ARTICLE 10

FIRE PROTECTION SYSTEMS

(This Article is entirely unique to Massachusetts)

SECTION 1000.0 GENERAL

1000.1 Scope: The provisions of this article shall specify where fire protection systems are required in all buildings or structures or portions thereof.

1000.1.1 Authority: Plans submitted under Section 113.5 and Article 6 of this code relative to this article shall be reviewed by the local fire official for approval of the following items:

1. source and capacity of water supply, including size of water main;
2. location of hydrants and siamese connections;
3. access for fire fighting apparatus and rescue vehicles;
4. provisions for a fire pump, if necessary, including electrical supervisory control;
5. design and location of standpipes and/or sprinkler systems and related equipment;
6. design and location of required fire alarm systems, including detection, supervision, and all related equipment;
7. smoke control;
8. firefighter elevator key location and associated equipment;
9. location and protection of furnace rooms, boiler rooms and rooms of similar uses; and
10. fire access panels (see Section 1019.2.1.)

1000.2 Installation requirements: The installation methods, repair, operation and maintenance of fire protection systems shall be in accordance with this code and the BOCA National Fire Prevention Code and/or 527 CMR as applicable (listed in Appendices A and G respectively).

1000.3 Maintenance: The owner, tenant or lessee of every building or structure shall be responsible for the care and maintenance of all fire protection systems, including equipment and devices, to ensure the safety and welfare of the occupants. Fire protection systems shall not be disconnected or otherwise rendered

unserviceable without first notifying the fire department. When installations of required fire protection systems are interrupted for repairs or other necessary reasons, the owner, tenant or lessee shall immediately advise the fire department and shall diligently prosecute the restoration of the protection.

1000.4 Threads: All threads provided for fire department connections to sprinkler systems, standpipe systems, yard hydrants or any other fire hose connections shall be uniform to those used by the local fire department.

1000.5 Signs: Where fire suppression control valves are located in a separate room or building, a sign shall be provided on the entrance door. The lettering for such sign shall be of a conspicuous color and shall be at least 4 inches in height, and shall read *Sprinkler Control Valves* or *Standpipe Control Valves* or indicate other types of systems (see Sections 1012.4.1 and 1014.8 for additional signs).

1000.6 Tests: Where required by this article and the standards referenced herein, all flow test connections and points of fluid discharge shall be reasonably accessible and acceptable to the administrative authority.

SECTION 1001.0 PLANS AND SPECIFICATIONS

1001.1 Required: Plans shall be submitted to indicate conformance with this code and shall be reviewed by the department prior to issuance of the permit.

> Note: Since the fire department is responsible for inspection for the proper maintenance of fire protection systems in buildings, the administrative authority shall cooperate with the fire department in the discharging of responsibility to enforce this article.

1001.2 Plans: The plans and specifications submitted to the department shall contain sufficient detail to evaluate the hazard and the effectiveness of the system. The details on the hazards shall include materials involved, the location and arrangement, and the exposure to the hazard.

1001.3 Calculations: The details on the fire protection system shall include the design considerations, calculations and other information as required by this code.

SECTION 1002.0 FIRE SUPPRESSION SYSTEMS

1002.1 Where required: Fire suppression systems shall be installed and maintained in full operating condition, as specified in this code, in the locations indicated in Sections 1002.2 through 1002.21. (Note: Requirements for detoxification facilities, Use Group R-1, are contained in Section 637.0).

Exception: Buildings of Use Group R-3.

1002.2 Use Group A-1: In all buildings or structures or portions thereof of Use Group A-1.

1002.3 Use Group A-2: In all buildings or structures or portions thereof of Use Group A-2:

1. When more than 5,000 square feet in area; or
2. When more than one story in height.

1002.4 Use Group A-3: In all buildings or structures or portions thereof of Use Group A-3 when more than 12,000 square feet in area.

1002.5 Stages and enclosed platforms: Stages under the roof and gridiron, in the tie and fly galleries, and in all places behind the proscenium wall of the stage; over and within enclosed platforms in excess of 500 square feet in area; and in dressing rooms, lounges, workshops and storerooms accessory to such stages or enclosed platforms.

Exceptions:
1. Stages or enclosed platforms open to the auditorium room on three or more sides.
2. Altars, pulpits or similar platforms and their accessory rooms.
3. Stage gridirons when sidewall sprinklers with 135 degrees F. (57 degrees C.) rated heads with heat-baffle plates are installed around the perimeter of the stage except for the proscenium opening at points not more than 30 inches below the gridiron nor more than 6 inches below the baffle plate.
4. Under stage or under enclosed platform areas less than 4 feet in clear height used exclusively for chair or table storage and lined on the inside with materials approved for 1-hour fireresistance rated construction.

1002.6 High-rise buildings: In all high-rise buildings exceeding seventy (70) feet in height, as required by Chapter 148, Section 26A of the Massachusetts General Laws, as amended.

1002.7 Use Group H: In all buildings or structures or portions thereof of Use Group H.

1002.8 Use Group I: In all buildings or structures or portions thereof of Use Group I.

Exceptions:

1. One-story hospitals with patient rooms having direct egress to grade level at the exterior of the building.
2. In hospitals of Type 1 construction, the automatic fire suppression system may be omitted from operating rooms, X-ray rooms, delivery rooms, cardiac and intensive care rooms and patient sleeping rooms not exceeding six hundred (600) square feet in area when such room is protected by an automatic fire alarm system connected to a central annunciator panel.
3. For sprinklerer requirements for child day care centers of I-2 Use, see Section 633.0
4. I-3 (institutional-restrained) occupancies having an occupancy load of less than six (6).
5. In I-3 (institutional-restrained) occupancies the fire suppression system shall be a sprinkler system which may be manual or automatic in operation.

1002.9 Use Groups M, S-1 and F-1: In all buildings or structures or portions thereof of Use Groups M, S-1 and F-1:

1. When more than 12,000 square feet in area; or
2. When more than 24,000 square feet in total area on all floors; or
3. When more than three stories in height.

1002.10 Public garages (Group 1): In all Group 1 public garages:

1. When more than 10,000 square feet in area.
2. When more than 7,500 square feet in area and more than one story in height.
3. When more than 5,000 square feet in area and more than two stories in height.
4. When more than three stories in height.
5. When located in buildings where the upper stories are designed for other uses.
6. When located in any story that is more than 50 percent below grade.
7. In fuel dispensing areas.

1002.11 Public garages (Group 2): In all Group 2 public garages:

1. When more than 10,000 square feet in area and more than one story in height.

2. When more than two stories in height.
3. When located in buildings where the upper stories are designed for other uses.

Exception: Open parking structures or portions of buildings classified as open parking structures according to the definition in Section 607.1.

1002.12 Bus garages: In all bus garages:

1. When required by Section 1002.10.
2. When used as passenger terminals for four or more buses.
3. When used for storage or loading of four or more buses.

1002.13 Unlimited area buildings: In unlimited area buildings as required by Section 504.0.

Exception: Special industrial uses as indicated in Section 501.1.1.

1002.14 Storage and workshop areas: In all portions of Use Groups A, B, E, I, R-1 and R-2 occupied for storage, workshop or similar purposes.

Exceptions:

1. Individual storage or workshop areas located entirely within unsprinklered dwelling units.
2. Storage and workshop rooms less than 24 square feet in area.

1002.15 Windowless story: In every story or basement of all buildings where there is not provided at least one of the following types of openings:

1. An exterior stairway meeting Section 819.0, or outside ramp meeting Section 815.0, leading directly to grade in each fifty (50) lineal feet or fraction thereof of exterior wall in the story or basement, on at least one side of the building.
2. Twenty (20) square feet of opening above the adjoining ground level in each fifty (50) lineal feet or fraction thereof of exterior wall in the story or basement, on at least one side of the building. Openings shall have minimum dimensions of not less than twenty-two (22) inches. Such openings shall be accessible to the fire department from the exterior and shall be unobstructed to allow firefighting and rescue operations from the exterior.

When openings in a story are provided on only one side and the opposite wall of such story is more than seventy-five (75) feet from such openings, the story shall be provided with an approved automatic fire suppression system, or openings as specified above shall be provided on at least two sides of the exterior walls of the story. If any portion of a basement is located more than seventy-five (75) feet from

openings required in this section, the basement shall be provided with an approved automatic fire suppression system.

1002.16 Painting rooms: In spray painting rooms or shops where painting, brushing, dipping or mixing is regularly conducted using flammable materials.

1002.17 Trash rooms and chutes: In rooms or areas used for incineration, trash and laundry collection or similar uses; and at alternate floor levels and at the top of all chutes used in conjunction with these rooms or areas.

1002.18 Furnace rooms: In furnace rooms, boiler rooms and rooms for similar uses and as provided in Sections 610.2 and 611.7 for Use Groups I-2 and I-3 respectively.

Exception: Such a room located entirely within and serving a single dwelling unit.

1002.19 Unenclosed vertical openings: In unenclosed vertical openings between floors as required by Section 606.3.

1002.20 Kitchen exhaust systems: In commercial kitchen exhaust systems when such systems are required by the BOCA National Mechanical Code listed in Appendix A.

1002.21 Hazardous exhaust systems: In duct systems exhausting hazardous material in accordance with the BOCA National Mechanical Code listed in Appendix A.

1002.22 Alternative protection: In special use areas of buildings or structures, an automatic fire detection system shall be installed in lieu of a fire suppression system where such fire suppression system installation would be detrimental or dangerous to the specific use or occupancy, as approved by the code official and the fire prevention code official.

1002.22.1 Telephone central office equipment buildings: Within telephone central office equipment buildings, the automatic fire suppression system is not required in the following rooms or areas when such rooms or areas are protected with an approved automatic fire alarm system.

1. Generator and transformer rooms.
2. Communication equipment areas when such areas are separated from the remainder of the building by 1-hour fireresistance rated wall and 2-hour fireresistance rated floor/ceiling assemblies, and are used exclusively for such equipment.

SECTION 1003.0 SUPPRESSION SYSTEM SELECTION

1003.1 General: To guide the administrative authority with the selection of the proper type of fixed fire suppression system, the extinguishing agents for each type of hazard or fire are classified as follows.

Class A: Fires involving ordinary combustible materials (such as wood, cloth, paper, rubber and many plastics) requiring the heat-absorbing (cooling) effects of water, water solutions, or the coating effects of certain dry chemicals which retard combustion.

Class B: Fires involving flammable or combustible liquids, flammable gases, greases and similar materials where extinguishment is most readily secured by excluding air (oxygen), inhibiting the release of combustible vapors, or interrupting the combustion chain reaction.

Class C: Fires involving energized electrical equipment where safety to the operator requires the use of electrically nonconductive extinguishing agents.

Note: Portable Class A or B extinguishers and hand-held solid stream nozzles are inappropriate for fighting electrical fires. However, fixed water spray systems are appropriate for fighting fires in energized electrical systems.

1003.2 Special hazards: In rooms or buildings containing combustibles such as aluminum powder, calcium carbide, calcium phosphide, metallic sodium and potassium, quick-lime, magnesium powder or sodium peroxide, which are incompatible with the use of water as an extinguishing agent, other extinguishing agents shall be used.

1003.3 Types: Where a fire suppression system is required in this code, Table 1003 provides the code official with information to assist in the determination of the type of suppression system suitable for the hazard involved, if not otherwise specified in this code.

--SEE TABLE 1003 ON THE FOLLOWING PAGES--

TABLE 1003
GUIDE FOR SUPPRESSION SYSTEM SELECTION

Hazard	Water Sprinklers or Spray 1004.0 to 1016.0	Foam 1007.0	Carbon Dioxide or Halogenated 1008.0 to 1009.0	Dry Chemical 1010.0	Wet Chemical 1011.0
Class A fire potential	X	X	X	X	X
Class B fire potential	X	X	X	X	X
Class C fire potential	X		X		
SPECIAL FIRE HAZARD AREAS[a]					
Aircraft hangars	X	X	X	X	
Alcohol storage	X	X	X	X	
Ammunition loading	X				
Ammunition magazines	X				
Asphalt impregnating	X	X			
Battery rooms			X		
Carburetor overhaul shops	X	X	X	X	
Cleaning plant equipment	X	X	X	X	
Computer rooms	X		X		
Dowtherm	X				
Drying ovens	X		X	X	X

TABLE 1003 (continued)
GUIDE FOR SUPPRESSION SYSTEM SELECTION

Hazard	Water Sprinklers or Spray 1004.0 to 1016.0	Foam 1007.0	Carbon Dioxide or Halogenated 1008.0 to 1009.0	Dry Chemical 1010.0	Wet Chemical 1011.0
Elevator equipment rooms with open-type mechanical relays			X		
Engine test cells	X	X	X		
Escalator, stair wells	X				
Explosives: Manufacturing, storage	X				
Flammable liquids storage	X	X	X		
Flammable solids storage	X				
Fuel oil storage	X	X			
Hangar decks	X	X			
High piled storage in excess of 15 feet in height	X	X			
HPM USE FACILITY					
Fabrication areas (Ordinary Hazard Group 3)	X				
Service passages (Ordinary Hazard Group 3)	X				

TABLE 1003 (continued)
GUIDE FOR SUPPRESSION SYSTEM SELECTION

Hazard	Water Sprinklers or Spray 1004.0 to 1016.0	Foam 1007.0	Carbon Dioxide or Halogenated 1008.0 to 1009.0	Dry Chemical 1010.0	Wet Chemical 1011.0
Separate Inside HPM storage rooms without dispensing (Ordinary Hazard Group 3)	X				
Separate Inside HPM storage rooms with dispensing (Extra Hazard group 2)	X				
Egress corridors (Ordinary Hazard Group 3)	X				
Hydraulic oil, lubricating oil	X		X		
Hydroturbine generators	X		X		
Jet engine test cells	X	X	X		
Library stacks	X		X		
Lignite storage and handling	X				
Liquified petroleum gas storage	X				
Oil quenching bath	X	X	X	X	
Paints: manufacturing, storage	X	X	X	X	

TABLE 1003 (continued)
GUIDE FOR SUPPRESSION SYSTEM SELECTION

Hazard	Water Sprinklers or Spray 1004.0 to 1016.0	Foam 1007.0	Carbon Dioxide or Halogenated 1008.0 to 1009.0	Dry Chemical 1010.0	Wet Chemical 1011.0
Paint spray booths	X		X	X	
Petrochemical storage	X	X	X		
Petroleum testing laboratories	X	X	X		
Printing presses	X		X		
Rack and palletized storage in excess of 12 feet in height	X	X			
Range hoods	X		X	X	X
Reactor with fractioning towers	X				
Record vaults			X		
Rubber mixing and heat treating	X				
Service stations (inside buildings)	X		X		
Shipboard storage	X		X		
Solvent cleaning tanks		X	X	X	
Solvent thinned coatings		X	X	X	

TABLE 1003 (continued)
GUIDE FOR SUPPRESSION SYSTEM SELECTION

Hazard	Water Sprinklers or Spray 1004.0 to 1016.0	Foam 1007.0	Carbon Dioxide or Halogenated 1008.0 to 1009.0	Dry Chemical 1010.0	Wet Chemical 1011.0
Transformers, circuit breakers (outdoors)	X				
Transformers, circuit breakers (indoors)	X		X		
Turbine lubricating oil	X	X	X	X	
Vegetable oil, solvent extraction	X	X			

Note a: Within buildings or areas, so classified, as to require a suppression system.

SECTION 1004.0 WATER SPRINKLER SYSTEMS

1004.1 General: Water sprinkler extinguishing systems shall be of an approved type and installed in accordance with the provisions of this code and NFiPA 13 listed in Appendix A.

1004.2 Occupancy sprinkler system: Within a building of mixed occupancies and where an occupancy is required by this code to be sprinklered with more than 20 sprinklers, the use group requiring sprinklers shall be separated from other uses by fire separation walls and floor/ceiling assemblies having a fireresistance rating corresponding to the highest fire grading prescribed in Table 902 for the separate uses and equipped throughout with a complete automatic sprinkler system.

1004.3 Design: The details of the system supplied with the plans and specifications shall include information and the calculations of the sprinkler spacing and arrangement with water supply and discharge requirements, size and equivalent lengths of pipe and fittings and water supply source. Sufficient information shall be included to identify the apparatus and devices used. The design of the sprinkler system for a HPM use facility shall be in accordance with NFiPA 13 listed in Appendix A, and not less than that required for the special fire hazard areas shown in Table 1003.

1004.4 Actuation: Water sprinkler extinguishing systems shall be automatically actuated unless otherwise specifically provided in this code.

1004.5 Sprinkler alarms: Approved audible or visual alarm devices shall be connected to every water sprinkler system. Such alarm devices shall be activated by water flow and shall be located in an approved location.

Exception: Alarms and alarm attachments shall not be required for limited area sprinkler systems (see Section 1005.5).

1004.5.1 Additional alarms: At least one additional audible or visual alarm device shall be installed within the building.

1004.6 Water control valve tags: Identification tags shall be provided in accordance with NFiPA 26 listed in Appendix A.

1004.7 Sprinkler riser: A sprinkler system riser which also serves as the wet standpipe riser in buildings required to have or having both systems shall conform to Section 1012.4.1.

1004.8 Tests: All sprinkler systems shall be tested in accordance with the BOCA National Fire Prevention Code and 527 CMR listed in Appendix A and Appendix G, respectively.

SECTION 1005.0 LIMITED AREA SPRINKLER SYSTEMS

1005.1 General: A limited area sprinkler system shall be of an approved type and installed in accordance with the provisions of this section.

1005.2 Installation: Where the provisions of this code require a limited number of sprinklers, a limited area sprinkler system is permitted to be installed to comply with these requirements.

1005.3 Design: The details of the system supplied with the plans and specifications shall include information and the calculations of the sprinkler spacing and arrangement with water supply and discharge requirements, size and equivalent lengths of pipe and fittings and water supply source. Sufficient information shall be included to identify the apparatus and devices used.

1005.4 Actuation: A limited area sprinkler system shall be automatically actuated.

1005.5 Sprinkler alarms: Alarms and alarm attachments shall not be required.

1005.6 Standpipe connection: The water supply for the limited area sprinkler system shall be from the building standpipe system when the building is equipped with a standpipe system that is sized for 500 gallons per minute minimum flow and has an automatic water supply (see Section 1012.4.1).

1005.6.1 Domestic supply: Where limited area sprinklers are supplied from the domestic water system, the domestic water system shall be designed to adequately support the design flow of the largest number of sprinklers in any one of the enclosed areas. When supplied by the domestic water system, the maximum number of sprinklers in any one enclosed room or area shall not exceed 20, and the sprinklers shall be capable of totally protecting the room or area.

Note: See Section 637.16 for requirements for limited area sprinkler systems in detoxification facilities (Use Group R-1).

1005.6.2 Fire department connections: A fire department connection is not required for limited area sprinkler systems supplied from the domestic water system.

1005.6.3 Cross connection: There shall not be a cross connection between the domestic water system and the standpipe system.

1005.6.4 Domestic connection: A check valve shall be provided at the point where the suppression system piping is connected to the domestic water piping to prevent contamination of the domestic water supply. Shutoff valves shall not be permitted in the suppression system piping. Water supply shall be controlled by the riser control valve to the domestic water piping.

1005.7 Use: Limited area sprinklers shall be used only in rooms or areas enclosed with construction assemblies as required by this code.

1005.8 Tests: All limited area sprinkler systems shall be tested in accordance with the BOCA National Fire Prevention Code and 527 CMR listed in Appendix A and Appendix G, respectively.

SECTION 1006.0 WATER-SPRAY FIXED SYSTEMS

1006.1 General: Water-spray extinguishing systems shall be of an approved type and installed in accordance with the provisions of this code and NFiPA 15 listed in Appendix A.

