1,2,3,4,5,6}

Type of Protection	Minimum Required Connector Clearances for: (inches)		
	Ranges, Room Heaters Fireplace Stoves, Combinations	Furnaces	Residential Appliances (Boilers)
No protection.	36	18	6
0.013 in. (28 gage) sheet metal spaced out a minimum of one inch.	18	9	2
3-½ in. thick masonry wall spaced out a mini- mum of one inch and ade- quately tied to the wall being protected (see Note 4).	18	9	2
0.027 in. (22 gage) sheet metal on one-inch mineral wool batts reinforced with wire or equivalent spaced out a minimum of one inch.	12	3	2

¹ Spacers and ties shall be of noncombustible material.

² All methods of protection require adequate ventilation between protective material and adjacent combustible walls and ceilings.

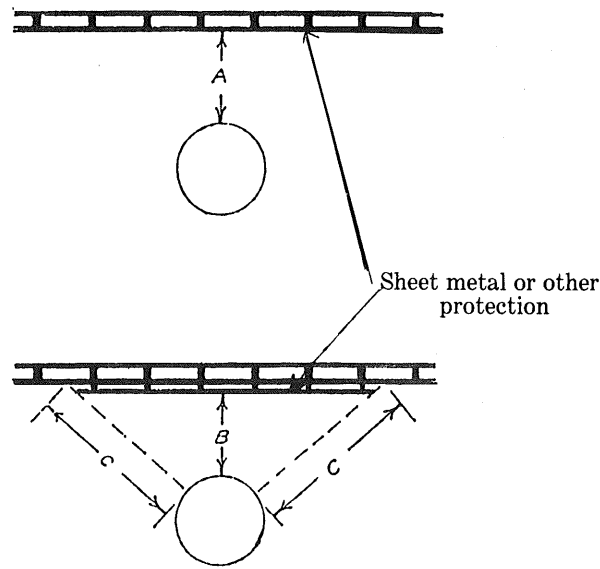
³ Mineral wool batts (blanket or board) shall have a minimum density of 8 pounds per cubic foot and a minimum melting point of 1550° F.

⁴ If a single wall connector passes through the masonry wall there shall be at least ½ inch of open ventilated air space between the connector and the masonry.

⁵ There shall be at least one inch between the appliance and the protector.

⁶ Clearances in front of the appliances shall not be reduced from those in Table 23.045-C.

FIGURE 23.045
CONSTRUCTION USING COMBUSTIBLE MATERIAL



“A” Equals the required clearance with no protection, specified in Table 23.045-D.

“B” Equals the reduced clearance permitted in accordance with Table 23.045-D. The wall protection should extend far enough in each direction to make ‘C’ equal to ‘A’.

(7) ACCESSORIES. Accessories for solid fuel-burning appliances such as heat exchangers, stove mats, floor pad and protection shields, shall be listed and shall be installed in accordance with the terms of their listing.

(8) SUPPLEMENTAL UNITS. Supplemental solid fuel-burning units connected to a furnace shall be connected to the warm air side of the furnace and shall conform to the following provisions:

(a) *Return Air Duct.* The area of the return air duct shall be at least equal to the area of the warm air supply duct. The return air duct shall be of the same material as specified for supply air ducts.

(b) *Blower.* The blower on the furnace shall maintain the manufacturer’s specifications for cubic feet per minute air flow and static pressure when the supplemental unit is in operation.

(c) *Outside Air Intake.* The outside air intake shall be connected to the cold air return plenum of the furnace. A volume damper shall be placed in the duct for the fresh air intake.

(d) *Thermostat.* The thermostat control on the supplemental heating unit shall activate the blower motor at a temperature between 100° and 120° F.

(9) SUPPLY DUCTS. Supply ducts connected to solid fuel-burning appliances shall have the following minimum clearances to combustibles:

(a) *Horizontal ducts.* The clearance from combustibles for horizontal ducts shall be as specified in Table 23.045-E.

TABLE 23.045-E

Distance of Ducts From Bonnet or Plenum (inches)	Clearance to Combustibles ¹ Required (inches)
0 to 36	18
over 36 to 72	6
over 72	1

¹Clearance can be reduced in accordance with Table 23.045-D

(b) *Vertical ducts.* 1. Air shall travel 6 feet and change directions equivalent to one 90° turn before entering an enclosure of combustible material.

2. Ducts shall have 3/16 inch clearance between the duct and any combustible material.

(10) COMBINATION APPLIANCES. Appliances capable of burning multi-types of fuel shall be listed and installed in accordance with their listing.

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

ILHR 23.05 Safety controls. High limit, maximum outlet air temperature and similar safety controls shall be provided on heating equipment.

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

ILHR 23.06 Combustion air. All fuel-burning heating equipment, except sealed combustion appliances, cooking appliances, refrigerators and clothes dryers, shall be provided with a supply of air for fuel combustion.

(1) EQUIPMENT LOCATED IN UNCONFINED SPACES. (a) *Infiltration.* Combustion air may be provided by means of infiltration where the volume of the room (measured in cubic feet) in which the burner is located is greater than 1/20 of the maximum input BTU rating of the burner(s).

(b) *Openings.* Where exterior openings are used to provide combustion air from the outside to appliances located in unconfined spaces, the opening shall be designed to provide one square inch of area for each 5,000 BTU per hour of input rating.

(2) EQUIPMENT LOCATED IN CONFINED SPACES. Combustion air provided to equipment located in confined spaces shall be installed in accordance with the following:

(a) *Air from inside the dwelling.* Two openings shall be provided to the equipment enclosure. One opening shall be located within 12 inches from the floor and one opening shall be located within 24 inches from the top of the room. Each opening shall provide a minimum area of one square inch per 1,000 BTU per hour input.

(b) *Air from outside the dwelling.* Two openings shall be provided to the equipment enclosure. One opening shall be located within 12 inches from the floor and one opening shall be located within 24 inches from the top of the room. Each opening shall provide a minimum area of one square inch per 4,000 BTU per hour input.

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

SUBCHAPTER IV—DELIVERY SYSTEMS

ILHR 23.07 Air distribution systems. (1) **SIZING.** All air distribution systems shall be sized using the velocities and static pressure losses listed in Table 23.07.

TABLE 23.07
DUCT VELOCITIES

Designation	Maximum Static Pressure Loss (in WG 100 ft)	Minimum Velocity (feet minute)	Maximum Velocity (feet minute)
Main trunk duct	.10	700-900	800-1200
Branch duct	.10	600	700-1000
Branch riser	.10	500	650-800
Outdoor intake	.10	500	800
Grilles or openings	.10	400	600
Return air door undercuts	.10	200	300
Return air door or wall louvers	.10	200	300

WG = Water gauge per 100 feet.

(2) **SYSTEM SIZING.** The distribution system, including the evaporator coil, air filters (installed external to the heating unit), ducts, fittings, grilles and registers, shall be sized so that the total external static pressure shall not exceed the static pressure capacity of the fan at the system rated air flow.

(3) **CHANGES IN DUCT SIZE.** Where duct sizes are changed, the slope angle of the transition duct shall not exceed 45°.

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

ILHR 23.08 Ductwork. (1) **DUCT USE.** Ducts designed for the transmission of air shall be used for no other purpose.

(2) **INTERIOR DUCTS.** All interior ducts shall be constructed in accordance with the following:

(a) *Supply and return air ducts.* All supply and return air ducts shall be constructed of sheet metal or lined with sheet metal or other noncombustible materials.

1. Exception. Nonmetallic ducts or flexible ducts may be used except in connection with kitchen exhaust ducts or where the duct air temperature exceeds 250° F. Nonmetallic or flexible ducts shall not be connected to a furnace unless a connecting duct of sheet metal, having a length of at least 6 feet, is used to separate nonmetallic ducts from the appliance.

2. Exception. Unlined wood joists and stud spaces may be used as return air ducts. Wood joists and stud spaces used as return air ducts shall

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Heating, Ventilating and Air Conditioning Standards

be cut off from all remaining unused portions by tight-fitting stops of sheet metal or of wood at least 2 inches nominal thickness. Bridging shall be removed from the joist space.

(3) **EXTERIOR DUCTS.** Ducts located outside the dwelling (in garages, attics and similar spaces) shall be constructed of galvanized steel or corrosion-resistive metal.

(4) **UNDERGROUND DUCTS.** Ducts, plenums and fittings constructed of asbestos cement, metal encased in concrete or ceramic, or other approved materials, may be installed in the ground. Supply air ducts installed parallel and adjacent to an outside wall shall be insulated with a moistureproof material having a resistance value of at least R-5 to a depth of at least 48 inches.

(5) **METAL STANDARDS.** All sheet metal ducts and fittings shall be constructed in compliance with standards approved by the department.

Note: The department will accept ducts designed in accordance with the ASHRAE Handbook of Fundamentals, published by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, or as illustrated in the low velocity or high velocity duct construction standards published by the Sheet Metal and Air Conditioning Contractors National Association, Inc.

(6) **THICKNESS.** Ducts shall conform to the minimum thicknesses listed in Table 23.08-A.

(7) **DUCT SUPPORT.** Ductwork shall be fastened in place and braced to prevent lateral displacement in accordance with Table 23.08-B.

TABLE 23.08-A
DUCT CONSTRUCTION MINIMUM SHEET METAL GAUGES

	Minimum thickness galvanized sheet gauge	Minimum thickness aluminum B & S gauge
Metal gauges (duct not enclosed in partitions)		
Round ducts		
Diameter, inches		
Less than 12	30	26
12-14	28	26
15-18	26	24
Over 18	24	22
Rectangular Ducts		
Width, inches		
Less than 14	28	24
14-24	26	22
25-30	24	22
Over 30	22	20
Metal gauges (ducts enclosed in partition)		
Width, inches		
14 or less	30	26
Over 14	28	24

TABLE 23.08-B

DUCT SUPPORT MATERIAL

Duct Type	Maximum Size of Diameter (inches)	Duct Position	Hanger or Strap Size and Spacing
Circular	10	Vertical	No. 18 gage galvanized steel x 2" @ 12' o.c.
		Horizontal	No. 30 gage galvanized steel x 1" or No. 18 steel wire @ 10' o.c.
	20	Vertical	No. 16 gage galvanized steel x 2" @ 12' o.c.
		Horizontal	No. 28 gage galvanized steel x 1" or No. 18 steel wire @ 10' o.c.
Rectangular ¹	24	Vertical	1" x 1/8" steel galvanized strap @ 12' o.c.
		Horizontal	No. 18 gage galvanized steel x 1" @ 10' o.c.
		Vertical	1" x 1-1/8" galvanized steel angle @ 12' o.c.
		Horizontal	1" x 1/8" galvanized steel strap @ 10' o.c.

¹Rectangular metal duct supports should consist of one hanger attached to one-inch wide circular bands of the duct extending around and supporting ducts exceeding 10 inches in diameter.

Note: This table does not prohibit nailing for duct support.

(8) JOINTS AND SEAMS. All joints and seams shall be securely fastened or locked. Round pipe slip joints shall be lapped at least one inch.

(9) VIBRATION CONTROL. When used, vibration isolation connectors shall be installed at the joint between the duct and fan or heating equipment. Vibration isolation connectors shall not be used where the air temperature is in excess of 250° F.

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

ILHR 23.09 Dampers, registers and grilles. (1) VOLUME AND BACKDRAFT DAMPERS. Volume duct dampers shall be provided to permit balancing of the system. No supply ducts shall terminate in a garage without a backdraft damper.

(2) AIR REGISTERS AND GRILLES. (a) *Supply air registers.* All supply air outlets shall be provided with registers or devices which will provide a uniform distribution of air.

(b) *Return air grilles.* Return air grilles shall not be located in bathrooms, kitchens, garages, utility spaces or a confined space in which a draft diverter or draft regulator is located. All other habitable spaces shall have permanent openings to a return air grille equal in area to the supply outlet serving those areas. At least one return air opening shall be provided for each floor.

ILHR 23.10 Piping. (1) PIPE SIZES AND ARRANGEMENT. All steam and hot water supply and return piping, air-line piping and auxiliary equipment shall be of appropriate sizes, elevations and arrangements to accomplish the calculated results without stress or other detriment.

Note: The sizes of pipe to be used for mains and risers may be selected from the ASHRAE Guide and Data Book, published by the American Society of Heating, Refrigerating and Air Register, February, 1985, No. 350 Heating, Ventilating and Air Conditioning Standards

Conditioning Engineers; or the manuals published by the Institute of Boiler and Radiator Manufacturers or the Mechanical Contractors Association of America.

(2) EXPANSION AND CONTRACTION. The piping for the heating system shall be equipped with anchors, expansion swings or joints, supports and similar devices to relieve stress and strain caused by temperature change of the pipe material.

(3) PIPE INSULATION. Unguarded steam, hot water supply and return piping shall be covered with insulating material where the pipes pass through occupied areas and the surface temperature exceeds 180° F.

(4) STEAM AND HOT WATER PIPES. No pipe carrying hot water or steam at a surface temperature exceeding 250° F shall be placed within one inch of any combustible material, pass through a combustible floor, ceiling or partition unless the pipe is protected by a metal sleeve one inch larger in diameter than the pipe or with approved pipe covering.

(5) BALANCING. Balancing cocks shall be provided in each circuit of a hot water distribution system.

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

SUBCHAPTER V—CHIMNEYS AND VENTS

ILHR 23.11 General requirements. (1) TYPES OF CHIMNEYS AND VENTS. All heating appliances using solid, liquid or gas fuels shall be vented to the outside by an all-fuel factory-built, masonry chimney or other listed venting system designed to remove the products of combustion.

(2) TERMINATION. All chimneys or vents depending on a principle of gravity for the removal of the products of combustion shall extend at least 3 feet above the highest point where the chimneys and vents pass through the roof of the building, and at least 2 feet higher than any ridge, peak, wall, or roof within 10 feet horizontally of the chimney or vent.

(3) CHIMNEY OR VENT INLETS. Two appliances using the same type of fuel may be vented into the same flue provided the separate inlets are offset at least 12 inches vertically; or the separate inlets occur at right angles to each other; or the appliances are connected to a single inlet through a common manifold. Chimneys serving fireplaces or other solid-fuel-burning appliances shall not be used to vent any other equipment or appliance.

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

ILHR 23.12 Masonry chimneys. Masonry chimneys shall conform to the following provisions:

(1) MATERIALS. No masonry chimney shall rest upon wood. The foundation shall be designed and built in conformity with the requirements for foundations. Masonry chimney walls shall be at least 4 inches in nominal thickness. Hollow-cored masonry units may be used to meet the 4 inch nominal thickness requirement.

(2) FLUE SIZE. Chimney flues for appliances shall be at least equal in area to that of the area of the connector from the appliance.

Register, February, 1985, No. 350 Heating, Ventilating and Air Conditioning Standards

(3) **MULTIPLE FLUE SEPARATION.** When more than one flue is contained in the same chimney, a masonry separation of at least 4 inches nominal in thickness shall be provided between the individual flues. The joints of adjacent flue liners shall be staggered by at least 7 inches.

(4) **CORBELING.** Unless designed through structural analysis, masonry chimneys shall not be corbeled from a wall more than 6 inches nor shall a masonry chimney be corbeled from a wall less than 12 inches in nominal thickness unless it projects equally on each side of the wall. The corbeling shall not exceed one-inch projection for each brick course.

(5) **INLETS.** Inlets to masonry chimneys shall enter the side and be provided with thimbles. Thimbles shall be at least No. 24 manufacturer's standard gauge (0.024 inch) or 5/8-inch thick refractory material. Each chimney shall have an inlet installed at the time of construction.

(6) **CLEAN-OUT OPENING.** Every masonry chimney shall be provided with a clean-out opening at the base. Such openings shall be equipped with metal doors and frames arranged to remain closed when not in use. Clean-out openings shall be located below the lowest inlet to the flue.

(7) **FLUE LINERS.** (a) Masonry chimneys shall be lined with fireclay flue lining at least 5/8-inch thick, vitrified clay sewer pipe or with material that will resist corrosion, softening or cracking from flue gases at temperatures up to 1800° F. Flue liners shall commence at the chimney footings.

(b) All flue liners shall be laid in a full mortar bed.

(c) Variations in inside and outside dimensions shall not exceed 1/4 inch for clay flue liners.

(8) **CHIMNEY CAPS.** Precast or cast-in-place concrete caps shall have a minimum thickness of 2 inches. A minimum of a 1/4 inch mortar joint shall be used between flues and caps and shall be caulked or sealed.

Note: Mortar means refractory cement.

(9) **CLEARANCE TO COMBUSTIBLES.** (a) The minimum clearance between masonry chimneys and combustible material shall be 2 inches for interior chimneys and 1/2 inch for chimneys located at the exterior wall.

(b) The clearance between the masonry chimney and combustible flooring and trim shall be at least 1/2 inch.

(c) Ends of wood girders may be supported on a corbeled shelf of a masonry chimney provided there is at least 8 inches of solid masonry between the ends of the girder and the flue liner.

(d) Combustible lath, combustible furring or combustible plaster grounds shall not be placed closer than 1-1/2 inches from the masonry. This requirement shall not:

1. Prevent plastering directly on the masonry or on metal lath and metal furring or

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

ILHR 23.13 Factory-built chimneys or vents. Factory-built chimneys or vents shall be of an approved type.

Note: The department recognizes as approved, factory-built chimneys or vents designated as "residential type and building heating appliance," "building heating appliance," "B," "BW," and "L" types listed by Underwriters' Laboratories, Inc.

(1) **RESIDENTIAL TYPE AND BUILDING HEATING APPLIANCE.** An approved "residential type and building heating appliance" chimney or a "building heating appliance only" chimney may be used with solid, liquid or gas-fired heating appliances where the flue gas temperature does not exceed 1000° F continuously, and does not exceed 1400° F for infrequent brief periods of forced firing.

(2) **TYPE "B".** An approved type "B" gas vent may be used with a vented, recessed wall heater.

(3) **TYPE "BW".** An approved type "BW" gas vent may be used with a vented, recessed wall heater.

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

ILHR 23.14 Gas vents. All gas-fired equipment shall be provided with vent pipes conforming to the requirements for smoke pipes or for gas vents as specified in s. ILHR 23.15 (2) (g).

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

ILHR 23.15 Chimney connectors, smoke pipes and stovepipes. (1) **DEFINITION.** Chimney connectors, smoke pipes or stovepipes are passages for conducting the products of combustion from a fuel-fired appliance to the chimney.

(2) **CONSTRUCTION AND INSTALLATION.** The construction and installation of chimney connectors shall conform with the following requirements:

(a) **Concealed space.** No chimney connector shall pass through any outside window, door or combustible outside wall, nor be concealed in any closet, attic or similar space.

(b) **Combustible partitions.** Connectors for appliances shall not pass through walls or partitions constructed of combustible material unless they are guarded at the point of passage by:

1. Metal ventilated thimbles not less than 12 inches larger in diameter than the connector;

2. Metal or burned fireclay thimbles built in brickwork or other approved fireproofing materials extending not less than 8 inches beyond all sides of the thimble.

(c) **Distance from materials.** No part of any chimney connector shall be placed nearer to any combustible partition or wall than the diameter of the pipe, nor nearer to any non-fire-resistive ceiling than 1-1/2 times the diameter. The above distances may be reduced by one-half if the wall or

ceiling is covered with not less than ¼-inch asbestos board covered with sheet metal or with equivalent protection.

Note: See Table 23.04-B for reduced clearances.

(d) *Multiple appliance venting.* Two or more listed appliances using the same type of fuel may be connected to a common gravity-type flue provided the appliances are equipped with listed primary safety controls and listed shutoff devices and comply with the following requirements.

1. The appliances shall be located in the same story, except for engineered venting systems.

2. The appliances shall be joined at a manifold or Y-type fitting as close to the chimney as possible, unless the connector from each appliance enters a separate chimney inlet and the inlets are offset in accordance with the requirements of s. ILHR 23.11 (2).

3. The chimney connector and chimney flue shall be sized to accommodate the total volume of flue gases. For gas-burning appliances, the venting area shall be at least equal to the size of the largest vent connectors plus at least 50% of the area of the other vent connectors.

(e) *Pitch and length.* Chimney or vent connectors shall have no more than two 45° offsets with the vertical. The horizontal length shall not exceed 75% of the total vertical height of the total venting system measured from the appliance outlet. Chimney or vent connectors shall be pitched at least ¼-inch per foot from the appliance outlet collar vent to the chimney inlet.

(f) *Dampers.* The use of manually operated dampers shall be prohibited in chimney or vent connectors of all appliances except wood-burning appliances. When used, listed automatically operated dampers interlocked with the heating appliance shall be installed in accordance with the approved listing.

(g) *Materials and thickness.* Chimney or vent connectors serving liquid and solid fuel appliances shall conform to the type of material and thickness indicated in tables 23.15-A or 23.15-B.

(h) *Clearance.* Single wall metal connectors shall be installed with clearance to combustibles as indicated in Table 23.15-C. These clearances may be reduced if the combustible material is protected in accordance with the requirements of Table 23.04-B.

TABLE 23.15-A
MINIMUM CHIMNEY CONNECTOR GAGES FOR OIL, WOOD AND COAL

Diameter of Connector	Galvanized Steel Gage Number	
	Min. thickness (inch)	Gage
Less than 6 inches	.019	26
6 inches to less than 10 inches	.024	24
10 inches to 13 inches	.030	22
14 inches to 16 inches	.036	20
Greater than 16 inches	.058	16

TABLE 23.15-B
MINIMUM VENT CONNECTOR GAGES FOR GAS

Diameter of Connector	Galvanized Steel Gage Number	
	Min. thickness (inch)	Gage
1 inch through 4 inches	.016	28
5 inches or over	.026	24

TABLE 23.15-C
CHIMNEY CONNECTOR AND VENT CONNECTOR CLEARANCES
FROM COMBUSTIBLE MATERIALS (See Note 4)

Description of Appliance	Minimum Clearance Inches (See Note 1)
Single-Wall Metal Pipe Connectors	
Gas Appliances Without Draft Hoods	18
Electric, Gas, and Oil Incinerators	18
Oil and Solid-Fuel Appliances	18
Unlisted Gas Appliances With Draft Hoods	9
Boilers and Furnaces Equipped With Listed Gas Burners and With Draft Hoods	9
Oil Appliances Listed as Suitable for Use With Type L Venting Systems, but only when connected to chimneys	9
Listed Gas Appliances With Draft Hoods. See Note 3.	6
Type L Vent Piping Connectors	
Gas Appliances Without Draft Hoods	9
Electric, Gas, and Oil Incinerators	9
Oil and Solid-Fuel Appliances	9
Unlisted Gas Appliances With Draft Hoods	6
Boilers and Furnaces Equipped With Listed Gas Burners and With Draft Hoods	6
Oil Appliances Listed as Suitable for Use with Type L Vents	(See Note 2)
Listed Gas Appliances With Draft Hoods	(See Note 3)
Type B Gas Vent Piping Connectors	
Listed Gas Appliances With Draft Hoods	(See Note 3)

¹These clearances apply except if the listing of an appliance specifies different clearance, in which case the listed clearance takes precedence.

²If listed type L venting system piping is used, the clearance may be in accordance with the venting system listing.

³If listed type B or type L venting system piping is used, the clearance may be in accordance with the venting system listing.

⁴The clearances from connectors to combustible materials may be reduced if the combustible material is protected in accordance with Table 23.04-B.

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

SUBCHAPTER VI—FUEL SUPPLY SYSTEMS

ILHR 23.16 Fuel storage. (1) **LIQUEFIED PETROLEUM GAS STORAGE TANKS.** All liquefied petroleum gas storage tanks shall be constructed to conform with the applicable sections of chs. ILHR 11 and 12, Liquefied Petroleum Gases and Liquefied Natural Gases.

(a) No tanks shall be located inside dwellings.

(b) Gas shutoff valves shall be provided at each tank, at the gas service entry into the dwelling, and at each heating unit.

(c) Tanks shall have welded steel supports and be permanently installed on concrete pads or foundations.

(2) OIL STORAGE TANKS. (a) Oil storage tanks on the inside of any dwelling shall be located at the same level as the furnace it serves.

(b) The total storage capacity inside any dwelling unit shall be limited to 550 gallons in one tank, or not more than 275 gallons in each of 2 storage tanks cross-connected to a single burner.

(c) Underground tanks shall be constructed of steel or other approved noncombustible material, provided the material is compatible with fuel oil.

(d) Storage of fuel oil above ground shall not be in excess of 550 gallons. Storage tanks installed outside and above ground shall be installed on a firm and level foundation.

(e) The fuel oil tank shall be equipped with a fill pipe, vent pipe, oil gauge, oil filter and shutoff valve. The vent pipe and fill pipe shall terminate outside of the dwelling and be located at least 2 feet from any opening. The fill pipe shall be at least 2 inches in diameter and the vent pipe shall be at least 1½ inches in diameter. The vent pipe and fill pipe shall be provided with a weatherproof cap.

Note: The department will accept installations which conform with NFPA standard No. 31, Oil-Burning Equipment.

(3) GAS PIPING. (a) *Materials.* Gas piping materials shall be black IPS wrought iron or steel or other approved piping or tubing and fittings designed for use with fuel gas. Gas valves and connections shall be approved types designed for use with fuel gas.

(b) *Piping support.* Gas piping shall be supported by metal straps or hooks spaced not more than 10 feet apart.

(4) SHUTOFF AND CONTROL DEVICES. (a) An accessible approved shutoff valve shall be installed ahead of the union or other connection in the fuel piping. Service valves on gas-fired equipment shall be located between 4 and 6 feet above the floor.

(b) Automatic gas-burning heating appliances shall be equipped with listed devices which will shut off the gas to the pilot light and main burner(s) in the event of pilot failure.

(c) Liquid fuel-burning appliances shall be equipped with primary safety controls which will shut off the flow of fuel to the burner(s) in the event of ignition failure.

Note: The department will accept installations conforming to NFPA standard No. 54, National Fuel Gas Code.

History: Cr. Register, November, 1979, No. 287, eff. 6-1-80; correction in (1) (intro.), made under s. 13.93 (2m) (b) 7, Stats. Register, February, 1985, No. 350, 3-1-85.

SUBCHAPTER VII—EQUIPMENT LOCATION AND OPERATION

ILHR 23.17 Equipment location. (1) **OUTDOOR EQUIPMENT.** Outdoor equipment shall be located so as to not restrict the air flow or recirculation of air. Outdoor equipment so located as to be subject to damage shall be protected.

Register, February, 1985, No. 350
Heating, Ventilating and Air Conditioning Standards

(2) **INDOOR EQUIPMENT.** All indoor equipment shall be installed with a minimum of 24 inches of clearance for service.

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

ILHR 23.18 Operation. (1) **INSTRUCTIONS.** Written instructions shall be provided the owner for the operation and maintenance of the system and equipment.

(2) **FINAL TEST REQUIRED.** The installer shall test and balance every heating, ventilating and air conditioning system.

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

Chapter ILHR 24

ELECTRICAL STANDARDS

ILHR 24.01 Electrical standards (p. 109)

Note: Chapter Ind 24 was renumbered to be chapter ILHR 24, Register, February, 1985, No. 350, effective 3-1-85.

ILHR 24.01 Electrical standards. All electrical wiring, installations, equipment and materials used in the construction of dwellings shall comply with the requirements of the Wisconsin Administrative Electrical Code, Vol. 2.

Note: Section 167.16, Stats., requires that the company furnishing the electric current obtain proof that the wiring complies with these standards before furnishing the current. Proof must be a certificate furnished by the inspection department or officer, or if there is no officer, an affidavit furnished by the person doing the wiring.

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

Chapter ILHR 25

PLUMBING AND POTABLE WATER STANDARDS

Subchapter I—Scope	ILHR 25.03 Well water supply (p. 111)
ILHR 25.01 Scope (p. 111)	Subchapter III—Plumbing Systems
Subchapter II—Potable Water	ILHR 25.04 Plumbing Systems (p. 111)
ILHR 25.02 Public water supply (p. 111)	

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.