1006.2 Design: The details of the system supplied with the plans and specifications shall include information and the calculations of the sprinkler spacing and arrangement with water supply and discharge requirements, size and equivalent lengths of pipe and fittings and water supply source. Sufficient information shall be included to identify the apparatus and devices used.

1006.3 Actuation: Water-spray extinguishing systems shall be automatically actuated with supplementary manual tripping capability.

1006.4 Tests: All new system piping shall be hydrostatically tested in accordance with the provisions of NFiPA 15 listed in Appendix A.

SECTION 1007.0 FOAM EXTINGUISHING SYSTEMS

1007.1 General: Foam extinguishing systems shall be of an approved type and installed in accordance with the provisions of this code and NFiPA 11, 11A and 16 listed in Appendix A.

1007.2 Design: The details of the system supplied with the plans and specifications shall include complete computations showing pressure drop in all system piping, friction loss calculations of liquid lines and a detailed layout of the entire hazard area to be protected. Hydraulic characteristics of foam proportioners and foam makers as determined by tests shall be supplied by the manufacturer to the department (including the range of operating conditions required for the proposed installation) to permit determination of the adequacy of the hydraulics of the proposed protection.

1007.3 Actuation: A foam extinguishing system shall be automatically actuated with supplementary manual tripping capability.

1007.4 Tests: All piping, except that piping which handles expanded foam, shall be subjected to a two (2) hour hydrostatic pressure test of 200 psi or 50 psi in excess of the maximum pressure anticipated, whichever is greater, without leakage. The system shall be subjected to a flow test to ensure that the hazard area is fully protected in conformance with the design specifications, and to determine the flow pressures, actual discharge capacity, foam quality, consumption rate of foam-producing materials, manpower requirements and other operating characteristics.

SECTION 1008.0 CARBON DIOXIDE EXTINGUISHING SYSTEMS

1008.1 General: Carbon dioxide extinguishing systems shall be of an approved type and installed in accordance with the provisions of this code and NFiPA 12 listed in Appendix A.

1008.2 Design: The details of the system supplied with the plans and specifications shall include information and calculations of the amount of carbon dioxide, the location and flow rate of each nozzle including equivalent orifice area and the location, size and the carbon dioxide storage facility. Information shall be submitted pertaining to the location and function of the detection devices, operating devices, auxiliary equipment and electrical circuitry, if used. Sufficient information shall be indicated to identify properly the apparatus and devices used. Any special features shall be adequately explained.

1008.3 Actuation: Carbon dioxide extinguishing systems shall be automatically actuated with supplementary manual tripping capability.

1008.4 Safety requirements: In any proposed use of a carbon dioxide system where there is a possibility that persons will enter or be trapped in atmospheres made hazardous by a carbon dioxide discharge, warning signs, discharge alarms and breathing apparatus shall be provided to ensure prompt evacuation of and to prevent entry into such atmospheres, and also to provide means for prompt rescue of any trapped personnel.

1008.5 Tests: A completed system shall be tested for tightness up to the selector valve, and for continuity of piping with free unobstructed flow beyond the selector valve. The labeling of devices with proper designations and instructions shall be checked. Operational tests shall be conducted on all devices except cylinder valves in multi-cylinder high pressure systems. Where conditions prevail that make it difficult to determine adequately the system requirements or design, a suitable discharge test and concentration analysis test shall be made. All tests are to be conducted as indicated in NFiPA 12 listed in Appendix A.

1008.6 Range hoods: In addition to the requirements of this section, Section 1002.20 and the BOCA National Mechanical Code listed in Appendix A, range hood CO_2 systems shall bear the label of an approved agency. The system shall be installed in accordance with the manufacturer's installation instructions.

SECTION 1009.0 HALOGENATED FIRE EXTINGUISHING SYSTEMS

1009.1 General: Halogenated fire extinguishing systems shall be of an approved type and installed in accordance with the provisions of this code and NFiPA 12A and 12B listed in Appendix A.

1009.2 Design: The details of the system supplied with the plans and specifications shall include information and calculations of the amount of extinguishing agent; container storage pressure; the location and flow rate of each nozzle including equivalent orifice area; the location, size and equivalent lengths of pipe, fittings and hose; and the location and size of the storage facility. Information shall be submitted pertaining to the location and function of the detection devices, auxiliary equipment and electrical circuitry, if used. Sufficient information shall be indicated to identify properly the apparatus and devices used. Any special features shall be adequately explained.

1009.3 Actuation: Halogenated fire extinguishing systems shall be automatically actuated with supplementary manual tripping capability.

1009.4 Safety requirements: In any proposed use of a halogenated fire extinguishing system where there is a possibility that persons will enter or be trapped in atmospheres made hazardous by a discharge, warning signs, discharge alarms and breathing apparatus shall be provided to ensure prompt evacuation of and to prevent entry into such atmospheres, and also to provide means for prompt rescue of any trapped personnel.

1009.5 Tests: A completed system shall be tested for tightness up to the selector valve, and for continuity of piping with free unobstructed flow beyond the selector valve. The labeling of devices with proper designations and instructions shall be checked. Operational tests shall be conducted on all devices except cylinder valves in multi-cylinder systems. Where conditions prevail that make it difficult to determine adequately the system requirements or design, a suitable discharge test and concentration analysis shall be made. All tests are to be conducted as indicated in NFiPA l2A and 12B listed in Appendix A.

SECTION 1010.0 DRY CHEMICAL EXTINGUISHING SYSTEMS

1010.1 General: Dry chemical extinguishing systems shall be of an approved type and installed in accordance with the provisions of this code and NFiPA 17 listed in Appendix A.

1010.2 Design: The details of the system supplied with the plans and specifications shall include sufficient information and calculations of the amount of dry chemical; the size, length, and arrangement of connected piping, or piping and hose; description and location of nozzles so that the adequacy of the system can be determined. Information shall be submitted pertaining to the location and function of detection devices, operating devices, auxiliary equipment and electrical circuitry, if used. Sufficient information shall be indicated to identify properly the apparatus and devices used. Any special features shall be adequately explained.

1010.3 Actuation: Dry chemical extinguishing systems shall be automatically actuated with supplementary manual tripping capability.

1010.4 Safety requirements: Where there is a possibility that personnel will be exposed to a dry chemical discharge, warning signs, discharge alarms and breathing apparatus shall be provided to ensure prompt evacuation of such locations, and also to provide means for prompt rescue for any trapped personnel.

1010.5 Tests: A completed system shall be tested by a discharge of expellant gas through the piping and nozzles. Observations for gas leakage and for continuity of piping with free unobstructed flow shall be made. Observations shall be made of the flow of expellant gas through all nozzles. The labeling of devices with proper designations and instructions shall be checked. After testing, all piping and nozzles are to be blown clean, using compressed air or nitrogen and the system properly charged and placed in the normal "set" condition. All tests are to be conducted as indicated in NFiPA 17 listed in Appendix A.

1010.6 Range hoods: In addition to the requirements of this section, Section 1002.20 and the BOCA National Mechanical Code listed in Appendix A, range hood dry chemical systems shall bear the label of an approved agency. The system shall be installed in accordance with the manufacturer's installation instructions. The dry chemical agent of the system shall be nontoxic.

SECTION 1011.0 WET CHEMICAL RANGE HOOD EXTINGUISHING SYSTEMS

1011.1 General: Wet chemical extinguishing systems shall be installed in accordance with the provisions of this section, and the BOCA National Mechanical Code and NFiPA 17A listed in Appendix A. The system shall bear the label of an approved agency and be installed in accordance with the manufacturer's installation instructions. Wet chemical is defined as a solution of water and potassium-carbonate-based chemical, potassium-acetate-based chemical or a combination thereof which forms the extinguishing agent.

1011.2 Tests: A completed system shall be tested by a discharge of wet chemical in sufficient amounts to verify that the system is properly installed and functional. Tests shall include a check of the detection systems, alarms, and releasing devices, including manual stations, fuel and power shutoff devices and other associated equipment. All tests are to be conducted as indicated in NFiPA 17A listed in Appendix A.

SECTION 1012.0 STANDPIPE SYSTEMS

1012.1 General: Standpipe systems shall be of an approved type and installed and maintained in accordance with the provisions of this code, the BOCA National Fire Prevention Code and 527 CMR and NFiPA 14 listed in Appendix G and Appendix A, respectively.

1012.2 Where required: Standpipe systems shall be installed in the locations prescribed in Sections 1012.2.1 through 1012.2.11.

1012.2.1 Use Group A: In all buildings or structures or portions thereof of Use Group A when:

1. Two or more stories in height of Use Group A-1, A-2, or A-3, and having an occupant load of more than 300; or
2. Three or more stories in height regardless of the area per floor; or
3. Having an auditorium seating over 500. Standpipes shall be located one on each side of the auditorium in each tier, one in each mezzanine, one in each tier of dressing rooms, and protecting each property, store and work room; or
4. Having a stage. Standpipes shall be located on each side of the stage. Such standpipes shall be not less than 2 ½-inch diameter, equipped with 1 ½-inch hose and ⅜-inch nozzles.

1012.2.2 Use Group B: In all buildings or structures or portions thereof of Use Group B when:

1. Three or more stories in height, and more than 3,000 square feet in area per floor; or
2. Four or more stories in height regardless of the area per floor.

1012.2.3 Use Group E: In all buildings or structures or portions thereof of Use Group E when three or more stories in height regardless of the area per floor or when having a stage or auditorium in accordance with Sections 1012.2.1(3) and 1012.2.1(4).

1012.2.4 Use Group F: In all buildings or structures or portions thereof of Use Group F when:

1. Three or more stories in height, and more than 3,000 square feet in area per floor; or
2. Four or more stories in height regardless of the area per floor.

1012.2.5 Use Group H: In all buildings or structures or portions thereof of Use Group H when:

1. Three or more stories in height, and more than 10,000 square feet in area per floor; or
2. Four or more stories in height regardless of the area per floor.

1012.2.6 Use Group I: In all buildings or structures or portions thereof of Use Group I, three or more stories in height, regardless of the area per floor.

1012.2.7 Use Group M: In all buildings or structures or portions thereof of Use Group M when:

1. Three stories or more in height, and more than 3,000 square feet in area per floor; or
2. Four or more stories in height regardless of the area per floor; or
3. Classified as a covered mall building within the mall portions (see Section 601.10).

1012.2.8 Use Group R: In all buildings or structures or portions thereof of Use Group R when:

1. Three or more stories in height and of Use Group R-1 regardless of the area per floor; or
2. Three or more stories in height and more than 10,000 square feet in area per floor; or
3. Four or more stories in height regardless of the area per floor.

1012.2.9 Use Group S: In all buildings or structures or portions thereof of Use Group S, other than public garages which shall conform to Section 1012.2.10. when:

1. Three or more stories in height, of Use Group S-1, and more than 3,000 square feet in area per floor; or
2. Three or more stories in height, of Use Group S-2, and more than 10,000 square feet in area per floor; or
3. Four or more stories in height of Use Groups S-1 or S-2 regardless of the area per floor.

1012.2.10 Use Group U: In all buildings or structures or portions thereof of Use Group U when:

1. Three or more stories in height and more than 10,000 square feet in area per floor; or
2. Four or more stories in height regardless of the area per floor.

1012.2.11 Public garages: In all Group I and II public garages when:

1. More than 10,000 square feet in area per floor; or
2. More than 7,500 square feet in area per floor and more than one story in height; or
3. More than 5,000 square feet in area per floor, and more than two stories in height; or
4. More than three stories in height; or
5. Located in buildings where the upper stories are designed for other uses; or
6. When located in any story that is more than 50 percent below grade.

Note: Open parking structures are not public garages (see Section 607.1).

1012.3 Standpipe system piping sizes: The riser piping, supply piping, and the water service piping shall be sized to maintain a residual pressure of at least 65 psi at the topmost outlet of each riser while flowing the minimum quantities of water specified in Sections 1012.3.1 and 1012.3.2 of this code.

Exception: The 65 psi residual pressure is not required to be maintained in buildings less than 70 feet in height which are equipped throughout with an approved automatic fire suppression system.

1012.3.1 Riser sizing: The vertical water pipe(s) within a building to which fire hose outlets and valves are attached shall be sized for a minimum flow of 500 gpm.

Exceptions:

1. Where only 1 ½-inch valves are required or are provided, the riser(s) shall be sized to provide a minimum flow of 100 gpm. The minimum size shall be 2 ½ inches.
2. In buildings where limited area sprinkler systems are supplied water from a common standpipe riser, the riser shall be sized to satisfy total demand.

3. In buildings equipped throughout with an approved automatic fire suppression system where both the suppression system and standpipe fire hose outlets are supplied water from a common riser, the minimum riser diameter shall be adequate for the suppression system or the standpipe system, whichever is greater. The minimum riser diameter shall be not less than that based on hydraulic calculations.
4. In buildings which are not equipped throughout with an approved automatic fire suppression system wherein the minimum diameter of the common riser is based on hydraulic calculations, all risers shall have a minimum diameter as described in Table 1012.
5. In buildings of Use Groups B, R-1, R-2, and I equipped throughout with an approved automatic fire suppression system, each vertical standpipe riser shall be sized for a minimum flow of 250 gpm.
6. Standpipe systems in covered mall buildings as provided in Section 601.10.

Table 1012
BUILDING HEIGHT AND STANDPIPE RISER SIZE

Maximum building height	Minimum riser size
4 stories or 50 feet	2 1/2 inches
6 stories or 75 feet	4 inches
76 feet to 250 feet	6 inches
over 250 feet	8 inches

1012.3.2 Supply pipe sizing: The supply piping, including the horizontal or common feeder lines within a building and the water service line outside of the building, shall be sized for a minimum flow of 500 gpm. When more than one standpipe riser is required or provided, all common supply piping shall be sized for a minimum flow of 500 gpm for the first riser plus 250 gpm for each additional riser, and the total need not exceed 2,500 gpm.

Exceptions:
1. Where only 1 ½-inch valves are required or are provided, the supply piping shall be sized for a minimum flow of 100 gpm for each riser, and the total need not exceed 500 gpm. The minimum size shall be 2 ½ inches.
2. In buildings where limited area sprinkler systems are supplied water from a common standpipe riser, the supply piping shall be sized for a minimum flow of 500 gpm plus the sprinkler demand for the first riser, plus 250 gpm for each additional riser, and the total need not exceed 2,500 gpm.
3. In buildings of Use Groups B, I, R-1 and R-2 equipped throughout with an approved automatic fire suppression system, all common supply piping

shall be sized for a minimum flow of 250 gpm for the first riser plus 250 gpm for each additional riser, and the total need not exceed 1,500 gpm.

1012.4 Number of risers: The number of standpipe risers shall be such that all parts of every floor area can be reached by a thirty (30) foot hose stream from a nozzle attached to not more than 100 feet of hose connected to a riser outlet. In those buildings equipped with an interior smokeproof enclosure vestibule, at least one standpipe hose connection shall be located in the vestibule. In covered mall buildings, outlets shall be located in accordance with Section 601.10.

1012.4.1 Combination: Where a standpipe system riser also serves as the water sprinkler system riser in buildings required to have both systems or in buildings having both systems, control valves shall be installed where sprinklers are connected to the riser so that sprinklers are under the control of a separate floor control valve(s) to allow standpipes to remain operational while the sprinkler system is in a closed position. If control valves are located in a separate room or building, a sign shall be provided on the entrance door. The lettering of such sign shall be of a conspicuous color and shall be at least 4 inches in height and shall read *Standpipe Control Valve* or indicate other types of systems.

1012.4.2 High-rise buildings: All buildings seventy (70) feet in height or greater shall have each floor supplied by a minimum of two (2) combination risers.

1012.5 Outlets: Standpipe system outlets shall comply with the provisions of Sections 1012.5.1 through 1012.5.4.

1012.5.1 Hose connections: At each floor level, and not more than five (5) feet above the floor, there shall be connected to each standpipe a 2 ½-inch hose connection capped with a reducing coupling to a 1 ½-inch hose connection which shall also be capped.

1012.5.2 Roof hydrants: Where standpipes are installed in buildings more than six stories or 75 feet in height, at least one riser shall extend through the roof and terminate in a two-way, 2 ½-inch hose connection. The main control valve on a roof hydrant or manifolded hose connection shall be located in an area not subject to freezing, as close to the roof access as practical and plainly marked (see Section 1014.8).

1012.5.3 Pressure reducers: When the residual pressure at any standpipe fire hose outlet exceeds 100 psi, approved pressure reducing devices or discs shall be installed at the outlets to reduce the pressure to 100 psi while the required quantity of water per minute is flowing. Any standpipe riser over 250 feet in height shall be equipped with an approved pressure regulating device on each hose outlet, which controls discharge pressures under both flow (residual) and no-flow (static) conditions.

1012.5.4 Test gauges: An approved water pressure gauge shall be attached to the top of each standpipe riser for inspection and test purposes. Shutoff valves, with provisions for bleeding pressure from the gauge, shall be installed between the gauge and the top of the riser. Gauges shall be accessible and located in spaces not subject to freezing.

1012.6 Materials: All standpipes shall be constructed of approved materials. All pipe, fittings and valves shall be of extra heavy pattern when the normal working pressure will exceed 175 psi.

1012.7 Tests: All standpipe systems shall be flow tested and hydrostatically tested in accordance with the BOCA National Fire Prevention Code and/or 527 CMR, as applicable, and listed in Appendix A and Appendix G, respectively.

SECTION 1013.0 STANDPIPES FOR BUILDINGS UNDER CONSTRUCTION OR DEMOLITION

1013.1 General: Standpipes required by this section are to be either temporary or permanent in nature, with or without a water supply, provided, however, that such standpipes conform to the requirements of Section 1012.0 as to number of risers, capacity, outlets and materials.

1013.2 Where required: Temporary or permanent standpipes shall be installed, as the work of the building progresses, beginning at the fourth story or at forty (40) feet in height.

1013.3 Height: The standpipe systems shall be carried up with each floor and shall be installed and ready for use as each floor progresses. Standpipes shall be extended as construction progresses to within one floor of the highest point of construction having secured decking or flooring.

1013.4 Outlets: Hose outlets shall be provided with caps and attachment chains. The 1 ½-inch hose and nozzle shall not be required during construction.

1013.5 Fire department connections: At the street level there shall be provided for each temporary or permanent standpipe installation one or more two-way fire department inlet connections. Fire department inlet connections shall be prominently marked and readily and easily accessible at all times (see Section 1014.8).

1013.6 Buildings under demolition: Where a building is being demolished and a standpipe is existing within such a building, such standpipe shall be maintained in an operable condition so as to be available for use by the fire department. Such standpipe shall be demolished with the building but shall not be more than one floor below the floor above being demolished.

SECTION 1014.0 FIRE DEPARTMENT CONNECTIONS (See Section 1013.5 for temporary standpipes)

1014.1 Required: All water sprinkler and standpipe systems shall be provided with at least one two-way fire department connection. Each inlet of the fire department connection shall be at least 2 ½ inches in diameter. The pipe from the standpipe system and the pipe from the water sprinkler system to the fire department connection shall not be smaller than four (4) inches. Single fire department connections shall not be installed unless approved by the fire official.

Exceptions:

1. A fire department connection shall not be required for limited area sprinkler systems (see Section 1005.6.2).
2. On standpipe or sprinkler systems where the supply pipe to the system is less than four (4) inches, the pipe from the system to the fire department connection shall not be smaller than 2 ½-inches.

1014.2 Connections: Fire department connections shall be arranged in such a manner that the use of any one water sprinkler connection will serve all the sprinklers, and the use of any one standpipe connection will serve all the standpipes within the building.

1014.3 Location: Fire department connections shall be located and be visible on a street front or in a location approved by the department. Such connections shall be located so that immediate access can be made by the fire department. Obstructions such as fences, bushes, trees, walls or any other similar object, shall not be permitted for new or existing installations.

1014.4 Height: Fire department connections shall not be less than 18 inches and not more than 42 inches in elevation, measured from the ground level to the center line of the inlets.

1014.5 Projection: Where the fire department connection would project beyond the property line or into the public way, a flush-type fire department connection shall be provided.

1014.6 Hose thread: Hose thread in the fire department connection shall be uniform with that used by the local fire department.

1014.7 Fittings: Fire department inlet connections shall be fitted with check valves, ball drip valves and plugs with chains or frangible caps.

1014.8 Signs: A metal sign with raised letters at least one (1) inch in height shall be mounted on all fire department connections serving sprinklers or standpipes. Such signs shall read *Automatic Sprinklers* and/or *Standpipe*.

SECTION 1015.0 WATER SUPPLY AND OTHER EXTINGUISHING MEDIA

1015.1 Required: All fire suppression and standpipe systems shall be provided with at least one automatic supply of extinguishing material of adequate pressure, capacity and reliability to perform the function intended, except as provided in Section 1013.0.

1015.2 Combination sprinkler/standpipe water supply: Where both sprinklers and standpipes are installed and have a common fire water service as their combined source of supply, the water supply line shall be adequately sized to meet the flow and pressure demands of the water supplies for the sprinkler system or the standpipe system, whichever is greater.

1015.3 Combination sprinkler/domestic water supply: Where a sprinkler system is connected to the domestic water supply system, the supply system shall be of adequate pressure, capacity and size for the simultaneous operation of the water sprinkler system and domestic water needs. Taps for domestic water from water sprinkler systems are prohibited.

1015.4 Size: The extinguishing material supply for fire suppression systems shall be sized in an approved manner in accordance with this code.

1015.5 Standpipe water service: All standpipe systems shall be connected to a street water main. Water mains shall be adequately sized and have enough pressure and discharge capacity to supply the total water demand for the building. Taps into the main and water service lines from the main to the building shall be at least equal in size to the largest supply line inside the building. Common supply lines from the main, from which standpipes, domestic or sprinkler systems are supplied, shall be sized to satisfy total demand.

1015.6 Standpipe interconnection: The required water supply shall be connected to the base of each standpipe riser. Where more than one standpipe riser is required, all risers shall be interconnected at their base with a common supply line and an approved indicating valve shall be installed at the base of each riser so as to permit individual risers to be taken out of service if damaged or broken without interrupting the water supply to other risers.

1015.7 Standpipes in unheated areas: Standpipes installed so that all or any portion of the system is installed through unheated areas subject to freezing shall be

so arranged through the use of approved devices as to admit water to the system automatically by opening a hose valve or through the use of approved remote control devices located at each hose station.

SECTION 1016.0 YARD HYDRANTS

1016.1 Fire hydrants: Fire hydrants installed on private property shall be located and installed as directed by the fire department. Hydrants shall conform to the standards of the administrative authority of the jurisdiction and the fire department. Hydrants shall not be installed on a water main less than six (6) inches in diameter.

SECTION 1017.0 FIRE PROTECTIVE SIGNALING SYSTEMS

1017.1 Plans and specifications: Where a fire protective signaling system is required by this code, the plans and specifications shall show the location and number of all sending stations and signals with specifications of the type, construction and operation of the system. Installation of all equipment shall conform to the requirements of this code and the applicable NFiPA Standards listed in Appendix A.

1017.2 Approval: The fire protective signaling system shall be approved for the particular application and shall be used for the fire protective signaling purpose only. Alarm boxes shall be painted a distinctive red color.

1017.3 Where required: A fire protective signaling system shall be installed and maintained in full operating condition in the locations described in Sections 1017.3.1 through 1017.3.6.

1017.3.1 Use Groups A and E: In all buildings of Use Groups A and E.

1017.3.2 Use Group B: In all buildings of Use Group B when three or more stories in height.

1017.3.3 Use Group I: In all buildings of Use Group I.

1017.3.4 Use Group I-3: In all buildings of Use Group I-3. The manual pull boxes shall be permitted to be locked, provided that staff is present within the subject area when occupied.

1017.3.5 Use Group R-1: In all buildings of Use Group R-1.

1017.3.6 Use Group R-2: In all buildings of Use Group R-2 when four or more stories in height.

1017.4 Location: Manual pull stations shall be located in each story, including basements, not more than five (5) feet from each exit. In buildings of Use Group A, where a stage is provided, a manual pull station shall be located adjacent to the lighting control panel.

> **Exception:** In buildings of Use Group A, manual pull stations may be omitted at exits, but shall be provided at constantly attended locations such as ticket booths, refreshment facilities, bars, etc. Where the building official determines that it is impractical to have a constantly attended location in an assembly occupancy other than a theater, manual pull stations shall be provided at each required building exit.

1017.4.1 Pull station height: The height of the manual pull station boxes shall be a minimum of forty-two (42) inches and a maximum of fifty-four (54) inches measured vertically, from the floor level to the activating handle or lever of the pull station.

1017.5 Coding: Systems shall be either coded or noncoded. Coded stations shall be coded in conformance with NFiPA 72A listed in Appendix A.

1017.6 Power supply: The power for the fire protective signaling system shall be provided from an emergency electrical system conforming to NFiPA 72A listed in Appendix A.

1017.7 Requirements: Fire protective signaling systems shall be of the closed circuit type and shall be electrically or mechanically supervised. In addition, such systems shall comply with Sections 1017.7.1 through 1017.7.4.

1017.7.1 Wiring: All wiring or mechanical tubing shall conform to the requirements of the Massachusetts Electrical Code - 527 CMR (12.00).

1017.7.2 Alarms: Audible alarms of the approved type shall be provided. The operation of any fire alarm device shall cause all audible or visual alarms to operate. Visual and audible alarms shall be provided in occupancies housing the hard of hearing. Alarm sounding devices shall be of approved type, shall provide a distinctive tone and shall not be used for any purpose other than that of a fire alarm. They shall be of such character and so located as to be seen or effectively heard above all other sounds, by all the occupants, in every occupied space within the building.

> **Exceptions:**
> 1. Smoke detectors in buildings of Use Group I-3 shall be permitted to alarm at a constantly attended location and are not required to accomplish general alarm indication.

2. Audible alarms in buildings of Use Group A shall sound only in a constantly attended receiving station within the building for purposes of initiating emergency action. Occupant notification shall be by means of either voice or prerecorded message announcement initiated by the person in the constantly attended receiving station. In buildings of Use Group A utilizing reduced lighting levels on a regular basis, lights providing normal lighting levels shall be activated simultaneously with the beginning of the voice or prerecorded message announcement. Where the building official determines that it is impractical to have a constantly attended location in an assembly occupancy other than a theater, the fire alarm system shall be arranged to automatically provide prerecorded evacuation instructions.

1017.7.2.1 Definition of evacuation signal for voice evacuation signaling systems: The evacuation signal shall be a standard "slow whoop" tone. The slow whoop shall be an ascending tone commencing at approximately 600 Hertz and terminating at approximately 1100 Hertz with a duration of approximately 3-½ seconds and an interruption between tones of approximately ½ second. The slow whoop shall be transmitted in a temporal pattern of three (3) pulses with a silent period of approximately four (4) seconds between each group of pulses.

1017.7.2.2 Definition of evacuation signal for systems using bells or horns: The general evacuation signal for fire alarm systems using bells, horns or other non-verbal signaling, except chimes, shall be the sounding of such devices in a temporal pattern. This pattern shall be a series of pulses. Each pulse shall be on for approximately 3-½ seconds with an interruption between pulses of approximately ½ second. The evacuation signal shall be transmitted in a temporal pattern of three (3) pulses with a silent period of approximately four (4) seconds between each group of pulses.

1017.7.2.3 Definition of evacuation signal for systems using chimes and other single stroke devices: Chimes and similar single stroke devices shall use a temporal pattern of three (3) distinct pulses with approximately one (1) second separation. There shall be a separation of approximately four (4) seconds between each three (3) pulse group. In hospital intensive care units, special care units and operating rooms, the audible signal need not be sounded; however a visual alarm shall be displayed on an approved device. The audible signal shall have a sound intensity at least ten (10) dbA above the ambient background noise level. If this sound level would exceed ninety-two (92) dbA at ten (10) feet from the sounding device, then the signal level shall be held at such a level as to produce an intensity of ninety-two (92) dbA at ten feet from the sounding device, and an approved visual signaling device(s) shall be installed. The device(s) shall be so located as to be readily visible to persons in the high sound level area. All sound levels shall be measured using an approved sound level meter.

1017.7.2.4 Length of the general evacuation signal: Once initiated, the general evacuation signal shall sound continuously on all connected devices for at least fifteen (15) minutes. The general evacuation signal may be automatically terminated at the end of this fifteen (15) minute period in order to preserve standby battery power. This automatic termination shall be permitted only if the alarm is transmitted directly to the fire department having jurisdiction. Transmitted directly shall mean transmission of the alarm via transmission facilities covered by NFiPA 71, 72B or 72C listed in Appendix A and with the permission of the head of the fire department. The term general evacuation signal shall mean the signal sounded/displayed on all signaling devices as required by NFiPA 72F or 72G listed in Appendix A which is used to require all occupants to evacuate the protected property.

1017.7.2.5 Taped message: Where voice alarm is required, the following taped message shall be provided to all areas requiring voice alarm:

> *Attention please. The signal tone you have just heard indicates a report of an emergency in this building. If your floor evacuation signal sounds after this message, walk to the nearest stairway exit and leave the floor. Do not use elevators. All handicapped occupants shall follow the building evacuation plan. While the report is being verified, occupants on other floors should await further instructions.*

This message shall be repeated once. A female voice shall be used for this message.

1017.7.3 Presignal system: Presignal systems shall not be installed unless approved by the code official and by the fire department. Where a presignal system is installed, twenty-four (24) hour personnel supervision shall be provided at a location approved by the fire department, in order that the alarm signal can be actuated in the event of fire or other emergency.

1017.7.4 Zones: Each floor shall be zoned separately. If the floor area exceeds 20,000 square feet, additional zoning shall be provided. The length of any zone shall not exceed 300 feet in any direction. Zoning indicator panels and controls shall be located as approved by the department. Annunciators shall lock in until the system is reset.

1017.8 Acceptance tests: Upon completion of the fire protective signaling system, the installation shall be subjected to a performance test to demonstrate its efficiency of operation.

SECTION 1018.0 AUTOMATIC FIRE DETECTION SYSTEMS

1018.1 Plans and specifications: Where an automatic fire detection system is required by this code, the plans and specifications shall show the location and number of all sending stations and signals with specifications of the type,

construction and operation of the system including all automatic detection devices. Installation of all equipment shall conform to requirements of this code and NFiPA 72E listed in Appendix A. The system shall be installed in accordance with this section and shall be part of and subject to the requirements of a fire protective signaling system specified in Section 1017.0.

1018.2 Approval: The automatic fire detection system shall be approved for the particular application and shall only be used for detection and signaling in the event of fire. The automatic detecting devices shall be smoke detectors, except an approved alternative type of detector shall be installed in spaces such as boiler rooms where during normal operation products of combustion are present in sufficient quantity to cause alarm.

1018.3 Where required: An automatic fire detection system shall be installed and maintained in full operating condition in the locations described in Sections 1018.3.1 through 1018.3.5.

1018.3.1 Use Group I-2: Buildings of Use Group I-2 shall be equipped with a fire protective signaling system in accordance with this section or Article 6 as applicable.

1018.3.2 Use Group I-3: Automatic smoke detectors shall be installed throughout all resident housing areas.

Exceptions:

1. Smoke detectors shall not be required in sleeping rooms with four or less occupants in Use Condition II or III (see Section 307.4).
2. Smoke detectors shall not be required in sleeping rooms with four or less occupants in buildings protected throughout with an approved automatic fire suppression system.

1018.3.3 Use Group B: In all buildings of Use Group B when such buildings have floors used for human occupancy located more than 70 feet above the lowest level of fire department vehicle access.

1018.3.4 Automatic fire warning systems in residential use groups R-1, R-2, R-3 and R-4: Every building, structure or portion thereof for which a permit was issued on or after January 1, 1975, and not exceeding seventy (70) feet in height above mean grade, in use groups R-1, R-2, R-3 or R-4 shall be subject to the provisions of this section. Such buildings in use groups R-1 or R-2 which exceed seventy (70) feet in height shall be subject to the provisions of Section 1018.3.4.1, Item 6 (also see Section 602). Buildings or structures which are altered or repaired shall be subject to the provisions of Section 106.0. A summary of the requirements is given in Table 1018.

1018.3.4.1 R-1 and R-2 use groups: All buildings or portions thereof of R-1 and R-2 use groups shall incorporate automatic fire detectors located as required in the following Items 1 through 9 (see Section 1018.3.4.3 for type of system):

1. All buildings of R-1 and R-2 use groups which contain six (6) or less separate residential units shall use a Type III or Type II system with multiple station smoke detectors on each level of the common space as defined in Section 1018.3.4.1, Item 7a (see Item 4 if three (3) or more stories).
2. All buildings of R-1 and R-2 use groups which contain seven (7) to twelve (12) separate residential units shall be provided with a Type II system (see Item 4 if three (3) or more stories).
3. All buildings of R-1 and R-2 use groups which contain thirteen (13) or more separate residential units shall be provided with a Type I system and zoned in conformance with Section 1018.3.4.5.
4. All buildings of R-1 and R-2 use groups which contain thirteen (13) or more separate residential units, or are three (3) or more stories in height, shall incorporate manual pull stations located in conformance with Section 1018.3.4.4.
5. All buildings of R-1 and R-2 use groups which contain twenty-five (25) or more separate residential units shall incorporate provisions for automatic fire department notification in conformance with Section 1018.3.4.6.
6. Approved single or multiple station smoke detectors shall be located within each residential unit to comply with the following minimum requirements:

    a. Minimum number of detectors:

        i. One (1) approved smoke detector shall be located outside of each separate sleeping area, in accordance with the definition for "separate sleeping area" as defined in Section 1018.3.4.2, item 2.b.i and NFiPA 74 as listed in Appendix A.
        ii. In residential units twelve hundred (1200) square feet or more in area, at least one (1) permanently wired multiple station smoke detector shall be provided for each twelve hundred (1200) square feet of area or part thereof.

    b. Location of detectors:

        i. One (1) approved smoke detector shall be located outside of each separate sleeping area, as defined in Section 1018.3.4.2, item 2.b.i, and NFiPA 74 as listed in Appendix A.
        ii. One (1) approved smoke detector shall be located on the ceiling near the base of, but not within, each stairway.

iii. A smoke detector shall not be required to be located in or within six (6) feet of a kitchen or cooking area. (This provision does not preclude installation in these areas.)

7. Approved fire detectors also shall be located within the structure to comply with the following minimum requirements:
   a. Corridors, lobbies and exitway discharge: All lobbies, common corridors, hallways and exitway access and discharge routes shall be provided with approved smoke detectors with not more than a thirty (30) foot spacing between detectors.
   b. Inside residential unit entrance doorways: All residential unit doorways to corridors or hallways shall be provided with an approved heat detector located not more than six (6) feet inside the doorway and in conformance with the requirements of NFiPA 72E as listed in Appendix A.
   c. Other rooms: All rooms one hundred (100) square feet in area or more, not in residential units, shall be equipped with approved heat detectors or smoke detectors located in accordance with the requirements of their listing and in conformance with NFiPA 72E as listed in Appendix A.

8. All detectors in Section 1018.3.4.1, Item 7, shall be arranged to activate the building fire alarm in accordance with Section 1018.3.4.3.

9. Any building of R-1 and R-2 use groups that is completely protected by an approved automatic sprinkler system may omit the detectors required in Section 1018.3.4.1, Item 7, provided that water flow will sound the building fire alarms in accordance with Section 1018.3.4.3. When a building in use group R-1 and R-2 is completely sprinklered, sprinklers may be omitted in closets and similar spaces which are located within an individual dwelling unit when the least dimension of such spaces is not greater than thirty (30) inches and the floor area within such spaces does not exceed twenty-four (24) square feet.

Exceptions:
1. See Section 637 for types of systems required in R-1 detoxification facilities.
2. Required smoke detectors shall not be deleted when an approved automatic sprinkler system is installed.

1018.3.4.2 R-3 and R-4 use groups, including manufactured homes:

1. All buildings which are defined by this code as one or two-family dwellings shall contain a Type III system in conformance with Section

1018.3.4.3 with smoke detectors located as required in Section 1018.3.4.2, Item 2, of this section and in accordance with NFiPA 72E as listed in Appendix I.

2. Smoke detectors shall be located to comply with the following minimum requirements:

   a. Minimum number of detectors:
      i. Not less than one (1) approved smoke detector shall be provided on the highest habitable level and on each floor, story or level below, including basements or cellars.
      ii. For any floor, level or story exceeding twelve hundred (1200) square feet in area, one (1) approved smoke detector shall be provided for each twelve hundred (1200) square feet or part thereof.

   b. Location of detectors:
      i. One (1) approved smoke detector shall be located outside of each separate sleeping area. By sleeping area is meant the area or areas of the family living unit in which the bedrooms (or sleeping rooms) are located. Bedrooms (or sleeping rooms) separated by other use areas, such as kitchens or living rooms (but not bathrooms), shall be considered as separate sleeping areas for the purposes of this regulation.
      ii. One (1) approved smoke detector shall be located on the ceiling near the base of, but not within, each stairway.
      iii. A smoke detector shall not be required to be located in or within six (6) feet of a kitchen, cooking area or garage. (This provision does not preclude installation in these areas.)

   c. Combined coverage:
      Smoke detectors required by Section 1018.3.4.2, Item 2.a, may be used to fulfill the requirements of Section 1018.3.4.2, Item 2.b.

1018.3.4.3 Type of systems: Systems shall be one (1) of the following types as required by this section:

1. Type I: A Type I system shall be installed in conformance with the Massachusetts Electrical Code (527 CMR 12.00) and NFiPA 72A as listed in Appendix G and Appendix A, respectively. A Type I system shall include an approved secondary source of power and incorporate an annunciator at the grade level located as directed by the local fire department.

2. Type II: A Type II system shall be installed in conformance with the Massachusetts Electrical Code (527 CMR 12.00) and NFiPA 72A as listed in Appendix G and Appendix A, respectively. A Type II system shall include an approved secondary source of power.
3. Type III: A Type III system shall be installed in accordance with NFiPA 74 as listed in Appendix A. Power shall be supplied from a permanently-wired connection directly to an AC primary source of power or monitored batteries. All power for AC powered detectors shall be taken from a single branch circuit serving a habitable area; and the power source for the detectors shall be on the supply side, ahead of any switches. All required smoke detectors shall be provided with a visible power-on indication. All required smoke detectors shall be interconnected so that when one actuates all will sound to meet the requirements of NFiPA 74, Section 2-2.4, as listed in Appendix A. All required smoke detectors shall conform with Section 1018.3.4.7, Items 1, 2 and 5.

1018.3.4.4 Manual pull stations: Where required, manual pull stations shall be located on the corridor side of, and within six (6) feet of each entrance to an exitway. Manual pull stations shall be connected to the building fire alarm system in conformance with NFiPA 72A as listed in Appendix A.

1018.3.4.5 Zones: Where required, each floor, level or story shall be separately zoned. The length of any zone on any floor, level or story shall not exceed two hundred (200) feet in any direction.

1018.3.4.6 Automatic fire department notification: Where required to provide automatic fire department notification, the system shall be connected to the fire department alarm headquarters if so directed by the head of the local fire department, in conformance with NFiPA 72B, NFiPA 72C, or NFiPA 71 as listed in Appendix A.