APPENDIX

CHAPTER ILHR 20

State of Wisconsin Department of Industry, Labor & Human Relations Division of Safety & Buildings Box 7969 Madison, WI 53707 Wisconsin Statutes 101.53, 101.73	WISCONSIN UNIFORM BUILDING PERMIT APPLICATION (See instruction on back)	APPLICATION NO. _____ PARCEL NO. _____																											
PERMIT REQUESTED Owner's Name _____ Mailing Address _____ Telephone _____ Contractor's Name _____ Mailing Address _____ Telephone _____																													
PROJECT LOCATION Building Address _____ Subdivision Name _____ Lot No. _____ Block No. _____ Zoning District _____ Lot Area _____ Sq. ft. Setbacks _____ Front _____ ft. Rear _____ ft. Left _____ ft. Right _____ ft.																													
1. PROJECT ☐ New ☐ Addition ☐ Alteration ☐ Repair ☐ Garage ☐ Raze ☐ Attached ☐ Move ☐ Detached ☐ Foundation ☐ Master plan no. (If applicable)	3. TYPE ☐ Single Family ☐ Two Family ☐ Other	6. ELEC. RICAL Entrance Panel _____ amp Service: ☐ Underground ☐ Overhead ☐ Central Air Conditioning ☐ Other																											
2. AREA Basements _____ Sq. ft. Living Area _____ Sq. ft. Garage _____ Sq. ft.	4. CONST. TYPE ☐ Site constructed ☐ Concrete ☐ Manufactured ☐ Masonry ☐ Treated Wood ☐ Other	9. HVAC EQUIPMENT ☐ Forced Air Furnace ☐ Radiant Baseboard or Panel ☐ Heat Pump ☐ Boiler ☐ Other																											
5. STORIES ☐ 1-Story ☐ Seasonal ☐ 2-Story ☐ Permanent ☐ Other		10. PLUMBING ☐ Sewer ☐ Municipal ☐ Septic ☐ Permit No. _____																											
8. USE ☐ Seasonal ☐ 11. WATER ☐ Permanent ☐ Private-on-site Well ☐ Other ☐ Municipal Utility		12. ENERGY SOURCE <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Fuel</th> <th>Space Htg.</th> <th>Water Htg.</th> </tr> </thead> <tbody> <tr><td>LP Gas</td><td>☐</td><td>☐</td></tr> <tr><td>Nat. Gas</td><td>☐</td><td>☐</td></tr> <tr><td>Fuel Oil</td><td>☐</td><td>☐</td></tr> <tr><td>Electric</td><td>☐</td><td>☐</td></tr> <tr><td>Wood</td><td>☐</td><td>☐</td></tr> <tr><td>Solar</td><td>☐</td><td>☐</td></tr> <tr><td>Coal</td><td>☐</td><td>☐</td></tr> <tr><td>Other</td><td>☐</td><td>☐</td></tr> </tbody> </table>	Fuel	Space Htg.	Water Htg.	LP Gas	☐	☐	Nat. Gas	☐	☐	Fuel Oil	☐	☐	Electric	☐	☐	Wood	☐	☐	Solar	☐	☐	Coal	☐	☐	Other	☐	☐
Fuel	Space Htg.	Water Htg.																											
LP Gas	☐	☐																											
Nat. Gas	☐	☐																											
Fuel Oil	☐	☐																											
Electric	☐	☐																											
Wood	☐	☐																											
Solar	☐	☐																											
Coal	☐	☐																											
Other	☐	☐																											
The applicant agrees to comply with the Wisconsin Uniform Dwelling Code and other Municipal Ordinances and with the conditions of this permit; understands that the issuance of the permit creates no legal liability, express or implied, on the Department or Municipality; and certifies that all the above information is accurate.																													
SIGNATURE OF APPLICANT _____		DATE _____																											
CONDITIONS OF APPROVAL																													
This permit is issued pursuant to the following conditions. Failure to comply may result in suspension or revocation of this permit or other penalty.																													
ISSUING JURISDICTION _____ _____ _____ _____ _____																													
NAME _____ MUNIC. NO. _____																													
FEES: Plan Reviewer \$ _____ Inspection \$ _____ Wis. Permit Seal(s) \$ _____ Other \$ _____ TOTAL \$ _____	PERMIT(S) ISSUED ☐ Construction ☐ HVAC ☐ Electrical ☐ Plumbing ☐ Other	WIS. UNIFORM PERMIT SEAL NO. _____ PERMIT ISSUED BY: NAME _____ DATE _____ CERT. NO. _____																											
DILHR-SHD 5923 (R-1/82) WHITE — Issuing Jurisdiction YELLOW — DILHR GREEN — Inspector PINK — Owner/Agent																													

WIS STATISTICS 101 63

WISCONSIN UNIFORM

BUILDING PERMIT

☐ const; ☐ hvac; ☐ elec; ☐ plumb;

Site Info

SUBDIVISION _____
 LOT NO. _____ BLOCK NO. _____
 ZONING DISTRICT _____
 SETBACKS: _____
 _____'s, _____'s, _____'s T_N_R_E or W
 FRONT YARD _____ feet
 REAR YARD _____ feet
 LEFT YARD _____ feet

PHASE	RHG	FNL
FOUNDATION		
CONSTRUCTION		
INSULATION		
PLUMBING		
HEAT/VENT/AC		
ELECTRICAL		
OCCUPANCY		

Issued to	OWNER	
	AGENT/ID	
	BUSINESS SITE	
	CITY/VILLAGE	
	TOWN, COUNTY	

Issued by	MUNICIPALITY OR AUTHORIZED AGENCY	CERT. NO.
	PERSON ISSUING	
	DATE	TELEPHONE
	ISSUED	NUMBER
	stix uniform permit seal (if applicable)	

Keep this card posted until final inspection has been made. Inspections shall be arranged 48 hrs. in advance. Work shall not proceed until the inspector has approved the various stages of construction or the 48 hr. period since notification has elapsed. This permit will expire 24 months after the date of issuance if construction has not commenced.

NOTICE OF NONCOMPLIANCE

This Issuing jurisdiction shall notify the applicant in writing of any violations to be corrected. All cited violations shall be corrected within 30 days after notification, unless extension of time is granted.

APPENDIX

CHAPTER ILHR 21

FASTENER SCHEDULE TABLE

Description of Building Materials/Connection	Number and Type of Fastener ^{1 2 3 4}
Joist to sill or girder, toe nail	2-16d, 3-8d
Bridging to joist, toe nail each end	2-8d
1" x 6" subfloor or less to each joist, face nail	2-8d or 2 staples, 1 1/4"
Wider than 1" x 6" subfloor to each joist, face nail	3-8d or 4 staples, 1 1/4"
2" subfloor to joist or girder, blind and face nail	2-16d
Sole plate to joist or blocking, face nail	16d at 16" o.c.
Top or sole plate to stud, end nail	2-16d
Stud to sole plate, toe nail	4-8d or 3-16d
Doubled studs, face nail	16d at 24" o.c.
Doubled top plates, face nail	16d at 16" o.c.
Top plates, laps and intersections, face nail	2-16d
Continuous header, two pieces	16d at 16" o.c. along each edge
Ceiling joists to plate, toe nail	2-16d, 3-8d
Continuous header to stud, toe nail	4-8d
Ceiling joist, laps over partitions, face nail	3-16d
Ceiling joist to parallel rafters, face nail	3-16d
Rafter to plate, toe nail	2-16d, 3-8d
1" brace to each stud and plate, face nail	2-8d or 2 staples, 1 1/4"
1" x 6" sheathing to each bearing, face nail	2-8d or 2 staples, 1 1/4"
1" x 8" sheathing to each bearing, face nail	2-8d or 3 staples, 1 1/4"
Wider than 1" x 8" sheathing to each bearing, face nail	3-8d or 4 staples, 1 1/4"
Built-up corner studs	16d at 30" o.c., 16d at 24" o.c.
Built-up girder and beams	20d at 32" o.c. at top and bottom and staggered 2-20d at ends and at each splice
2-inch planks	2-16d at each bearing
Roof rafters to ridge, valley or hip rafters, toe nail	4-16d
Roof rafters to ridge, valley or hip rafters, face nail	3-16d
Collar ties to rafters, face nail	3-8d
Plywood subfloor, roof and wall sheathing (to framing) ⁶	
1/2-inch to 5/16-inch	6d ⁵ or staple
3/8-inch to 1/2-inch	8d smooth or common, 6d deformed, or staple
1/2-inch to 1-inch	8d ⁵
1 1/4-inch to 1 1/2-inch	10d smooth or common, or 8d deformed
Fiberboard sheathing ⁷	
1/2-inch	6d common or staple, 1 1/2" long or roofing nail ¹¹
25/32-inch	8d common or staple, 1 1/2" long or roofing nail ¹¹
Gypsum sheathing, 1/2" ⁸	1 1/2" galvanized roofing nail, or 6d common, or staple
Particleboard wall sheathing (to framing) ⁶	
1/2-inch to 5/8-inch	6d common
5/8-inch to 3/4-inch	8d common or staple
Insulated sheathing	11-gauge roofing nails, 6d, 8d, or staple
Combination subfloor underlayment (to framing) ⁶	
1/2-inch and less	6d deformed
5/8-inch to 1-inch	8d deformed
1 1/4-inch to 1 1/2-inch	10d smooth ⁹ or common or 8d deformed ⁹
Panel siding (to framing) ¹⁰	
1/2-inch or less	6d
3/4-inch	8d

¹All nails are smooth-common, box or deformed shank except where otherwise stated.

²Nail is a general description and may be T-head, modified round head or round head.

³Staples are 16-gauge wire and have a minimum 7/16-inch o.d. crown width.

⁴Common or box nails may be used except where otherwise stated.

⁵Common or deformed shank.

⁶Nails spaced at 6 inches on center at edges, 12 inches at intermediate supports (10 inches at intermediate supports for floors), except 6 inches at all supports where spans are 48 inches or more.

⁷Nails spaced at 3 inches on center at edges, 6 inches at intermediate supports.

⁸Nails spaced at 4 inches on center at edges, 8 inches at intermediate supports.

⁹Nails spaced at 6 inches on center at edges and at intermediate supports.

¹⁰Corrosion-resistant siding and casing nails.

¹¹Galvanized roofing nails with 7/16-inch diameter head and 1 1/2-inch length for 1/2-inch sheathing and 1 3/4-inch for 25/32-inch sheathing.

SPAN TABLES FOR JOISTS AND RAFTERS (Recommended by National Forest Products Association)

EXPLANATION OF TABLES

These span tables for joists and rafters are calculated on the basis of a series of modulus of elasticity (E) and fiber bending stress (F_b) values. The range of values in the tables provides allowable spans for all species and grades of nominal 2-inch framing lumber customarily used in construction.

Tables J-1 through J-6 list spans for floor and ceiling joists used over a single span with calculations based on E and the required F_b values shown.

Tables R-2 through R-15 list spans for rafters used over a single span with calculations based on F_b and the required E values shown.

Tables TSJ-1 and TSJ-2 list spans for floor joists continuous over two equal spans with calculations based on E and the required F_b values shown.

Applicable design criteria for each condition of use appear at the top of each table. While these criteria are directed principally to residential construction, they are suitable for other occupancies having similar conditions of loading. Tabulated spans for rafters also apply to other types of occupancy, since the occupancy has little bearing on roof loading.

LUMBER SIZES

Tabulated spans apply to surfaced (S4S) lumber having dimensions which conform to the American Softwood Lumber Standard, PS 20-70. These sizes are as follows:

Reference	Dressed Size (inches)	
	Surfaced Dry	Surfaced Green
2 x 4	1 1/2 x 3 1/2	1-9/16 x 3-9/16
2 x 6	1 1/2 x 5 1/2	1-9/16 x 5 5/8
2 x 8	1 1/2 x 7 1/4	1-9/16 x 7 1/2

2 x 10	1½ x 9¾	1-9/16 x 9¾
2 x 12	1½ x 11¼	1-9/16 x 11¼

MOISTURE CONTENT

The listed dry and green sizes are related at 19% maximum moisture content. Tabulated spans are calculated on the basis of the dry sizes and are also applicable to the corresponding green sizes. The spans in these tables are intended for use in covered structures or where moisture content in use does not exceed 19%.

SPAN MEASUREMENT

Tabulated spans are the clear distance between supports. For sloping rafters, the span is measured along the horizontal projection.

LUMBER DESIGN VALUES

Use of these span tables requires reference to the applicable design values for the various species and grades of lumber. "Design Values for Joists and Rafters", a supplement to these span tables, provide such values in convenient-to-use form. Modulus of elasticity (E) and fiber bending stress (F_b) values therein are based on the National Design Specification for Wood Construction (formerly National Design Specification for Stress Grade Lumber and Its Fastenings) and incorporate adjustments appropriate for repetitive-member use under various durations of load.

Repetitive-member use is that condition where framing members such as joists, rafters, studs, planks, decking or similar members are spaced not more than 24 inches, are not less than 3 in number and are joined by floor, roof or other load-distributing elements adequate to support the design load. Design values in bending (F_b) for such use are 15% greater than for single-member use.

The "Joists" column in the design value tables provide values for bending for repetitive-member use under normal conditions. The "Rafters" column if the design value tables provide values for bending for repetitive-member use adjusted for snow-loading.

ROOF LOADS

Rafter spans are tabulated for the most common roof loads. For roof loads intermediate between those tabulated, straight line interpolation may be used.

LUMBER IDENTIFICATION

When used with the tabulated spans in these tables, lumber should be identified by the grademark of an agency recognized as being competent by the Board of Review of the American Lumber Standards Committee or the Canadian Lumber Standards Administrative Board.

USE OF THE SPAN TABLES

Spans for floor and ceiling joists are calculated on the basis of the modulus of elasticity (E) with the required fiber bending stress (F_b) listed below each span. Spans for rafters are calculated on the basis of fiber bending stress (F_b) with the required modulus of elasticity (E) listed below each span. Use of the tables is illustrated in the examples which follow.

Example 1. Floor joists. Assume a required span of 12'-9", a live load of 40 psf and joists spaced 16 inches on centers. Table J-1 shows that a grade of 2 x 8 having an E value of 1,600,000 psi and an F_b value of 1250 psi would have a span of 12'-10", which satisfies the condition.

Example 2. Rafters. Assume a horizontal projection span of 13'-0", a live load of 30 psf, dead load of 15 psf and rafters spaced 16 inches on centers. Table R-2 shows that a 2x8 having an F_b value of 1300 psi and an E value of 1,000,000 psi would have a span of 13'-3" of horizontal projection.

Since many combinations of size, spacing, E and F_b values are possible, it is recommended that the users examine the tables to determine which combination fits their particular case most effectively.

TABLE J-1
FLOOR JOISTS

40 Lbs. Per Sq. Ft. Live Load
(All rooms except those used for sleeping areas and attic floors.)

DESIGN CRITERIA:
Deflection - For 40 lbs. per sq. ft. live load.
Limited to span in inches divided by 360.
Strength - Live Load of 40 lbs. per sq. ft. plus
dead load of 10 lbs. per sq. ft. determines the
required floor stress value.

JOIST SIZE SPACING (IN)		Modulus of Elasticity, "E", in 1,000,000 psi																			
		0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4	
12.0	6.9	7.3	7.9	8.2	8.6	8.10	9.2	9.6	9.9	10.0	10.3	10.6	10.9	10.11	11.2	11.4	11.7	11.11	12.3		
	4.50	5.20	5.80	6.60	7.20	7.80	8.50	8.80	9.40	9.90	10.40	10.90	11.40	11.90	12.50	12.80	13.20	14.10	14.90		
	6.6	7.0	7.5	7.9	8.2	8.6	8.9	9.1	9.4	9.7	9.10	10.0	10.3	10.6	10.8	10.10	11.1	11.5	11.9		
	13.7	4.70	5.50	6.20	6.80	7.50	8.10	8.70	9.30	9.80	10.40	10.90	11.40	11.90	12.50	12.90	13.40	13.80	14.70	15.60	
2x6	6.2	6.7	7.0	7.5	7.9	8.4	8.8	8.7	8.10	9.1	9.4	9.6	9.9	9.11	10.2	10.4	10.6	10.10	11.2		
	5.00	5.80	6.50	7.20	7.90	8.60	9.20	9.80	10.40	10.90	11.50	12.00	12.50	13.10	13.60	14.10	14.60	15.50	16.40		
	5.9	6.3	6.7	7.0	7.3	7.7	7.10	8.1	8.4	8.7	8.9	9.0	9.2	9.4	9.6	9.8	9.10	10.2	10.6		
	19.2	5.30	6.10	6.90	7.70	8.40	9.10	9.70	10.40	11.00	11.60	12.20	12.80	13.30	13.90	14.40	15.00	15.50	16.50	17.50	
24.0	5.4	5.9	6.2	6.6	6.9	7.0	7.3	7.6	7.9	7.11	8.2	8.4	8.6	8.8	8.10	9.0	9.2	9.6	9.9		
	5.70	6.60	7.50	8.30	9.00	9.80	10.50	11.20	11.90	12.50	13.10	13.80	14.40	15.00	15.50	16.10	16.70	17.80	18.60		
					6.2	6.5	6.7	6.10	7.0	7.3	7.5	7.7	7.9	7.11	8.0	8.2	8.4	8.7	8.10		
	32.0				10.10	10.80	11.50	12.30	13.00	13.90	14.50	15.20	15.90	16.60	16.90	17.60	18.40	19.50	20.60		
12.0	8.11	9.7	10.2	10.9	11.3	11.8	12.1	12.6	12.10	13.2	13.6	13.10	14.2	14.5	14.8	15.0	15.3	15.9	16.2		
	5.80	5.20	5.90	6.60	7.20	7.80	8.30	8.90	9.40	9.90	10.40	10.90	11.40	11.90	12.30	12.80	13.20	14.10	14.80		
	8.6	9.2	9.9	10.3	10.9	11.2	11.7	11.11	12.3	12.7	12.11	13.3	13.6	13.10	14.1	14.4	14.7	15.0	15.6		
	13.7	4.70	5.50	6.20	6.80	7.50	8.10	8.70	9.30	9.80	10.40	10.90	11.40	11.90	12.40	12.90	13.40	13.80	14.70	15.60	
2x8	8.1	8.9	9.3	9.9	10.2	10.7	11.0	11.4	11.8	12.0	12.3	12.7	12.10	13.1	13.4	13.7	13.10	14.3	14.8		
	5.00	5.80	6.50	7.20	7.90	8.50	9.20	9.80	10.40	10.90	11.50	12.00	12.50	13.10	13.60	14.10	14.60	15.50	16.40		
	7.7	8.2	8.9	9.2	9.7	10.0	10.4	10.8	11.0	11.3	11.7	11.10	12.1	12.4	12.7	12.10	13.0	13.5	13.10		
	19.2	5.30	6.10	6.90	7.70	8.40	9.10	9.70	10.40	11.00	11.60	12.20	12.80	13.30	13.90	14.40	15.00	15.50	16.50	17.50	
24.0	7.1	7.7	8.1	8.6	8.11	9.3	9.7	9.11	10.2	10.6	10.9	11.0	11.3	11.5	11.8	11.11	12.1	12.6	12.10		
	5.70	6.60	7.50	8.30	9.00	9.80	10.50	11.20	11.90	12.50	13.10	13.80	14.40	15.00	15.50	16.10	16.70	17.80	18.60		
					8.1	8.5	8.9	9.0	9.3	9.6	9.9	10.0	10.2	10.5	10.7	10.10	11.0	11.4	11.8		
	32.0				9.90	10.80	11.70	12.30	13.00	13.70	14.50	15.20	15.70	16.50	17.00	17.60	18.40	19.50	20.70		

JOIST SIZE SPACING (IN)		0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4
12.0	12.0	11-4	12-3	13-0	13-8	14-4	14-11	15-5	15-11	16-5	16-10	17-3	17-8	18-0	18-5	18-9	19-1	19-5	20-1	20-8
	13.7	10-10	11-8	12-5	13-1	13-8	14-3	14-9	15-3	15-8	16-1	16-6	16-11	17-3	17-7	17-11	18-3	18-7	19-2	19-9
	16.0	9-9	10-6	11-1	11-8	12-3	12-9	13-2	13-7	14-0	14-5	14-9	15-1	15-5	15-9	16-0	16-4	16-7	17-2	17-8
	19.2	9-0	9-9	10-4	10-10	11-4	11-10	12-3	12-8	13-0	13-4	13-8	14-0	14-4	14-7	14-11	15-2	15-5	15-11	16-5
2x10	12.0	11-4	12-3	13-0	13-8	14-4	14-11	15-5	15-11	16-5	16-10	17-3	17-8	18-0	18-5	18-9	19-1	19-5	20-1	20-8
	13.7	10-10	11-8	12-5	13-1	13-8	14-3	14-9	15-3	15-8	16-1	16-6	16-11	17-3	17-7	17-11	18-3	18-7	19-2	19-9
	16.0	9-9	10-6	11-1	11-8	12-3	12-9	13-2	13-7	14-0	14-5	14-9	15-1	15-5	15-9	16-0	16-4	16-7	17-2	17-8
	19.2	9-0	9-9	10-4	10-10	11-4	11-10	12-3	12-8	13-0	13-4	13-8	14-0	14-4	14-7	14-11	15-2	15-5	15-11	16-5
2x12	12.0	11-4	12-3	13-0	13-8	14-4	14-11	15-5	15-11	16-5	16-10	17-3	17-8	18-0	18-5	18-9	19-1	19-5	20-1	20-8
	13.7	10-10	11-8	12-5	13-1	13-8	14-3	14-9	15-3	15-8	16-1	16-6	16-11	17-3	17-7	17-11	18-3	18-7	19-2	19-9
	16.0	9-9	10-6	11-1	11-8	12-3	12-9	13-2	13-7	14-0	14-5	14-9	15-1	15-5	15-9	16-0	16-4	16-7	17-2	17-8
	19.2	9-0	9-9	10-4	10-10	11-4	11-10	12-3	12-8	13-0	13-4	13-8	14-0	14-4	14-7	14-11	15-2	15-5	15-11	16-5
32.0		8-1	8-5	8-9	9-0	9-3	9-7	10-0	10-4	10-8	11-2	11-6	12-0	12-4	12-8	13-2	13-6	14-0	14-4	14-8

Note: The required extreme fiber stress in bending, "F_b", in pounds per square inch is shown below each span.

DESIGN CRITERIA:
Deflection for 30 lbs. per sq. ft. live load.
Uniformly distributed load divided by 960.
Strength - Live Load of 30 lbs. per sq. ft. plus
dead load of 10 lbs. per sq. ft. determines
the required fiber stress value.

TABLE J-2
FLOOR JOISTS
30 lbs. Per Sq. Ft. Live Load
(All rooms used for sleeping areas and attic floors.)

JOIST SIZE SPACING (IN)		Modulus of Elasticity, "E", in 1,000,000 psi																		
		0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4
2x6	12.0	7-5	8-0	8-6	8-11	9-4	9-9	10-1	10-5	10-9	11-0	11-3	11-7	11-10	12-0	12-3	12-6	12-9	13-1	13-6
	13.7	7-1	7-8	8-2	8-7	8-11	9-4	9-8	10-0	10-3	10-6	10-10	11-1	11-3	11-6	11-9	12-2	12-7	12-11	14-50
	16.0	6-9	7-3	7-9	8-2	8-6	8-10	9-2	9-6	9-9	10-0	10-3	10-6	10-9	11-0	11-2	11-4	11-7	11-11	12-3
	19.2	6-4	6-10	7-3	7-8	8-0	8-4	8-8	8-11	9-2	9-5	9-8	10-1	10-4	10-6	10-8	10-10	10-11	11-3	11-7
2x8	12.0	5-11	6-4	6-9	7-1	7-5	7-9	8-0	8-3	8-6	8-9	8-11	9-2	9-4	9-7	9-9	9-11	10-1	10-5	10-9
	13.7	4-11	5-4	5-10	6-1	6-5	6-9	7-2	7-6	7-9	8-0	8-2	8-4	8-6	8-8	8-10	8-11	9-2	9-6	9-9
	16.0	4-11	5-4	5-10	6-1	6-5	6-9	7-2	7-6	7-9	8-0	8-2	8-4	8-6	8-8	8-10	8-11	9-2	9-6	9-9
	19.2	4-11	5-4	5-10	6-1	6-5	6-9	7-2	7-6	7-9	8-0	8-2	8-4	8-6	8-8	8-10	8-11	9-2	9-6	9-9
2x10	12.0	9-10	10-7	11-3	11-10	12-4	12-10	13-4	13-9	14-2	14-6	14-11	15-3	15-7	15-10	16-2	16-6	16-9	17-4	17-10
	13.7	9-4	10-1	10-9	11-4	11-10	12-3	12-9	13-2	13-6	13-11	14-3	14-7	14-11	15-2	15-6	15-9	16-0	16-7	17-0
	16.0	8-11	9-7	10-2	10-9	11-3	11-8	12-1	12-6	12-10	13-2	13-6	13-10	14-2	14-5	14-8	15-0	15-3	15-9	16-2
	19.2	8-5	9-0	9-7	10-1	10-7	11-0	11-4	11-9	12-1	12-5	12-9	13-0	13-4	13-7	13-10	14-1	14-4	14-9	15-3
32.0	12.0	7-9	8-5	9-11	9-4	9-10	10-2	10-7	10-11	11-3	11-6	11-10	12-1	12-4	12-7	12-10	13-1	13-4	13-9	14-2
	13.7	7-9	8-5	9-11	9-4	9-10	10-2	10-7	10-11	11-3	11-6	11-10	12-1	12-4	12-7	12-10	13-1	13-4	13-9	14-2
	16.0	6-11	6-8	7-10	7-4	8-0	8-6	9-0	9-4	9-8	10-2	10-6	10-9	11-0	11-3	11-5	11-8	11-11	12-1	12-5
	19.2	6-11	6-8	7-10	7-4	8-0	8-6	9-0	9-4	9-8	10-2	10-6	10-9	11-0	11-3	11-5	11-8	11-11	12-1	12-5

		12.6	13.6	14.4	15.1	15.9	16.5	17.0	17.6	18.0	18.6	19.0	19.5	19.10	20.3	20.8	21.0	21.5	22.1	22.9
2x10	12.0	440	510	570	640	700	750	810	860	910	960	1010	1060	1110	1150	1200	1240	1280	1370	1450
	13.7	480	530	600	670	730	790	840	900	950	1010	1060	1110	1160	1200	1250	1300	1340	1430	1510
	16.0	480	560	630	700	770	830	890	950	1000	1060	1110	1160	1220	1270	1320	1360	1410	1500	1590
	19.2	510	600	670	740	810	880	940	1010	1070	1130	1180	1240	1290	1350	1400	1450	1500	1600	1690
2x12	24.0	511	608	720	800	880	950	1020	1080	1150	1210	1270	1330	1390	1450	1510	1560	1620	1720	1820
	32.0					11.4	11.10	12.3	12.8	13.0	13.4	13.8	14.0	14.4	14.7	14.11	15.2	15.5	15.11	16.5
	12.0	440	510	570	640	700	750	810	860	910	960	1010	1060	1100	1150	1200	1240	1280	1370	1450
	13.7	460	530	600	670	730	790	840	900	950	1010	1060	1110	1160	1200	1250	1300	1340	1430	1510
2x12	16.0	480	560	630	700	770	830	890	950	1000	1060	1110	1160	1210	1270	1320	1360	1410	1500	1590
	19.2	510	600	670	740	810	880	940	1010	1070	1130	1180	1240	1290	1350	1400	1450	1500	1600	1690
	24.0	550	640	720	800	880	950	1020	1080	1150	1210	1270	1330	1390	1450	1510	1560	1620	1720	1820
	32.0					13.10	14.4	14.11	15.4	15.10	16.3	16.8	17.0	17.5	17.9	18.1	18.5	18.9	19.4	19.11

Note: The required extreme fiber stress in bending, "F_b", in pounds per square inch is shown below each span.

TABLE J-3
CEILING JOISTS

20 Lbs. Per Sq. Ft. Live Load
(Limited attic storage where development of future rooms is not possible)
(Plaster Ceiling)

DESIGN CRITERIA:
Deflection - For 20 lbs. per sq. ft. live load.
Limited to span in inches divided by 360.
Strength - Live load of 20 lbs. per sq. ft. plus
dead load of 10 lbs. per sq. ft. determines
required fiber stress value.

JOIST SIZE SPACING (IN)		Modulus of Elasticity, "E", in 1,000,000 psi																		
		0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4
2x4	12.0	5-5 430	5-10 500	6-2 560	6-6 630	6-10 680	7-1 740	7-4 790	7-7 850	7-10 900	8-0 950	8-3 990	8-5 1040	8-7 1090	8-9 1130	8-11 1170	9-1 1220	9-3 1260	9-7 1340	9-10 1420
	13.7	5-2 450	5-7 520	5-11 590	6-3 650	6-6 720	6-9 770	7-0 830	7-3 880	7-6 940	7-8 990	7-10 1040	8-1 1090	8-3 1140	8-5 1180	8-7 1230	8-8 1270	8-10 1320	9-2 1400	9-5 1490
	16.0	4-11 470	5-4 550	5-8 620	5-11 690	6-2 750	6-5 810	6-8 870	6-11 930	7-1 990	7-3 1040	7-6 1090	7-8 1140	7-10 1200	8-0 1240	8-1 1290	8-3 1340	8-5 1390	8-8 1480	8-11 1570
	19.2	4-8 500	5-0 580	5-4 660	5-7 730	5-10 800	6-1 870	6-3 930	6-6 990	6-8 1050	6-10 1110	7-0 1160	7-2 1220	7-4 1270	7-6 1320	7-8 1370	7-9 1420	7-11 1470	8-2 1570	8-5 1660
	24.0	4-4 540	4-8 630	4-11 710	5-2 790	5-5 860	5-8 930	5-10 1000	6-0 1070	6-2 1130	6-4 1190	6-6 1250	6-8 1310	6-10 1370	7-0 1420	7-1 1480	7-3 1530	7-4 1590	7-7 1690	7-10 1790
2x6	12.0	8-6 430	9-2 500	9-9 560	10-3 630	10-9 680	11-2 740	11-7 790	11-11 850	12-3 900	12-7 950	12-11 990	13-3 1040	13-6 1090	13-9 1130	14-1 1170	14-4 1220	14-7 1260	15-0 1340	15-6 1420
	13.7	8-2 450	8-9 520	9-4 590	9-10 650	10-3 720	10-8 770	11-1 830	11-5 880	11-9 940	12-1 990	12-4 1040	12-8 1090	12-11 1140	13-2 1180	13-5 1230	13-8 1270	13-11 1320	14-4 1400	14-9 1490
	16.0	7-9 470	8-4 550	8-10 620	9-4 690	9-9 750	10-2 810	10-6 870	10-10 930	11-2 990	11-5 1040	11-9 1090	12-0 1140	12-3 1200	12-6 1240	12-9 1290	13-0 1340	13-3 1390	13-8 1480	14-1 1570
	19.2	7-3 500	7-10 580	8-4 660	8-9 730	9-2 800	9-6 870	9-10 930	10-2 990	10-6 1050	10-9 1110	11-1 1160	11-4 1220	11-7 1270	11-9 1320	12-0 1370	12-3 1420	12-5 1470	12-10 1570	13-3 1660
	24.0	6-9 540	7-3 630	7-9 710	8-2 790	8-6 860	8-10 930	9-2 1000	9-6 1070	9-9 1130	10-0 1190	10-3 1250	10-6 1310	10-9 1370	10-11 1420	11-2 1480	11-4 1530	11-7 1590	11-11 1690	12-3 1790

2x8	12.0	11-3 430	12-1 500	12-10 560	13-6 630	14-2 680	14-8 740	15-3 790	15-9 850	16-2 900	16-7 950	17-0 990	17-5 1040	17-10 1090	18-2 1130	18-6 1170	18-10 1220	19-2 1260	19-10 1340	20-5 1420
	13.7	10-9 450	11-7 520	12-3 590	12-11 650	13-6 720	14-1 770	14-7 830	15-0 880	15-6 940	15-11 990	16-3 1040	16-8 1090	17-0 1140	17-5 1180	17-9 1230	18-0 1270	18-4 1320	18-11 1400	19-6 1490
	16.0	10-2 470	11-0 550	11-8 620	12-3 690	12-10 750	13-4 810	13-10 870	14-3 930	14-8 990	15-1 1040	15-6 1090	16-1 1140	16-2 1200	16-6 1240	16-10 1290	17-2 1340	17-5 1390	18-0 1480	18-6 1570
	19.2	9-7 500	10-4 580	11-0 660	11-7 730	12-1 800	12-7 870	13-0 930	13-5 990	13-10 1050	14-2 1110	14-7 1160	14-11 1220	15-3 1270	15-6 1320	16-1 1370	16-1 1420	16-5 1470	16-11 1570	17-5 1660
	24.0	8-11 540	9-7 630	10-2 710	10-9 790	11-3 860	11-8 930	12-1 1000	12-6 1070	13-2 1130	13-6 1190	13-10 1250	14-1 1310	14-2 1370	14-5 1420	14-8 1480	15-0 1530	15-3 1590	15-9 1690	16-2 1790
2x10	12.0	14-4 430	15-5 500	16-5 560	17-3 630	18-0 680	18-9 740	19-5 790	20-1 850	20-8 900	21-2 950	21-9 990	22-3 1040	22-9 1090	23-2 1130	23-8 1170	24-1 1220	24-6 1260	25-3 1340	26-0 1420
	13.7	13-8 450	14-9 520	15-8 590	16-6 650	17-3 720	17-11 770	18-7 830	19-2 880	19-9 940	20-3 990	20-9 1040	21-3 1090	21-9 1140	22-2 1180	22-7 1230	23-0 1270	23-5 1320	24-2 1400	24-10 1490
	16.0	13-0 470	14-0 550	14-11 620	15-8 690	16-5 750	17-0 810	17-8 870	18-3 930	18-9 990	19-3 1040	19-9 1090	20-2 1140	20-8 1200	21-1 1240	21-6 1290	21-10 1340	22-3 1390	22-11 1480	23-8 1570
	19.2	12-3 500	13-2 580	14-0 660	14-9 730	15-5 800	16-0 870	16-7 930	17-2 990	17-8 1050	18-1 1110	18-7 1160	19-0 1220	19-5 1270	19-10 1320	20-2 1370	20-7 1420	21-1 1470	21-7 1570	22-3 1660
	24.0	11-4 540	12-3 630	13-0 710	13-8 790	14-4 860	14-11 930	15-5 1000	15-11 1070	16-5 1130	16-10 1190	17-3 1250	17-8 1310	18-0 1370	18-5 1420	18-9 1480	19-1 1530	19-5 1590	20-1 1690	20-8 1790

Note: The required extreme fiber stress in bending, "F_b", in pounds per square inch is shown below each span.

TABLE J-4
CEILING JOISTS
20 Lbs. Per Sq. Ft. Live Load
(Limited attic storage where development of future rooms is not possible)
(Drywall Ceiling)

DESIGN CRITERIA:
Deflection: For 20 lbs. per sq. ft. live load.
Limited to span in inches divided by 240.
Strength: In addition to 20 lbs. per sq. ft. plus dead load of 10 lbs. per sq. ft. determines required fiber stress value.

JOIST SIZE SPACING (IN)	Modulus of Elasticity, "E", in 1,000,000 psi																		
	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4
2x4	12.0	6-2 560	6-8 660	7-1 740	7-6 820	7-10 900	8-1 970	8-5 1040	8-8 1110	8-11 1170	9-2 1240	9-5 1300	9-8 1360	9-10 1420	10-0 1480	10-3 1540	10-5 1600	10-7 1660	10-11 1760
	13.7	5-11 590	6-5 690	7-2 770	7-6 860	7-9 940	8-1 1010	8-4 1090	8-7 1160	8-9 1230	8-9 1300	9-0 1360	9-3 1420	9-5 1480	9-7 1550	9-9 1610	10-0 1670	10-2 1730	10-9 1840
	16.0	5-8 620	6-1 720	6-5 810	6-9 900	7-1 990	7-5 1070	7-8 1140	7-11 1220	8-1 1290	8-4 1360	8-7 1430	8-9 1500	8-11 1570	9-1 1630	9-4 1690	9-6 1750	9-8 1820	10-3 1940
	19.2	5-4 660	5-9 770	6-1 870	6-5 960	6-8 1050	6-11 1130	7-2 1220	7-5 1300	7-8 1370	7-10 1450	8-3 1520	8-5 1590	8-7 1660	8-9 1730	8-11 1800	9-1 1870	9-4 1930	9-8 2060
2x6	24.0	4-11 710	5-4 830	5-8 930	5-11 1030	6-2 1130	6-5 1220	6-8 1310	7-1 1400	7-3 1480	7-6 1560	7-8 1640	7-10 1720	7-10 1790	8-0 1870	8-1 1940	8-3 2010	8-5 2080	8-11 2220
	12.0	9-9 560	10-6 660	11-2 740	11-9 820	12-3 900	12-9 970	13-3 1040	13-8 1110	14-1 1170	14-5 1240	14-9 1300	15-2 1360	15-6 1420	15-9 1480	16-1 1540	16-4 1600	16-8 1660	17-8 1860
	13.7	8-4 590	9-0 690	9-6 770	10-2 860	10-8 940	11-2 1010	11-7 1090	12-0 1160	12-3 1230	12-9 1300	13-5 1360	14-2 1420	14-6 1480	14-9 1550	15-1 1610	15-5 1670	15-8 1730	16-11 1950
	16.0	8-10 620	9-6 720	10-2 810	10-8 900	11-2 990	11-7 1070	12-0 1140	12-3 1220	12-9 1290	13-1 1360	13-5 1430	14-1 1500	14-4 1570	14-7 1630	14-7 1690	14-11 1760	15-2 1820	16-1 2050
2x8	19.2	8-4 660	9-0 770	9-6 870	10-2 960	10-8 1050	11-1 1130	11-4 1220	11-8 1300	12-0 1370	12-4 1450	12-8 1520	13-3 1590	13-6 1660	13-9 1730	14-0 1800	14-3 1870	14-8 1930	15-2 2180
	24.0	7-9 710	8-4 830	8-10 930	9-4 1030	9-9 1130	10-2 1220	10-6 1310	11-2 1400	11-5 1480	11-9 1560	12-0 1640	12-3 1720	12-6 1790	12-9 1870	13-0 1940	13-3 2010	13-8 2080	14-1 2220

2x8	12.0	12-10 560	13-10 660	14-8 740	15-6 820	16-2 900	16-10 970	17-5 1040	18-0 1110	18-6 1170	19-0 1240	19-6 1300	19-11 1360	20-5 1420	20-10 1480	21-2 1540	21-7 1600	21-11 1660	22-8 1760	23-4 1860
	13.7	12-3 590	13-3 690	14-1 770	14-10 860	15-6 940	16-1 1010	16-8 1090	17-2 1160	17-9 1230	18-2 1300	18-8 1360	19-1 1420	19-6 1480	19-11 1550	20-3 1610	20-8 1670	21-0 1730	21-8 1840	22-4 1950
	16.0	11-8 620	12-7 720	13-4 810	14-1 900	14-8 990	15-3 1070	15-10 1140	16-4 1220	16-10 1290	17-3 1360	17-9 1430	18-2 1500	18-6 1570	18-11 1630	19-3 1690	19-7 1760	19-11 1820	20-7 1940	21-2 2050
	19.2	11-0 660	11-10 770	12-7 870	13-3 960	13-10 1050	14-5 1130	14-11 1220	15-5 1300	15-10 1370	16-3 1450	16-8 1520	17-1 1590	17-5 1660	17-9 1730	18-2 1800	18-5 1870	18-9 1930	19-5 2060	19-11 2180
24.0	10-2 710	11-0 830	11-8 930	12-3 1030	12-10 1130	13-4 1220	13-10 1310	14-3 1400	14-8 1480	15-1 1560	15-6 1640	16-0 1720	16-6 1790	16-10 1870	17-2 1940	17-7 2010	18-0 2080	18-6 2220	19-11 2350	
2x10	12.0	16-5 560	17-8 660	18-9 740	19-9 820	20-8 900	21-6 970	22-3 1040	22-11 1110	23-8 1170	24-3 1240	25-5 1300	26-0 1360	26-6 1420	27-1 1480	27-6 1540	28-0 1600	28-11 1660	29-9 1860	
	13.7	15-8 590	16-11 690	17-11 770	18-11 860	19-9 940	20-6 1010	21-3 1090	21-11 1160	22-7 1230	23-3 1300	23-9 1360	24-4 1420	24-10 1480	25-5 1550	26-10 1610	26-4 1670	27-8 1840	28-6 1950	
	16.0	14-11 620	15-0 720	16-0 810	17-0 900	18-9 990	19-6 1070	20-2 1140	20-10 1220	21-6 1290	22-1 1360	22-7 1430	23-2 1500	23-8 1570	24-1 1630	24-7 1690	25-0 1760	26-5 1940	27-1 2050	
	19.2	14-0 660	15-1 770	16-0 870	17-0 960	18-3 1050	19-4 1130	20-2 1220	21-0 1300	21-8 1370	22-3 1450	23-3 1520	24-3 1590	25-3 1660	26-3 1730	27-3 1800	28-3 1870	29-3 1930	30-8 2060	31-8 2180
24.0	13-0 710	14-0 830	14-10 930	15-8 1030	16-5 1130	17-0 1220	17-8 1310	18-3 1400	18-9 1480	19-3 1560	19-9 1640	20-2 1720	20-8 1790	21-1 1870	21-6 1940	22-3 2010	22-11 2080	23-8 2220	24-11 2350	

Note: The required extreme fiber stress in bending, "F_b", in pounds per square inch is shown below each span.

TABLE J5
CEILING JOISTS
10 Lbs. Per Sq. Ft. Live Load
(No attic storage and roof slope not steeper than 3 in 12)
(Plaster Ceiling)

DESIGN CRITERIA:
Deflection - F_{d10} , lbs. per sq. ft. live load.
Limited to span in inches divided by 360.
Strength - live load of 10 lbs. per sq. ft. plus
dead load of 5 lbs. per sq. ft. determines
required fiber stress value.

JOIST SIZE SPACING (IN)		Modulus of Elasticity, "E", in 1,000,000 psi																
		0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
2x4	12.0	6-10	7-4	7-10	8-3	8-7	8-11	9-3	9-7	9-10	10-1	10-4	10-7	10-10	11-1	11-3	11-6	11-8
		340	400	450	500	540	590	630	670	710	750	790	830	860	900	930	970	1000
	13.7	6-6	7-0	7-6	7-10	8-3	8-7	8-10	9-2	9-5	9-8	9-11	10-2	10-4	10-7	10-9	11-0	11-2
		360	410	470	520	570	610	660	700	740	780	820	860	900	940	970	1010	1050
	16.0	6-2	6-8	7-1	7-6	7-10	8-1	8-5	8-8	8-11	9-2	9-5	9-8	9-10	10-0	10-3	10-5	10-7
2x6	12.0	10-9	11-7	12-3	12-11	13-6	14-1	14-7	15-0	15-6	15-11	16-3	16-8	17-0	17-4	17-8	18-0	18-4
		340	400	450	500	540	590	630	670	710	750	790	830	860	900	930	970	1000
	13.7	10-3	11-1	11-9	12-4	12-11	13-5	13-11	14-4	14-9	15-2	15-7	15-11	16-3	16-7	16-11	17-3	17-6
		360	410	470	520	570	610	660	700	740	780	820	860	900	940	970	1010	1050
	16.0	9-9	10-6	11-2	11-9	12-3	12-9	13-3	13-8	14-1	14-5	14-9	15-2	15-6	15-9	16-1	16-4	16-8
2x8	12.0	12-1	13-0	13-10	14-7	15-3	15-10	16-5	16-11	17-5	17-11	18-4	18-9	19-2	19-7	19-11	20-4	20-8
		340	400	450	500	540	590	630	670	710	750	790	830	860	900	930	970	1000
	13.7	11-3	12-1	12-10	13-6	14-2	14-8	15-3	15-9	16-2	16-7	17-0	17-5	17-10	18-2	18-6	18-10	18-10
		360	410	470	520	570	610	660	700	740	780	820	860	900	940	970	1010	1050
	16.0	12-10	13-10	14-8	15-6	16-2	16-10	17-5	18-0	18-6	19-0	19-6	19-11	20-5	20-10	21-2	21-7	21-11
2x10	12.0	13-0	14-0	15-0	16-0	17-0	18-0	19-0	20-0	21-0	22-0	23-0	24-0	25-0	26-0	27-0	28-0	29-0
		340	400	450	500	540	590	630	670	710	750	790	830	860	900	930	970	1000
	13.7	12-10	13-10	14-8	15-6	16-2	16-10	17-5	18-0	18-6	19-0	19-6	19-11	20-5	20-10	21-2	21-7	21-11
		360	410	470	520	570	610	660	700	740	780	820	860	900	940	970	1010	1050
	16.0	13-10	14-0	15-0	16-0	17-0	18-0	19-0	20-0	21-0	22-0	23-0	24-0	25-0	26-0	27-0	28-0	29-0
2x12	12.0	14-0	15-0	16-0	17-0	18-0	19-0	20-0	21-0	22-0	23-0	24-0	25-0	26-0	27-0	28-0	29-0	30-0
		340	400	450	500	540	590	630	670	710	750	790	830	860	900	930	970	1000
	13.7	14-0	15-0	16-0	17-0	18-0	19-0	20-0	21-0	22-0	23-0	24-0	25-0	26-0	27-0	28-0	29-0	30-0
		360	410	470	520	570	610	660	700	740	780	820	860	900	940	970	1010	1050
	16.0	15-0	16-0	17-0	18-0	19-0	20-0	21-0	22-0	23-0	24-0	25-0	26-0	27-0	28-0	29-0	30-0	31-0

JOIST SIZE SPACING (IN)		Modulus of Elasticity, "E", in 1,000,000 psi																
		0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
2x4	12.0	6-10	7-4	7-10	8-3	8-7	8-11	9-3	9-7	9-10	10-1	10-4	10-7	10-10	11-1	11-3	11-6	11-8
		340	400	450	500	540	590	630	670	710	750	790	830	860	900	930	970	1000
	13.7	6-6	7-0	7-6	7-10	8-3	8-7	8-10	9-2	9-5	9-8	9-11	10-2	10-4	10-7	10-9	11-0	11-2
		360	410	470	520	570	610	660	700	740	780	820	860	900	940	970	1010	1050
	16.0	6-2	6-8	7-1	7-6	7-10	8-1	8-5	8-8	8-11	9-2	9-5	9-8	9-10	10-0	10-3	10-5	10-7
2x6	12.0	10-9	11-7	12-3	12-11	13-6	14-1	14-7	15-0	15-6	15-11	16-3	16-8	17-0	17-4	17-8	18-0	18-4
		340	400	450	500	540	590	630	670	710	750	790	830	860	900	930	970	1000
	13.7	10-3	11-1	11-9	12-4	12-11	13-5	13-11	14-4	14-9	15-2	15-7	15-11	16-3	16-7	16-11	17-3	17-6
		360	410	470	520	570	610	660	700	740	780	820	860	900	940	970	1010	1050
	16.0	9-9	10-6	11-2	11-9	12-3	12-9	13-3	13-8	14-1	14-5	14-9	15-2	15-6	15-9	16-1	16-4	16-8
2x8	12.0	12-1	13-0	13-10	14-7	15-3	15-10	16-5	16-11	17-5	17-11	18-4	18-9	19-2	19-7	19-11	20-4	20-8
		340	400	450	500	540	590	630	670	710	750	790	830	860	900	930	970	1000
	13.7	11-3	12-1	12-10	13-6	14-2	14-8	15-3	15-9	16-2	16-7	17-0	17-5	17-10	18-2	18-6	18-10	18-10
		360	410	470	520	570	610	660	700	740	780	820	860	900	940	970	1010	1050
	16.0	12-10	13-10	14-8	15-6	16-2	16-10	17-5	18-0	18-6	19-0	19-6	19-11	20-5	20-10	21-2	21-7	21-11
2x10	12.0	13-0	14-0	15-0	16-0	17-0	18-0	19-0	20-0	21-0	22-0	23-0	24-0	25-0	26-0	27-0	28-0	29-0
		340	400	450	500	540	590	630	670	710	750	790	830	860	900	930	970	1000
	13.7	12-10	13-10	14-8	15-6	16-2	16-10	17-5	18-0	18-6	19-0	19-6	19-11	20-5	20-10	21-2	21-7	21-11
		360	410	470	520	570	610	660	700	740	780	820	860	900	940	970	1010	1050
	16.0	13-10	14-0	15-0	16-0	17-0	18-0	19-0	20-0	21-0	22-0	23-0	24-0	25-0	26-0	27-0	28-0	29-0
2x12	12.0	14-0	15-0	16-0	17-0	18-0	19-0	20-0	21-0	22-0	23-0	24-0	25-0	26-0	27-0	28-0	29-0	30-0
		340	400	450	500	540	590	630	670	710	750	790	830	860	900	930	970	1000
	13.7	14-0	15-0	16-0	17-0	18-0	19-0	20-0	21-0	22-0	23-0	24-0	25-0	26-0	27-0	28-0	29-0	30-0
		360	410	470	520	570	610	660	700	740	780	820	860	900	940	970	1010	1050
	16.0	15-0	16-0	17-0	18-0	19-0	20-0	21-0	22-0	23-0	24-0	25-0	26-0	27-0	28-0	29-0	30-0	31-0

Note: The required extreme fiber stress in bending, "F_b" in pounds per square inch is shown below each span.

TABLE J46
CEILING JOISTS
10 Lbs. Per Sq. Ft. Live Load
(No attic storage and roof slope not steeper than 3 in 12)
(Drywall Ceiling)

DESIGN CRITERIA:
Deflection For 10 lbs. per sq. ft. live load.
Limited to span in inches divided by 240.
Strength limited to 10 lbs. per sq. ft. plus
dead load of 5 lbs. per sq. ft. determines
required fiber stress value.

JOIST SIZE SPACING (IN)		Modulus of Elasticity, "E", in 1,000,000 psi																		
		0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4
2x4	12.0	7-10	8-5	8-11	9-5	9-10	10-3	10-7	10-11	11-3	11-7	11-10	12-2	12-5	12-8	12-11	13-2	13-4	13-9	14-2
	13.7	7-6	8-1	8-7	9-0	9-5	9-9	10-2	10-6	10-9	11-1	11-4	11-7	11-10	12-1	12-4	12-7	12-9	13-2	13-7
	16.0	7-1	7-8	8-1	8-7	8-11	9-4	9-8	9-11	10-3	10-6	10-9	11-0	11-3	11-6	11-9	11-11	12-2	12-6	12-11
	19.2	6-8	7-2	7-8	8-1	8-5	8-9	9-1	9-4	9-8	9-11	10-2	10-4	10-7	10-10	11-0	11-3	11-5	11-9	12-2
	24.0	6-2	6-8	7-1	7-6	7-10	8-1	8-5	8-8	8-11	9-2	9-5	9-8	9-10	10-0	10-3	10-5	10-7	10-11	11-3
2x6	12.0	12-3	13-3	14-1	14-9	15-6	16-1	16-8	17-2	17-8	18-2	18-8	19-1	19-6	19-11	20-3	20-8	21-0	21-8	22-4
	13.7	11-9	12-8	13-5	14-2	14-9	15-5	15-11	16-5	16-11	17-5	17-10	18-3	18-8	19-0	19-5	19-9	20-1	20-9	21-4
	16.0	11-2	12-0	12-9	13-5	14-1	14-7	15-2	15-7	16-1	16-6	16-11	17-4	17-8	18-1	18-5	18-9	19-1	19-8	20-3
	19.2	10-6	11-4	12-0	12-8	13-3	13-9	14-3	14-8	15-2	15-7	16-11	16-4	16-8	17-0	17-4	17-8	17-11	18-6	19-1
	24.0	9-9	10-6	11-2	11-9	12-3	12-9	13-3	13-8	14-1	14-5	14-9	15-2	15-6	15-9	16-1	16-4	16-8	17-2	17-8

JOIST SIZE SPACING (IN)		16.2	17.5	18.6	19.6	20.5	21.2	21-11	22-8	23-4	24-0	24-7	25-2	25-8	26-2	26-9	27-2	27-8	28-7	29-5
		12.0	450	520	590	650	710	770	830	880	930	980	1030	1080	1130	1180	1220	1270	1310	1400
		13.7	470	540	610	680	740	800	860	920	970	1030	1080	1130	1180	1230	1280	1320	1370	1480
		16.0	490	570	650	720	780	850	910	970	1030	1080	1140	1190	1240	1290	1340	1390	1440	1630
		19.2	520	610	690	760	830	900	970	1040	1110	1170	1240	1300	1360	1420	1480	1540	1600	1730
2x8	12.0	20-8	22-3	23-8	24-10	26-0	27-1	28-0	28-11	29-9	30-7	31-4	32-1	32-9	33-5	34-1	34-8	35-4	36-5	37-6
	13.7	19-9	21-3	22-7	23-9	24-10	25-10	26-10	27-8	28-6	29-3	30-0	30-8	31-4	32-0	32-7	33-2	33-9	34-10	35-10
	16.0	18-9	20-2	21-6	22-7	23-8	24-7	25-5	26-3	27-1	27-9	28-6	29-2	29-9	30-5	31-0	31-6	32-1	33-1	34-1
	19.2	17-8	19-0	20-2	21-3	22-3	23-2	23-11	24-9	25-5	26-2	26-10	27-5	28-0	28-7	29-2	29-8	30-2	31-2	32-1
	24.0	16-5	17-8	18-9	19-9	20-8	21-6	22-3	22-11	23-8	24-3	24-10	25-5	26-0	26-6	27-1	27-6	28-0	28-11	29-9

Note: The required extreme fiber stress in bending, "F_b", in pounds per square inch is shown below each span.

TABLE R-2
FLAT OR SLOPED RAFTERS
Supporting Drywall Ceiling
(Flat roof or cathedral ceiling with no attic space)
Live Load - 30 lb. per sq. ft.
Use in Zone 2

DESIGN CRITERIA:
Strength - 15 lbs. per sq. ft. dead load plus 30
lbs. per sq. ft. live load determines required
fiber stress.
Deflection - For 30 lbs. per sq. ft. live load.
Limited to span in inches divided by 240.