1018.3.4.7 Approved devices:

1. Single station and multiple station smoke detection devices: Smoke detectors of single station and multiple station types shall meet the requirements of UL 217 as listed in Appendix A and be listed or approved by a nationally recognized fire testing laboratory.
2. Smoke detectors, other than single station and multiple station devices, shall meet the room fire test provisions of UL 167 in addition to carrying a listing or approval as meeting UL 167 or UL 168.
3. All heat detectors shall be listed or approved for a spacing not less than thirty (30) feet.
4. All other alarm equipment used in this section shall be listed or approved by a nationally recognized fire testing laboratory.

5. The State Board of Building Regulations and Standards shall withdraw the approval from any device or equipment which repeatedly fails to perform under this section.

1018.3.4.8 Maintenance and testing:

1. It shall be the responsibility of the owner to properly maintain the system.
2. All Type I and Type II systems shall be tested at least annually in conformance with the NFiPA 72A as listed in Appendix I with the performance of each initiating device and indicating device recorded with the head of the fire department.
3. In addition to the above, all Type I systems connected to the fire department shall be tested with advance notice as required by the head of the fire department.

1018.3.5 Use Groups A-4 and E: In all buildings of use groups A-4 and E (churches, schools, etc.).

TABLE 1018
Residential Fire Protection Requirements

Use Group	Number of Units	Unit Occupant Protection	Other Occupant Protection	Standby Power	Manual Stations	Zoned	Provision for Fire Department Notification
R-3	1 or 2	Yes 1018.3.4.2	N.A.	N.A.	N.A.	N.A.	N.A.
R-1 and R-2	6 or less	Yes 1018.3.4.1	Yes 1018.3.4.1	N.A.	N.A. (note a)	N.A.	N.A.
R-1 and R-2	7 to 12	Yes 1018.3.4.1	Yes 1018.3.4.1	Yes 1018.3.4.3	N.A. (note a)	N.A.	N.A.
R-1 and R-2	13 to 24	Yes 1018.3.4.1	Yes 1018.3.4.1	Yes 1018.3.4.3	Yes 1018.3.4.4	Yes 1018.3.4.5	N.A.
R-1 and R-2	25 or more	Yes 1018.3.4.1	Yes 1018.3.4.1	Yes 1018.3.4.3	Yes 1018.3.4.4	Yes 1018.3.4.5	Yes 1018.3.4.6

Note a: Manual pull stations required for all Use Group R-1 buildings and for Use Group R-2 buildings four (4) stories or more in height.

1018.4 Sprinklered buildings exception: Buildings or portions thereof equipped throughout with an automatic fire suppression system are not required to be equipped with an automatic fire detection system, but are required to be equipped with a manual fire protective signaling system conforming to Section 1017.0. This exception does not apply to buildings of Use Group I, or to single-station smoke detectors as required in Section 1018.3.4.

1018.5 Distances: Smoke detectors shall be installed not to exceed the lineal or square footage allowances specified, based on the test standards under which they were tested and approved.

1018.6 Zones: The automatic fire detection system shall be connected to the same zones as those required for the fire protective signaling system in Section 1017.0. Automatic detectors which have separate indication on the annunciator panel from the manual pull stations and the fire suppression systems shall have detection zones which match the pull station zones in size and arrangement.

SECTION 1019.0 SMOKE CONTROL SYSTEMS

1019.1 General: Smoke control systems required by this code shall conform to the provisions of this section.

1019.1.1 Acceptance: Before a certificate of occupancy is issued, the smoke control system shall be tested in an approved manner to show compliance with the applicable requirements of this section.

1019.1.2 Standby power: All equipment required to provide smoke control shall be equipped with a standby source of power complying with the Massachusetts Electrical Code.

Exceptions:
1. Mechanical air-handling equipment designed to accomplish smoke control in systems specified in Sections 1019.2 and 1019.3 when the building is equipped throughout with an approved automatic fire suppression system.
2. Smoke control systems specified in Section 1019.4.

1019.1.3 Inspections: All operating parts of the smoke control systems specified in Sections 1019.5 and 1019.6 (including dampers) shall be tested by the owner every three months and a log of the tests shall be kept for examination by the fire department. At six month intervals, the system shall be inspected and operated in accordance with the BOCA National Fire Prevention Code and 527 CMR listed in Appendix A and Appendix G, respectively.

1019.2 High-rise buildings: Where required by Section 602.7, natural or mechanical ventilation for the removal of products of combustion shall be provided in every story and shall consist of one of the methods described in Sections 1019.2.1 through 1019.2.3.

1019.2.1 Panels or windows: Panels or windows shall be provided in the exterior walls which can be opened remotely from an approved location other than the fire floor. Such venting facilities shall be provided at the rate of 20 square feet per 50 lineal feet of exterior wall in each story and shall be distributed around the perimeter at not more than 50 foot intervals. Such windows or panels and their controls shall be clearly identified.

Exception: Where an approved automatic fire suppression system is installed throughout, remotely operated openable panels and windows are not required when windows or panels manually openable from within the fire floor are installed or approved fixed tempered glass is used. Such windows shall be clearly identified and shall be of the size and spacing indicated above.

1019.2.2 Mechanical system: Where an approved automatic fire suppression system is installed throughout, and the mechanical air handling equipment is designed to accomplish smoke removal, the return and exhaust air shall be moved directly to the outside without recirculation to other sections of the building under fire conditions. The air handling system shall provide a minimum of one exhaust air change each 10 minutes for the area involved.

1019.2.3 Other designs: Any other approved design which will adequately remove smoke from each compartment served in an unsprinklered building is permitted, provided the system is tested and approved by the code official before the building is certified for occupancy.

1019.3 Elevators: When equipped with a mechanical smoke control system that will restrict smoke and hot gases from entering the elevator shaft in the fire floor, hoistway venting specified in Section 2608.3 is not required. In high-rise buildings equipped with this system and equipped throughout with an approved automatic fire suppression system, the 1-hour fireresistance rated elevator lobbies specified in Section 602.8 are not required.

1019.4 Covered mall buildings: Where required by Section 601.11, the mall and adjacent tenant spaces shall be equipped with an approved smoke control system. Smoke control equipment serving the mall shall be sized to provide a minimum of six air changes per hour for malls having a volume of 600,000 cubic feet or less, and a minimum of four air changes per hour for malls having a volume of more than 600,000 cubic feet. The volume shall be measured from the entrance to tenant spaces and to a height of 12 feet above each pedestrian area. Exhaust inlets for the mall shall be located a minimum of 6 feet above the walking surface. Necessary outside air to accomplish the required air changes per hour shall be provided.

1019.4.1 Activation: The exhaust system shall be activated by smoke detectors complying with NFiPA 72E listed in Appendix A, by operation of the sprinkler system, and manually. A smoke detector shall be installed in the return air portion of every heating and cooling system ahead of any fresh air intake. The activation system shall be installed in an approved manner.

1019.4.2 Operation: The approved automatic exhaust system shall be a separate system or shall be integrated with an approved air conditioning system. Where a separate system is provided, operation of the fire emergency ventilating system shall automatically shut down the air conditioning system or any other devices which interfere with the effective operation of the fire emergency ventilating system.

1019.4.2.1 Tenant space zones: When a fire occurs within a tenant space zone, that zone shall operate at 100 percent exhaust, and supply air to that zone shall be shut down. Adjoining tenant space zones shall go to normal operations and the mall system shall operate at 100 percent fresh air supply.

1019.4.2.2 Mall system: When a fire occurs within the mall, the mall system shall operate at 100 percent exhaust, and adjoining tenant spaces shall go to normal operation.

1019.5 Atriums: Where required by Section 606.2.1, a smoke control system shall be designed to control the migration of products of combustion in the atrium spaces. A mechanically operated air handling system shall be installed that will exhaust smoke either entering or developed within the atrium. Exhaust openings shall be located in the ceiling or in a smoke trap area immediately adjacent to the ceiling of the atrium. Supply openings sized to provide 50 percent of the exhaust volume shall be located at the lowest level of the atrium. For purposes of this section, the volume of the atrium shall include all spaces not separated from the atrium in accordance with Section 606.2.2.

1019.5.1 Supply air: Where the height of the atrium is 55 feet or less, supply air introduced by gravity is permitted provided smoke control is accomplished. When the height of the atrium is more than 55 feet, supply air shall be introduced mechanically from the floor of the atrium and be directed vertically toward the exhaust outlets. In atriums over six stories in height or having open floors above the second story, introduction of supplemental supply air at upper levels is permitted.

1019.5.2 Exhaust: The atrium smoke control system shall exhaust not less than the following quantities of air:

1. For atriums having a volume of not more than 600,000 cubic feet, including the volume of any levels not physically separated from the atrium, not less than 40,000 cfm nor less than six air changes per hour.
2. For atriums having a volume of more than 600,000 cubic feet, including the volume of any levels not physically separated from the atrium, not less than four air changes per hour.

1019.5.3 Smoke detectors: Smoke detectors shall be installed at the perimeter and on the ceiling of the atrium and on the underside of each floor level that is open to the atrium space. Detectors shall be located in accordance with their listing.

1019.5.4 Smoke control activation: The smoke control system required for the atrium spaces shall be activated by the fire suppression system, by smoke detectors required by Section 1019.5.3, and by manual controls provided for fire department use. The system shall not be activated by a manual fire protective signaling system required by Section 1017.0. Manual controls shall be located in the central control

station or other location approved by the fire department. When the smoke control system is activated, other air handling systems which interfere with its function shall shut off automatically.

1019.5.5 Other approved methods: Any other approved design which will achieve the same level of smoke control as described in this section is permitted in lieu of these requirements.

1019.6 Floor openings: The smoke control system required by Section 606.3.1 shall be an automatic exhaust system designed to prevent the passage of smoke to the story above in accordance with Sections 1019.6.1 through 1019.6.3, or any other approved system of smoke control which will accomplish the same purpose.

1019.6.1 Control: The system shall be a separate unit or shall be integrated with an approved air handling system and shall be thermostatically controlled to operate simultaneously with the detection of fire.

1019.6.2 Capacity: The system shall be of adequate capacity to create a controlled draft in the floor opening with sufficient velocity of flow over the entire area of the floor opening under normal conditions of window and door openings in the building.

1019.6.3 Operation: The system shall be so arranged as to automatically stop the operation of the normal mechanical air handling and ventilating systems, and close the dampers of the return air duct connections, in the event of fire.

SECTION 1020.0 SUPERVISION

1020.1 Fire suppression systems: Fire suppression systems required for buildings of Use Groups A, E, I or R shall be supervised by methods 1, 2, 3 or 4 below. All other fire suppression systems shall be supervised by one of the following methods:

1. Approved central station system in accordance with NFiPA 71 listed in Appendix A.
2. Approved proprietary system in accordance with NFiPA 72D listed in Appendix A.
3. Approved remote station system of the jurisdiction in accordance with NFiPA 72C listed in Appendix A.
4. Approved local alarm service which will cause the sounding of an audible signal at a constantly attended location in accordance with NFiPA 72A listed in Appendix A.
5. Locking valves open.
6. Approved auxiliary protective system(s) which will cause the sounding of an audible signal at a constantly attended location in accordance with NFiPA 72B as listed in Appendix A.

Exceptions:
1. Underground gate valves with roadway boxes.
2. Halogenated extinguishing systems.
3. Carbon dioxide extinguishing systems.
4. Dry chemical extinguishing systems.
5. Limited area sprinkler systems.

1020.2 Fire protection systems: All required fire protection systems, other than fire suppression systems, shall be connected to an approved central station system, proprietary system, or remote station system of the jurisdiction when approved by the fire department. Fire suppression systems shall conform to Section 1020.1.

Exceptions:
1. Standpipe systems.
2. Fire alarm systems in buildings of Use Group R when less than five stories in height.
3. Single-station detectors required by Section 1018.3.4.
4. Smoke detectors in buildings of Use Group I-3.

SECTION 1021.0 FIRE EXTINGUISHERS

1021.1 Approval: Portable fire extinguishers shall bear the label of an approved agency and shall be installed in a location visible and accessible to the occupants.

1021.2 Where required: A portable fire extinguisher shall be installed in the following locations in accordance with NFiPA 10 listed in Appendix A.

1. In all buildings of Use Groups A-1, A-2, A-3, A-4, E, I-2, R-1 and H.
2. In all areas containing commercial kitchen exhaust hood systems.
3. In all areas where fuel is dispensed.
4. In all areas where a flammable or combustible liquid is used in the operation of spraying, coating or dipping.
5. In all buildings of Use Group I-3 at staff locations. Access to portable extinguishers shall be permitted to be locked.
6. On each completed floor of buildings under construction, other than buildings of Use Group R-3.

ARTICLE 11

STRUCTURAL LOADS

(This Article is entirely unique to Massachusetts)

SECTION 1100.0 GENERAL

1100.1 Scope: The provisions of this article shall control the structural design of all buildings and structures or potions thereof hereafter erected.

SECTION 1101.0 PLANS AND SPECIFICATIONS

1101.1 General: Design plans drawn to appropriate scale shall show the size, section and relative locations of all structural members with floor levels, column centers and all offsets fully dimensioned. The design loads shall be clearly indicated for all parts of the building or structure.

SECTION 1102.0 DESIGN SAFE LOAD

1102.1 Safe support required: Buildings or other structures, and all parts thereof, shall be designed and constructed to support safely all loads, including dead loads, without exceeding the allowable stresses (or specified strengths when appropriate load factors are applied) for the materials of construction in the structural members and connections.

1102.2 Load tests: The building official is authorized to require a load test, or certified reports of such tests, conducted in an approved manner by approved testing agencies, of any construction whenever there is reason to question its safety for intended occupancy or use. Load test provisions are presented in Section 1302.0.

SECTION 1103.0 DESIGN LIVE LOAD

1103.1 Required live load: The live loads to be assumed in the design of buildings and structures shall be the greatest load produced by the intended use and occupancy, but not less than the minimum uniformly distributed unit loads required in Section 1106.0 for specific uses.

1103.2 Loads not specified: The building official shall approve the live load for any use not specifically provided for in Table 1106.

SECTION 1104.0 DESIGN DEAD LOAD

1104.1 Weights of materials and construction: In estimating dead load for the purposes of structural design, the actual weights of materials and constructions shall be used, but not less than the unit dead loads prescribed in Appendix B and ANSI A58.1 listed in Appendix A. In the absence of definite information, any values assumed by the designers shall be subject to the approval of the building official.

1104.2 Weight of fixed service equipment: In estimating dead loads for the purposes of design, the weight of service equipment such as plumbing stacks and risers, electrical feeders, heating, ventilating, air conditioning and sprinkler systems shall be included.

1104.3 Partition load: In offices and other buildings, in which subdividing partitions are subsequently erected, rearranged or relocated, provisions shall be made to support the actual weight of such partitions where they occur or for an equivalent uniform load, which shall be assumed not less than 20 pounds per square foot (psf) of floor area in addition to the specified uniformly distributed live load. Provisions for partition weight shall be made whether or not partitions are shown on the plans, unless the specified live load exceeds 80 psf.

SECTION 1105.0 EXISTING BUILDINGS

1105.1 General: In the reconstruction, repair, extension or alteration of existing buildings, comply with Sections 1105.2 through 1105.5 and Article 32.

1105.2 Building extended: When an existing building is altered by an extension in height or area, all existing structural parts affected by the addition shall be strengthened where necessary, and all new structural parts shall be designed to meet the requirements for buildings hereafter erected.

1105.3 Building repaired: When repairs are made to the structural portion of an existing building, and the uncovered structural portions are found unsound, such parts shall be made to conform to the requirements for buildings hereafter erected.

1105.4 Existing live load: When an existing building heretofore approved is altered or repaired within the limitations prescribed in Article 32, the structure may be designed for the loads and stresses applicable at the time of erection, provided the public safety is not endangered thereby.

1105.5 Posted live load: Any existing building heretofore approved, in which there is not a change in use to a new use group requiring greater floor loads, may be posted for the originally approved live loads, provided the building is structurally

safe in all its parts, adequate for its existing use, and the public safety is not endangered thereby.

SECTION 1106.0 UNIFORMLY DISTRIBUTED LIVE LOADS

1106.1 Uniform live load: The plans for all buildings and structures intended for other than R-3 and R-4 use groups shall specify the live and partition loads for which each floor or part thereof has been designed. The minimum uniformly distributed live load in pounds per square foot (psf) shall be as provided in Table 1106, and for all concentrated loads wherever they occur as provided in Section 1107.0.

Table 1106
MINIMUM UNIFORMLY DISTRIBUTED LIVE LOADS

Occupancy and use	Live load (psf)
Apartments (see Residential)	
Armories and drill rooms	150
Assembly halls and other places of assembly:	
Fixed seats	60
Movable seats	100
Platforms (assembly)	100
Balcony and Open decks	60 (or as required by occupancy load)
Bowling alleys, poolrooms, and similar recreational areas	75
Cornices	75
Court rooms	100
Corridors:	
First floor	100
Other floors, same as occupancy served except as indicated	
Dance halls and ballrooms	100
Dining rooms and restaurants	100
Dwellings (see Residential)	
Elevator machine rooms	150
File and computer rooms in all building types	Unit load based on anticipated occupancy
Fire escapes:	100
On multi or single family residential buildings only	40
Garages (passenger cars only)	50
(For trucks and buses use AASTHO[a] lane loads)	
(see Table 1107 for concentrated load requirements)	
(see Section 1110.1 for roofs)	

Table 1106 (continued)
MINIMUM UNIFORMLY DISTRIBUTED LIVE LOAD

Occupancy or use	Live load (psf)
Grandstands (see reviewing stands)	
Gymnasiums, main floors and balconies	100
Hospitals:	
Operating rooms, laboratories	100
Private rooms	40
Wards	40
Corridors, above first floor	80
Hotels (see residential)	
Libraries:	
Reading rooms	60
Stack rooms (books & shelving at 40 pcf) but not less than	150
Corridors, above first floor	80
Manufacturing:	
Light	125
Heavy	150 (min) or occupancy load, if greater
Marquees	75
Office buildings:	
Offices	50
Lobbies	100
Corridors, above first floor	80
Open parking structures (passenger cars only)	50
Penal institutions:	
Cell blocks	40
Corridors	100
Residential:	
Multi family:	
Private apartments	40
Public rooms	100
Corridors, balconies, open decks	80
1 & 2 family dwellings:	
First floor	40
Second floor and habitable attics	30
Unhabitable attics[b]	20
Open decks or balconies	60
Hotels:	
Guest rooms	40
Public rooms	100
Corridors, balconies or open decks serving public rooms	100

Table 1106 (continued)
MINIMUM UNIFORMLY DISTRIBUTED LIVE LOAD

Occupancy or use	Live load (psf)
Hotels (cont'd.):	
Corridors, balconies or open decks	80
Reviewing stands and bleachers[c]	100
Schools:	
Classrooms	50
Corridors	100
Flexible open plan areas	100
Sidewalks, vehicular driveways and yards, subject to trucking	250
Skating rinks	100
Stairs and exits	100
Storage warehouse:	
Light	125
Heavy	250
Stores:	
Retail	
First floor, rooms	100
Upper floors	75
Wholesale	125
Theaters	
Aisles, corridors and lobbies	100
Orchestra floors	60
Balconies	60
Stage floors	150
Yards and terraces, pedestrians	100

Note a. American Association of State Highway transportation Officials.

Note b. Live load need be applied to joists or to bottom chords of trusses or trussed rafters only in those portions of attic space having a clear height of forty-two (42) inches or more between joist and rafter in conventional rafter construction, and between bottom chord and any other member in trusses or trussed rafter construction. However, joists or the bottom chords of trusses or trussed rafters shall be designed to sustain the imposed dead load or ten (10) pounds per square foot (psf) whichever is greater, uniformly distributed over the entire span.

A further ceiling dead load reduction to a minimum of five (5) pounds per square foot (psf) or the actual dead load, whichever is greater, may be applied to joists in conventional rafter construction, or to the bottom chords of trusses of trussed rafters under either or both of the following conditions.