RAFTER SIZE SPACING (IN)	Extreme Fiber Stress in Bending, "F _b " (psi).										
	300	400	500	600	700	800	900	1000	1100	1200	1300
2x6	12.0	5-10 0.13	6-8 0.19	7-6 0.27	8-2 0.36	8-10 0.45	9-6 0.55	10-0 0.66	10-7 0.77	11-7 0.89	12-1 1.14
	13.7	5-5 0.12	6-3 0.18	7-0 0.25	7-8 0.33	8-3 0.42	8-10 0.52	9-5 0.61	9-11 0.72	10-5 0.83	11-3 1.07
	16.0	5-0 0.11	5-10 0.17	6-6 0.24	7-1 0.31	7-8 0.39	8-2 0.48	8-8 0.57	9-2 0.67	10-0 0.77	10-5 0.99
	19.2	4-7 0.10	5-4 0.15	5-11 0.22	6-6 0.28	7-0 0.36	7-6 0.44	7-11 0.52	8-4 0.61	9-2 0.70	9-6 0.90
	24.0	4-1 0.09	4-9 0.14	5-4 0.19	5-10 0.25	6-3 0.32	6-8 0.39	7-1 0.46	7-6 0.54	8-2 0.63	8-6 0.81
2x8	12.0	7-8 0.13	8-10 0.19	9-10 0.27	10-10 0.36	11-8 0.45	12-6 0.55	13-3 0.66	13-11 0.77	14-8 0.89	15-11 1.14
	13.7	7-2 0.12	8-3 0.18	9-3 0.25	10-1 0.33	10-11 0.42	11-8 0.52	12-5 0.61	13-1 0.72	13-8 0.83	14-4 1.07
	16.0	6-7 0.11	7-8 0.17	8-7 0.24	9-4 0.31	10-1 0.39	10-10 0.48	11-6 0.57	12-1 0.67	12-8 0.77	13-3 0.99
	19.2	6-1 0.10	7-0 0.15	7-10 0.22	8-7 0.28	9-3 0.36	9-10 0.44	10-6 0.52	11-0 0.61	11-7 0.70	12-1 0.90
	24.0	5-5 0.09	6-3 0.14	7-0 0.19	7-8 0.25	8-3 0.32	8-10 0.39	9-4 0.46	9-10 0.54	10-4 0.63	11-3 0.81

2x10	12.0	9-9 0.13	11-3 0.19	12-7 0.27	13-9 0.36	14-11 0.45	15-11 0.55	16-11 0.66	17-10 0.77	18-8 0.89	19-6 1.01	20-4 1.14
	13.7	9-1 0.12	10-6 0.18	11-9 0.25	12-11 0.33	13-11 0.42	14-11 0.52	15-10 0.61	16-8 0.72	17-6 0.83	18-3 0.95	19-0 1.07
	16.0	8-5 0.11	9-9 0.17	10-11 0.24	11-11 0.31	12-11 0.39	13-9 0.48	14-8 0.57	15-5 0.67	16-2 0.77	16-11 0.88	17-7 0.99
	19.2	7-8 0.10	8-11 0.15	9-11 0.22	10-11 0.28	11-9 0.36	12-7 0.44	13-4 0.52	14-1 0.61	14-9 0.70	15-5 0.80	16-1 0.90
	24.0	6-11 0.09	8-0 0.14	8-11 0.19	9-9 0.25	10-6 0.32	11-3 0.39	11-11 0.46	12-7 0.54	13-2 0.63	13-9 0.72	14-4 0.81
2x12	12.0	11-10 0.13	13-8 0.19	15-4 0.27	16-9 0.36	18-1 0.45	19-4 0.55	20-6 0.66	21-8 0.77	22-8 0.89	23-9 1.01	24-8 1.14
	13.7	11-1 0.12	12-10 0.18	14-4 0.25	15-8 0.33	16-11 0.42	18-1 0.52	19-3 0.61	20-3 0.72	21-3 0.83	22-2 0.95	23-1 1.07
	16.0	10-3 0.11	11-10 0.17	13-3 0.24	14-6 0.31	15-8 0.39	16-9 0.48	17-9 0.57	18-9 0.67	19-8 0.77	20-6 0.88	21-5 0.99
	19.2	9-5 0.10	10-10 0.15	12-1 0.22	13-3 0.28	14-4 0.36	15-4 0.44	16-3 0.52	17-1 0.61	17-11 0.70	18-9 0.80	19-6 0.90
	24.0	8-5 0.09	9-8 0.14	10-10 0.19	11-10 0.25	12-10 0.32	13-8 0.39	14-6 0.46	15-4 0.54	16-1 0.63	16-9 0.72	17-5 0.81

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-2 (cont.)

RAFTERS: Spans are measured along the horizontal projection and loads are considered as applied on the horizontal projection.

Extreme Fiber Stress in Bending, "F _b " (psi).												RAFTER SPACING SIZE (IN)
1400	1500	1600	1700	1800	1900	2000	2100	2200	2400	2700		
12-6 1.28	13-0 1.41	13-5 1.56	13-10 1.71	14-2 1.86	14-7 2.02	15-0 2.18	15-4 2.34	15-8 2.51				12.0
11-9 1.19	12-2 1.32	12-6 1.46	12-11 1.60	13-3 1.74	13-8 1.89	14-0 2.04	14-4 2.19	14-8 2.35				13.7
10-10 1.10	11-3 1.22	11-7 1.35	11-11 1.48	12-4 1.61	12-8 1.75	13-0 1.89	13-3 2.03	13-7 2.18	14-2 2.48			16.0 2x6
9-11 1.01	10-3 1.12	10-7 1.23	10-11 1.35	11-3 1.47	11-6 1.59	11-10 1.72	12-2 1.85	12-5 1.99	13-0 2.26			19.2
8-10 0.90	9-2 1.00	9-6 1.10	9-9 1.21	10-0 1.31	10-4 1.43	10-7 1.54	10-10 1.66	11-1 1.78	11-7 2.02	12-4 2.41		24.0
16-6 1.28	17-1 1.41	17-8 1.56	18-2 1.71	18-9 1.86	19-3 2.02	19-9 2.18	20-3 2.34	20-8 2.51				12.0
15-5 1.19	16-0 1.32	16-6 1.46	17-0 1.60	17-6 1.74	18-0 1.89	18-5 2.04	18-11 2.19	19-4 2.35				13.7
14-4 1.10	14-10 1.22	15-3 1.35	15-9 1.48	16-3 1.61	16-8 1.75	17-1 1.89	17-6 2.03	17-11 2.18	18-9 2.48			16.0 2x8
13-1 1.01	13-6 1.12	13-11 1.23	14-5 1.35	14-10 1.47	15-2 1.59	15-7 1.72	16-0 1.85	16-4 1.99	17-1 2.26			19.2
11-8 0.90	12-1 1.00	12-6 1.10	12-10 1.21	13-3 1.31	13-7 1.43	13-11 1.54	14-4 1.66	14-8 1.78	15-3 2.02	16-3 2.41		24.0

21-1 1.28	21-10 1.41	22-6 1.56	23-3 1.71	23-11 1.86	24-6 2.02	25-2 2.18	25-10 2.34	26-5 2.51				12.0
19-8 1.19	20-5 1.32	21-1 1.46	21-9 1.60	22-4 1.74	22-11 1.89	23-7 2.04	24-2 2.19	24-8 2.35				13.7
18-3 1.10	18-11 1.22	19-6 1.35	20-1 1.48	20-8 1.61	21-3 1.75	21-10 1.89	22-4 2.03	22-10 2.18	23-11 2.48			16.0 2x10
16-8 1.01	17-3 1.12	17-10 1.23	18-4 1.35	18-11 1.47	19-5 1.59	19-11 1.72	20-5 1.85	20-10 1.99	21-10 2.26			19.2
14-11 0.90	15-5 1.00	15-11 1.10	16-5 1.21	16-11 1.31	17-4 1.43	17-10 1.54	18-3 1.66	18-8 1.78	19-6 2.02	20-8 2.41		24.0
25-7 1.28	26-6 1.41	27-5 1.56	28-3 1.71	29-1 1.86	29-10 2.02	30-7 2.18	31-4 2.34	32-1 2.51				12.0
24-0 1.19	24-10 1.32	25-7 1.46	26-5 1.60	27-2 1.74	27-11 1.89	28-8 2.04	29-4 2.19	30-0 2.35				13.7
22-2 1.10	23-0 1.22	23-9 1.35	24-5 1.48	25-2 1.61	25-10 1.75	26-6 1.89	27-2 2.03	27-10 2.18	29-1 2.48			16.0 2x12
20-3 1.01	21-0 1.12	21-8 1.23	22-4 1.35	23-0 1.47	23-7 1.59	24-2 1.72	24-10 1.85	25-5 1.99	26-6 2.26			19.2
18-1 0.90	18-9 1.00	19-4 1.10	20-0 1.21	20-6 1.31	21-1 1.43	21-8 1.54	22-2 1.66	22-8 1.78	23-9 2.02	25-2 2.41		24.0

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-3
FLAT OR SLOPED RAFTERS
Supporting Drywall Ceiling
(Flat roof or cathedral ceiling with no attic space)
Live Load - 40 lbs. per sq. ft.
Use in Zone 1

DESIGN CRITERIA:
Strength - 15 lbs. per sq. ft. dead load plus 40 lbs. per sq. ft. live load determines required fiber stress.
Deflection - For 40 lbs. per sq. ft. live load. Limited to span in inches divided by 240.

RAFTER SIZE SPACING (IN)	Extreme Fiber Stress in Bending, "F _b " (psi).											
	300	400	500	600	700	800	900	1000	1100	1200	1300	
12x6	12.0	5-3 0.12	6-1 0.19	6-9 0.27	7-5 0.35	8-0 0.44	8-7 0.54	9-1 0.65	9-7 0.76	10-0 0.88	10-6 1.00	10-11 1.13
	13.7	4-11 0.12	5-8 0.18	6-4 0.25	6-11 0.33	7-6 0.42	8-0 0.51	8-6 0.61	8-11 0.71	9-5 0.82	9-10 0.93	10-3 1.05
	16.0	4-6 0.11	5-3 0.17	5-10 0.23	6-5 0.31	6-11 0.39	7-5 0.47	7-10 0.56	8-3 0.66	8-8 0.76	9-1 0.86	9-5 0.98
12x8	19.2	4-2 0.10	4-9 0.15	5-4 0.21	5-10 0.28	6-4 0.35	6-9 0.43	7-2 0.51	7-7 0.60	7-11 0.69	8-3 0.79	8-8 0.89
	24.0	3-8 0.09	4-3 0.14	4-9 0.19	5-3 0.25	5-8 0.31	6-1 0.38	6-5 0.46	6-9 0.54	7-1 0.62	7-5 0.71	7-9 0.80
	12.0	6-11 0.12	8-0 0.19	8-11 0.27	9-9 0.35	10-7 0.44	11-3 0.54	12-0 0.65	12-7 0.76	13-3 0.88	13-10 1.00	14-5 1.13
2x8	13.7	6-6 0.12	7-6 0.18	8-4 0.25	9-2 0.33	9-11 0.42	10-7 0.51	11-2 0.61	11-10 0.71	12-5 0.82	12-11 0.93	13-6 1.05
	16.0	6-0 0.11	6-11 0.17	7-9 0.23	8-6 0.31	9-2 0.39	9-9 0.47	10-4 0.56	10-11 0.66	11-6 0.76	12-0 0.86	12-6 0.98
	19.2	5-6 0.10	6-4 0.15	7-1 0.21	7-9 0.28	8-4 0.35	8-11 0.43	9-6 0.51	10-0 0.60	10-6 0.69	10-11 0.79	11-5 0.89
24.0	4-11 0.09	5-8 0.14	6-4 0.19	6-11 0.25	7-6 0.31	8-0 0.38	8-6 0.46	8-11 0.54	9-4 0.62	9-9 0.71	10-2 0.80	10-8 0.80

12x10	12.0	8-10 0.12	10-2 0.19	11-5 0.27	12-6 0.35	13-6 0.44	14-5 0.54	15-3 0.65	16-1 0.76	16-11 0.88	17-8 1.00	18-4 1.13
	13.7	8-3 0.12	9-6 0.18	10-8 0.25	11-8 0.33	12-7 0.42	13-6 0.51	14-3 0.61	15-1 0.71	15-10 0.82	16-6 0.93	17-2 1.05
	16.0	7-8 0.11	8-10 0.17	9-10 0.23	10-10 0.31	11-8 0.39	12-6 0.47	13-3 0.56	13-11 0.66	14-8 0.76	15-3 0.86	15-11 0.98
2x12	19.2	7-0 0.10	8-1 0.15	9-0 0.21	9-10 0.28	10-8 0.35	11-5 0.43	12-1 0.51	12-9 0.60	13-4 0.69	14-6 0.79	14-6 0.89
	24.0	6-3 0.09	7-2 0.14	8-1 0.19	8-10 0.25	9-6 0.31	10-2 0.38	10-10 0.46	11-5 0.54	11-11 0.62	12-6 0.71	13-0 0.80
	12.0	10-9 0.12	12-5 0.19	13-10 0.27	15-2 0.35	16-5 0.44	17-6 0.54	18-7 0.65	19-7 0.76	20-6 0.88	21-5 1.00	22-4 1.13
2x12	13.7	10-0 0.12	11-7 0.18	12-11 0.25	14-2 0.33	15-4 0.42	16-5 0.51	17-5 0.61	18-4 0.71	19-3 0.82	20-1 0.93	20-11 1.05
	16.0	9-3 0.11	10-9 0.17	12-0 0.23	13-2 0.31	14-2 0.39	15-2 0.47	16-1 0.56	17-0 0.66	17-9 0.76	18-7 0.86	19-4 0.98
	19.2	8-6 0.10	9-10 0.15	10-11 0.21	12-0 0.28	12-11 0.35	13-10 0.43	14-8 0.51	15-6 0.60	16-3 0.69	17-0 0.79	17-8 0.89
24.0	7-7 0.09	8-9 0.14	9-10 0.19	10-9 0.25	11-7 0.31	12-5 0.38	13-2 0.46	14-1 0.54	15-2 0.62	16-1 0.71	17-1 0.80	18-0 0.80

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-3 (cont.)

RAFTERS: Spans are measured along the horizontal projection and loads are considered as applied on the horizontal projection.

Extreme Fiber Stress in Bending, "F _b " (psi).												RAFTER SPACING SIZE (IN)
1400	1500	1600	1700	1800	1900	2000	2100	2200	2400	2700		
11-4 1.26	11-9 1.40	12-1 1.54	12-6 1.68	12-10 1.83	13-2 1.99	13-6 2.15	13-10 2.31	14-2 2.48				12.0
10-7 1.18	11-0 1.31	11-4 1.44	11-8 1.57	12-0 1.72	12-4 1.86	12-8 2.01	13-0 2.16	13-3 2.32				13.7
9-10 1.09	10-2 1.21	10-6 1.33	10-10 1.46	11-1 1.59	11-5 1.72	11-9 1.86	12-0 2.00	12-4 2.15	12-10 2.45			16.0 2x6
8-11 0.99	9-3 1.10	9-7 1.22	9-10 1.33	10-2 1.45	10-5 1.57	10-8 1.70	11-0 1.83	11-3 1.96	11-9 2.23			19.2
8-0 0.89	8-3 0.99	8-7 1.09	8-10 1.19	9-1 1.30	9-4 1.41	9-7 1.52	9-10 1.63	10-0 1.75	10-6 2.00	11-1 2.38		24.0
14-11 1.26	15-5 1.40	16-0 1.54	16-5 1.68	16-11 1.83	17-5 1.99	17-10 2.15	18-3 2.31	18-9 2.48				12.0
14-0 1.18	14-6 1.31	14-11 1.44	15-5 1.57	15-10 1.72	16-3 1.86	16-8 2.01	17-1 2.16	17-6 2.32				13.7
12-11 1.09	13-5 1.21	13-10 1.33	14-3 1.46	14-8 1.59	15-1 1.72	15-5 1.86	15-10 2.00	16-3 2.15	16-11 2.45			16.0 2x8
11-10 0.99	12-3 1.10	12-7 1.22	13-0 1.33	13-5 1.45	13-9 1.57	14-1 1.70	14-6 1.83	14-10 1.96	15-5 2.23			19.2
10-7 0.89	10-11 0.99	11-3 1.09	11-8 1.19	12-0 1.30	12-4 1.41	12-7 1.52	12-11 1.63	13-3 1.75	13-10 2.00	14-8 2.38		24.0

19-1 1.26	19-9 1.40	20-4 1.54	21-0 1.68	21-7 1.83	22-2 1.99	22-9 2.15	23-4 2.31	23-11 2.48				12.0
17-10 1.18	18-5 1.31	19-1 1.44	19-8 1.57	20-2 1.72	20-9 1.86	21-4 2.01	21-10 2.16	22-4 2.32				13.7
16-6 1.09	17-1 1.21	17-8 1.33	18-2 1.46	18-9 1.59	19-3 1.72	19-9 1.86	20-2 2.00	20-8 2.15	21-7 2.45			16.0 2x10
15-1 0.99	15-7 1.10	16-1 1.22	16-7 1.33	17-1 1.45	17-7 1.57	18-0 1.70	18-5 1.83	18-11 1.96	19-9 2.23			19.2
13-6 0.89	13-11 0.99	14-5 1.09	14-10 1.19	15-3 1.30	15-8 1.41	16-1 1.52	16-6 1.63	16-11 1.75	17-8 2.00	18-9 2.38		24.0
23-2 1.26	24-0 1.40	24-9 1.54	25-6 1.68	26-3 1.83	27-0 1.99	27-8 2.15	28-5 2.31	29-1 2.48				12.0
21-8 1.18	22-5 1.31	23-2 1.44	23-11 1.57	24-7 1.72	25-3 1.86	25-11 2.01	26-7 2.16	27-2 2.32				13.7
20-1 1.09	20-9 1.21	21-5 1.33	22-1 1.46	22-9 1.59	23-5 1.72	24-0 1.86	24-7 2.00	25-2 2.15	26-3 2.45			16.0 2x12
18-4 0.99	19-0 1.10	19-7 1.22	20-2 1.33	20-9 1.45	21-4 1.57	21-11 1.70	22-5 1.83	23-0 1.96	24-0 2.23			19.2
16-5 0.89	17-0 0.99	17-6 1.09	18-1 1.19	18-7 1.30	19-1 1.41	19-7 1.52	20-1 1.63	20-6 1.75	21-5 2.00	22-9 2.38		24.0

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-5
FLAT OR SLOPED RAFTERS
Supporting Plaster Ceiling
(Flat roof or cathedral ceiling with no attic space)
Live Load - 30 lb. per sq. ft.
Use in Zone 2

DESIGN CRITERIA:
Strength - 15 lbs. per sq. ft. dead load plus 30
lbs. per sq. ft. live load determines required
fiber stress.
Deflection - For 30 lbs. per sq. ft. live load.
Limited to Span in inches divided by 360.

RAFTER SIZE SPACING (IN)	Extreme Fiber Stress in Bending, "F _b " (psi).									
	300	400	500	600	700	890	900	1000	1100	1200
12.0	5-10	6-8	7-6	8-2	8-10	9-6	10-0	10-7	11-1	11-7
	0-19	0-29	0-41	0-54	0-68	0-83	0-99	1-15	1-33	1-52
	5-5	6-3	7-0	7-6	8-3	8-10	9-5	9-11	10-5	10-10
13.7	0-18	0-27	0-38	0-50	0-63	0-77	0-92	1-08	1-25	1-42
	5-0	5-10	6-6	7-1	7-8	8-2	8-8	9-2	9-7	10-0
	0-16	0-25	0-35	0-46	0-59	0-72	0-85	1-00	1-15	1-31
2x6	4-7	5-4	5-11	6-6	7-0	7-6	7-11	8-4	8-9	9-2
	0-15	0-23	0-32	0-42	0-53	0-65	0-78	0-91	1-05	1-20
	4-1	4-9	5-4	5-10	6-3	6-8	7-1	7-6	7-10	8-2
24.0	0-13	0-21	0-29	0-38	0-48	0-58	0-70	0-82	0-94	1-07
	7-8	8-10	9-10	10-10	11-8	12-6	13-3	13-11	14-8	15-3
	0-19	0-29	0-41	0-54	0-68	0-83	0-99	1-15	1-33	1-52
13.7	7-2	8-3	9-3	10-1	10-11	11-8	12-5	13-1	13-8	14-4
	0-18	0-27	0-38	0-50	0-63	0-77	0-92	1-08	1-25	1-42
	6-7	7-8	8-7	9-4	10-1	10-10	11-6	12-1	12-8	13-3
2x8	0-16	0-25	0-35	0-46	0-59	0-72	0-85	1-00	1-15	1-31
	6-1	7-0	7-10	8-7	9-3	9-10	10-6	11-0	11-7	12-1
	0-15	0-23	0-32	0-42	0-53	0-65	0-78	0-91	1-05	1-20
19.2	5-5	6-3	7-0	7-8	8-3	8-10	9-4	9-10	10-4	10-10
	0-13	0-21	0-29	0-38	0-48	0-58	0-70	0-82	0-94	1-07

12.0	9-9	11-3	12-7	13-9	14-11	15-11	16-11	17-10	18-8	19-6
	0-19	0-29	0-41	0-54	0-68	0-83	0-99	1-15	1-33	1-52
	9-1	10-6	11-9	12-11	13-11	14-11	15-10	16-8	17-6	18-3
13.7	0-18	0-27	0-38	0-50	0-63	0-77	0-92	1-08	1-25	1-42
	8-5	9-9	10-11	11-11	12-11	13-9	14-8	15-5	16-2	16-11
	0-16	0-25	0-35	0-46	0-59	0-72	0-85	1-00	1-15	1-31
2x10	7-8	8-11	9-11	10-11	11-9	12-7	13-4	14-1	14-9	15-5
	0-15	0-23	0-32	0-42	0-53	0-65	0-78	0-91	1-05	1-20
	6-11	8-0	8-11	9-9	10-6	11-3	11-11	12-7	13-2	13-9
24.0	0-13	0-21	0-29	0-38	0-48	0-58	0-70	0-82	0-94	1-07
	11-10	13-8	15-4	16-9	18-1	19-4	20-6	21-8	22-8	23-9
	0-19	0-29	0-41	0-54	0-68	0-83	0-99	1-15	1-33	1-52
13.7	11-1	12-10	14-4	15-8	16-11	18-1	19-3	20-3	21-3	22-2
	0-18	0-27	0-38	0-50	0-63	0-77	0-92	1-08	1-25	1-42
	10-3	11-10	13-3	14-6	15-8	16-9	17-9	18-9	19-8	20-6
2x12	0-16	0-25	0-35	0-46	0-59	0-72	0-85	1-00	1-15	1-31
	9-5	10-10	12-1	13-3	14-4	15-4	16-3	17-1	17-11	18-9
	0-15	0-23	0-32	0-42	0-53	0-65	0-78	0-91	1-05	1-20
24.0	8-5	9-8	10-10	11-10	12-10	13-8	14-6	15-4	16-1	16-9
	0-13	0-21	0-29	0-38	0-48	0-58	0-70	0-82	0-94	1-07

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-5 (cont.)

RAFTERS: Spans are measured along the horizontal projection and loads are considered as applied on the horizontal projection.

Extreme Fiber Stress in Bending, "F _b " (psi).										RAFTER SPACING SIZE (IN)
1300	1400	1500	1600	1700	1800	1900	2000	2100		
12-1 1.71	12-6 1.91	13-0 2.12	13-5 2.34	13-10 2.56						12.0
11-3 1.60	11-9 1.79	12-2 1.98	12-6 2.19	12-11 2.39						13.7
10-5 1.48	10-10 1.66	11-3 1.84	11-7 2.02	11-11 2.22	12-4 2.41					16.0
9-6 1.35	9-11 1.51	10-3 1.68	10-7 1.85	10-11 2.02	11-3 2.20	11-6 2.39	11-10 2.58			19.2
8-6 1.21	8-10 1.35	9-2 1.50	9-6 1.65	9-9 1.81	10-0 1.97	10-4 2.14	10-7 2.31	10-10 2.48		24.0
15-11 1.71	16-6 1.91	17-1 2.12	17-8 2.34	18-2 2.56						12.0
14-11 1.60	15-5 1.79	16-0 1.98	16-6 2.19	17-0 2.39						13.7
13-9 1.48	14-4 1.66	14-10 1.84	15-3 2.02	15-9 2.22	16-3 2.41					16.0
12-7 1.35	13-1 1.51	13-6 1.68	13-11 1.85	14-5 2.02	14-10 2.20	15-2 2.39	15-7 2.58			19.2
11-3 1.21	11-8 1.35	12-1 1.50	12-6 1.65	12-10 1.81	13-3 1.97	13-7 2.14	13-11 2.31	14-4 2.48		24.0

20-4 1.71	21-1 1.91	21-10 2.12	22-6 2.34	23-3 2.56						12.0
19-0 1.60	19-8 1.79	20-5 1.98	21-1 2.19	21-9 2.39						13.7
17-7 1.48	18-3 1.66	18-11 1.84	19-6 2.02	20-1 2.22	20-8 2.41					16.0
16-1 1.35	16-8 1.51	17-3 1.68	17-10 1.85	18-4 2.02	18-11 2.20	19-5 2.39	19-11 2.58			19.2
14-4 1.21	14-11 1.35	15-5 1.50	15-11 1.65	16-5 1.81	16-11 1.97	17-4 2.14	17-10 2.31	18-3 2.48		24.0
24-8 1.71	25-7 1.91	26-6 2.12	27-5 2.34	28-3 2.56						12.0
23-1 1.60	24-0 1.79	24-10 1.98	25-7 2.19	26-5 2.39						13.7
21-5 1.48	22-2 1.66	23-0 1.84	23-9 2.02	24-5 2.22	25-2 2.41					16.0
19-6 1.35	20-3 1.51	21-0 1.68	21-8 1.85	22-4 2.02	23-0 2.20	23-7 2.39	24-2 2.58			19.2
17-5 1.21	18-1 1.35	18-9 1.50	19-4 1.65	20-0 1.81	20-6 1.97	21-1 2.14	21-8 2.31	22-2 2.48		24.0

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-6
FLAT OR SLOPED RAFTERS
Supporting Plaster Ceiling
(Flat roof or cathedral ceiling with no attic space)
Live Load - 40 lb. per sq. ft.
Use in Zone 1

DESIGN CRITERIA:
Strength - 15 lbs. per sq. ft. dead load plus 40 lbs. per sq. ft. live load determines required fiber stress.
Deflection - For 40 lbs. per sq. ft. live load. Limited to span in inches divided by 360.

RAFTER SIZE SPACING (IN)	Extreme Fiber Stress in Bending, "F _b " (psi).									
	300	400	500	600	700	800	900	1000	1100	1200
2x6	12.0	5-3 0.19	6-1 0.29	6-9 0.40	7-5 0.53	8-0 0.67	8-7 0.82	9-1 0.97	9-7 1.14	10-6 1.50
	13.7	4-11 0.18	5-8 0.27	6-4 0.38	6-11 0.50	7-6 0.62	8-0 0.76	8-6 0.91	8-11 1.07	9-10 1.40
	16.0	4-6 0.16	5-3 0.25	5-10 0.35	6-5 0.46	6-11 0.58	7-5 0.71	7-10 0.84	8-3 0.99	8-8 1.30
	19.2	4-2 0.15	4-9 0.23	5-4 0.32	6-10 0.42	6-4 0.53	6-9 0.64	7-2 0.77	7-7 0.90	8-3 1.18
2x8	24.0	3-8 0.13	4-3 0.20	4-9 0.28	5-3 0.37	5-8 0.47	6-1 0.58	6-5 0.69	6-9 0.81	7-5 1.06
	12.0	6-11 0.19	8-0 0.29	8-11 0.40	9-9 0.53	10-7 0.67	11-3 0.82	12-0 0.97	12-7 1.14	13-3 1.50
	13.7	6-6 0.18	7-6 0.27	8-4 0.38	9-2 0.50	9-11 0.62	10-7 0.76	11-2 0.91	11-10 1.07	12-5 1.40
	16.0	6-0 0.16	6-11 0.25	7-9 0.35	8-6 0.46	9-2 0.58	9-9 0.71	10-4 0.84	10-11 0.99	11-6 1.30
2x10	19.2	5-6 0.15	6-4 0.23	7-1 0.32	7-9 0.42	8-4 0.53	8-11 0.64	9-6 0.77	10-0 0.90	10-11 1.18
	24.0	4-11 0.13	5-8 0.20	6-4 0.28	6-11 0.37	7-6 0.47	8-0 0.58	8-6 0.69	8-11 0.81	9-4 1.06

2x10	12.0	8-10 0.19	10-2 0.29	11-5 0.40	12-6 0.53	13-6 0.67	14-5 0.82	15-3 0.97	16-1 1.14	16-11 1.31	17-8 1.50
	13.7	8-3 0.18	9-6 0.27	10-8 0.38	11-8 0.50	12-7 0.62	13-6 0.76	14-3 0.91	15-1 1.07	15-10 1.23	16-6 1.40
	16.0	7-8 0.16	8-10 0.25	9-10 0.35	10-10 0.46	11-8 0.58	12-6 0.71	13-3 0.84	13-11 0.99	14-8 1.14	15-3 1.30
	19.2	7-0 0.15	8-1 0.23	9-0 0.32	9-10 0.42	10-8 0.53	11-5 0.64	12-1 0.77	12-9 0.90	13-4 1.04	13-11 1.18
2x12	24.0	6-3 0.13	7-2 0.20	8-1 0.28	8-10 0.37	9-6 0.47	10-2 0.58	10-10 0.69	11-5 0.81	11-11 0.93	12-6 1.06
	12.0	10-9 0.19	12-5 0.29	13-10 0.40	15-2 0.53	16-5 0.67	17-6 0.82	18-7 0.97	19-7 1.14	20-6 1.31	21-5 1.50
	13.7	10-0 0.18	11-7 0.27	12-11 0.38	14-2 0.50	15-4 0.62	16-5 0.76	17-5 0.91	18-4 1.07	19-3 1.23	20-1 1.40
	16.0	9-3 0.16	10-9 0.25	12-0 0.35	13-2 0.46	14-2 0.58	15-2 0.71	16-1 0.84	17-0 0.99	17-9 1.14	18-7 1.30
2x12	19.2	8-6 0.15	9-10 0.23	10-11 0.32	12-0 0.42	12-11 0.53	13-10 0.64	14-8 0.77	15-6 0.90	16-3 1.04	17-0 1.18
	24.0	7-7 0.13	8-9 0.20	9-10 0.28	10-9 0.37	11-7 0.47	12-5 0.58	13-2 0.69	13-10 0.81	14-6 0.93	15-2 1.06

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-6 (cont.)