1. If the clear height is not over thirty (30) inches between joist and rafter in conventional construction and between the bottom chord and any other member for trusses or trussed rafter construction.
2. If a clear height of greater than thirty (30) inches, as defined in item (1) above, does not exist for a horizontal distance of more than twelve (12) inches along the member.

Note c. For detailed recommendations, see the Standards for Tents, Grandstands, and Air-Supported Structures Used for Places of Assembly, NFiPA 102, listed in Appendix A.

1106.2 Partial live loading: The full intensity of the appropriately reduced live load applied only to a portion of the length of a structure or member shall be considered if it produces a more unfavorable effect than the same intensity applied over the full length of the structure or member.

1106.3 Posting of live loads: In every building or other structure or part thereof of Use Groups B, F, M or S, the design loads shall be marked on plates of approved design which shall be supplied and securely affixed by the owner of the building, or the owner's authorized agent, in a conspicuous place in each space to which they relate. Any plates lost, removed or defaced shall be replaced by the owner or the owner's agent.

SECTION 1107.0 CONCENTRATED LOADS

1107.1 General: Floors and roofs of buildings of buildings shall be designed to support the uniformly distributed live loads prescribed in Section 1106.0 or the concentrated loads prescribed in Table 1107, whichever produces the greater effects. The indicated concentrated load shall be located so as to produce the maximum stress conditions in the structural members.

Table 1107
CONCENTRATED LOADS

Location	Concentrated Load (lbs.)	Applied Area (inches each side of a square)
Garages, open parking structures	See note 1	See note 1
Manufacturing and storage buildings	2,000	See note 2
Hospital floors	1,000	30
Library floors	1,000	30
Mercantile floors	2,000	30
Office floors	2,000	30
Roofs	200	6
School floors	1,000	30
Sidewalks	8,000	15
Elevator machine room grating	300	2
Finish light floor plate construction	200	1
Greenhouse, roof bars, purlins and rafters	100	1
Scuttle, skylight and accessible ceiling ribs and hangers	200	1
Stair treads	300	2

Note 1: Open parking structures, garages or portions of buildings used for storage of motor vehicles (see Section 1110.1 for roofs):

1) for passenger cars accommodating not more than (9) passengers, two thousand (2,000) pounds acting on an area of six (6) inches each side of a square;

2) for trucks or buses, maximum axle load on two areas of 8 inches by 20 inches, 6 feet apart.

Note 2: Buildings in which mechanical material handling equipment, machines or apparatus will be utilized: the actual concentrated loads of the machinery.

SECTION 1108.0 IMPACT LOADS

1108.1 General: The live loads specified in Section 1106.0 may be assumed to include adequate allowance for ordinary impact conditions. Provision shall be made in the structural design for special uses and loads which involve vibration and impact forces. Where dynamic effects such as resonance and fatigue are likely to be important as a result of cyclical loading, a dynamic analysis shall be carried out.

1108.2 Elevators: Structural supports for elevators, dumbwaiters, escalators and moving walks shall be designed for the loads and within the limits of the deflection specified in the Massachusetts State Department of Public Safety Board Elevator Regulations (524 CMR 1.0 through 34.0). (In accordance with the Regulations, all suspended elevator loads shall be increased one hundred percent (100 %) for impact.)

1108.3 Machinery and moving loads: For machinery and moving loads, the minimum applied load shall be the total of the maximum weight of the machinery or moving loads multiplied by the impact factor listed below:

	Impact Factor
Motor-driven cranes	1.25
Hand-driven cranes	1.10
Light machinery, shaft or motor driven	1.20
Reciprocating machinery	1.50

The impact factor for machinery or cranes shall be increased, when so recommended by the manufacturer.

1108.4 Hangers for floors and stairs: Live loads on hangers supporting floors or stairs shall be multiplied by an impact factor of 1.33.

SECTION 1109.0 SPECIAL LOADS

1109.1 General: Provisions shall be made for all special loads herein prescribed and all other special loads to which the building or structure may be subjected.

1109.2 Loads on below grade walls: All retaining walls and other walls below grade shall be designed to resist lateral soil pressures with appropriate allowance for hydrostatic pressure, for all superimposed vertical loads and seismic effects.

1109.3 Hydrostatic uplift: All foundation slabs and other footings subjected to water pressure shall be designed to resist a uniformly distributed uplift equal to the maximum hydrostatic pressure which may occur. Counteracting weight shall be reduced as prescribed in Section 1114.0.

1109.4 Construction loads and erection loads: Procedures of construction and erection shall be adopted which prevent loading of the structure above its design capacity. Where specified or proposed procedures require the strengthening of structural elements beyond that required in the finished building, such increase in the capacity of the structural elements shall be provided.

1109.5 Horizontal crane loads: A lateral force shall be applied perpendicular (normal) to the span of runway beams and a lateral force shall be applied parallel (longitudinal) to the beam span.

(a) The lateral force acting normal to the runway shall be applied at the top of the rail, and shall be twenty (20) percent for power-operated crane trolleys, and ten (10) percent for hand-operated trolleys, of the sum of the weights of the maximum lifted load and of the crane trolley. This force shall be distributed to tributary supporting structural members based on the relative lateral stiffness of each component structure supporting the rails.

(b) The longitudinal force acting parallel to the runway and applied at the top of the rail shall be ten (10) percent of the maximum wheel loads of the crane.

(c) Reductions in these loads may be permitted if substantiating technical data acceptable to the building official is provided.

(d) These loads need not be considered in combination with wind loads.

1109.6 Partitions and interior finish: Partitions, their components and other interior finish shall have adequate strength to resist a horizontal load of not less than 5 psf.

1109.7 Guardrails and handrails: All required guardrails and handrails shall be designed and constructed to the structural loading conditions set forth in Table 1109

without exceeding the allowable design working stresses of the materials, anchorage and connecting devices utilized. The allowable working stresses shall be as defined by the appropriate design standard. Each load shall be applied so as to produce the maximum stress in each of the respective components.
Each load shall be applied in the direction indicated in the table. The concentrated load and uniformly distributed loads need not be applied simultaneously. The loads applied to in-fill areas need not be applied simultaneously with the loads applied on the top railing.

1109.8 Railings and barriers in places of public assembly, grandstands and stadia: Railings and barriers around stairways, stair wells, balconies and other floor openings, both exterior and interior, shall be designed to resist a concentrated load of at least three hundred (300) pounds applied in any direction at any point at the top of the barrier and also to resist a uniformly distributed load of one hundred (100) pounds per lineal feet applied in any direction at the top of the barrier, whichever is more severe.

Table 1109
LOADS ON GUARDRAILS AND HANDRAILS

Type of occupancy	Location of load	Type of load	Direction of load	Magnitude of load
All	Handrails	Concentrated	Any	200 lbs.
All, except dwelling units in Use Groups R-2 and R-3	Handrails	Uniformly distributed	Any	50 lbs./ft.
All	Guardrails, top railing members	Concentrated	Any	200 lbs.
All, except dwelling units in Use Groups R-2 and R-3	Guardrails, top railing members	Uniformly distributed	Vertical simultaneously with horizontal	100 lbs./ft. 50 lbs./ft.
All	Guardrails, in-fill areas	Concentrated	Any	200 lbs. applied over 1 s. f. area

1109.9 Driveways and parking areas: Columns, walls, spandrel panels, barriers, bumpers or similar devices in driveways and parking areas that are subject to possible impact of moving vehicles shall be designed to resist a concentrated lateral load of not less than seven thousand (7,000) pounds, applied at least eighteen (18) inches above the roadway.

1109.10 Grandstands, stadia and similar structures shall be designed to resist, in combination with design wind loads, a horizontal swaying load applied parallel to the row of seats of not less than twenty-four (24) pounds per lineal foot of seats per row, and a horizontal swaying load applied transversely of not less than ten (10) pounds per lineal foot of seats per row. Design footboards and seat boards for a minimum vertical load of 120 lbs. per lineal foot.

1109.11 Temperature loads: Movements, and forces resulting from restraint of movements, produced by changes in temperature shall be considered in the design of buildings and structures.

SECTION 1110.0 SPECIAL CONSIDERATIONS FOR ROOFS

1110.1 Parking on roofs: Where roofs are used for parking of vehicles, the appropriate live load shall be added to the snow load.

1110.2 Other special uses: Where roofs are used for roof gardens or assembly use, the minimum uniformly distributed live load shall be 100 psf. Where roofs are used for incidental promenade purposes, the minimum uniformly distributed live load shall be 60 psf. The structure shall be designed for the effects of the appropriate roof live load, or the effects of the snow loads specified in Section 1111.0 whichever are larger.

1110.3 Landscaped roofs: Where roofs are to be landscaped, the weight of the landscaping shall be considered a dead load. Soils shall be considered to be fully saturated when computing the weight of the soils.

1110.4 Ponding: Roofs shall be designed for the maximum possible depth of water that may be ponded thereon as determined by the relative levels of roof deck, overflow weirs, scuppers, edges of serviceable drains, and the deflected shape of structural elements. In determining the maximum possible depth of water, all primary roof drainage means shall be assumed to be blocked.

SECTION 1111.0 SNOW LOAD

1111.1 General: Design snow loads shall be determined in accordance with this section, and shall be applied to the roofs and open decks of all buildings and other structures.

1111.2 Basic snow load: Figures 1111.1A, 1111.1B, 1111.1C, and 1111.1D define four snow load zones in the state. The basic snow load for each zone shall be a uniformly distributed load, P_f, in pounds per square foot of horizontal projection, as follows:

Snow Load Zone	P_f
1	25 psf
2	30 psf
3	35 psf
4	40 psf

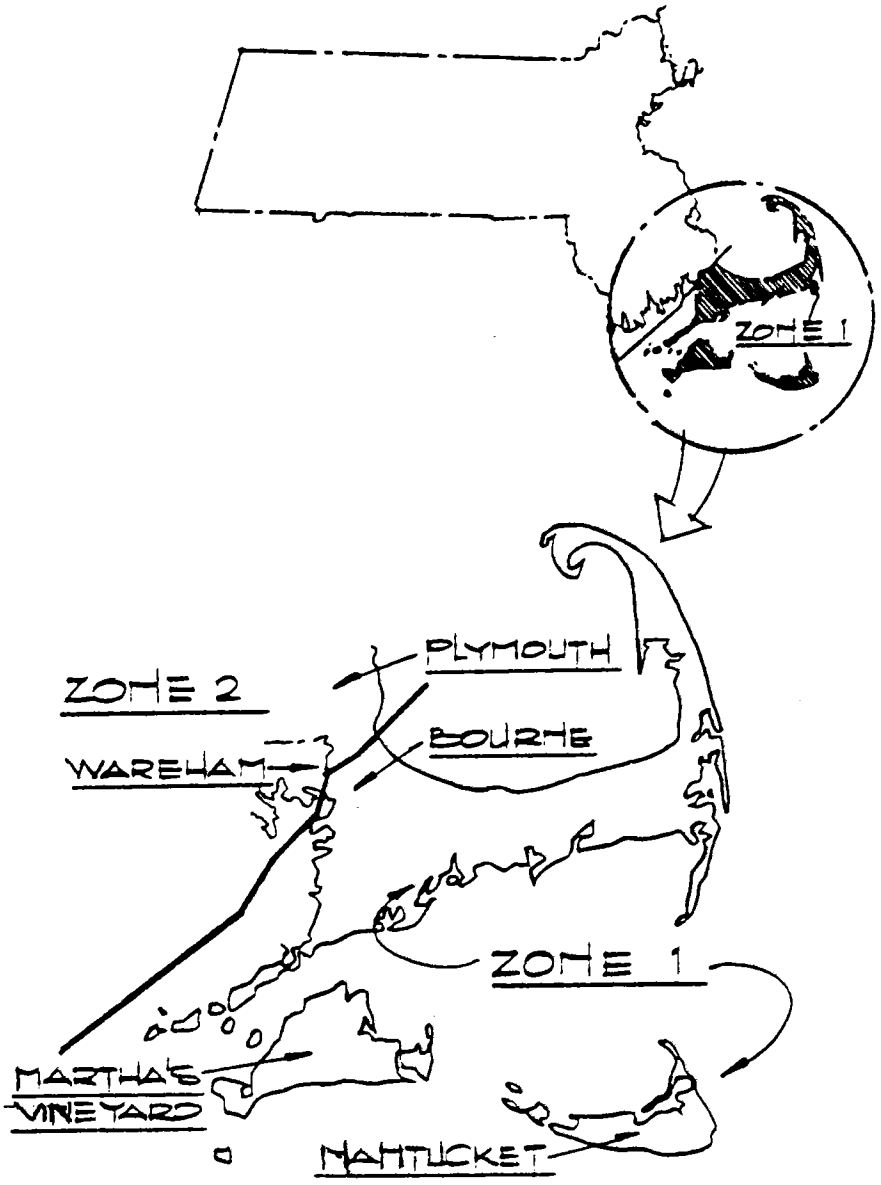


Figure 1111.1A
SNOW LOAD MAP - ZONE 1

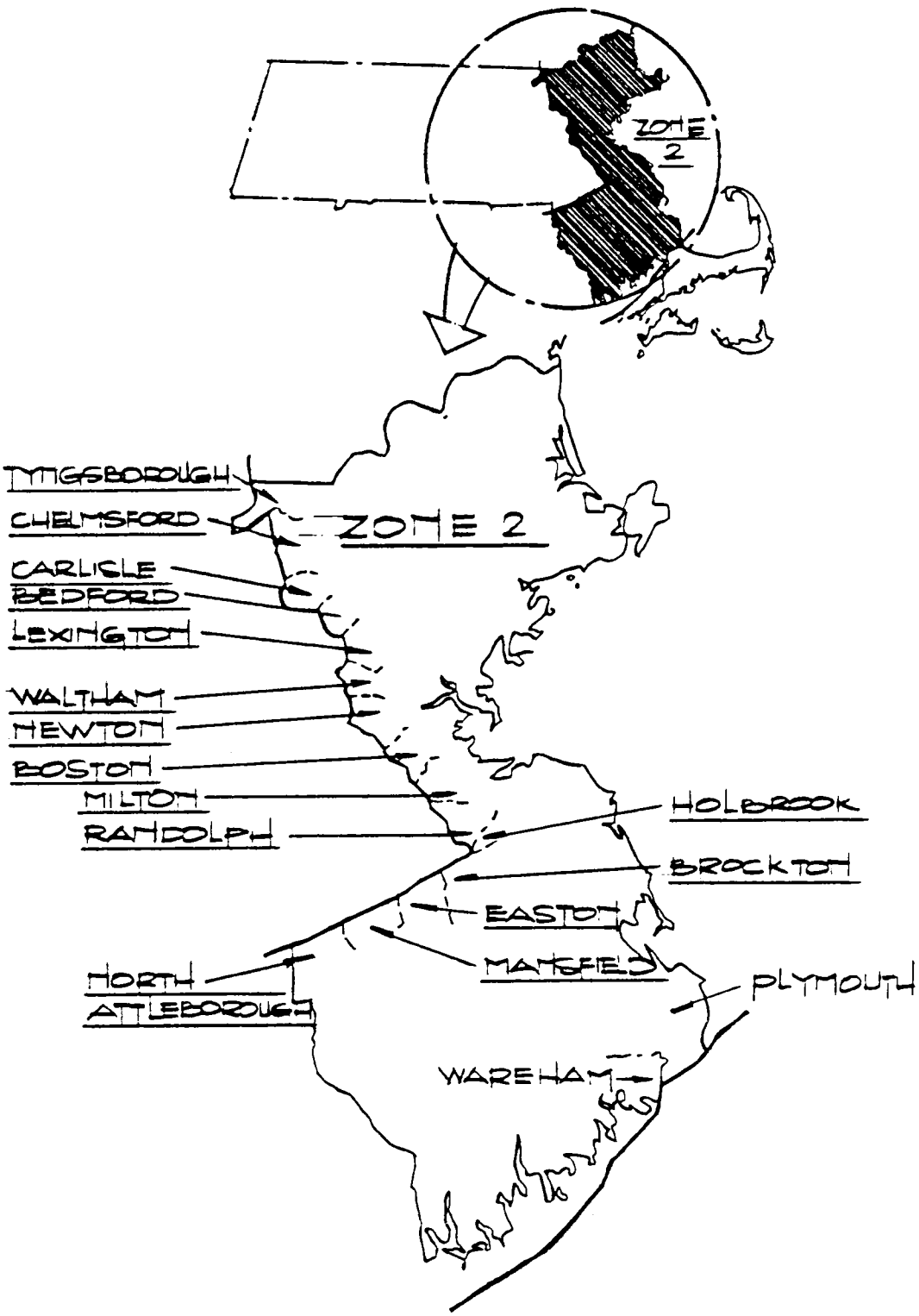


Figure 1111.1B
SNOW LOAD MAP - ZONE 2

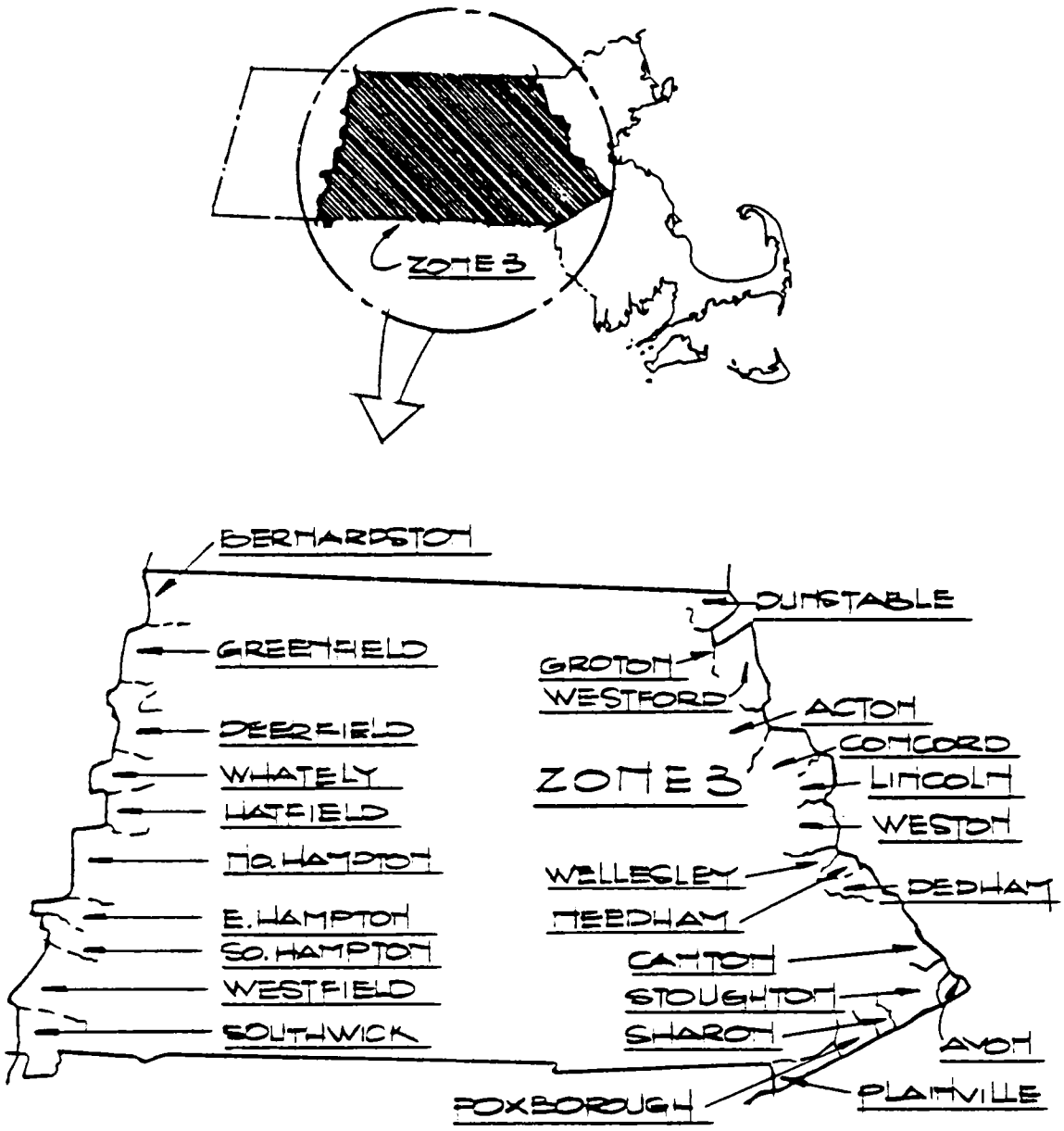
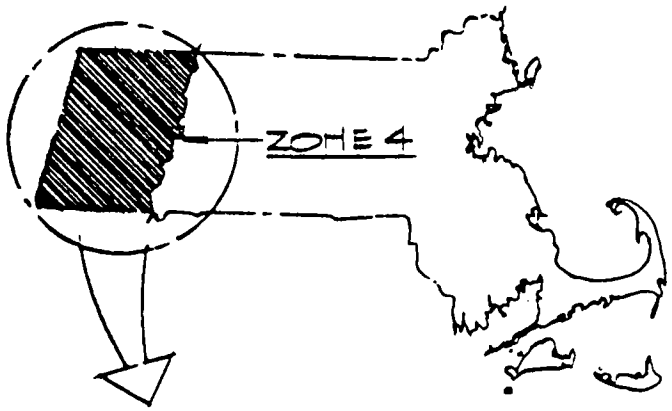