RAFTERS: Spans are measured along the horizontal projection and loads are considered as applied on the horizontal projection.

Extreme Fiber Stress in Bending, "F _b " (psi).										RAFTER SPACING SIZE (IN)
1300	1400	1500	1600	1700	1800	1900	2000	2100		
10-11 1.69	11-4 1.89	11-9 2.09	12-1 2.31	12-6 2.53						12.0
10-3 1.58	10-7 1.77	11-0 1.96	11-4 2.16	11-8 2.36	12-0 2.57					13.7
9-5 1.46	9-10 1.63	10-2 1.81	10-6 2.00	10-10 2.19	11-1 2.38	11-5 2.58				16.0
8-8 1.34	8-11 1.49	9-3 1.65	9-7 1.82	9-10 2.00	10-2 2.18	10-5 2.36	10-8 2.55			19.2
7-9 1.19	8-0 1.33	8-3 1.48	8-7 1.63	8-10 1.79	9-1 1.95	9-4 2.11	9-7 2.28	9-10 2.45		24.0
14-5 1.69	14-11 1.89	15-5 2.09	16-0 2.31	16-5 2.53						12.0
13-6 1.58	14-0 1.77	14-6 1.96	14-11 2.16	15-5 2.36	15-10 2.57					13.7
12-6 1.46	12-11 1.63	13-5 1.81	13-10 2.00	14-3 2.19	14-8 2.38	15-1 2.58				16.0
11-5 1.34	11-10 1.49	12-3 1.65	12-7 1.82	13-0 2.00	13-5 2.18	13-9 2.36	14-1 2.55			19.2
10-2 1.19	10-7 1.33	10-11 1.48	11-3 1.63	11-8 1.79	12-0 1.95	12-4 2.11	12-7 2.28	12-11 2.45		24.0

18-4 1.69	19-1 1.89	19-9 2.09	20-4 2.31	21-0 2.53						12.0
17-2 1.58	17-10 1.77	18-5 1.96	19-1 2.16	19-8 2.36	20-2 2.57					13.7
15-11 1.46	16-6 1.63	17-1 1.81	17-8 2.00	18-2 2.19	18-9 2.38	19-3 2.58				16.0
14-6 1.34	15-1 1.49	15-7 1.65	16-1 1.82	16-7 2.00	17-1 2.18	17-7 2.36	18-0 2.55			19.2
13-0 1.19	13-6 1.33	13-11 1.48	14-5 1.63	14-10 1.79	15-3 1.95	15-8 2.11	16-1 2.28	16-6 2.45		24.0
22-4 1.69	23-2 1.89	24-0 2.09	24-9 2.31	25-6 2.53						12.0
20-11 1.58	21-8 1.77	22-5 1.96	23-2 2.16	23-11 2.36	24-7 2.57					13.7
19-4 1.46	20-1 1.63	20-9 1.81	21-5 2.00	22-1 2.19	22-9 2.38	23-5 2.58				16.0
17-8 1.34	18-4 1.49	19-0 1.65	19-7 1.82	20-2 2.00	20-9 2.18	21-4 2.36	21-11 2.55			19.2
15-9 1.19	16-5 1.33	17-0 1.48	17-6 1.63	18-1 1.79	18-7 1.95	19-1 2.11	19-7 2.28	20-1 2.45		24.0

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-8
FLAT OR LOW SLOPE RAFTERS
No Ceiling Load
Slope 3 in 12 or less
Live Load - 30 lb. per sq. ft.
Use in Zone 2

DESIGN CRITERIA:
Strength - 10 lbs. per sq. ft. dead load plus 30
lbs. per sq. ft. live load determines required
fiber stress.
Deflection - For 30 lbs. per sq. ft. live load,
Limited to span in inches divided by 240.

RAFTER SIZE SPACING (IN)	Extreme Fiber Stress In Bending, "F _b " (psi).										
	300	400	500	600	700	800	900	1000	1100	1200	1300
12.0	6-2	7-1	7-11	8-8	9-5	10-0	10-8	11-3	11-9	12-4	12-10
	0.15	0.23	0.32	0.43	0.54	0.66	0.78	0.92	1.06	1.21	1.36
	5-9	6-8	7-5	8-2	8-9	9-5	10-0	10-6	11-0	11-6	12-0
	0.14	0.22	0.30	0.40	0.50	0.61	0.73	0.86	0.99	1.13	1.27
2x6	5-4	6-2	6-11	7-6	8-2	8-8	9-3	9-9	10-2	10-8	11-1
	0.13	0.20	0.28	0.37	0.47	0.57	0.68	0.80	0.92	1.05	1.18
	4-10	5-7	6-3	6-11	7-5	7-11	8-5	8-11	9-4	9-9	10-1
	0.12	0.18	0.26	0.34	0.43	0.52	0.62	0.73	0.84	0.95	1.08
24.0	4-4	5-0	5-7	6-2	6-8	7-1	7-6	7-11	8-4	8-8	9-1
	0.11	0.16	0.23	0.30	0.38	0.46	0.55	0.65	0.75	0.85	0.96
	8-1	9-4	10-6	11-6	12-5	13-3	14-0	14-10	15-6	16-3	16-10
	0.15	0.23	0.32	0.43	0.54	0.66	0.78	0.92	1.06	1.21	1.36
13.7	7-7	8-9	9-9	10-9	11-7	12-5	13-2	13-10	14-6	15-2	15-9
	0.14	0.22	0.30	0.40	0.50	0.61	0.73	0.86	0.99	1.13	1.27
	7-0	8-1	9-1	9-11	10-9	11-6	12-2	12-10	13-5	14-0	14-7
	0.13	0.20	0.28	0.37	0.47	0.57	0.68	0.80	0.92	1.05	1.18
2x8	6-5	7-5	8-3	9-1	9-9	10-6	11-1	11-8	12-3	12-10	13-4
	0.12	0.18	0.26	0.34	0.43	0.52	0.62	0.73	0.84	0.95	1.08
	5-9	6-7	7-5	8-1	8-9	9-4	9-11	10-6	11-0	11-6	11-11
	0.11	0.16	0.23	0.30	0.38	0.46	0.55	0.65	0.75	0.85	0.96

12.0	10-4	11-11	13-4	14-8	15-10	16-11	17-11	18-11	19-10	20-8	21-6
	0.15	0.23	0.32	0.43	0.54	0.66	0.78	0.92	1.06	1.21	1.36
	9-8	11-2	12-6	13-8	14-9	15-10	16-9	17-8	18-6	19-4	20-2
	0.14	0.22	0.30	0.40	0.50	0.61	0.73	0.86	0.99	1.13	1.27
2x10	8-11	10-4	11-7	12-8	13-8	14-8	15-6	16-4	17-2	17-11	18-8
	0.13	0.20	0.28	0.37	0.47	0.57	0.68	0.80	0.92	1.05	1.18
	8-2	9-5	10-7	11-7	12-6	13-4	14-2	14-11	15-8	16-4	17-0
	0.12	0.18	0.26	0.34	0.43	0.52	0.62	0.73	0.84	0.95	1.08
24.0	7-4	8-5	9-5	10-4	11-2	11-11	12-8	13-4	14-0	14-8	15-3
	0.11	0.16	0.23	0.30	0.38	0.46	0.55	0.65	0.75	0.85	0.96
	12-7	14-6	16-3	17-9	19-3	20-6	21-9	23-0	24-1	25-2	26-2
	0.15	0.23	0.32	0.43	0.54	0.66	0.78	0.92	1.06	1.21	1.36
13.7	11-9	13-7	15-2	16-8	18-0	19-3	20-5	21-6	22-6	23-6	24-6
	0.14	0.22	0.30	0.40	0.50	0.61	0.73	0.86	0.99	1.13	1.27
	10-11	12-7	14-1	15-5	16-8	17-9	18-10	19-11	20-10	21-9	22-8
	0.13	0.20	0.28	0.37	0.47	0.57	0.68	0.80	0.92	1.05	1.18
2x12	9-11	11-6	12-10	14-1	15-2	16-3	17-3	18-2	19-0	19-11	20-8
	0.12	0.18	0.26	0.34	0.43	0.52	0.62	0.73	0.84	0.95	1.08
	8-11	10-3	11-6	12-7	13-7	14-6	15-5	16-3	17-0	17-9	18-6
	0.11	0.16	0.23	0.30	0.38	0.46	0.55	0.65	0.75	0.85	0.96

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-8 (cont.)

RAFTERS: Spans are measured along the horizontal projection and loads are considered as applied on the horizontal projection.

Extreme Fiber Stress in Bending, "F _b " (psi).										RAFTER SPACING SIZE (IN)
1400	1500	1600	1700	1800	1900	2000	2100	2200	2400	
13.3 1.52	13.9 1.69	14.2 1.86	14.8 2.04	15.1 2.22	15.6 2.41	15.11 2.60				12.0
12.5 1.42	12.10 1.58	13.3 1.74	13.8 1.90	14.1 2.08	14.6 2.25	14.10 2.43				13.7
11.6 1.32	11.11 1.46	12.4 1.61	12.8 1.76	13.1 1.92	13.5 2.08	13.9 2.25	14.1 2.42	14.5 2.60		16.0
10.6 1.20	10.10 1.33	11.3 1.47	11.7 1.61	11.11 1.75	12.3 1.90	12.7 2.05	12.10 2.21	13.2 2.37		19.2
9.5 1.08	9.9 1.19	10.0 1.31	10.4 1.44	10.8 1.57	10.11 1.70	11.3 1.84	11.6 1.98	11.9 2.12	12.4 2.41	24.0
17.6 1.52	18.2 1.69	18.9 1.86	19.4 2.04	19.10 2.22	20.5 2.41	20.11 2.60				12.0
16.5 1.42	16.11 1.58	17.6 1.74	18.1 1.90	18.7 2.08	19.1 2.25	19.7 2.43				13.7
15.2 1.32	15.8 1.46	16.3 1.61	16.9 1.76	17.2 1.92	17.8 2.08	18.2 2.25	18.7 2.42	19.0 2.60		16.0
13.10 1.20	14.4 1.33	14.10 1.47	15.3 1.61	15.8 1.75	16.2 1.90	16.7 2.05	16.11 2.21	17.4 2.37		19.2
12.5 1.08	12.10 1.19	13.3 1.31	13.8 1.44	14.0 1.57	14.5 1.70	14.10 1.84	15.2 1.98	15.6 2.12	16.3 2.41	24.0

22.4 1.52	23.2 1.69	23.11 1.86	24.7 2.04	25.4 2.22	26.0 2.41	26.8 2.60				12.0
20.11 1.42	21.8 1.58	22.4 1.74	23.0 1.90	23.8 2.08	24.4 2.25	25.0 2.43				13.7
19.4 1.32	20.0 1.46	20.8 1.61	21.4 1.76	21.11 1.92	22.6 2.08	23.2 2.25	23.8 2.42	24.3 2.60		16.0
17.8 1.20	18.3 1.33	18.11 1.47	19.6 1.61	20.0 1.75	20.7 1.90	21.1 2.05	21.8 2.21	22.2 2.37		19.2
15.10 1.08	16.4 1.19	16.11 1.31	17.5 1.44	17.11 1.57	18.5 1.70	18.11 1.84	19.4 1.98	19.10 2.12	20.8 2.41	24.0
27.2 1.52	28.2 1.69	29.1 1.86	29.11 2.04	30.10 2.22	31.8 2.41	32.6 2.60				12.0
25.5 1.42	26.4 1.58	27.2 1.74	28.0 1.90	28.10 2.08	29.7 2.25	30.5 2.43				13.7
23.6 1.32	24.4 1.46	25.2 1.61	25.11 1.76	26.8 1.92	27.5 2.08	28.2 2.25	28.10 2.42	29.6 2.60		16.0
21.6 1.20	22.3 1.33	23.0 1.47	23.8 1.61	24.4 1.75	25.0 1.90	25.8 2.05	26.4 2.21	26.11 2.37		19.2
19.3 1.08	19.11 1.19	20.6 1.31	21.2 1.44	21.9 1.57	22.5 1.70	23.0 1.84	23.6 1.98	24.1 2.12	25.2 2.41	24.0

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-9
FLAT OR LOW SLOPE RAFTERS
No Ceiling Load
Slope 3 in 12 or less
Live Load - 40 lb. per sq. ft.
Use in Zone 1

DESIGN CRITERIA:
Strength - 10 lbs. per sq. ft. dead load plus 40
lbs. per sq. ft. live load determines required
fiber stress.
Deflection - For 40 lbs. per sq. ft. live load.
Limited to span in inches divided by 240.

RAFTER SIZE SPACING (IN)	Extreme Fiber Stress in Bending, "F _b " (psi).											
	300	400	500	600	700	800	900	1000	1100	1200	1300	
12.0	5-6	6-4	7-1	7-9	8-5	9-0	9-6	10-0	10-6	11-0	11-5	
	0.14	0.22	0.31	0.41	0.51	0.63	0.75	0.88	1.01	1.15	1.30	
	13.7	5-2	5-11	6-8	7-3	7-10	8-5	9-11	9-5	10-3	10-9	
	0.13	0.21	0.29	0.38	0.48	0.59	0.70	0.82	0.95	1.08	1.22	
2x6	16.0	4-9	5-6	6-2	6-9	7-3	7-9	8-3	8-8	9-1	9-6	
		0.12	0.19	0.27	0.35	0.44	0.54	0.65	0.76	0.88	1.00	
	19.2	4-4	5-0	5-7	6-2	6-8	7-1	7-6	7-11	8-4	8-8	
		0.11	0.18	0.24	0.32	0.41	0.50	0.59	0.69	0.80	0.91	
2x8	24.0	3-11	4-6	5-0	5-6	5-11	6-4	6-9	7-1	7-5	7-9	
		0.10	0.16	0.22	0.29	0.36	0.44	0.53	0.62	0.71	0.81	
	12.0	7-3	8-4	9-4	10-3	11-1	11-10	12-7	13-3	13-11	14-6	
		0.14	0.22	0.31	0.41	0.51	0.63	0.75	0.88	1.01	1.15	
2x8	13.7	6-9	7-10	8-9	9-7	10-4	11-1	11-9	12-5	13-0	13-7	
		0.13	0.21	0.29	0.38	0.48	0.59	0.70	0.82	0.95	1.08	
	16.0	6-3	7-3	8-1	8-11	9-7	10-3	10-11	11-6	12-0	12-7	
		0.12	0.19	0.27	0.35	0.44	0.54	0.65	0.76	0.88	1.00	
2x8	19.2	5-9	6-7	7-5	8-1	8-9	9-4	9-11	10-6	11-0	11-6	
		0.11	0.18	0.24	0.32	0.41	0.50	0.59	0.69	0.80	0.91	
	24.0	5-2	5-11	6-7	7-3	7-10	8-4	8-11	9-4	9-10	10-3	
		0.10	0.16	0.22	0.29	0.36	0.44	0.53	0.62	0.71	0.81	

12.0	9-3	10-8	11-11	13-1	14-2	15-1	16-0	16-11	17-9	18-6	19-3	
	0.14	0.22	0.31	0.41	0.51	0.63	0.75	0.88	1.01	1.15	1.30	
	13.7	8-8	10-0	11-2	12-3	13-3	14-2	15-0	15-10	16-7	17-4	
		0.13	0.21	0.29	0.38	0.48	0.59	0.70	0.82	0.95	1.08	
2x10	16.0	8-0	9-3	10-4	11-4	12-3	13-1	13-11	14-8	15-4	16-0	
		0.12	0.19	0.27	0.35	0.44	0.54	0.65	0.76	0.88	1.00	
	19.2	7-4	8-5	9-5	10-4	11-2	11-11	12-8	13-4	14-0	14-8	
		0.11	0.18	0.24	0.32	0.41	0.50	0.59	0.69	0.80	0.91	
2x10	24.0	6-6	7-7	8-5	9-3	10-0	10-8	11-4	11-11	12-6	13-1	
		0.10	0.16	0.22	0.29	0.36	0.44	0.53	0.62	0.71	0.81	
	12.0	11-3	13-0	14-6	15-11	17-2	18-4	19-6	20-6	21-7	22-6	
		0.14	0.22	0.31	0.41	0.51	0.63	0.75	0.88	1.01	1.15	
2x12	13.7	10-6	12-2	13-7	14-11	16-1	17-2	18-3	19-3	20-2	21-1	
		0.13	0.21	0.29	0.38	0.48	0.59	0.70	0.82	0.95	1.08	
	16.0	9-9	11-3	12-7	13-9	14-11	15-11	16-11	17-9	18-8	19-6	
		0.12	0.19	0.27	0.35	0.44	0.54	0.65	0.76	0.88	1.00	
2x12	19.2	8-11	10-3	11-6	12-7	13-7	14-6	15-5	16-3	17-0	17-9	
		0.11	0.18	0.24	0.32	0.41	0.50	0.59	0.69	0.80	0.91	
	24.0	7-11	9-2	10-3	11-3	12-2	13-0	13-9	14-6	15-3	15-11	
		0.10	0.16	0.22	0.29	0.36	0.44	0.53	0.62	0.71	0.81	

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-9 (cont.)

RAFTERS: Spans are measured along the horizontal projection and loads are considered as applied on the horizontal projection.

Extreme Fiber Stress in Bending, "F _b " (psi)											RAFTER SPACING SIZE (IN)
1400	1500	1600	1700	1800	1900	2000	2100	2200	2400	2400	
11-11 1.45	12-4 1.61	12-8 1.77	13-1 1.94	13-6 2.12	13-10 2.30	14-2 2.48					12.0
11-1 1.36	11-6 1.51	11-11 1.66	12-3 1.82	12-7 1.98	12-11 2.15	13-3 2.32	13-7 2.49				13.7
10-3 1.26	10-8 1.39	11-0 1.54	11-4 1.68	11-8 1.83	12-0 1.99	12-4 2.15	12-7 2.31	12-11 2.48			16.0
9-5 1.15	9-9 1.27	10-0 1.40	10-4 1.54	10-8 1.67	10-11 1.81	11-3 1.96	11-6 2.11	11-9 2.26	12-4 2.58		19.2
8-5 1.03	8-8 1.14	9-0 1.25	9-3 1.37	9-6 1.50	9-9 1.62	10-0 1.75	10-3 1.89	10-6 2.02	11-0 2.30		24.0
15-8 1.45	16-3 1.61	16-9 1.77	17-3 1.94	17-9 2.12	18-3 2.30	18-9 2.48					12.0
14-8 1.36	15-2 1.51	15-8 1.66	16-2 1.82	16-7 1.98	17-1 2.15	17-6 2.32	17-11 2.49				13.7
13-7 1.26	14-0 1.39	14-6 1.54	14-11 1.68	15-5 1.83	15-10 1.99	16-3 2.15	16-7 2.31	17-0 2.48			16.0
12-5 1.15	12-10 1.27	13-3 1.40	13-8 1.54	14-0 1.67	14-5 1.81	14-10 1.96	15-2 2.11	15-6 2.26	16-3 2.58		19.2
11-1 1.03	11-6 1.14	11-10 1.25	12-2 1.37	12-7 1.50	12-11 1.62	13-3 1.75	13-7 1.89	13-11 2.02	14-6 2.30		24.0

20-0 1.45	20-8 1.61	21-4 1.77	22-0 1.94	22-8 2.12	23-3 2.30	23-11 2.48					12.0
18-8 1.36	19-4 1.51	20-0 1.66	20-7 1.82	21-2 1.98	21-9 2.15	22-4 2.32	22-11 2.49				13.7
17-4 1.26	17-11 1.39	18-6 1.54	19-1 1.68	19-7 1.83	20-2 1.99	20-8 2.15	21-2 2.31	21-8 2.48			16.0
15-10 1.15	16-4 1.27	16-11 1.40	17-5 1.54	17-11 1.67	18-5 1.81	18-11 1.96	19-4 2.11	19-10 2.26	20-8 2.58		19.2
14-2 1.03	14-8 1.14	15-1 1.25	15-7 1.37	16-0 1.50	16-6 1.62	16-11 1.75	17-4 1.89	17-9 2.02	18-6 2.30		24.0
24-4 1.45	25-2 1.61	26-0 1.77	26-9 1.94	27-7 2.12	28-4 2.30	29-1 2.48					12.0
22-9 1.36	23-6 1.51	24-4 1.66	25-1 1.82	25-9 1.98	26-6 2.15	27-2 2.32	27-10 2.49				13.7
21-1 1.26	21-9 1.39	22-6 1.54	23-2 1.68	23-10 1.83	24-6 1.99	25-2 2.15	25-9 2.31	26-5 2.48			16.0
19-3 1.15	19-11 1.27	20-6 1.40	21-2 1.54	21-9 1.67	22-5 1.81	23-0 1.96	23-6 2.11	24-1 2.26	25-2 2.58		19.2
17-2 1.03	17-9 1.14	18-4 1.25	18-11 1.37	19-6 1.50	20-0 1.62	20-6 1.75	21-1 1.89	21-7 2.02	22-6 2.30		24.0

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per inch is shown below each span.

TABLE R-11
MEDIUM OR HIGH SLOPE RAFTERS
No Ceiling Load
Slope over 3 in 12
Live Load - 30 lb. per sq. ft.
(Heavy roof covering)
Use in Zone 2

DESIGN CRITERIA:
Strength - 15 lbs. per sq. ft. dead load plus
30 lbs. per sq. ft. live load determines
required fiber stress.
Deflection - For 30 lbs. per sq. ft. live load.
Limited to span in inches divided by 180.

Extreme Fiber Stress in Bending, "F _b " (psi).												
RAFTER SIZE SPACING (IN)	200	300	400	500	600	700	800	900	1000	1100	1200	1300
2x4	3.0	3.8	4.3	4.9	5.3	5.8	6.0	6.5	6.9	7.1	7.5	7.8
	0.05	0.09	0.15	0.20	0.27	0.34	0.41	0.49	0.58	0.67	0.76	0.86
	2.10	3.5	4.0	4.5	4.11	5.3	5.8	6.0	6.4	6.7	6.11	7.2
	0.05	0.09	0.14	0.19	0.25	0.32	0.39	0.46	0.54	0.62	0.71	0.80
	2.7	3.2	3.8	4.1	4.6	4.11	5.3	5.6	5.10	6.1	6.5	6.8
	0.04	0.08	0.13	0.18	0.23	0.29	0.36	0.43	0.50	0.58	0.66	0.74
19.2	2.5	2.11	3.4	3.9	4.1	4.5	4.9	5.1	5.4	5.7	5.10	6.1
	0.04	0.08	0.12	0.16	0.21	0.27	0.33	0.39	0.46	0.53	0.60	0.68
	2.2	2.7	3.0	3.4	3.8	4.0	4.3	4.6	4.9	5.0	5.3	5.5
	0.04	0.07	0.10	0.14	0.19	0.24	0.29	0.35	0.41	0.47	0.54	0.61
	4.9	5.10	6.8	7.6	8.2	8.10	9.6	10.0	10.7	11.1	11.7	12.1
	0.05	0.09	0.15	0.20	0.27	0.34	0.41	0.49	0.58	0.67	0.76	0.86
2x6	4.5	5.5	6.3	7.0	7.8	8.3	8.10	9.5	9.11	10.5	10.10	11.3
	0.05	0.09	0.14	0.19	0.25	0.32	0.39	0.46	0.54	0.62	0.71	0.80
	4.1	5.0	5.10	6.6	7.1	7.8	8.2	8.8	9.2	9.7	10.0	10.5
	0.04	0.08	0.13	0.18	0.23	0.29	0.36	0.43	0.50	0.58	0.66	0.74
	3.9	4.7	5.4	5.11	6.6	7.0	7.6	7.11	8.4	8.9	9.2	9.6
	0.04	0.08	0.12	0.16	0.21	0.27	0.33	0.39	0.46	0.53	0.60	0.68
24.0	3.4	4.1	4.9	5.4	5.10	6.3	6.8	7.1	7.6	7.10	8.2	8.6
	0.04	0.07	0.10	0.14	0.19	0.24	0.29	0.35	0.41	0.47	0.54	0.61

12.0	6.3	7.8	8.10	9.10	10.10	11.8	12.6	13.3	13.11	14.8	15.3	15.11
	0.05	0.09	0.15	0.20	0.27	0.34	0.41	0.49	0.58	0.67	0.76	0.86
	5.10	7.2	8.3	9.3	10.1	10.11	11.8	12.5	13.1	13.8	14.4	14.11
13.7	0.05	0.09	0.14	0.19	0.25	0.32	0.39	0.46	0.54	0.62	0.71	0.80
	5.5	6.7	7.8	8.7	9.4	10.1	10.10	11.6	12.1	12.8	13.3	13.9
	0.04	0.08	0.13	0.18	0.23	0.29	0.36	0.43	0.50	0.58	0.66	0.74
2x8	4.11	6.1	7.0	7.10	8.7	9.3	9.10	10.6	11.0	11.7	12.1	12.7
	0.04	0.08	0.12	0.16	0.21	0.27	0.33	0.39	0.46	0.53	0.60	0.68
	4.5	5.5	6.3	7.0	7.8	8.3	8.10	9.4	9.10	10.4	10.10	11.3
24.0	0.04	0.07	0.10	0.14	0.19	0.24	0.29	0.35	0.41	0.47	0.54	0.61
	8.0	9.9	11.3	12.7	13.9	14.11	15.11	16.11	17.10	18.8	19.6	20.4
	0.05	0.09	0.15	0.20	0.27	0.34	0.41	0.49	0.58	0.67	0.76	0.86
13.7	7.5	9.1	10.6	11.9	12.11	13.11	14.11	15.10	16.8	17.6	18.3	19.0
	0.05	0.09	0.14	0.19	0.25	0.32	0.39	0.46	0.54	0.62	0.71	0.80
	6.11	8.5	9.9	10.11	11.11	12.11	13.9	14.8	15.5	16.2	16.11	17.7
2x10	0.04	0.08	0.13	0.18	0.23	0.29	0.36	0.43	0.50	0.58	0.66	0.74
	6.4	7.8	8.11	9.11	10.11	11.9	12.7	13.4	14.1	14.9	15.5	16.1
	0.04	0.08	0.12	0.16	0.21	0.27	0.33	0.39	0.46	0.53	0.60	0.68
19.2	5.8	6.11	8.0	8.11	9.9	10.6	11.3	11.11	12.7	13.2	13.9	14.4
	0.04	0.07	0.10	0.14	0.19	0.24	0.29	0.35	0.41	0.47	0.54	0.61

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per inch is shown below each span.

TABLE R-11 (cont.)

RAFTERS: Spans are measured along the horizontal projection and loads are considered as applied on the horizontal projection.

Extreme Fiber Stress in Bending, "F _b " (psi).												RAFTER SPACING SIZE (IN)
1400	1500	1600	1700	1800	1900	2000	2100	2200	2400	2700	3000	
8-0 0.96	8-3 1.06	8-6 1.17	8-9 1.28	9-0 1.39	9-3 1.51	9-6 1.63	9-9 1.76	10-0 1.88	10-5 2.15	11-1 2.56		12.0
7-5 0.89	7-9 0.99	8-0 1.09	8-3 1.20	8-5 1.30	8-8 1.41	8-11 1.53	9-2 1.64	9-4 1.76	9-9 2.01	10-4 2.40		13.7
6-11 0.83	7-2 0.92	7-5 1.01	7-7 1.11	7-10 1.21	8-0 1.31	8-3 1.41	8-5 1.52	8-8 1.63	9-0 1.86	9-7 2.22	10-1 2.60	2x4
6-4 0.76	6-6 0.84	6-9 0.92	6-11 1.01	7-2 1.10	7-4 1.20	7-6 1.29	7-9 1.39	7-11 1.49	8-3 1.70	8-9 2.03	9-3 2.37	19.2
5-8 0.68	5-10 0.75	6-0 0.83	6-3 0.90	6-5 0.99	6-7 1.07	6-9 1.15	6-11 1.24	7-1 1.33	7-5 1.52	7-10 1.81	8-3 2.12	24.0
12-6 0.96	13-0 1.06	13-5 1.17	13-10 1.28	14-2 1.39	14-7 1.51	15-0 1.63	15-4 1.76	15-8 1.88	16-5 2.15	17-5 2.56		12.0
11-9 0.89	12-2 0.99	12-6 1.09	12-11 1.20	13-3 1.30	13-8 1.41	14-0 1.53	14-4 1.64	14-8 1.76	15-4 2.01	16-3 2.40		13.7
10-10 0.83	11-3 0.92	11-7 1.01	11-11 1.11	12-4 1.21	12-8 1.31	13-0 1.41	13-3 1.52	13-7 1.63	14-2 1.86	15-1 2.22	15-11 2.60	2x6
9-11 0.76	10-3 0.84	10-7 0.92	10-11 1.01	11-3 1.10	11-6 1.20	11-10 1.29	12-2 1.39	12-5 1.49	13-0 1.70	13-9 2.03	14-6 2.37	19.2
8-10 0.68	9-2 0.75	9-6 0.83	9-9 0.90	10-0 0.99	10-4 1.07	10-7 1.15	10-10 1.24	11-1 1.33	11-7 1.52	12-4 1.81	13-0 2.12	24.0

16-6 0.96	17-1 1.06	17-8 1.17	18-2 1.28	18-9 1.39	19-3 1.51	19-9 1.63	20-3 1.76	20-8 1.88	21-7 2.15	22-11 2.56	12.0
15-5 0.89	16-0 0.99	16-6 1.09	17-0 1.20	17-6 1.30	18-0 1.41	18-5 1.53	18-11 1.64	19-4 1.76	20-3 2.01	21-5 2.40	13.7
14-4 0.83	14-10 0.92	15-3 1.01	15-9 1.11	16-3 1.21	16-8 1.31	17-1 1.41	17-6 1.52	17-11 1.63	18-9 1.86	19-10 2.22	20-11 2.60
13-1 0.76	13-6 0.84	14-5 0.92	14-10 1.01	14-10 1.10	15-2 1.20	15-7 1.29	16-0 1.39	16-4 1.49	17-1 1.70	18-2 2.03	19-1 2.37
11-8 0.68	12-1 0.75	12-6 0.83	12-10 0.90	13-3 0.99	13-7 1.07	14-4 1.15	14-8 1.24	15-3 1.33	15-8 1.52	16-3 1.81	17-1 2.12
21-1 0.96	21-10 1.06	22-6 1.17	23-3 1.28	23-11 1.39	24-6 1.51	25-2 1.63	25-10 1.76	26-5 1.88	27-7 2.15	29-3 2.56	12.0
19-8 0.89	20-5 0.99	21-1 1.09	21-9 1.20	22-4 1.30	22-11 1.41	23-7 1.53	24-2 1.64	24-8 1.76	25-10 2.01	27-4 2.40	
18-3 0.83	18-11 0.92	19-6 1.01	20-1 1.11	20-8 1.21	21-3 1.31	21-10 1.41	22-4 1.52	22-10 1.63	23-11 1.86	25-4 2.22	26-8 2.60
16-8 0.76	17-3 0.84	17-10 0.92	18-4 1.01	18-11 1.10	19-5 1.20	19-11 1.29	20-5 1.39	20-10 1.49	21-10 1.70	23-2 2.03	24-5 2.37
14-11 0.68	15-5 0.75	15-11 0.83	16-5 0.90	16-11 0.99	17-4 1.07	17-10 1.15	18-3 1.24	18-8 1.33	19-6 1.52	20-8 1.81	21-10 2.12

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-12
MEDIUM OR HIGH SLOPE RAFTERS
No Ceiling Load
Slope over 3 in 12
Live Load - 40 lb. per sq. ft.
(Heavy roof covering)
Use in Zone 1

DESIGN CRITERIA:
Strength - 15 lbs. per sq. ft. dead load plus
40 lbs. per sq. ft. live load determines
required fiber stress.
Deflection - For 40 lbs. per sq. ft. live load.
Limited to span in inches divided by 180.

RAFTER SIZE SPACING (IN)	Extreme Fiber Stress in Bending, "F _b " (psi).											
	200	300	400	500	600	700	800	900	1000	1100	1200	1300
12.0	2.9	3.4	3.10	4.4	4.9	5.1	5.5	5.9	6.1	6.5	6.8	6.11
	0.05	0.09	0.14	0.20	0.26	0.33	0.41	0.49	0.57	0.66	0.75	0.84
	2.7	3.1	3.7	4.0	4.5	4.9	5.1	5.5	5.8	6.0	6.3	6.6
13.7	0.05	0.09	0.13	0.19	0.25	0.31	0.38	0.46	0.53	0.61	0.70	0.79
	2.4	2.11	3.4	3.9	4.1	4.5	4.9	5.0	5.3	5.6	5.9	6.0
	0.04	0.08	0.12	0.17	0.23	0.29	0.35	0.42	0.49	0.57	0.65	0.73
2x4	2.2	2.8	3.1	3.5	3.9	4.0	4.4	4.7	4.10	5.1	5.3	5.6
	0.04	0.07	0.11	0.16	0.21	0.26	0.32	0.38	0.45	0.52	0.59	0.67
	1.11	2.4	2.9	3.1	3.4	3.7	3.10	4.1	4.4	4.6	4.9	4.11
12.0	0.04	0.07	0.10	0.14	0.19	0.24	0.29	0.34	0.40	0.46	0.53	0.60
	4.3	5.3	6.1	6.9	7.5	8.0	8.7	9.1	9.7	10.0	10.6	10.11
	0.05	0.09	0.14	0.20	0.26	0.33	0.41	0.49	0.57	0.66	0.75	0.84
13.7	4.0	4.11	5.8	6.4	6.11	7.6	8.0	8.6	8.11	9.5	9.10	10.3
	0.05	0.09	0.13	0.19	0.25	0.31	0.38	0.46	0.53	0.61	0.70	0.79
	3.8	4.6	5.3	5.10	6.5	6.11	7.5	7.10	8.3	8.8	9.1	9.5
2x6	0.04	0.08	0.12	0.17	0.23	0.29	0.35	0.42	0.49	0.57	0.65	0.73
	3.5	4.2	4.9	5.4	5.10	6.4	6.9	7.2	7.7	7.11	8.3	8.8
	0.04	0.07	0.11	0.16	0.21	0.26	0.32	0.38	0.45	0.52	0.59	0.67
19.2	3.0	3.8	4.3	4.9	5.3	5.8	6.1	6.5	6.9	7.1	7.5	7.9
	0.04	0.07	0.10	0.14	0.19	0.24	0.29	0.34	0.40	0.46	0.53	0.60
	4.3	5.3	6.1	6.9	7.5	8.0	8.7	9.1	9.7	10.0	10.6	10.11
24.0	0.05	0.09	0.14	0.20	0.26	0.33	0.41	0.49	0.57	0.66	0.75	0.84
	4.0	4.11	5.8	6.4	6.11	7.6	8.0	8.6	8.11	9.5	9.10	10.3
	0.05	0.09	0.13	0.19	0.25	0.31	0.38	0.46	0.53	0.61	0.70	0.79
2x8	3.8	4.6	5.3	5.10	6.5	6.11	7.5	7.10	8.3	8.8	9.1	9.5
	0.04	0.08	0.12	0.17	0.23	0.29	0.35	0.42	0.49	0.57	0.65	0.73
	3.5	4.2	4.9	5.4	5.10	6.4	6.9	7.2	7.7	7.11	8.3	8.8
19.2	0.04	0.07	0.11	0.16	0.21	0.26	0.32	0.38	0.45	0.52	0.59	0.67
	3.0	3.8	4.3	4.9	5.3	5.8	6.1	6.5	6.9	7.1	7.5	7.9
	0.04	0.07	0.10	0.14	0.19	0.24	0.29	0.34	0.40	0.46	0.53	0.60

12.0	5.8	6.11	8.0	8.11	9.9	10.7	11.3	12.0	12.7	13.3	13.10	14.5
	0.05	0.09	0.14	0.20	0.26	0.33	0.41	0.49	0.57	0.66	0.75	0.84
	5.3	6.6	7.6	8.4	9.2	9.11	10.7	11.2	11.10	12.5	12.11	13.6
13.7	0.05	0.09	0.13	0.19	0.25	0.31	0.38	0.46	0.53	0.61	0.70	0.79
	4.11	6.0	6.11	7.9	8.6	9.2	9.9	10.4	10.11	11.6	12.0	12.6
	0.04	0.08	0.12	0.17	0.23	0.29	0.35	0.42	0.49	0.57	0.65	0.73
2x8	4.6	5.6	6.4	7.1	7.9	8.4	8.11	9.6	10.0	10.6	10.11	11.5
	0.04	0.07	0.11	0.16	0.21	0.26	0.32	0.38	0.45	0.52	0.59	0.67
	4.0	4.11	5.8	6.4	6.11	7.6	8.0	8.6	8.11	9.4	9.9	10.2
24.0	0.04	0.07	0.10	0.14	0.19	0.24	0.29	0.34	0.40	0.46	0.53	0.60
	7.2	8.10	10.2	11.5	12.6	13.6	14.5	15.3	16.1	16.11	17.8	18.4
	0.05	0.09	0.14	0.20	0.26	0.33	0.41	0.49	0.57	0.66	0.75	0.84
13.7	6.9	8.3	9.6	10.8	11.8	12.7	13.6	14.3	15.1	15.10	16.6	17.2
	0.05	0.09	0.13	0.19	0.25	0.31	0.38	0.46	0.53	0.61	0.70	0.79
	6.3	7.8	8.10	9.10	10.10	11.8	12.6	13.3	13.11	14.8	15.3	15.11
2x10	0.04	0.08	0.12	0.17	0.23	0.29	0.35	0.42	0.49	0.57	0.65	0.73
	5.8	7.0	8.1	9.0	9.10	10.8	11.5	12.1	12.9	13.4	13.11	14.6
	0.04	0.07	0.11	0.16	0.21	0.26	0.32	0.38	0.45	0.52	0.59	0.67
24.0	5.1	6.3	7.2	8.1	8.10	9.6	10.2	10.10	11.5	11.11	12.6	13.0
	0.04	0.07	0.10	0.14	0.19	0.24	0.29	0.34	0.40	0.46	0.53	0.60
	4.3	5.3	6.1	6.9	7.5	8.0	8.7	9.1	9.7	10.0	10.6	10.11

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-12 (cont.)

RAFTERS: Spans are measured along the horizontal projection and loads are considered as applied on the horizontal projection.

Extreme Fiber Stress in Bending, "F _b " (psi).												RAFTER SPACING SIZE (IN)
1400	1500	1600	1700	1800	1900	2000	2100	2200	2400	2700	3000	
7-3 0.94	7-6 1.05	7-8 1.15	7-11 1.26	8-2 1.38	8-5 1.49	8-7 1.61	8-10 1.73	9-0 1.86	9-5 2.12	10-0 2.53		12.0
6-9 0.88	7-0 0.98	7-3 1.08	7-5 1.18	7-8 1.29	7-10 1.40	8-1 1.51	8-3 1.62	8-5 1.74	8-10 1.98	9-4 2.36		13.7
6-3 0.82	6-6 0.91	6-8 1.00	6-11 1.09	7-1 1.19	7-3 1.29	7-6 1.40	7-8 1.50	7-10 1.61	8-2 1.83	8-8 2.19	9-2 2.56	2x4
5-8 0.75	5-11 0.83	6-1 0.91	6-3 1.00	6-6 1.09	6-8 1.18	6-10 1.27	7-0 1.37	7-2 1.47	7-6 1.71	7-11 2.00	8-4 2.34	19.2
5-1 0.67	5-3 0.74	5-5 0.82	5-7 0.89	5-9 0.97	5-11 1.06	6-1 1.14	6-3 1.23	6-5 1.31	6-8 1.50	7-1 1.79	7-6 2.09	24.0
11-4 0.94	11-9 1.05	12-1 1.15	12-6 1.26	12-10 1.38	13-2 1.49	13-6 1.61	13-10 1.73	14-2 1.86	14-10 2.12	15-9 2.53		12.0
10-7 0.88	11-0 0.98	11-4 1.08	11-8 1.18	12-0 1.29	12-4 1.40	12-8 1.51	13-0 1.62	13-3 1.74	13-10 1.98	14-9 2.36		13.7
9-10 0.82	10-2 0.91	10-6 1.00	10-10 1.09	11-1 1.19	11-5 1.29	11-9 1.40	12-0 1.50	12-4 1.61	12-10 1.83	13-7 2.19	14-4 2.56	2x6
8-11 0.75	9-3 0.83	9-7 0.91	9-10 1.00	10-2 1.09	10-5 1.18	10-8 1.27	11-0 1.37	11-3 1.47	11-9 1.71	12-5 2.00	13-1 2.34	19.2
8-0 0.67	8-3 0.74	8-7 0.82	8-10 0.89	9-1 0.97	9-4 1.06	9-7 1.14	9-10 1.23	10-0 1.31	10-6 1.50	11-1 1.79	11-9 2.09	24.0

14-11 0.94	15-5 1.05	16-0 1.15	16-5 1.26	16-11 1.38	17-5 1.49	17-10 1.61	18-3 1.73	18-9 1.86	19-7 2.12	20-9 2.53		12.0
14-0 0.88	14-6 0.98	14-11 1.08	15-5 1.18	15-10 1.29	16-3 1.40	16-8 1.51	17-1 1.62	17-6 1.74	18-3 1.98	19-5 2.36		13.7
12-11 0.82	13-5 0.91	13-10 1.00	14-3 1.09	14-8 1.19	15-1 1.29	15-5 1.40	15-10 1.50	16-3 1.61	16-11 1.83	18-0 2.19	18-11 2.56	2x8
11-10 0.75	12-3 0.83	12-7 0.91	13-0 1.00	13-5 1.09	13-9 1.18	14-1 1.27	14-6 1.37	14-10 1.47	15-5 1.67	16-5 2.00	17-3 2.34	19.2
10-7 0.67	10-11 0.74	11-3 0.82	11-8 0.89	12-0 0.97	12-4 1.06	12-7 1.14	12-11 1.23	13-3 1.31	13-10 1.50	14-8 1.79	15-5 2.09	24.0
19-1 0.94	19-9 1.05	20-4 1.15	21-0 1.26	21-7 1.38	22-2 1.49	22-9 1.61	23-4 1.73	23-11 1.86	24-11 2.12	26-6 2.53		12.0
17-10 0.88	18-5 0.98	19-1 1.08	19-8 1.18	20-2 1.29	20-9 1.40	21-4 1.51	21-10 1.62	22-4 1.74	23-4 1.98	24-9 2.36		13.7
16-6 0.82	17-1 0.91	17-8 1.00	18-2 1.09	18-9 1.19	19-3 1.29	19-9 1.40	20-2 1.50	20-8 1.61	21-7 1.83	22-11 2.19	24-2 2.56	2x10
15-1 0.75	15-7 0.83	16-1 0.91	16-7 1.00	17-1 1.09	17-7 1.18	18-0 1.27	18-5 1.37	18-11 1.47	19-9 1.71	20-11 2.00	22-1 2.34	19.2
13-6 0.67	13-11 0.74	14-5 0.82	14-10 0.89	15-3 0.97	15-8 1.06	16-1 1.14	16-6 1.23	16-11 1.31	17-8 1.50	18-9 1.79	19-9 2.09	24.0

Note: The required modulus of elasticity, "E" in 1,000,000 pounds per square inch is shown below each span.

TABLE R-14
MEDIUM OR HIGH SLOPE RAFTERS

No Ceiling Load
Slope over 3 in 12
Live Load - 30 lb. per sq. ft.
(Light roof covering)
Use in Zone 2

DESIGN CRITERIA:
Strength - 7 lbs. per sq. ft. dead load plus
30 lbs. per sq. ft. live load determines
required fiber stress.
Deflection - For 30 lbs. per sq. ft. live load.
Limited to span in inches divided by 180.

RAFTER SIZE SPACING (IN)	Extreme Fiber Stress in Bending, "F _b " (psi).											
	200	300	400	500	600	700	800	900	1000	1100	1200	1300
12.0	3.4	4.1	4.8	5.3	5.9	6.3	6.8	7.1	7.5	7.9	8.2	8.6
	0.07	0.13	0.20	0.27	0.36	0.45	0.55	0.66	0.77	0.89	1.02	1.15
	3.1	3.10	4.5	4.11	5.5	5.10	6.3	6.7	6.11	7.3	7.7	7.11
	0.06	0.12	0.18	0.26	0.34	0.42	0.52	0.62	0.72	0.84	0.95	1.07
13.7	2.11	3.6	4.1	4.7	5.0	5.5	5.9	6.1	6.5	6.9	7.1	7.4
	0.06	0.11	0.17	0.24	0.31	0.39	0.48	0.57	0.67	0.77	0.88	0.99
	2.8	3.3	3.9	4.2	4.7	4.11	5.3	5.7	5.10	6.2	6.5	6.8
	0.05	0.10	0.15	0.22	0.28	0.36	0.44	0.52	0.61	0.71	0.80	0.91
16.0	2.4	2.11	3.4	3.9	4.1	4.5	4.8	5.0	5.3	5.6	5.9	6.0
	0.05	0.09	0.14	0.19	0.25	0.32	0.39	0.47	0.55	0.63	0.72	0.81
	5.3	6.5	7.5	8.3	9.1	9.9	10.5	11.1	11.8	12.3	12.9	13.4
	0.07	0.13	0.20	0.27	0.36	0.45	0.55	0.66	0.77	0.89	1.02	1.15
19.2	4.11	6.0	6.11	7.9	8.5	9.2	9.9	10.4	10.11	11.5	12.0	12.5
	0.06	0.12	0.18	0.26	0.34	0.42	0.52	0.62	0.72	0.84	0.95	1.07
	4.6	5.6	6.5	7.2	7.10	8.5	9.1	9.7	10.1	10.7	11.1	11.6
	0.06	0.11	0.17	0.24	0.31	0.39	0.48	0.57	0.67	0.77	0.88	0.99
24.0	4.2	5.1	5.10	6.6	7.2	7.9	8.3	8.9	9.3	9.8	10.1	10.6
	0.05	0.10	0.15	0.22	0.28	0.36	0.44	0.52	0.61	0.71	0.80	0.91
	3.8	4.6	5.3	5.10	6.5	6.11	7.5	7.10	8.3	8.8	9.1	9.5
	0.05	0.09	0.14	0.19	0.25	0.32	0.39	0.47	0.55	0.63	0.72	0.81

12.0	6.11	8.5	9.9	10.11	11.11	12.10	13.9	14.7	15.5	16.2	16.10	17.7
	0.07	0.13	0.20	0.27	0.36	0.45	0.55	0.66	0.77	0.89	1.02	1.15
	6.5	7.11	9.1	10.2	11.2	12.1	12.10	13.8	14.5	15.1	15.9	16.5
	0.06	0.12	0.18	0.26	0.34	0.42	0.52	0.62	0.72	0.84	0.95	1.07
13.7	6.0	7.4	8.5	9.5	10.4	11.2	11.11	12.8	13.4	14.0	14.7	15.2
	0.06	0.11	0.17	0.24	0.31	0.39	0.48	0.57	0.67	0.77	0.88	0.99
	5.5	6.8	7.8	8.7	9.5	10.2	10.11	11.6	12.2	12.9	13.4	13.10
	0.05	0.10	0.15	0.22	0.28	0.36	0.44	0.52	0.61	0.71	0.80	0.91
16.0	4.10	6.0	6.11	7.8	8.5	9.1	9.9	10.4	10.11	11.5	11.11	12.5
	0.05	0.09	0.14	0.19	0.25	0.32	0.39	0.47	0.55	0.63	0.72	0.81
	8.9	10.9	12.5	13.11	15.2	16.5	17.7	18.7	19.8	20.7	21.6	22.5
	0.07	0.13	0.20	0.27	0.36	0.45	0.55	0.66	0.77	0.89	1.02	1.15
19.2	8.3	10.1	11.7	13.0	14.3	15.4	16.5	17.5	18.4	19.3	20.1	20.11
	0.06	0.12	0.18	0.26	0.34	0.42	0.52	0.62	0.72	0.84	0.95	1.07
	7.7	9.4	10.9	12.0	13.2	14.3	15.2	16.2	17.0	17.10	18.7	19.5
	0.07	0.12	0.19	0.26	0.34	0.43	0.53	0.63	0.74	0.85	0.97	1.09
24.0	6.11	8.6	9.10	11.0	12.0	13.0	13.11	14.9	15.6	16.3	17.0	17.8
	0.05	0.10	0.15	0.22	0.28	0.36	0.44	0.52	0.61	0.71	0.80	0.91
	6.2	7.7	8.9	9.10	10.9	11.7	12.5	13.2	13.11	14.7	15.2	15.10
	0.05	0.09	0.14	0.19	0.25	0.32	0.39	0.47	0.55	0.63	0.72	0.81

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-14 (cont.)

RAFTERS: Spans are measured along the horizontal projection and loads are considered as applied on the horizontal projection.

Extreme Fiber Stress in Bending, "F _b " (psi)												RAFTER SPACING SIZE (IN)
1400	1500	1600	1700	1800	1900	2000	2100	2200	2400	2700		
8.9	9.1	9.5	9.8	10.0	10.3	10.6	10.9	11.0				12.0
1.28	1.42	1.57	1.72	1.87	2.03	2.19	2.36	2.53				
8.3	8.6	8.9	9.1	9.4	9.7	9.10	10.1	10.4				
1.20	1.33	1.47	1.61	1.75	1.90	2.05	2.20	2.36				13.7
7.7	7.11	8.2	8.5	8.8	8.10	9.1	9.4	9.7	10.0			
1.11	1.23	1.36	1.49	1.62	1.76	1.90	2.04	2.19	2.49			
6.11	7.2	7.5	7.8	7.11	8.1	8.4	8.6	8.9	9.1			16.0
1.01	1.12	1.24	1.36	1.48	1.60	1.73	1.86	2.00	2.28			
6.3	6.5	6.8	6.10	7.1	7.3	7.5	7.7	7.9	8.2	8.8		
0.91	1.01	1.11	1.21	1.32	1.43	1.55	1.67	1.79	2.04	2.43		24.0
13.10	14.4	14.9	15.3	15.8	16.1	16.6	16.11	17.4				
1.28	1.42	1.57	1.72	1.87	2.03	2.19	2.36	2.53				
12.11	13.4	13.10	14.3	14.8	15.1	15.5	15.10	16.2				13.7
1.20	1.33	1.47	1.61	1.75	1.90	2.05	2.20	2.36				
12.0	12.5	12.9	13.2	13.7	13.11	14.4	14.8	15.0	15.8			
1.11	1.23	1.36	1.49	1.62	1.76	1.90	2.04	2.19	2.49			16.0
10.11	11.4	11.8	12.0	12.5	12.9	13.1	13.4	13.8	14.4			
1.01	1.12	1.24	1.36	1.48	1.60	1.73	1.86	2.00	2.28			
9.9	10.1	10.5	10.9	11.1	11.5	11.8	12.0	12.3	12.9	13.7		24.0
0.91	1.01	1.11	1.21	1.32	1.43	1.55	1.67	1.79	2.04	2.43		

18.2	18.10	19.6	20.1	20.8	21.3	21.9	22.4	22.10				12.0
1.28	1.42	1.57	1.72	1.87	2.03	2.19	2.36	2.53				
17.0	17.8	18.2	18.9	19.4	19.10	20.4	20.10	21.4				13.7
1.20	1.33	1.47	1.61	1.75	1.90	2.05	2.20	2.36				
15.9	16.4	16.10	17.4	17.11	18.4	18.10	19.4	19.9	20.8			
	1.11	1.23	1.36	1.49	1.62	1.76	1.90	2.04	2.19	2.49		16.0
14.5	14.11	15.5	15.10	16.4	16.9	17.2	17.8	18.1	18.10			
1.01	1.12	1.24	1.36	1.48	1.60	1.73	1.86	2.00	2.28			
12.10	13.4	13.9	14.2	14.7	15.0	15.5	15.9	16.2	16.10	17.11		24.0
0.91	1.01	1.11	1.21	1.32	1.43	1.55	1.67	1.79	2.04	2.43		
23.3	24.1	24.10	25.7	26.4	27.1	27.9	28.5	29.1				
1.28	1.42	1.57	1.72	1.87	2.03	2.19	2.36	2.53				12.0
21.9	22.6	23.3	23.11	24.8	25.4	26.0	26.7	27.3				
1.20	1.33	1.47	1.61	1.75	1.90	2.05	2.20	2.36				
20.1	20.10	21.6	22.2	22.10	23.5	24.1	24.8	25.3				16.0
1.22	1.35	1.49	1.63	1.78	1.93	2.08	2.24	2.40				
18.4	19.0	19.8	20.3	20.10	21.5	21.11	22.6	23.0	24.1			
1.01	1.12	1.24	1.36	1.48	1.60	1.73	1.86	2.00	2.28			19.2
16.5	17.0	17.7	18.1	18.7	19.2	19.8	20.1	20.7	21.6	22.10		
0.91	1.01	1.11	1.21	1.32	1.43	1.55	1.67	1.79	2.04	2.43		

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-15
MEDIUM OR HIGH SLOPE RAFTERS
No Ceiling Load
Slope over 3 in 12
Live Load - 40 lbs. per sq. ft.
(Light roof covering)
Use in Zone I

DESIGN CRITERIA:
Strength - 7 lbs. per sq. ft. dead load plus
40 lbs. per sq. ft. live load determines
required fiber stress.
Deflection - For 40 lbs. per sq. ft. live load.
Limited to span in inches divided by 180.