Figure 1111.1C
SNOW LOAD MAP - ZONE 3



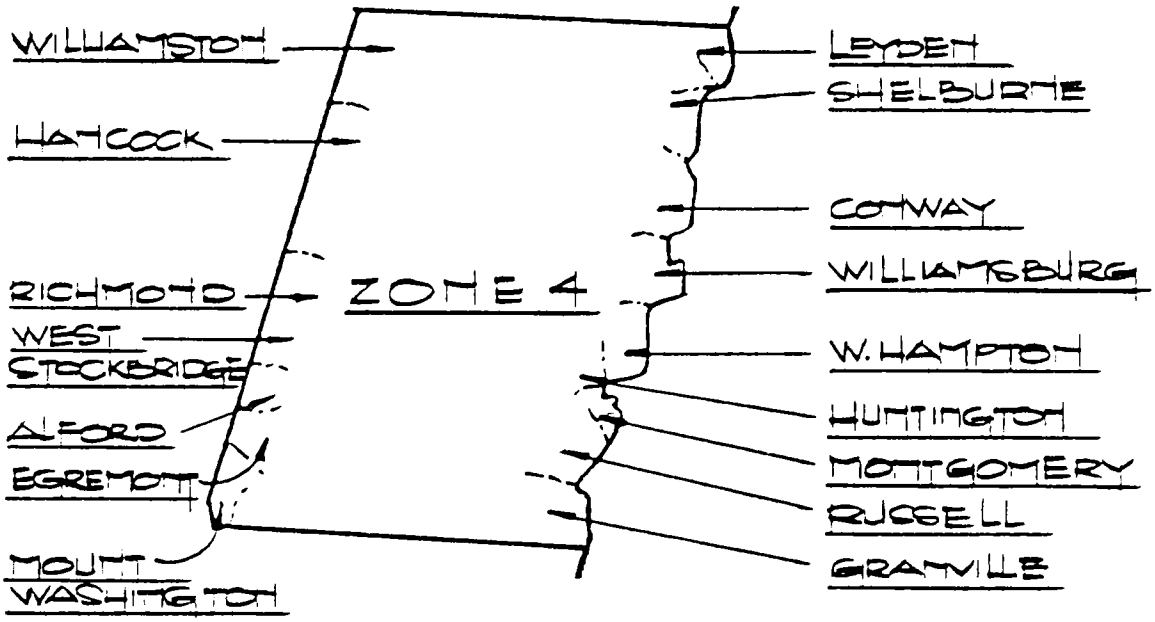


Figure 1111.1D
SNOW LOAD MAP - ZONE 4

1111.3 Symbols and notations: The following symbols and notations apply to the provisions of this section.

a	=	roof slope expressed in degrees
A	=	coefficient for amount of sliding snow
A_d	=	crossectional area of drift surcharge, expressed in square feet
C_s	=	slope factor (see Section 1111.5)
D	=	density of snow, expressed in pounds per cubic foot (pcf)
h_b	=	height of uniform snow load on lower roof or deck, expressed in feet
h_d	=	maximum height of drift surcharge, expressed in feet
h_{dr}	=	reduced height of drift surcharge, expressed in feet
H_{ol}	=	potential height of drift surcharge from snow blown from lower roof, expressed in feet
H_{ou}	=	potential height of drift surcharge from snow blown from upper roof, expressed in feet
h_r	=	difference in height between the upper and lower roof or deck, expressed in feet
L_T	=	length of upper roof or projecting element parallel to the line of separation, expressed in feet
P_f	=	basic uniform snow load, expressed in pounds per square foot (psf)
P_s	=	intensity of sloped roof snow load, expressed in pounds per square foot (psf)
P_{ds}	=	maximum intensity of surcharge load from sliding snow, expressed in pounds per square foot (psf)
S	=	horizontal separation between adjacent structures, expressed in feet (See Figure 1111.7)
W_a	=	horizontal dimension, in feet, of upper sloping roof (See Fig. 1111.10)
W_{bu}	=	horizontal dimension, in feet, of upper roof normal to the line of change in roof level (See Figure 1111.4)
W_{bl}	=	horizontal dimension, in feet, of lower roof normal to the line of change in roof level (See Figure 1111.4)
W_d	=	width of snow drift, expressed in feet (See Figure 1111.4)
W_s	=	width of sliding snow drift, expressed in feet (See Figure 1111.10)

1111.4 Flat roof snow loads: The snow load on an unobstructed flat roof with slope less than 30 degrees shall be equal to the basic snow load, P_f.

1111.5 Sloped roof snow loads: Snow loads acting on a sloping surface shall be considered to act on the horizontal projection of that surface. The sloped roof snow load on roofs having a slope greater than 30 degrees shall be calculated using the following formula: (See formula next page)

(Equation 1)

$$P_s = C_s P_f$$

where "C_s" is determined by the following formula:

(Equation 2)

$$C_s = 1 - \frac{(a - 30)}{40}$$

and "a" is the slope of the roof expressed in degrees.

1111.5.1 Roof slope factor for curved roofs: Portions of curved roofs having a slope exceeding 70 degrees shall be considered free from snow load. The point at which the slope exceeds 70 degrees shall be considered the "eave" for such roofs. For curved roofs, the slope factor shall be determined by basing the slope on the vertical angle from the "eave" to the crown.

1111.5.2 Roof slope factor for multiple roofs: For multiple folded-plate, sawtooth and barrel vault roofs with parallel ridge lines, the roof slope factor shall be considered to be equal to 1.0(C_s = 1.0) regardless of the slope of the roof.

1111.6 Unbalanced snow loads: Account shall be taken of the unbalanced snow loads relative to the stability and strength of structures by applying pattern loadings of one hundred (100) percent of design snow load alternating with fifty (50) percent of design snow load, located to maximize the various structural effects, except as provided below for roofs of special shapes.

1111.6.1 Unbalanced snow load for curved roofs: Portions of curved roofs having a slope exceeding 70 degrees shall be considered free of snow. The equivalent slope of a curved roof is equal to the slope of a line from the eave, or the point at which the slope exceeds 70 degrees, to the crown. If the equivalent slope is less than 10 degrees or greater than 60 degrees, the unbalanced snow loads need not be considered. Unbalanced snow loads shall be determined according to the loading diagrams in Figure 1111.2. In all cases, the windward side shall be considered free of snow. If the ground or another roof abuts a Case-II or Case-III (See Figure 1111.2) arched roof structure at, or within 3 feet of its eave, the snow load shall not be decreased between the 30 degree point and the eave but shall remain constant at $2P_s$. This distribution is shown as a dashed line in Figure 1111.2.

1111.6.2 Unbalanced snow load for multiple roofs: For multiple folded-plate, sawtooth and barrel vault roofs with parallel ridge lines, the roof snow load shall be increased from one-half the balanced load at the ridge or crown (0.5 P_f) to three times the balanced load at the valley (3.0 P_f). Balanced and unbalanced loading diagrams for a sawtooth roof are presented in Figure 1111.3. However, the snow surface above the valley shall not be at an elevation higher than that above the ridge, and if this condition limits the unbalanced load to something less than 3.0 P_f the minimum design unbalanced load shall be the lesser value.

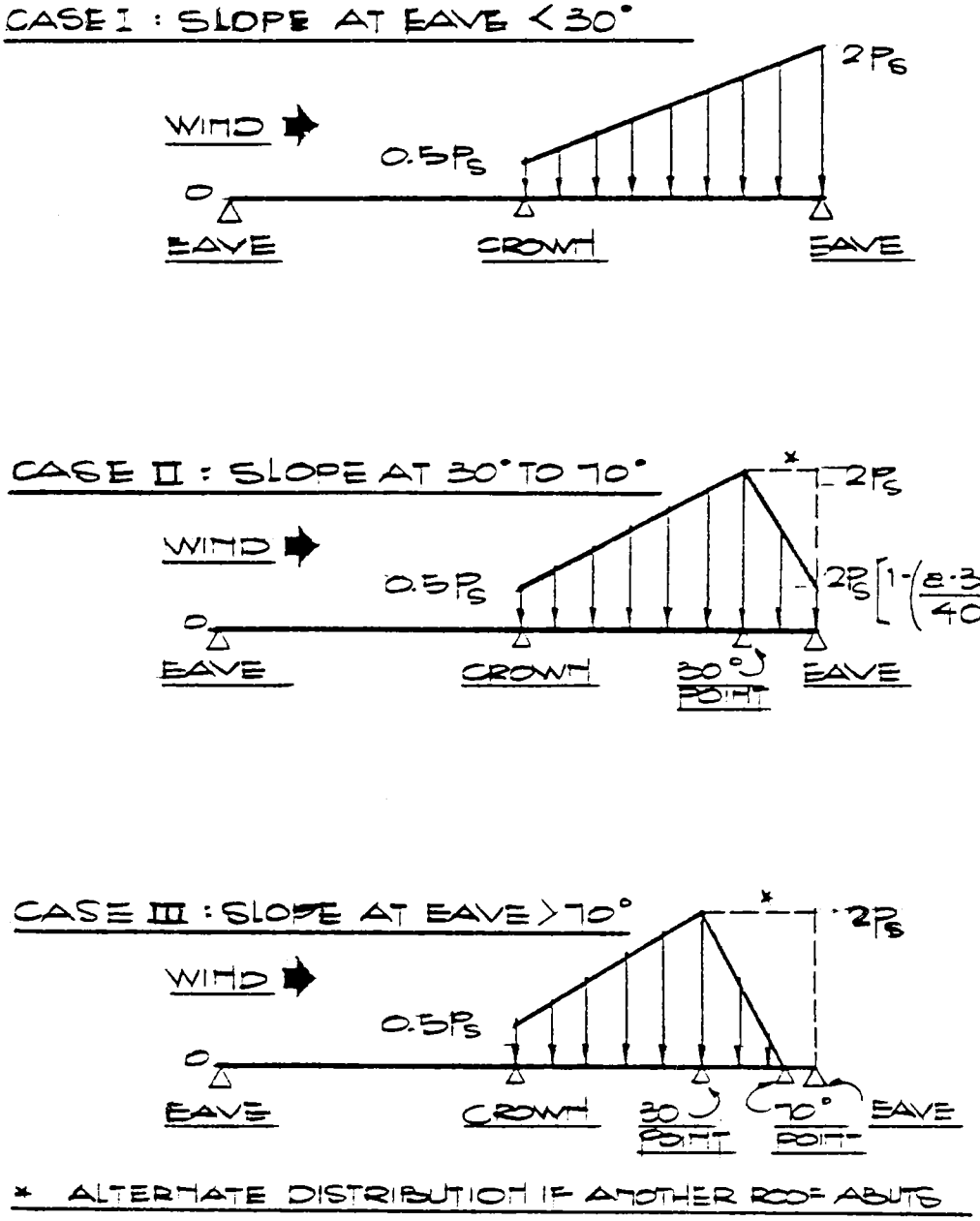


Figure 1111.2
UNBALANCED LOADING CONDITIONS FOR CURVED ROOFS

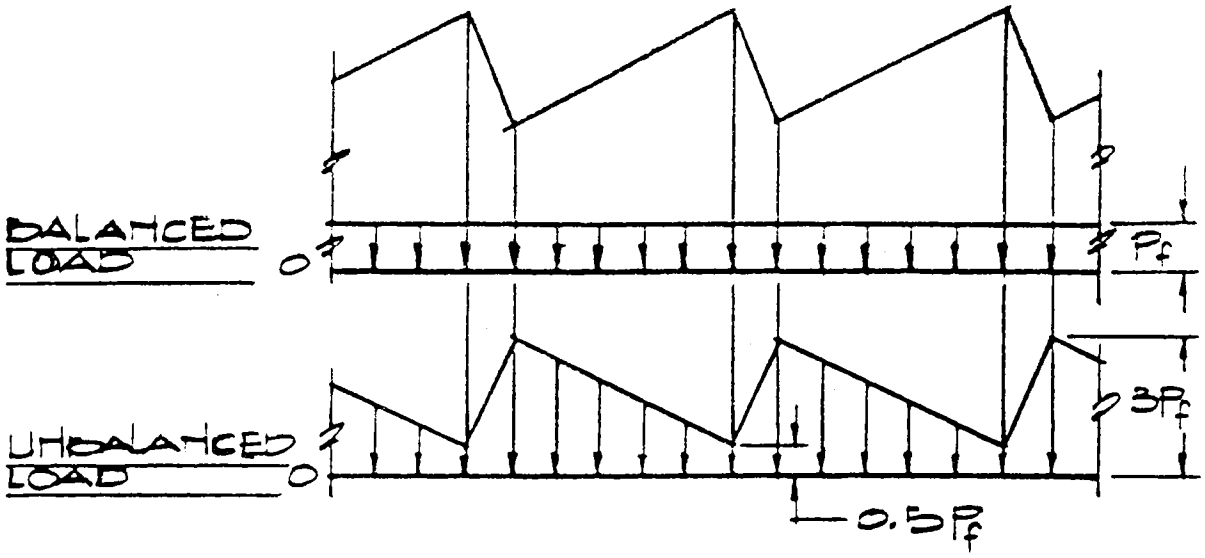


Figure 1111.3
BALANCED AND UNBALANCED LOADS ON A SAWTOOTH ROOF

1111.7 Drifts on lower roofs: Multi-level roofs, lower roofs and decks of adjacent structures, and roofs adjacent to projections shall be designed in accordance with Sections 1111.7.1 through 1111.7.6.

1111.7.1 Design loads at changes in roof elevation: The drift load on lower roofs or decks at changes in roof or deck elevation shall be taken as the triangular loading surcharge superimposed on the uniform roof snow load, P_f, as shown in Figure 1111.4.

Two types of drifts shall be considered:

1.) from wind blowing snow from the upper roof

2.) from wind in the opposite direction blowing snow from the lower roof

The drift causing the more severe structural effect shall be used for design.

The density of snow, D, in a snowdrift and in the uniform layer of snow underlying the drift shall be not less than:

(Equation 3)

$$D = 20\ psf$$

The height, h_b, of the uniform snow layer underlying the drift shall be:

(Equation 4)

$$h_b = \frac{P_f}{D}$$

The intensity of snow load at any point shall be the total depth, at that point, of the snowdrift and the underlying uniform layer of snow, times the density, D.

1111.7.1.1 Drifting of snow from upper roof:

The height of drift, h_d, and the width of drift, W_d, both in feet, shall be determined as follows:

a. Compute the potential drift height H_{ou}, in feet, and the cross-sectional area of drift, A_d, in square feet, as:

(Equation 5)

$$H_{ou} = 1.15\ (W_{bu})^{0.33} - 1.5$$

(Alternately, H_{ou} may be determined from Figure 1111.5)

(Equation 6)

$$A_d = \frac{(H_{ou})(4H_{ou})}{2} = 2(H_{ou})^2$$

b. If $(H_{ou} + h_b)$ is less than or equal to the difference in roof elevations, h_r then:

(Equation 7)

$$h_d = H_{ou}$$

(Equation 8)

$$W_d = 4(H_{ou})$$

c. If $(H_{ou} + h_b)$ is greater than h_r :

(Equation 9)

$$h_d = h_r - h_b$$

(Equation 10)

$$W_d = \frac{2(A_d)}{h_r - h_b}$$

But W_d need not exceed $10(h_r - h_b)$

1111.7.1.2 Drifting of snow from lower roof:

The height of drift, h_d, and the width of drift, W_d, both in feet, shall be determined as follows:

a. Compute the potential drift height, H_{ol}, in feet, as:

(Equation 11)

$$H_{ol} = 0.5[1.15(W_{bl})^{0.33} - 1.5]$$

(Alternatively, H_{ol} may be determined from Figure 1111.5.)

b. If (H_{ol} + h_b) is less than or equal to h_r, then:

(Equation 12)

$$h_d = H_{ol}$$

c. If (H_{ol} + h_b) is greater than h_r, then:

(Equation 13)

$$h_d = h_r - h_b$$

d. (Equation 14)

$$W_d = 8(h_d)$$

1111.7.1.3 Multiple level roofs:

For multiple stepped roofs similar to that shown in Figure 1111.6a, the sum of all the roof lengths upwind above the drift under consideration shall be considered as the length of upper roof for that drift (as shown, for example, in Figure 1111.6a).

For multiple level roofs similar to that shown in Figure 1111.6b, if the total calculated height of a drift and the underlying uniform snow layer on the upwind side of a higher roof (h'_d + h_b) is equal to or greater than 0.7h'_r, then the length, W_{bu}^*, as shown in Figure 1111.6b, shall be used in place of W_{bu} in Equation 5.

1111.7.2 Drift loads on adjacent lower structures: A drift surcharge shall be applied to roofs of lower adjacent structures if these structures are located within a distance of W_d, but not greater than 20 ft., of the higher structure as depicted in Figure 1111.7. The height of drift h_d and the width of drift W_d shall be computed for wind in either direction, in accordance with Section 1111.7.1, assuming, for these computations only that there is no space between the higher and lower structures. The actual triangular drift surcharge on the roof of the lower structure shall be as shown in Figure 1111.7.