RAFTER SIZE SPACING (IN)	Extreme Fiber Stress in Bending, "F _b " (psi).											
	200	300	400	500	600	700	800	900	1000	1100	1200	1300
12.0	2-11 0.06	3-7 0.12	4-2 0.18	4-8 0.25	5-1 0.34	5-6 0.42	5-11 0.52	6-3 0.62	6-7 0.72	6-11 0.83	7-3 0.95	7-6 1.07
	2-9 0.06	3-5 0.11	3-11 0.17	4-4 0.24	4-9 0.31	5-2 0.40	5-6 0.48	5-10 0.58	6-2 0.67	6-6 0.78	6-9 0.89	7-0 1.00
	2-7 0.06	3-2 0.10	3-7 0.16	4-0 0.22	4-5 0.29	4-9 0.37	5-1 0.45	5-5 0.53	5-8 0.62	6-0 0.72	6-3 0.82	6-6 0.93
13.7	2-4 0.05	2-10 0.09	3-4 0.14	3-8 0.20	4-0 0.26	4-4 0.33	4-8 0.41	4-11 0.49	5-3 0.57	5-6 0.66	5-8 0.75	5-11 0.85
	2-1 0.05	2-7 0.08	2-11 0.13	3-4 0.18	3-7 0.24	3-11 0.30	4-2 0.36	4-5 0.44	4-8 0.51	4-11 0.59	5-1 0.67	5-4 0.76
	12.0 0.06	4-8 0.12	6-7 0.18	7-4 0.25	8-0 0.34	8-8 0.42	9-3 0.52	9-10 0.62	10-4 0.72	10-10 0.83	11-4 0.95	11-10 1.07
16.0	4-4 0.06	5-4 0.11	6-2 0.17	6-10 0.24	7-6 0.31	8-1 0.40	8-8 0.48	9-2 0.58	9-8 0.67	10-2 0.78	10-7 0.89	11-1 1.00
	4-0 0.06	4-11 0.10	5-8 0.16	6-4 0.22	6-11 0.29	7-6 0.37	8-0 0.45	8-6 0.53	9-0 0.62	9-5 0.72	9-10 0.82	10-3 0.93
	3-8 0.05	4-6 0.09	5-2 0.14	5-9 0.20	6-4 0.26	6-10 0.33	7-4 0.41	7-9 0.49	8-2 0.57	8-7 0.66	9-0 0.75	9-4 0.85
19.2	3-3 0.05	4-0 0.08	4-8 0.13	5-2 0.18	5-8 0.24	6-2 0.30	6-7 0.36	6-11 0.44	7-4 0.51	7-8 0.59	8-0 0.67	8-4 0.76
	24.0 0.05											

2x8	12.0	6-1	7-6	8-8	9-8	10-7	11-5	12-3	12-11	13-8	14-4	14-11	15-7
		0.06	0.12	0.18	0.25	0.34	0.42	0.52	0.62	0.72	0.83	0.95	1.07
	13.7	5-9	7-0	8-1	9-0	9-11	10-8	11-5	12-1	12-9	13-5	14-0	14-7
		0.06	0.11	0.17	0.24	0.31	0.40	0.48	0.58	0.67	0.78	0.89	1.00
	16.0	5-3	6-6	7-6	8-4	9-2	9-11	10-7	11-3	11-10	12-5	12-11	13-6
		0.06	0.10	0.16	0.22	0.29	0.37	0.45	0.53	0.62	0.72	0.82	0.93
	19.2	4-10	5-11	6-10	7-8	8-4	9-0	9-8	10-3	10-10	11-4	11-10	12-4
		0.05	0.09	0.14	0.20	0.26	0.33	0.41	0.49	0.57	0.66	0.75	0.85
	24.0	4-4	5-3	6-1	6-10	7-6	8-1	8-8	9-2	9-8	10-2	10-7	11-0
		0.05	0.08	0.13	0.18	0.24	0.30	0.36	0.44	0.51	0.59	0.67	0.76
	12.0	7-9	9-6	11-0	12-4	13-6	14-7	15-7	16-6	17-5	18-3	19-1	19-10
		0.06	0.12	0.18	0.25	0.34	0.42	0.52	0.62	0.72	0.83	0.95	1.07
2x10	13.7	7-3	8-11	10-4	11-6	12-7	13-8	14-7	15-5	16-4	17-1	17-10	18-7
		0.06	0.11	0.17	0.24	0.31	0.40	0.48	0.58	0.67	0.78	0.89	1.00
	16.0	6-9	8-3	9-6	10-8	11-8	12-7	13-6	14-4	15-1	15-10	16-6	17-2
		0.06	0.10	0.16	0.22	0.29	0.37	0.45	0.53	0.62	0.72	0.82	0.93
	19.2	6-2	7-7	8-9	9-9	10-8	11-6	12-4	13-1	13-9	14-5	15-1	15-8
		0.05	0.09	0.14	0.20	0.26	0.33	0.41	0.49	0.57	0.66	0.75	0.85
24.0	5-6	6-9	7-9	8-9	9-6	10-4	11-0	11-8	12-4	12-11	13-6	14-1	14-1
	0.05	0.08	0.13	0.18	0.24	0.30	0.36	0.44	0.51	0.59	0.67	0.76	0.76

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-15 (cont.)

RAFTERS: Spans are measured along the horizontal projection and loads are considered as applied on the horizontal projection.

Extreme Fiber Stress in Bending, "F _b " (psi).											RAFTER SPACING SIZE (IN)
1400	1500	1600	1700	1800	1900	2000	2100	2200	2400	2700	
7-10 1.19	8-1 1.32	8-4 1.46	8-7 1.60	8-10 1.74	9-1 1.89	9-4 2.04	9-7 2.19	9-9 2.35			12.0
7-4 1.12	7-7 1.24	7-10 1.37	8-0 1.50	8-3 1.63	8-6 1.77	8-9 1.91	8-11 2.05	9-2 2.20	9-7 2.51		13.7
6-9 1.03	7-0 1.15	7-3 1.26	7-5 1.38	7-8 1.51	7-10 1.64	8-1 1.77	8-3 1.90	8-6 2.04	8-10 2.32		16.0 2x4
6-2 0.94	6-5 1.05	6-7 1.15	6-10 1.26	7-0 1.38	7-2 1.49	7-4 1.61	7-7 1.74	7-9 1.86	8-1 2.12	8-7 2.53	19.2
5-6 0.84	5-8 0.94	5-11 1.03	6-1 1.13	6-3 1.23	6-5 1.34	6-7 1.44	6-9 1.55	6-11 1.66	7-3 1.90	7-8 2.26	24.0
12-3 1.19	12-8 1.32	13-1 1.46	13-6 1.60	13-11 1.74	14-3 1.89	14-8 2.04	15-0 2.19	15-4 2.35			12.0
11-6 1.12	11-10 1.24	12-3 1.37	12-8 1.50	13-0 1.63	13-4 1.77	13-8 1.91	14-0 2.05	14-4 2.20	15-0 2.51		13.7
10-7 1.03	11-0 1.15	11-4 1.26	11-8 1.38	12-0 1.51	12-4 1.64	12-8 1.77	13-0 1.90	13-4 2.04	13-11 2.32		16.0 2x6
9-8 0.94	10-0 1.05	10-4 1.15	10-8 1.26	11-0 1.38	11-3 1.49	11-7 1.61	11-10 1.74	12-2 1.86	12-8 2.12	13-5 2.53	19.2
8-8 0.84	9-0 0.94	9-3 1.03	9-7 1.13	9-10 1.23	10-1 1.34	10-4 1.44	10-7 1.55	10-10 1.66	11-4 1.90	12-0 2.26	24.0

16-2 1.19	16-9 1.32	17-3 1.46	17-10 1.60	18-4 1.74	18-10 1.89	19-4 2.04	19-9 2.19	20-3 2.35			12.0
15-1 1.12	15-8 1.24	16-2 1.37	16-8 1.50	17-2 1.63	17-7 1.77	18-1 1.91	18-6 2.05	18-11 2.20	19-9 2.51		13.7
14-0 1.03	14-6 1.15	14-11 1.26	15-5 1.38	15-10 1.51	16-4 1.64	16-9 1.77	17-2 1.90	17-6 2.04	18-4 2.32		16.0 2x8
12-9 0.94	13-3 1.05	13-8 1.15	14-1 1.26	14-6 1.38	14-11 1.49	15-3 1.61	15-8 1.74	16-0 1.86	16-9 2.12	17-9 2.53	19.2
11-5 0.84	11-10 0.94	12-3 1.03	12-7 1.13	12-11 1.23	13-4 1.34	13-8 1.44	14-0 1.55	14-4 1.66	14-11 1.90	15-10 2.26	24.0
20-7 1.19	21-4 1.32	22-0 1.46	22-9 1.60	23-4 1.74	24-0 1.89	24-8 2.04	25-3 2.19	25-10 2.35			12.0
19-3 1.12	19-11 1.24	20-7 1.37	21-3 1.50	21-10 1.63	22-6 1.77	23-1 1.91	23-7 2.05	24-2 2.20	25-3 2.51		13.7
17-10 1.03	18-6 1.15	19-1 1.26	19-8 1.38	20-3 1.51	20-10 1.64	21-4 1.77	21-10 1.90	22-4 2.04	23-4 2.32		16.0 2x10
16-4 0.94	16-10 1.05	17-5 1.15	17-11 1.26	18-6 1.38	19-0 1.49	19-6 1.61	19-11 1.74	20-5 1.86	21-4 2.12	22-8 2.53	19.2
14-7 0.84	15-1 0.94	15-7 1.03	16-1 1.13	16-6 1.23	17-0 1.34	17-5 1.44	17-10 1.55	18-3 1.66	19-1 1.90	20-3 2.26	24.0

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE TSJ-1
TWO-SPAN FLOOR JOISTS
40 Lbs. Per Sq. Ft. Live Load
(All rooms except those used for sleeping areas and attic floors)

DESIGN CRITERIA:
Deflection - For 40 lbs. per sq. ft. live load on one span and 20 lbs. per sq. ft. on other.
Limited to span in inches divided by 360.
Strength - Live load of 40 lbs. per sq. ft. plus dead load of 10 lbs. per sq. ft. on both spans determines the required fiber stress value.

JOIST SIZE SPACING (IN)	Modulus of Elasticity, "E", in 1,000,000 psi															
	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4	2.6
2x6	12.0	10.3	10.8	11.1	11.5	11.9	12.1	12.5	12.8	13.0	13.3	13.6	14.0	14.2	14.5	14.8
	13.7	9.10	10.3	10.7	10.11	11.3	11.7	11.10	12.2	12.5	12.8	12.11	13.1	13.4	13.9	14.0
	16.0	9.4	9.9	10.1	10.5	10.8	11.0	11.3	11.6	11.9	12.0	12.3	12.6	12.8	13.2	13.4
	19.2	8.9	9.2	9.6	9.9	10.1	10.4	10.7	11.0	11.1	11.4	11.6	11.9	12.2	12.4	12.6
	24.0	8.2	8.6	8.9	9.1	9.4	9.7	9.10	10.1	10.3	10.6	10.8	11.1	11.3	11.5	11.7
2x8	12.0	10.6	11.50	12.30	13.10	13.90	14.60	15.40	16.9	17.1	17.5	17.9	18.1	18.5	18.9	19.0
	13.7	11.10	12.00	12.90	13.70	14.50	15.30	16.10	16.80	17.70	18.50	19.00	19.70	20.40	21.10	21.40
	16.0	11.7	12.10	13.3	13.8	14.1	14.6	15.2	15.6	16.4	16.8	17.0	17.4	17.7	18.2	18.6
	19.2	11.7	12.1	12.6	12.11	13.3	13.8	14.0	15.2	15.6	16.2	16.5	16.9	17.0	17.3	17.6
	24.0	10.9	11.2	11.7	12.0	12.4	12.8	13.0	13.3	13.7	14.1	14.4	14.7	15.1	15.4	15.7

2x10	12.0	17.4	18.0	18.8	19.3	19.10	20.4	20.10	21.4	21.10	22.3	22.8	23.1	23.6	23.11	24.3	24.8
	13.7	16.7	17.3	17.10	18.5	19.0	19.6	20.0	20.5	20.10	21.4	21.9	22.1	22.6	22.10	23.3	23.7
	16.0	15.9	16.4	16.11	17.6	18.0	18.6	19.0	19.5	19.10	20.3	20.7	21.0	21.4	21.9	22.1	22.5
	19.2	14.10	15.5	15.11	16.6	16.11	17.5	17.10	18.3	18.8	19.0	19.5	19.9	20.1	20.5	20.9	21.1
	24.0	13.9	14.3	14.9	15.3	15.9	16.2	16.7	16.11	17.4	17.8	18.0	18.4	18.8	19.0	19.3	19.7
2x12	12.0	21.1	21.11	22.8	23.5	24.1	24.9	25.5	26.0	26.7	27.1	27.7	28.1	28.7	29.1	29.6	30.0
	13.7	20.2	20.11	21.8	22.5	23.1	23.8	24.2	24.10	25.5	25.11	26.5	26.11	27.4	27.9	28.3	28.8
	16.0	19.2	19.11	20.7	21.3	21.11	22.6	23.1	23.7	24.1	24.7	25.1	25.7	26.0	26.5	26.10	27.3
	19.2	18.0	18.9	19.5	20.0	20.7	21.2	21.8	22.3	22.8	23.2	23.7	24.0	24.5	24.10	25.3	25.7
	24.0	16.9	17.5	18.0	18.7	19.2	19.8	20.2	20.8	21.1	21.6	21.11	22.4	22.8	23.1	23.5	23.9

Note: The required extreme fiber stress in bending, "F_b", in pounds per square inch is shown below each span.

TABLE TSJ-2
TWO-SPAN FLOOR JOISTS
30 Lbs. Per Sq. Ft. Live Load
(All rooms used for sleeping and attic floors)

DESIGN CRITERIA:
Deflection - For 30 lbs. per sq. ft. live load on one span and 15 lbs. per sq. ft. on other. Limited to span in inches divided by 360.
Strength - Live load of 30 lbs. per sq. ft. plus dead load of 10 lbs. per sq. ft. on both spans determines the required fiber stress value.

JOIST SIZE SPACING (IN)	Modulus of Elasticity, "E", in 1,000,000 psi															
	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4	2.6
2x6	11.4	11.9	12.2	12.7	13.0	13.4	13.8	14.0	14.3	14.7	14.10	15.1	15.5	15.8	15.10	16.1
	12.0	1030	1110	1190	1270	1340	1420	1490	1560	1630	1700	1830	1890	1950	2010	2070
	13.7	1070	1160	1250	1330	1410	1480	1560	1630	1700	1770	1910	1970	2040	2100	2170
	16.0	1130	1220	1310	1400	1480	1560	1640	1720	1790	1870	2010	2080	2150	2210	2280
	19.2	1200	1300	1390	1480	1570	1660	1740	1820	1900	1980	2130	2210	2280	2350	2420
2x8	14.11	15.6	16.1	16.7	17.1	17.7	18.0	18.5	18.10	19.2	19.7	20.3	20.7	20.7	20.11	21.3
	12.0	1030	1110	1190	1270	1350	1420	1490	1560	1630	1700	1830	1890	1950	2010	2070
	13.7	1080	1160	1250	1330	1410	1480	1560	1630	1700	1770	1910	1980	2040	2100	2170
	16.0	1130	1220	1310	1400	1480	1560	1640	1720	1790	1870	2010	2080	2150	2220	2280
	19.2	1200	1300	1390	1480	1570	1660	1740	1830	1910	1980	2140	2210	2280	2350	2430
24.0	1290	1400	1500	1600	1690	1790	1880	1970	2050	2140	2220	2300	2380	2460	2540	2610

2x10	19.1	19.10	20.6	21.2	21.10	22.5	23.0	23.6	24.0	24.6	25.0	25.5	25.11	26.4	26.9	27.1
	1030	1110	1190	1270	1350	1420	1490	1560	1630	1700	1760	1830	1890	1950	2010	2070
	13.7	1080	1160	1250	1330	1410	1480	1560	1630	1700	1770	1840	1910	1980	2040	2110
	16.0	1120	1220	1310	1400	1480	1560	1640	1720	1790	1870	1940	2010	2080	2150	2220
	19.2	1200	1300	1390	1480	1570	1660	1740	1830	1910	1980	2060	2140	2210	2280	2350
2x12	23.2	24.1	25.0	25.10	26.7	27.3	27.11	28.7	29.3	29.10	30.5	30.11	31.6	32.0	32.6	33.0
	1030	1110	1190	1270	1350	1420	1490	1560	1630	1700	1760	1830	1890	1950	2010	2070
	13.7	1080	1160	1250	1330	1410	1480	1560	1630	1700	1770	1840	1910	1980	2040	2110
	16.0	1120	1220	1310	1400	1480	1560	1640	1720	1790	1870	1940	2010	2080	2150	2220
	19.2	1200	1300	1390	1480	1570	1660	1740	1830	1910	1980	2060	2140	2210	2280	2350
24.0	1290	1400	1500	1600	1690	1790	1880	1970	2050	2140	2220	2300	2380	2460	2540	2610

Note: The required extreme fiber stress in bending, "F_b", in pounds per square inch is shown below each span.

DESIGN VALUES FOR JOISTS AND RAFTERS - VISUAL GRADING

These "F_b" values are for use where repetitive members are spaced not more than 24 inches. For wider spacing, the "F_b" values should be reduced 13 percent. Values for surfaced dry or surfaced green lumber apply at 19 percent maximum moisture content in use.

Species and Grade	Size	Design Value in Bending "F _b "		Modulus of Elasticity "E"	Grading Rules Agency
		Joists	Rafters		
BALSAM FIR (Surfaced dry or surfaced green)					
Select Structural		2000	2100	1,500,000	Northeastern Lumber Manufacturers Association
No. 1	2x4	1700	1790	1,500,000	
No. 2		1400	1470	1,300,000	
No. 3		775	810	1,200,000	
Appearance Stud		1700	1790	1,500,000	Northern Hardwood & Pine Manufacturers Association
		775	810	1,200,000	
Construction Standard Utility	2x4	1000	1050	1,200,000	(See notes 1 and 3)
		575	600	1,200,000	
		275	290	1,200,000	
Select Structural No. 1 & Appearance	2x5 and wider	1700	1790	1,500,000	
No. 2		1450	1520	1,500,000	
No. 3		1200	1260	1,300,000	
Stud		700	740	1,200,000	
		700	740	1,200,000	

DOUGLAS FIR - LARCH (Surfaced dry or surfaced green)	Dense Select Structural	2800	2940	1,900,000	Western Wood Products Association (See notes 1 and 3)
Dense Select Structural	Dense No. 1	2400	2520	1,800,000	West Coast Lumber Inspection Bureau
Dense No. 2	No. 2	1950	2050	1,700,000	
No. 3	Stud	925	970	1,500,000	
Construction Standard Utility	2x4	1200	1260	1,500,000	
Dense Select Structural	Dense No. 1	2400	2520	1,900,000	
No. 1 & Appearance	2x5 and wider	1750	1840	1,800,000	
Dense No. 2	No. 2	1700	1790	1,700,000	
No. 3	Stud	850	890	1,500,000	

DESIGN VALUES FOR JOISTS AND RAFTERS - VISUAL GRADING (Cont)

These "F_b" values are for use where repetitive members are spaced not more than 24 inches. For wider spacing, the "F_b" values should be reduced 13 percent. Values for surfaced dry or surfaced green lumber apply at 19 percent maximum moisture content in use.

Species and Grade	Size	Design Value in Bending "F _b "		Modulus of Elasticity "E"	Grading Rules Agency
		Joists	Rafters		
EASTERN HEMLOCK (Surfaced dry or surfaced green)					
Select Structural		2050	2150	1,200,000	Northern Hardwood & Pine Manufacturers Association
No. 1	2x4	1750	1840	1,200,000	
No. 2		1450	1520	1,100,000	
No. 3		800	840	1,000,000	
Appearance		1750	1840	1,200,000	Northeastern Lumber Manufacturers Association
Stud		800	840	1,000,000	
Construction		1050	1100	1,000,000	(See notes 1 and 3)
Standard	2x4	575	600	1,000,000	
Utility		275	290	1,000,000	
Select Structural		1750	1840	1,200,000	(See notes 1 and 3)
No. 1 & Appearance	2x5	1500	1580	1,200,000	
No. 2	and	1250	1310	1,100,000	
No. 3	wider	700	740	1,000,000	
Stud		700	740	1,000,000	

EASTERN SPRUCE (Surfaced dry or surfaced green)					
Select Structural		1600	1680	1,500,000	Northeastern Lumber Manufacturers Association
No. 1	2x4	1350	1420	1,500,000	
No. 2		1100	1160	1,400,000	
No. 3		625	660	1,200,000	
Appearance		1350	1420	1,500,000	Northern Hardwood & Pine Manufacturers Association
Stud		625	660	1,200,000	
Construction		800	840	1,200,000	(See notes 1 and 3)
Standard	2x4	450	470	1,200,000	
Utility		225	240	1,200,000	
Select Structural		1350	1420	1,500,000	(See notes 1 and 3)
No. 1 & Appearance	2x5	1150	1210	1,500,000	
No. 2	and	950	1000	1,400,000	
No. 3	wider	550	580	1,200,000	
Stud		550	580	1,200,000	

DESIGN VALUES FOR JOISTS AND RAFTERS - VISUAL GRADING (Cont)

These "F_b" values are for use where repetitive members are spaced not more than 24 inches. For wider spacing, the "F_b" values should be reduced 13 percent.
Values for surfaced dry or surfaced green lumber apply at 19 percent maximum moisture content in use.

Species and Grade	Size	Design Value in Bending "F _b "		Modulus of Elasticity "E"	Grading Rules Agency
		Joists	Rafters		
EASTERN WHITE PINE (Surfaced dry or surfaced green)					
Select Structural	2x4	1550	1630	1,200,000	Northeastern Lumber Manufacturers Association
No. 1 & Appearance		1350	1420	1,200,000	
No. 2		1100	1160	1,100,000	
No. 3		600	630	1,000,000	
Stud		600	630	1,000,000	
Construction Standard Utility	2x4	800	840	1,000,000	Northern Hardwood & Pine Manufacturers Association
		450	470	1,000,000	
		200	210	1,000,000	
Select Structural	2x5 and wider	1350	1420	1,200,000	(See notes 1 and 3)
No. 1 & Appearance		1150	1210	1,200,000	
No. 2		950	1000	1,100,000	
No. 3		550	580	1,000,000	
Stud		550	580	1,000,000	

EASTERN WHITE PINE (NORTH) (Surfaced dry or surfaced green)				
Select Structural		1550	1630	1,200,000
No. 1 & Appearance		1350	1420	1,200,000
No. 2	2x4	1100	1160	1,100,000
No. 3		600	630	1,000,000
Stud		600	630	1,000,000
Construction		800	840	1,000,000
Standard	2x4	450	470	1,000,000
Utility		200	210	1,000,000
Select Structural	2x5	1350	1420	1,200,000
No. 1 & Appearance	and	1150	1210	1,200,000
No. 2	wider	950	1000	1,100,000
No. 3		550	580	1,000,000
Stud		550	580	1,000,000

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DESIGN VALUES FOR JOISTS AND RAFTERS - VISUAL GRADING (Cont)

These "F_b" values are for use where repetitive members are spaced not more than 24 inches. For wider spacing, the "F_b" values should be reduced 13 percent. Values for surfaced dry or surfaced green lumber apply at 19 percent maximum moisture content in use.

Species and Grade	Size	Design Value in Bending "F _b "		Modulus of Elasticity "E"	Grading Rules Agency
		Joists	Rafters		
HEM - FIR (Surfaced dry or surfaced green)					
Select Structural		1900	2000	1,500,000	
No. 1 & Appearance		1600	1680	1,500,000	
No. 2		1350	1420	1,400,000	
No. 3	2x4	725	760	1,200,000	Western Wood Products Association (See notes 1 and 3)
Stud		725	760	1,200,000	
Construction		975	1020	1,200,000	
Standard	2x4	550	580	1,200,000	
Utility		250	260	1,200,000	
Select Structural		1650	1730	1,500,000	West Coast Lumber Inspection Bureau
No. 1 & Appearance		1400	1470	1,500,000	
No. 2	2x5 and wider	1150	1210	1,400,000	
No. 3		675	710	1,200,000	
Stud		675	710	1,200,000	

NORTHERN PINE (Surfaced dry or surfaced green)				Modulus of Elasticity "E"	Grading Rules Agency
Species and Grade	Size	Joists	Rafters		
Select Structural		1850	1940	1,400,000	
No. 1		1600	1680	1,400,000	
No. 2	2x4	1300	1370	1,300,000	Northeastern Lumber Manufacturers Association
No. 3		725	760	1,100,000	
Appearance		1400	1470	1,400,000	
Stud		725	760	1,100,000	Northern Hardwood & Pine Manufacturers Association
Construction		950	1000	1,100,000	
Standard	2x4	525	550	1,100,000	
Utility		250	260	1,100,000	
Select Structural		1600	1680	1,400,000	(See notes 1 and 3)
No. 1 & Appearance		1400	1470	1,400,000	
No. 2	2x5 and wider	1100	1160	1,300,000	
No. 3		650	680	1,100,000	
Stud		650	680	1,100,000	

DESIGN VALUES FOR JOISTS AND RAFTERS - VISUAL GRADING (Cont)

These "F_b" values are for use where repetitive members are spaced not more than 24 inches. For wider spacing, the "F_b" values should be reduced 13 percent. Values for surfaced dry or surfaced green lumber apply at 19 percent maximum moisture content in use.

Species and Grade	Size	Design Value in Bending "F _b "		Modulus of Elasticity "E"	Grading Rules Agency
		Joists	Rafters		
PONDEROSA PINE - SUGAR PINE (PONDEROSA PINE - LODGEPOLE PINE) (Surfaced dry or surfaced green)					
Select Structural		1650	1730	1,200,000	Western Wood Products Association
No. 1 & Appearance		1400	1470	1,200,000	
No. 2	2x4	1150	1210	1,100,000	
No. 3		625	660	1,000,000	
Stud		625	660	1,000,000	
Construction		825	870	1,000,000	(See notes 1 and 3)
Standard	2x4	450	470	1,000,000	
Utility		225	240	1,000,000	
Select Structural		1400	1470	1,200,000	
No. 1 & Appearance	2x5	1200	1260	1,200,000	
No. 2	and	975	1020	1,100,000	
No. 3	wider	575	600	1,000,000	
Stud		575	600	1,000,000	

SOUTHERN PINE (Surfaced dry) Select Structural Dense Select Structural No. 1 No. 1 Dense No. 2 No. 2 Dense No. 3 No. 3 Dense Stud	2x4	2300	2420	1,700,000	Southern Pine Inspection Bureau (See note 3)
		2700	2840	1,800,000	
		1950	2050	1,700,000	
		2300	2420	1,800,000	
		1650	1730	1,600,000	
Construction Standard Utility	2x4	1150	1210	1,400,000	
		675	710	1,400,000	
		300	320	1,400,000	
		2000	2100	1,700,000	
		2350	2470	1,800,000	
Select Structural Dense Select Structural No. 1 No. 1 Dense No. 2 No. 2 Dense No. 3 No. 3 Dense Stud	2x5 and wider	1400	1470	1,600,000	
		1650	1730	1,600,000	
		800	840	1,400,000	
		925	970	1,500,000	
		850	890	1,400,000	

DESIGN VALUES FOR JOISTS AND RAFTERS - VISUAL GRADING (Cont)

These "F_b" values are for use where repetitive members are spaced not more than 24 inches. For wider spacing, the "F_b" values should be reduced 13 percent. Values for surfaced dry or surfaced green lumber apply at 19 percent maximum moisture content in use.