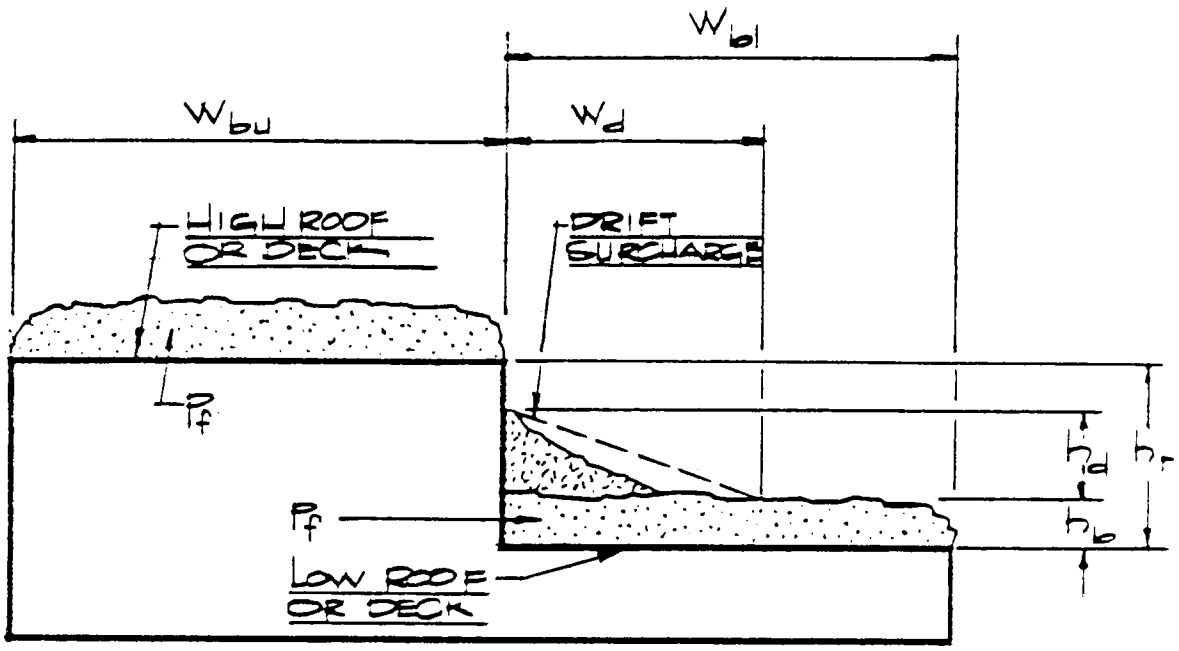


Figure 1111.4
DRIFTING SNOW ON LOWER ROOFS AND DECKS AT CHANGES IN ROOF OR DECK ELEVATIONS

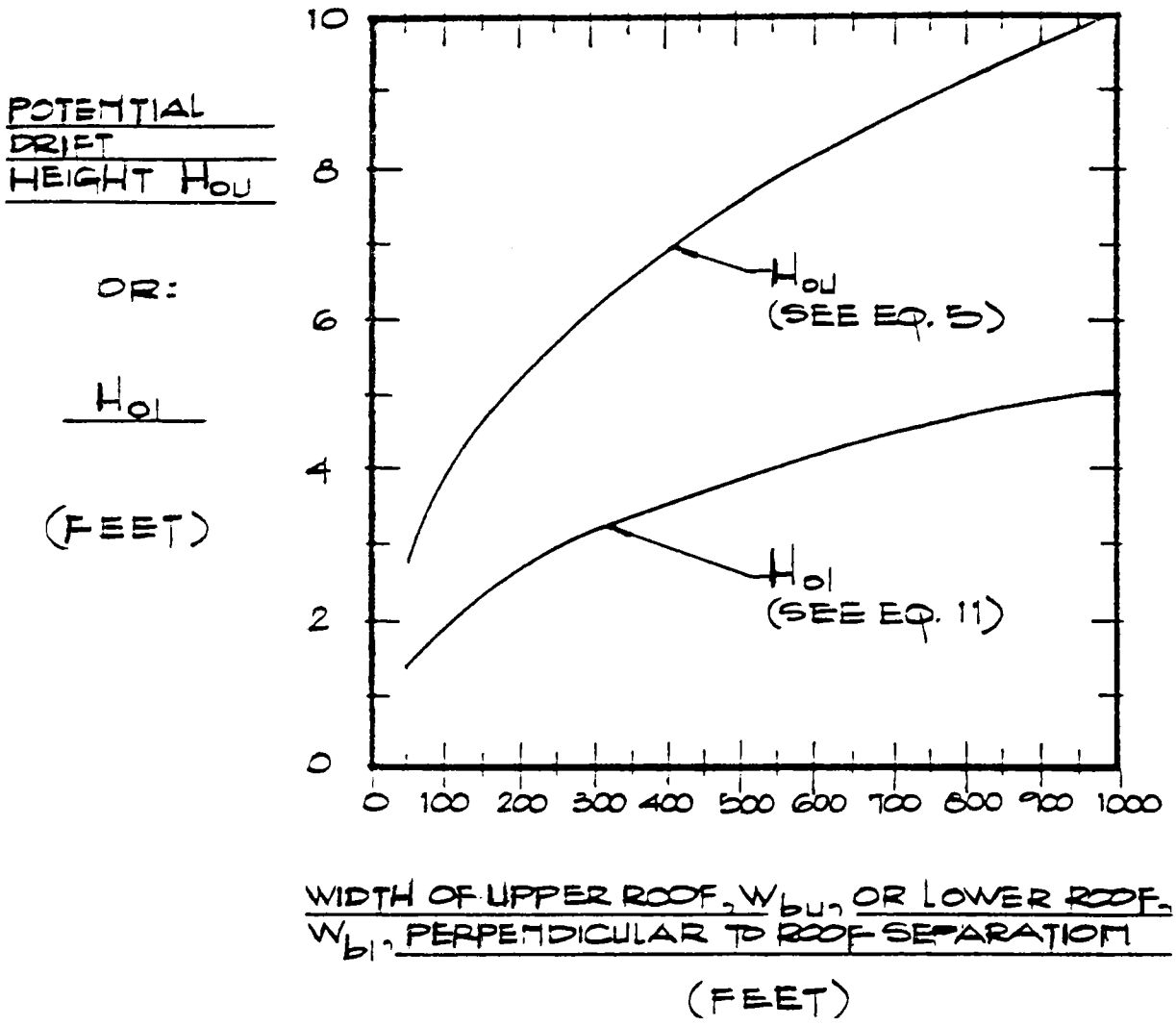


Figure 1111.5

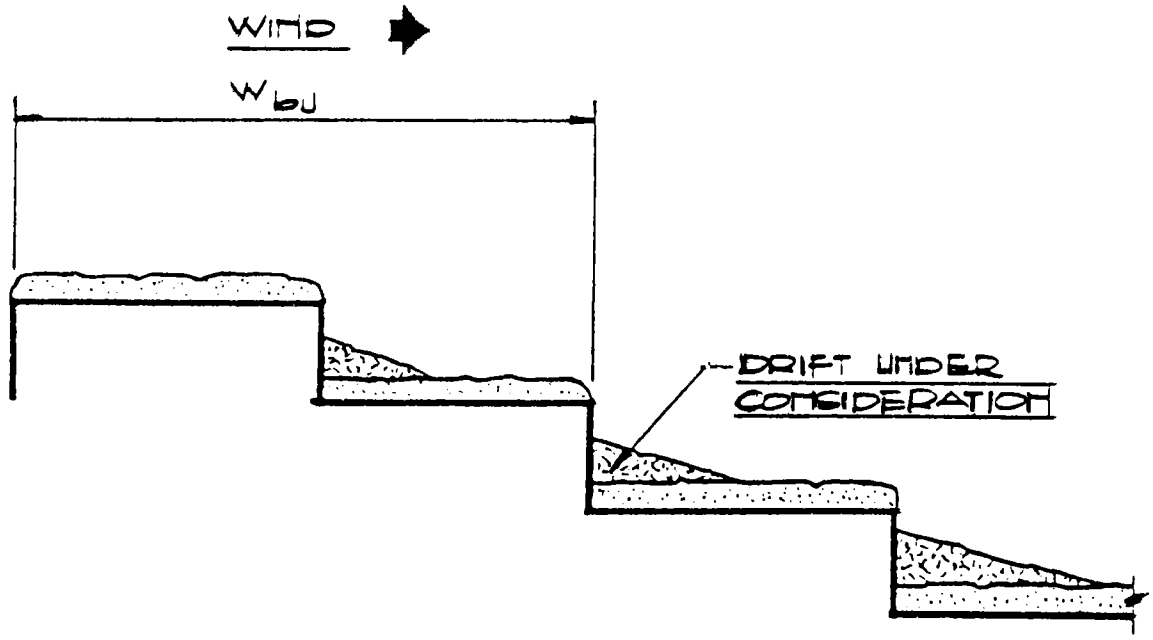
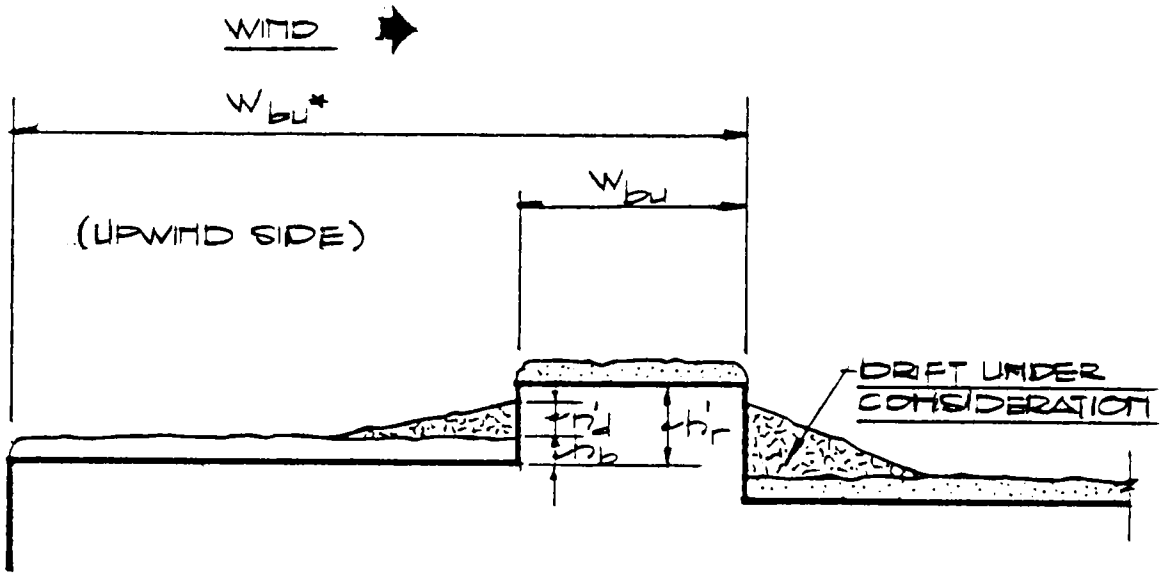