Species and Grade	Size	Design Value in Bending "F _b "		Modulus of Elasticity "E"	Grading Rules Agency
		Joists	Rafters		
SOUTHERN PINE (Surfaced at 15 percent maximum moisture content-KD)					
Select Structural		2500	2630	1,800,000	
Dense Select Structural		2900	3050	1,900,000	
No. 1		2100	2210	1,800,000	
No. 1 Dense		2450	2570	1,900,000	
No. 2	2x4	1750	1840	1,600,000	
No. 2 Dense		2050	2150	1,700,000	Southern
No. 3		975	1020	1,500,000	Pine
No. 3 Dense		1150	1210	1,500,000	Inspection
Stud		975	1020	1,500,000	Bureau
Construction	2x4	1250	1310	1,500,000	
Standard		725	760	1,500,000	
Utility		300	320	1,500,000	(See note 3)
Select Structural		2150	2260	1,800,000	
Dense Select Structural		2500	2630	1,900,000	
No. 1		1850	1940	1,800,000	
No. 1 Dense	2x5 and wider	2150	2260	1,900,000	
No. 2		1500	1580	1,600,000	
No. 2 Dense		1750	1840	1,700,000	
No. 3		875	920	1,500,000	
No. 3 Dense		1000	1050	1,500,000	
Stud		900	950	1,500,000	

SPRUCE - PINE - FIR (Surfaced dry or surfaced green)					
Select Structural		1650	1730	1,500,000	
No. 1 & Appearance		1400	1470	1,500,000	
No. 2	2x4	1150	1210	1,300,000	
No. 3		650	680	1,200,000	
Stud		650	680	1,200,000	
Construction Standard	2x4	850	890	1,200,000	
Utility		475	500	1,200,000	
		225	240	1,200,000	
Select Structural	2x5 and wider	1450	1520	1,500,000	
No. 1 & Appearance		1200	1260	1,500,000	
No. 2		1000	1050	1,300,000	
No. 3		575	600	1,200,000	
Stud		575	600	1,200,000	

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DESIGN VALUES FOR JOISTS AND RAFTERS - VISUAL GRADING (Cont)

These "F_b" values are for use where repetitive members are spaced not more than 24 inches. For wider spacing, the "F_b" values should be reduced 13 percent. Values for surfaced dry or surfaced green lumber apply at 19 percent maximum moisture content in use.

Species and Grade	Size	Design Value in Bending "F _b "		Modulus of Elasticity "E"	Grading Rules Agency
		Joists	Rafters		
WESTERN HEMLOCK (Surfaced dry or surfaced green)					
Select Structural		2100	2210	1,600,000	Western Wood Products Association (See notes 1 and 3)
No. 1 & Appearance		1800	1890	1,600,000	
No. 2	2x4	1450	1520	1,400,000	
No. 3		800	840	1,300,000	
Stud		800	840	1,300,000	
Construction Standard Utility	2x4	1050 600 275	1100 630 290	1,300,000 1,300,000 1,300,000	West Coast Lumber Inspection Bureau
Select Structural		1800	1890	1,600,000	
No. 1 & Appearance		1550	1630	1,600,000	
No. 2	2x5 and wider	1250	1310	1,400,000	
No. 3		750	790	1,300,000	
Stud		750	790	1,300,000	

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

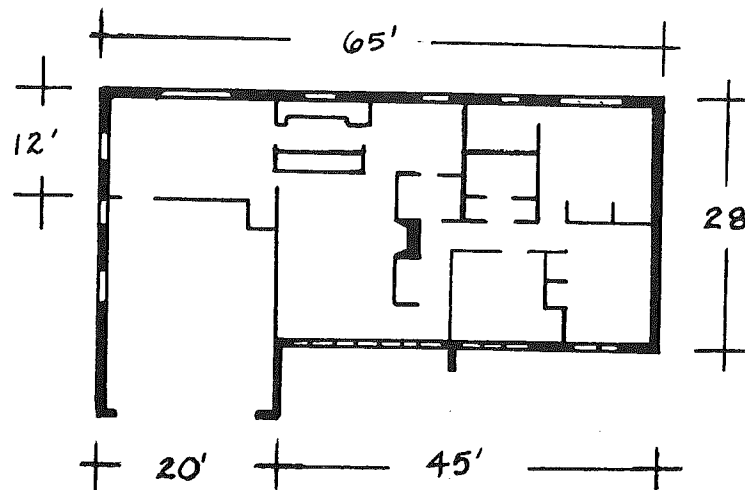
1. When 2-inch lumber is manufactured at a maximum moisture content of 15% (grade-marked MC-15) and used in a condition where the moisture content does not exceed 15%, the design values shown for "surfaced dry or surfaced green" lumber may be increased 8% for design value in bending "F_b", and 5% for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



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

Gross wall area = 8.13' x 186 lineal feet = 1,512.18 square feet
 Opaque wall area = 1,301.69 square feet (20% framing, 80% cavity)
 Box sill area = .81' x 186 lineal feet = 150.66 square feet
 Exposed foundation wall area = 108.97 square feet
 Basement window area = 15.65 square feet
 Insulated window area = 172.67 square feet
 Insulated door area = 37.82 square feet
 Ceiling area = 1,500 square feet (10% framing, 90% cavity)

METHOD I - ACCEPTABLE PRACTICE METHOD

The acceptable practice method outlined below can be used with minimum calculations for determining the acceptable level of insulation.

Problem: Using the acceptable practice method determine the level of insulation required for the 1,500 square foot dwelling in Phase I.

Step 1: Determine the percentage window and door area.

$$\begin{aligned} \text{Percent opening area} &= \frac{\text{Window area} + \text{Door area}}{\text{Gross wall area} + \text{Box sill area}} \times 100\% \\ &= \frac{172.67 \text{ sq. ft.} + 37.82 \text{ sq. ft.}}{1512.18 \text{ sq. ft.} + 150.66 \text{ sq. ft.}} \times 100\% \\ &= \frac{210.49 \text{ sq. ft.}}{1,662.84 \text{ sq. ft.}} \times 100\% = 12.66\% \end{aligned}$$

Step 2: Determine level of insulation required for the box sill and side-walls for the given window and door area from Table A-1. (Phase 1)

Using 5/8 inch plywood siding the table shows that an R-11 batt with R-1.22 fiberboard will allow up to 12.8% window and door area.

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

$$\begin{aligned} \text{Percent opening area} &= \frac{\text{Window area}}{\text{Total exposed foundation area}} \times 100\% \\ &= \frac{15.65 \text{ sq. ft.}}{108.97 \text{ sq. ft.} + 15.65 \text{ sq. ft.}} \times 100\% \\ &= 12.6\% \end{aligned}$$

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

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

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 an 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_o requirements above the foundation wall)

Insulation Type	Percent Window and Door Area					
	Phase I		Phase II (4/1/79)		Phase III (4/1/80)	
	$U_o = .14$		$U_o = .13$		$U_o = .12$	
	% inch Plywood Siding	Backed Aluminum Siding	% inch Plywood Siding	Backed Aluminum Siding	% inch Plywood Siding	Backed Aluminum Siding
R-11 Batt	11.0	12.6	8.9	10.5	6.8	8.4
R-11 Batt, R-1.22 Fiberboard	12.8	14.0	10.8	12.0	8.7	9.9
R-11 Batt, R-5.27 Extruded Polystyrene	16.4	17.0	14.4	15.0	12.4	13.0
R-11 Batt, R-10.54 Extruded Polystyrene	18.8	19.1	16.8	17.2	14.9	15.3
R-13 Batt	12.5	13.9	10.4	11.8	8.3	9.8
R-13 Batt, R-1.22 Fiberboard	14.1	15.4	12.2	13.3	10.3	11.2
R-13 Batt, R-5.27 Extruded Polystyrene	17.0	17.5	15.0	15.6	13.1	13.6
R-13 Batt, R-10.54 Extruded Polystyrene	19.2	19.5	17.3	17.6	15.3	15.6
R-19 Batt	15.3	16.2	13.2	14.2	11.2	12.2
R-19 Batt, R-1.22 Fiberboard	16.4	17.1	14.4	15.1	12.3	13.1
R-19 Batt, R-5.27 Extruded Polystyrene	18.6	19.0	16.7	17.0	14.7	15.1
R-19 Batt, R-10.54 Extruded Polystyrene	20.1	20.4	18.2	18.5	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. Insulated doors are used with a U -value of .47.
3. Insulated windows are used with a U -value of .56.
4. The insulation type is carried down through the box sill.

TABLE A-2
EXPOSED FOUNDATION INSULATION

Foundation exposure	Requirement	Insulation type	Percent window area	
			Single glazed	Double glazed
Less than 25% of foundation exposed	$U_o = .25$	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	$U_o = .14$	R-11 batt	4.9	10.8
		R-13 batt	5.8	12.7
		Multi-cell insul. block (R-12.06)	5.5	12.0
	$U_o = .13$	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
	$U_o = .12$	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

U_o Value	Insulation	R-Value Required	
		In Cavity	Over Framing
.033	Fiber glass batt	R-19 and R-13	R-13
	Fiber glass blown	12 in. (R-30)	6.4 in. (R-16)
	Rock wool	9.7 in. (R-29)	4.2 in. (R-13)
	Cellulose	8.4 in. (R-31)	2.9 in. (R-11)
.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

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 (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 and B.

Inside temperature = 70° F

Outside temperature = -20° F

$\Delta T = T_{\text{inside}} - T_{\text{outside}} = 70 - (-20) = 90^\circ \text{ F}$.

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, 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

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
¾" 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
¾" 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)

Figure A-1

WORKSHEET FOR SYSTEM DESIGN ANALYSIS

CODE REQUIREMENTS				
Component	U_o Req'd.	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	Δ 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 Req'd.	Area	Δ 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	Δ 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 thick- ness listed R-Value
BUILDING	Asbestos-cement board.....	120	0.25	—
BOARD Boards,	Asbestos-cement			
panels,	board ½ in.	120	—	0.03
subflooring,	Asbestos-cement			
sheathing,	board ½ in.	120	—	0.06
woodbased panel	Gypsum or plaster			
products	board ¾ in.	50	—	0.32
	Gypsum or plaster			
	board ½ in.	50	—	0.45
	Plywood.....	34	1.25	—
	Plywood..... ¼ in.	34	—	0.31
	Plywood..... ¾ 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..... ¾ 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	—
	Particleboard			
	Low density.....	37	1.85	—

Material	Description	Density (lb per cu ft)	Per inch thickness R-Value	For thick- ness listed R-Value
	Medium density	50	1.06	—
	High density	62.5	0.85	—
	Underlayment	40	—	0.82
	Wood subfloor	—	—	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	Cement mortar	116	0.20	—
Concrete	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 ag- gregate (oven dried).....	140	0.11	—
	Sand and gravel or stone ag- gregate (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			
	2 core, 8" 36 lb	—	—	1.04

Material	Description	Density (lb per cu ft)	Per inch thickness R-Value	For thick- ness listed R-Value
	Same with filled cores	—	—	1.93
	Lightweight			
	aggre- gate (expanded			
	shale, clay,			
	slate or slag,			
	pumice):.....	—	1.65	—
	3 core, 6" 19 lb	—	—	2.99
	Same with filled			2.18
	cores	—	—	5.03
	2 core, 8" 24 lb	—	—	2.48
	Same with filled			5.82
	cores	—	—	0.08
	Stone, lime or sand.....	—	—	—
	Gypsum partition tile:	—	—	1.26
	3 x 12 x 30 in. solid.....	—	—	1.35
	3 x 12 x 30 in. 4-cell.....	—	—	1.67
	4 x 12 x 30 in. 3-cell.....	—	—	—
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..... ¾ 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..... ¾ 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..... ¾ in.	70	—	0.33
	Slate	¾ 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 insu- lating 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 thick- ness listed R-Value
	Wood bevel, ¾ x 10" lapped	—	—	1.05
	Wood plywood ¾" lapped	—	—	0.59
	Aluminum or steel, over sheathing, hollow-backed	—	—	0.61
	Insulating-board backed nominal ¾"	—	—	1.82
	Insulating-board backed nominal ¾" 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 ¾ in.	—	—	0.28
	Terrazzo 1 in.	—	—	0.08
	Tile-asphalt, linoleum, vinyl, rubber	—	—	0.05
	Wood, hardwood finish ¾ in.	—	—	0.08
INSULATING MATERIALS	Mineral fiber, fibrous form processed from rock, slag or glass			
Blanket and batt	Approx. 2 to 2¼" ... 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	—
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	—

Material	Description	Density lb per cu ft)	Per inch thickness R-Value	For thick- ness listed R-Value
	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		Interior
	Winter	Summer	
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
1/4 in. air space	0.65	0.61	0.49
1/2 in. air space	0.58	0.56	0.46
1/2 in. air space, low			
emissivity coating ³	0.38	0.36	0.32
emissivity = 0.20	0.45	0.44	0.38
emissivity = 0.40	0.52	0.50	0.42
emissivity = 0.60			
insulating glass—triple ²			
1/4 in. air spaces	0.47	0.45	0.38
1/2 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

¹See Part C for adjustment for various window and sliding patio door types.

²Double and triple refer to the number of lights of glass.

³Coating on either glass surface facing air space; all other glass surfaces uncoated.

⁴Dimensions are nominal.

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

Description	Exterior ¹		Interior ⁵
	Winter ³	Summer ⁶	
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
1/4 in. air space	0.70	0.46	0.59
1/2 in. air space	0.66	0.44	0.56
1/2 in. air space, low			
emissivity coating ³	0.46	0.31	0.39
emissivity = 0.20	0.53	0.36	0.45
emissivity = 0.40	0.60	0.40	0.50
emissivity = 0.60			
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	—

⁵For heat flow up.

⁶For heat flow down.

⁷Based 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	—

⁸Refers to windows with negligible opaque area.

⁹Value 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			Summer, No Storm Door
	Solid Wood, No Storm Door	Storm Door ²		
		Wood	Metal	
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				
1½ in.				
A ³	0.59	—	—	0.58
B ⁴	0.40	—	—	0.39
C ⁵	0.47	—	—	0.46

¹Nominal thickness.

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

³A = Mineral fiber core (2 lb/cu ft).

⁴B = Solid urethane foam core.

⁵C = Solid polystyrene core.

Note: Hollow core doors 1 1/2 in. thick - R = 2.17; U = 0.46

1 1/4 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 =
$$\frac{U_{cav} A_{cav} + U_{sol} A_{sol} + U_{win} A_{win} + U_{door} A_{door} + U_{box} A_{box} + U_{found} A_{fou}}{A_o}$$

Where:

- U_o = Average 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_{fou} = 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 = Average 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 Register, February, 1985, No. 350

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

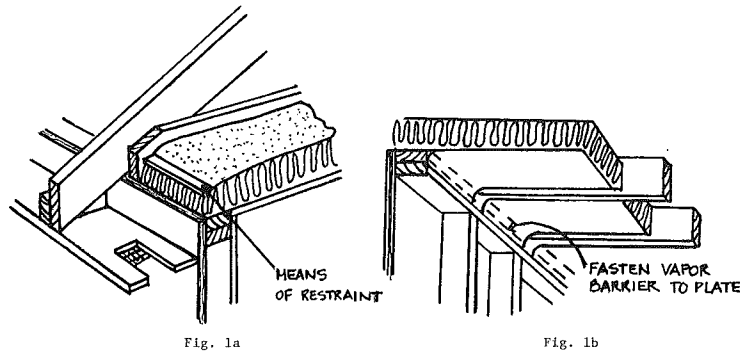
1. Install insulation so the vapor barrier faces the interior of the dwelling.
2. Vapor barriers should not be left exposed.
3. Insulate all voids of the building envelope including small spaces, gaps, around receptacles, pipes, etc.

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).



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).

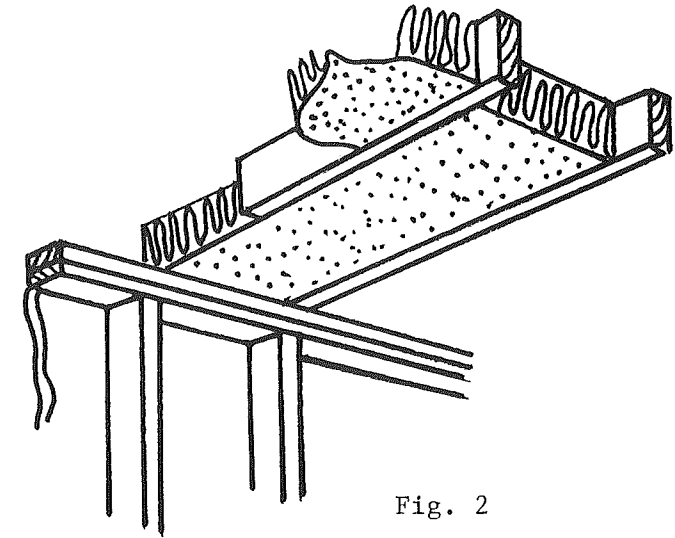


Fig. 2

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.

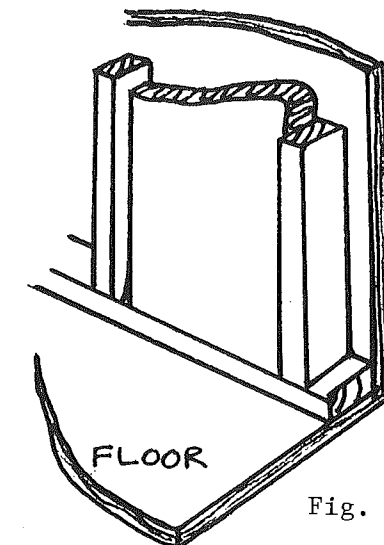


Fig. 3

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.

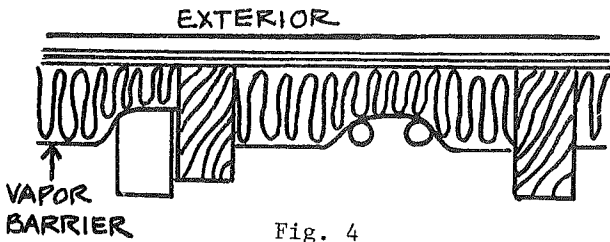


Fig. 4

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

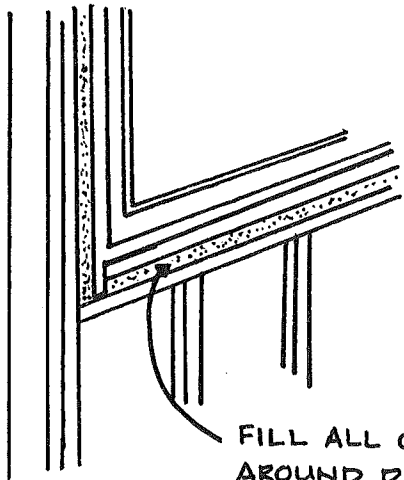


Fig. 5

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

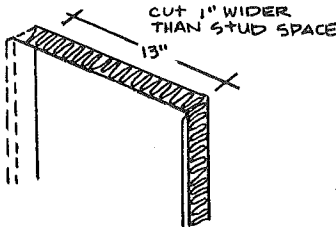


Fig. 6a

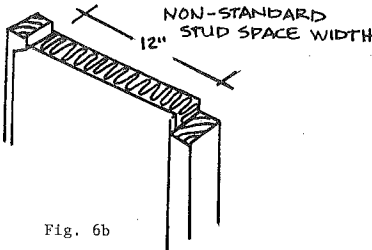


Fig. 6b

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.

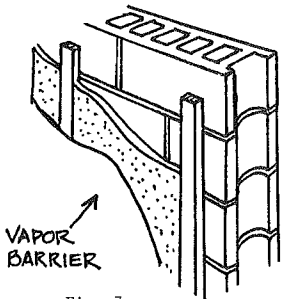


Fig. 7a

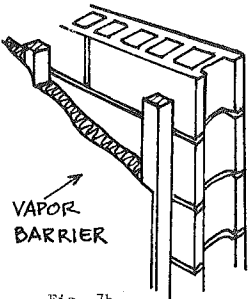
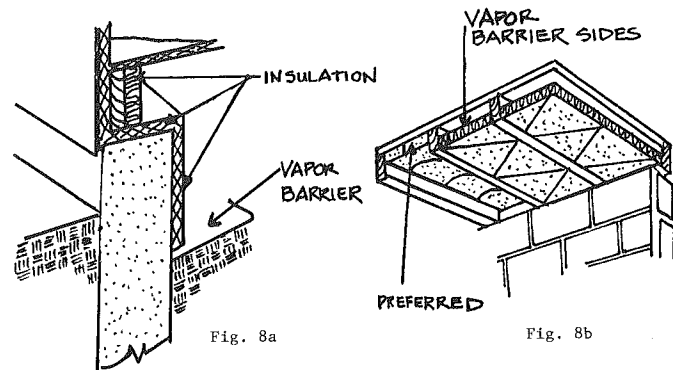


Fig. 7b

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

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.

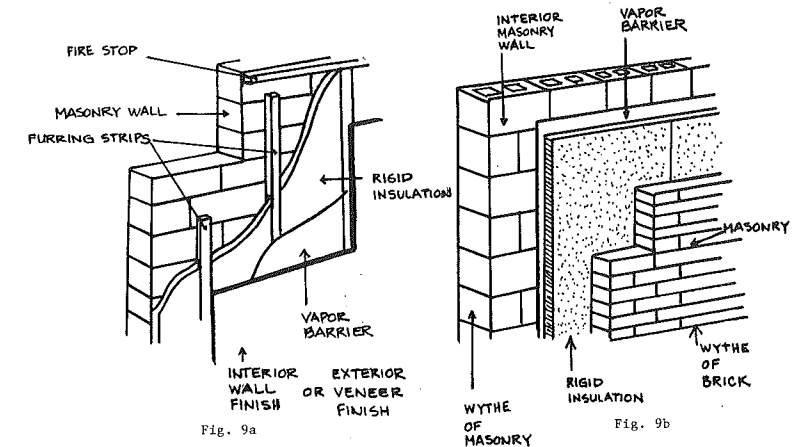
In multiple dwellings with back-to-back kitchens or baths, it is necessary to extend ceiling finish material over dropped soffits to the party wall to avoid loss of acoustical control and to provide adequate fire stops.

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.



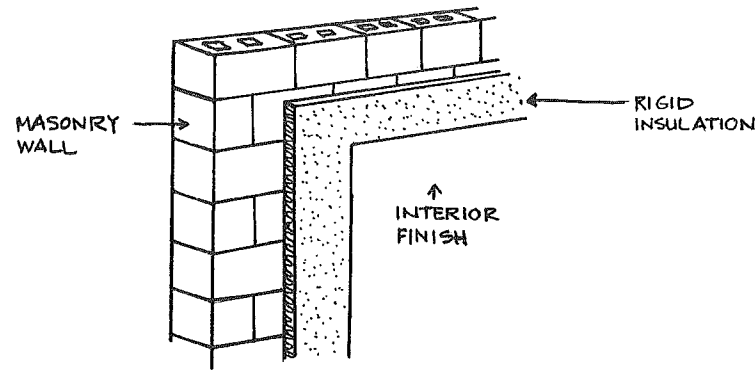


Fig. 9c

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.

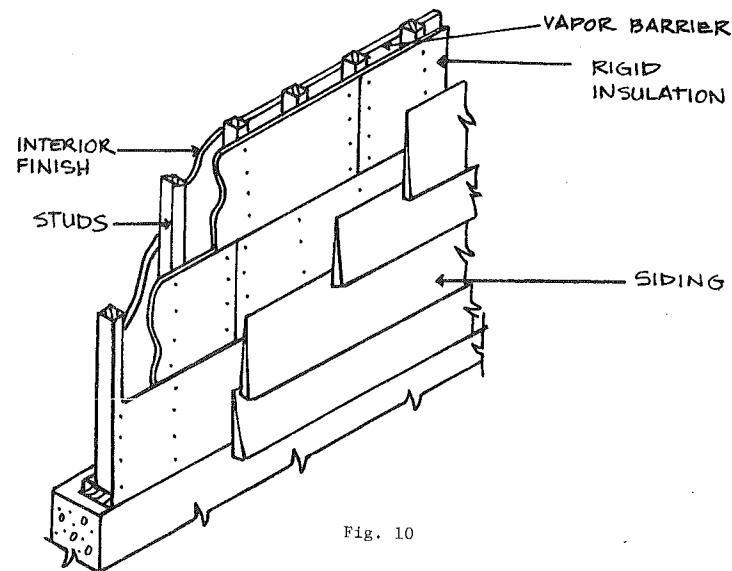


Fig. 10

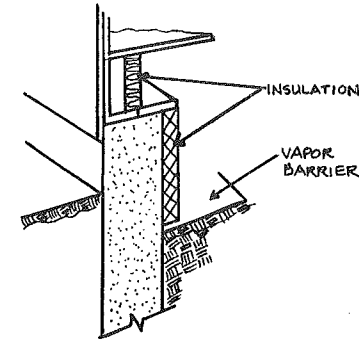


Fig. 11a

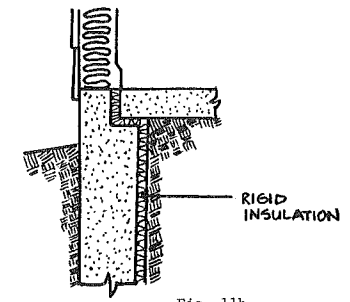


Fig. 11b

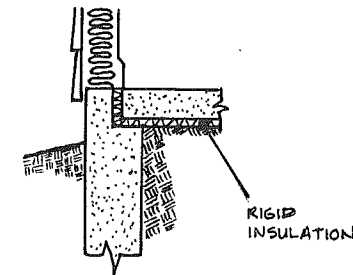


Fig. 11c

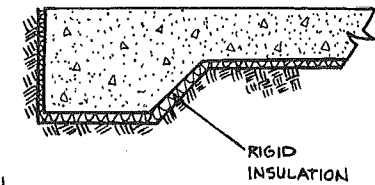


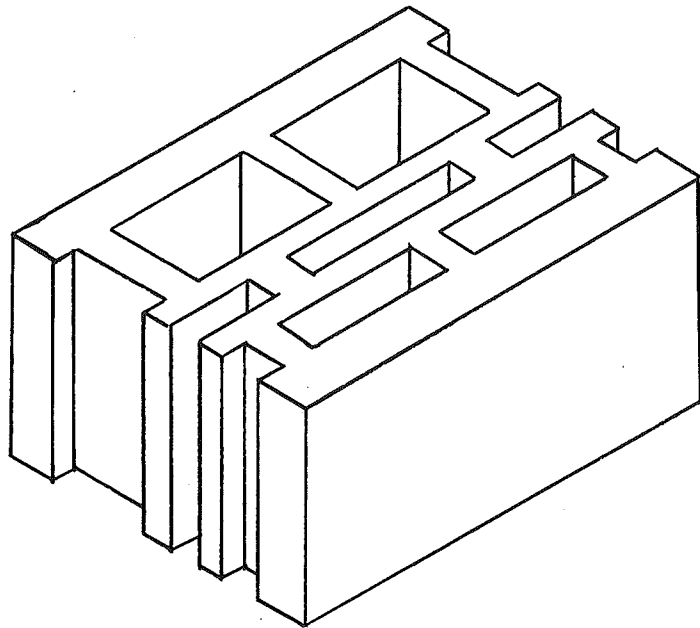
Fig. 11d

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.

WISCONSIN ADMINISTRATIVE CODE
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 maxi-

mum 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	5 1/8"	59 sq. ft. (40 lb. bag)	17
Glass fiber	8 3/4"	51 sq. ft. (24 lb. bag)	20
Rock wool	6 1/2"	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	13 3/4 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	8 3/4 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	3¾"
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	<u>19,744 Btu/hour</u>
	47,504 Btu/hour

Maximum furnace size:

$$47,504 \text{ Btu/hour} \div 47,504 (.15) \text{ Btu/hour} = 54,630 \text{ Btu/hour}$$

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 humidity. 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%.

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