Figure 1111.6a



NOTE: USE W_{bu}^* WHEN $h'_d + h_b \geq 0.7\, h'_r$

Figure 1111.6b

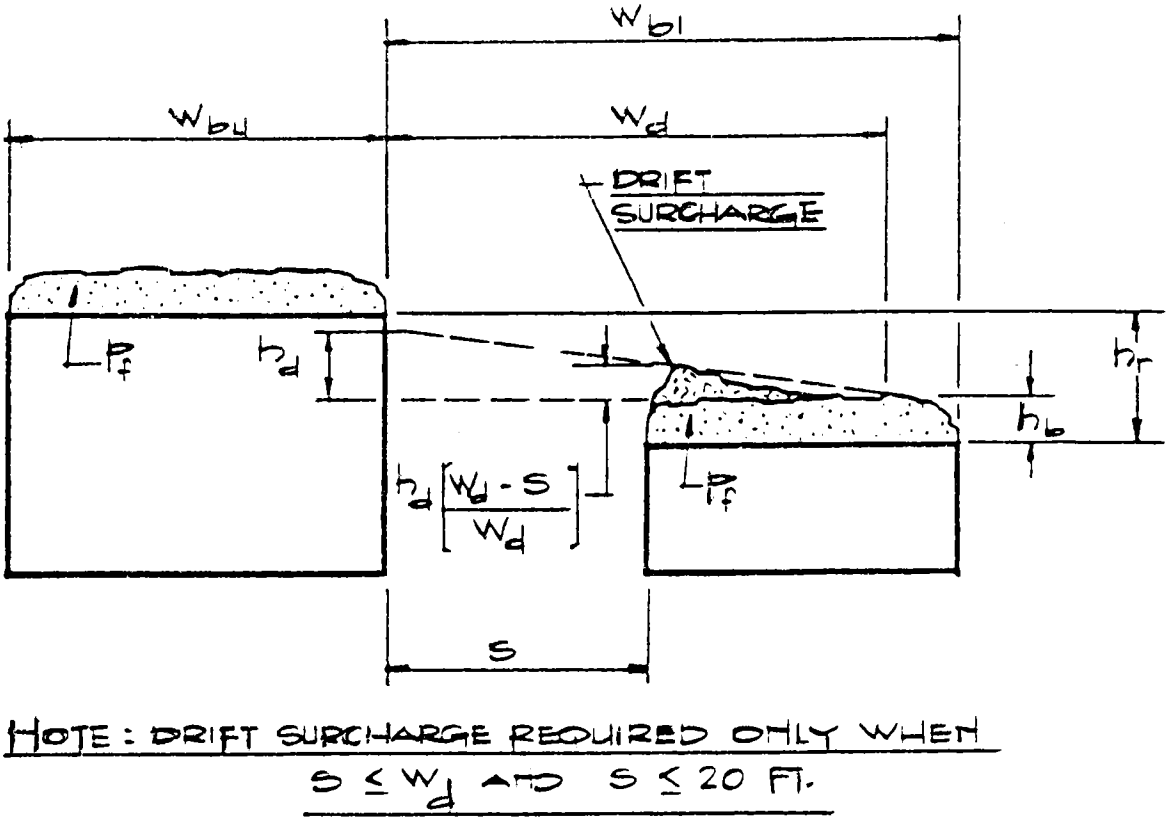


Figure 1111.7
DRIFTING SNOW ONTO ADJACENT LOW STRUCTURES

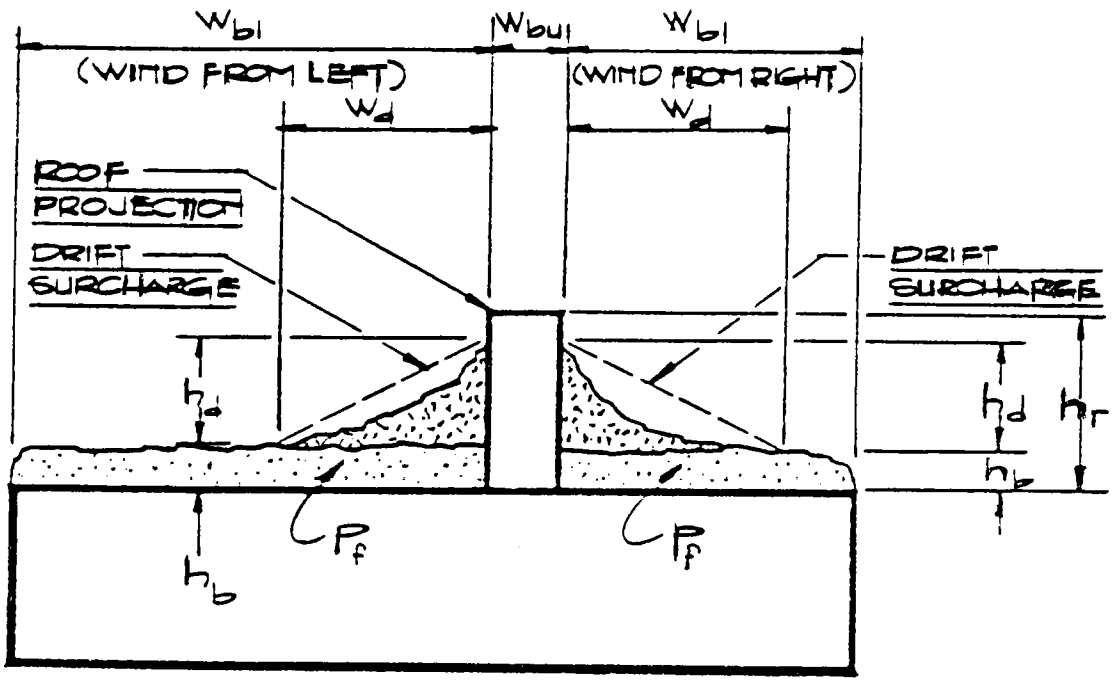


Figure 1111.8
SNOW DRIFTING AT ROOF PROJECTIONS

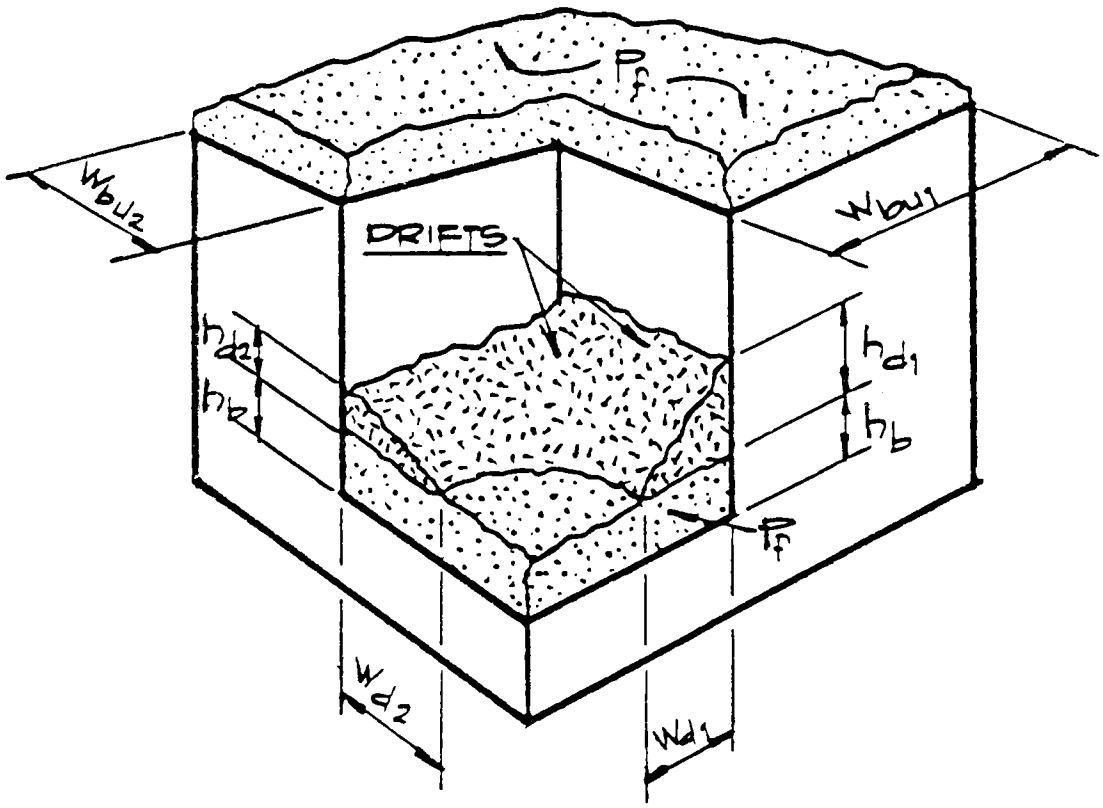


Figure 1111.9
INTERSECTING SNOW DRIFTS

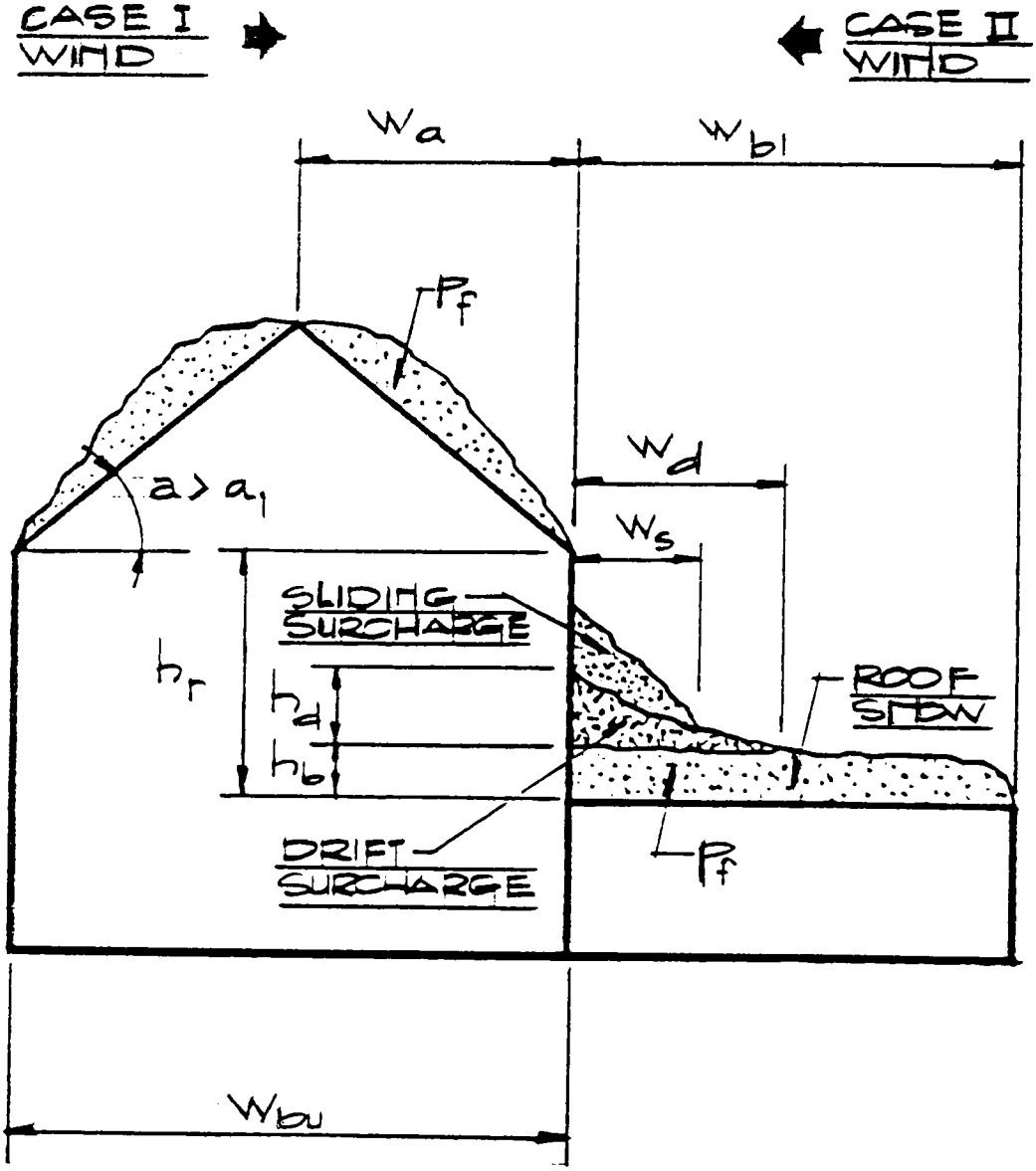


Figure 1111.10
ADDITIONAL SURCHARGE DUE TO SLIDING SNOW

1111.7.3 Very high roof separations: When h_r is greater than 30 ft., the drift surcharge load on the lower roof due to drifting of snow from the upper roof may be reduced because some of the snow is blown beyond the low roof. The reduced height of the drift surcharge shall be not less than:

(Equation 15)

$$h_{dr} = \frac{30(h_d)}{h_r}$$

1111.7.4 Limited extent of upper roof: When the dimension of an upper roof or projecting element, L_T, in feet, parallel to the line of separation (perpendicular to W_{bu} or W_{bl}) is less than 20 ft., the potential height of drift may be reduced and shall not be less than:

(Equation 16)

$$H_{our} = \frac{L_T}{20}(H_{ou})$$

(Equation 17)

$$H_{olr} = \frac{L_T}{20}(H_{ol})$$

1111.7.5 Parapets and other roof projections: Design drift loads for roofs adjacent to parapets and other roof projections, as shown in Figure 1111.8, shall be determined in accordance with Sections 1111.7.1 and 1111.7.4. Drifts due to snow from the top of a roof projection need only be considered when W_{bu} is 10 feet or greater.

1111.7.6 Intersecting drifts: When one snow drift intersects another at an angle as shown in Figure 1111.9, the unit snow load at any point shall be not less than the greater of the unit loads from the two individual drifts, plus the unit load of the underlying uniform snow layer.

1111.8 Sliding snow from sloped upper roofs: Two cases of drift loading shall be considered for roofs which are located below upper sloped roofs, as shown in Figure 1111.10 and as follows:

(a) Case I Drift loading due to snow from the upper roof computed in accordance with Section 1111.7.1, but without load from sliding snow (W_{bu} is the full width of the upper roof as shown in Figure 1111.10.)

(b) Case II Drift loading due to snow from the lower roof computed in accordance with Section 1111.7.1 and a sliding snow surcharge load as specified below and as shown in Figure 1111.10.

The maximum intensity of the sliding snow load, P_{ds}, shall be:

(Equation 18)

$$P_{ds} = \frac{AW_a}{W_s}(P_f)$$

where W_a and W_s are defined in Figure 1111.10 and the coefficient A is defined as follows:

(a) For roof surfaces of metal and slate, and for other roof surfaces smoother than mineral surfaced roofing: If the angle of slope of the upper roof, "a", as shown in Figure 1111.10 is equal to or greater than 15° (slope 3.2 in 12), A = 1.6; if "a" is less than 15°, A = 0 (no sliding snow load).

(b) For roof surfaces of mineral surfaced roofing or rougher surfaces: If "a" is equal to or greater than 25° (slope 5.6 in 12), A = 1.0; if "a" is less than 25°, A = 0.

The value of W_s, the width of the sliding snow surcharge, shall be computed as follows:

(a) For "a" less than or equal to 45°, (See equation next page)

(Equation 19)

$$W_s = h_r$$

or:

(Equation 20)

$$W_s = \frac{W_a}{4}$$

whichever is greater.

(b) For "a" greater than or equal to 45°

(Equation 21)

$$W_s = h_r(\cot a)$$

or:

(Equation 22)

$$W_s = \frac{W_a}{4}$$

whichever is greater.

1111.8.1 Snow guards: Sliding snow from an adjacent sloping high roof need not be considered on the low roof if proper snow guards are provided on the high roof. In this case, the sloping roof with snow guards shall be designed for the unit snow loads required for a flat roof.

1111.9 Snow pockets or wells: Consideration of potentially excessive snow accumulation shall be given to any roof areas which have pockets or wells which could serve as snow collectors.

1111.10 Snow storage and collection areas: Consideration of potentially excessive snow accumulation shall be given to portions of structures which may be designed or used as snow collection or storage areas during and after snow removal operations.

SECTION 1112.O WIND LOAD

1112.1 Wind load zones: The locations of wind load zones are shown in the Figures 1112.1A, 1112.1B, 1112.1C maps. Zone 1 consists of the Counties of Berkshire, Franklin, Hampshire and Hampden; Zone 2 consists of the County of Worcester; and Zone 3 consists of the Counties of Essex, Middlesex, Suffolk, Norfolk, Plymouth, Bristol, Barnstable, Dukes and Nantucket.

1112.2 Exposures: Exposure is defined as a measure of terrain roughness and is classified as follows:

Exposure A: centers of large cities and very rough, hilly terrain. Exposure A applies for downtown areas only when the terrain for at least one-half (½) mile upwind of the structure is heavily built up, with at least fifty (50) per cent of the buildings being in excess of four stories, and when Exposure B prevails beyond this boundary.

Exercise caution in using these reduced wind pressures for buildings and structures on high ground in the midst of cities or rough terrain.

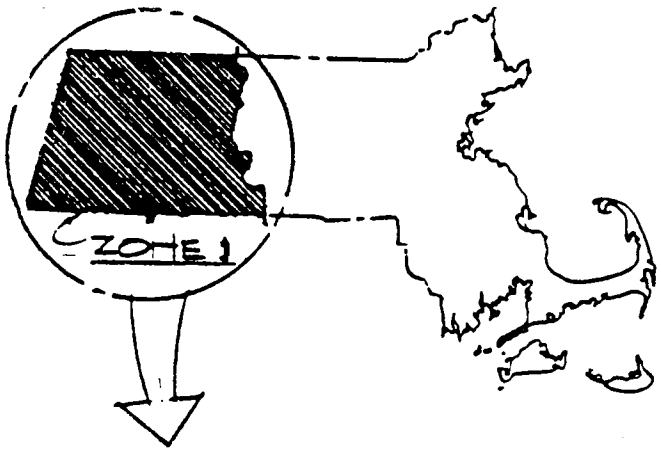
Exposure B: suburban areas, towns, city outskirts, wooded areas, and rolling terrain. Exposure B applies only when the terrain for at least one (1) mile upwind is a continuous urban development, forest, wooded area, or rolling terrain.

Exposure C: open level terrain with only scattered buildings, structures, trees or miscellaneous obstructions, open water, or shorelines.

1112.2.1 Special exposures: Consideration shall be given to the application of a more severe exposure (e.g., Exposure C instead of Exposures B or A) when the ground slope near the site of a structure changes abruptly, to account for the resulting higher wind speeds near ground level.

1112.3 Reference wind velocities: The reference wind velocity for each wind load zone is the "fastest-mile" wind velocity at thirty (30) feet above the ground (V_{30}) for Exposure C, as follows:

Zone	V_{30}-MPH
1	70
2	80
3	90



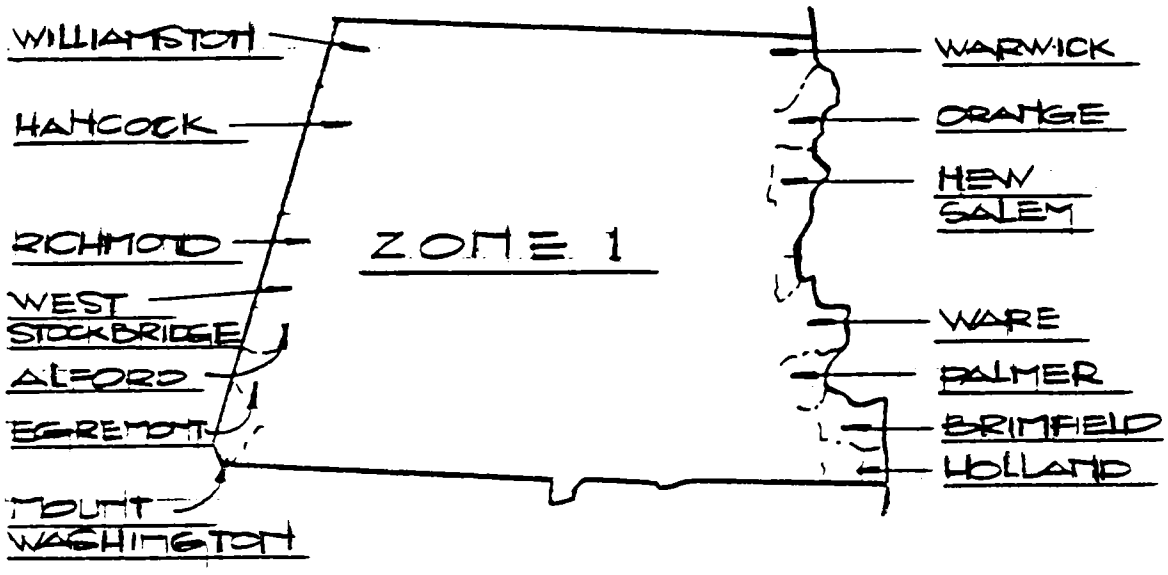


Figure 1112.1A
WIND LOAD MAP - ZONE 1

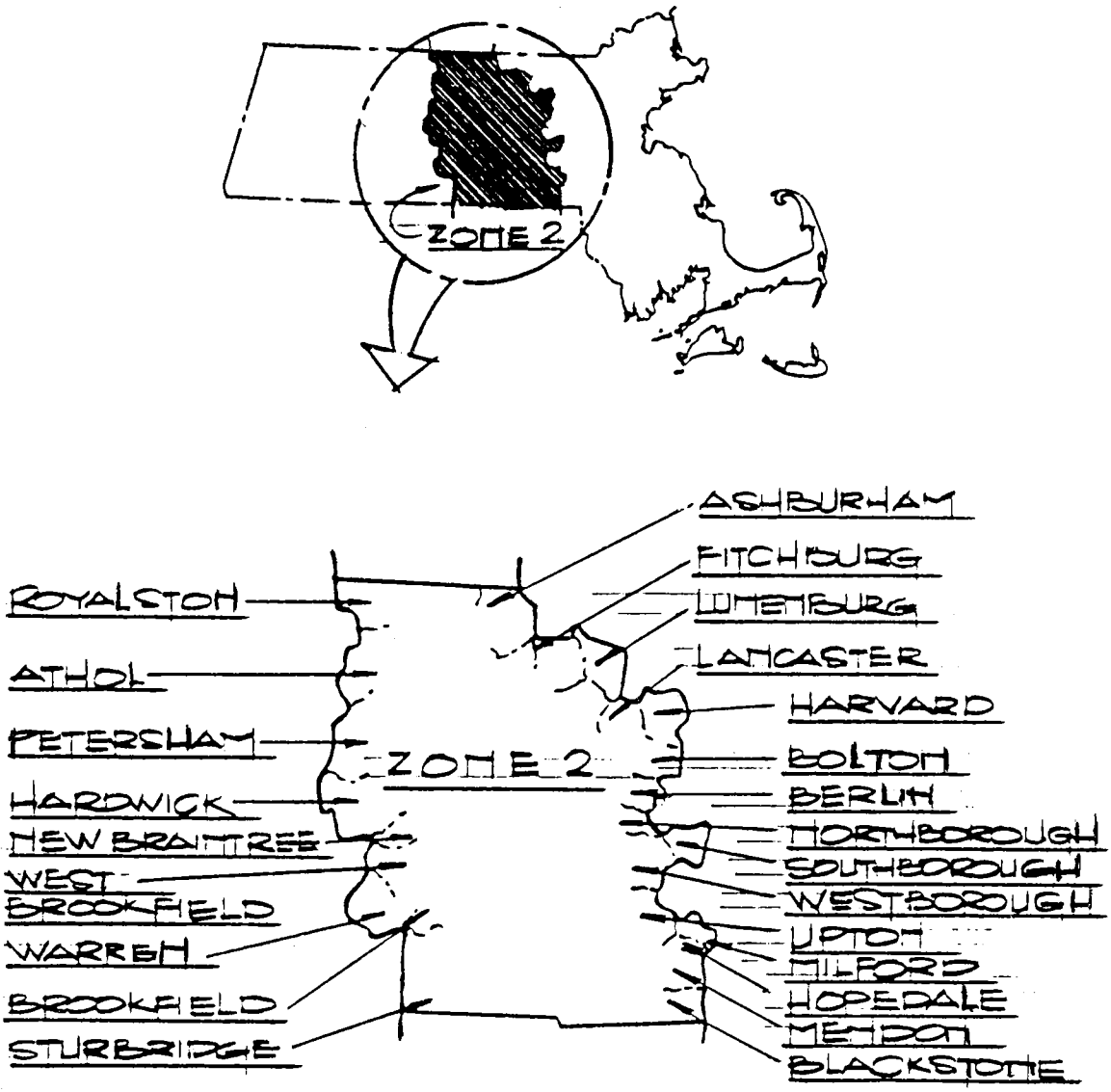


Figure 1112.1B
WIND LOAD MAP - ZONE 2

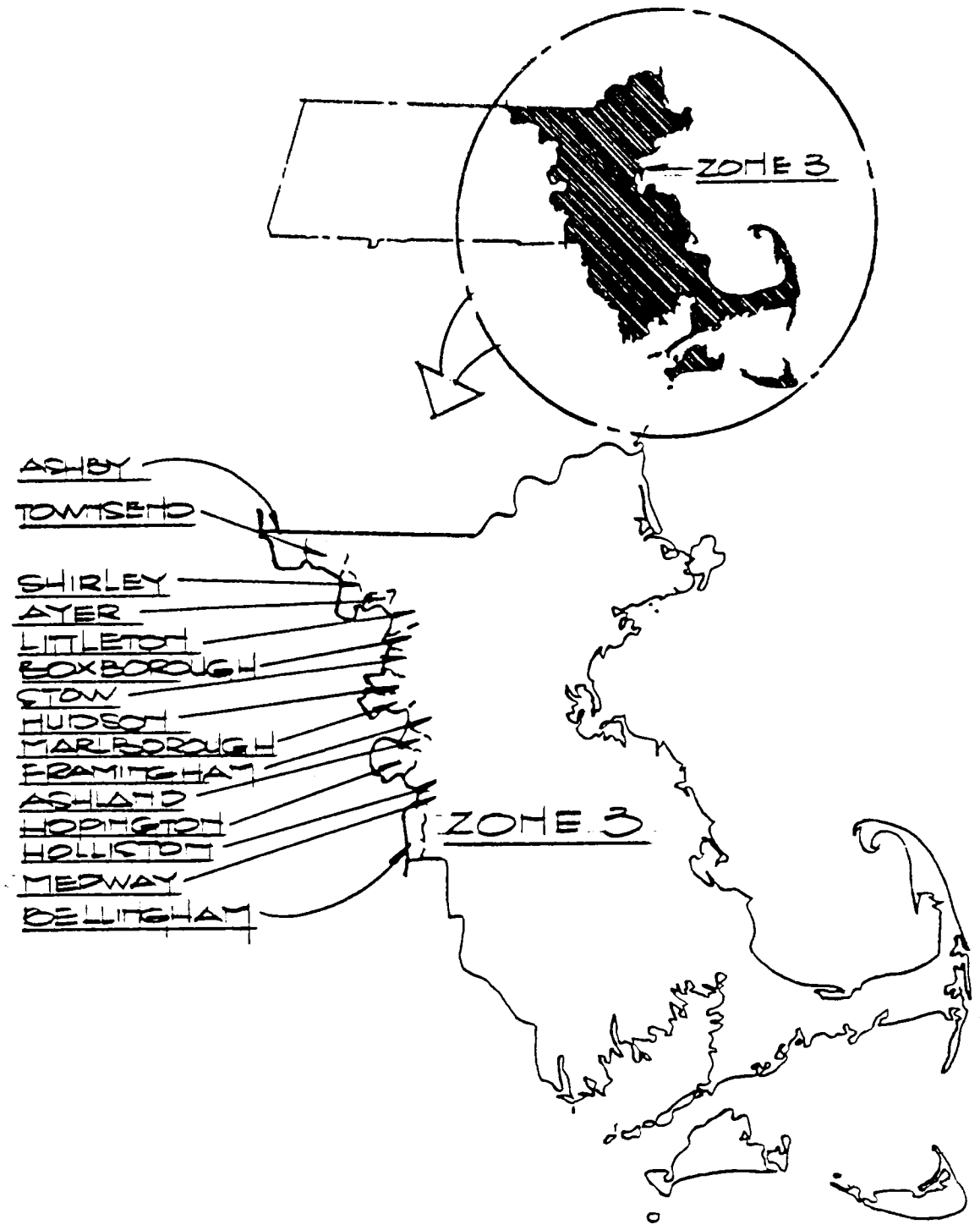


Figure 1112.1C
WIND LOAD MAP - ZONE 3

1112.4 Reference wind pressures: Reference wind pressures for the various exposures and wind zones are given in the following Table 1112.1. The tabulated pressures are combined windward and leeward pressures representing the overall effect of the wind on essentially rectangular structures, and account for typical gust effects as found in ordinary buildings. These pressures do not account for buffeting or channeling caused by positions of nearby structures, vortex shedding, or wind sensitive dynamic properties of a particular structure.

1112.5 Wind loads on structures as a whole: All buildings and enclosed or partially enclosed structures shall be designed to withstand a total wind load acting on the structure as a whole determined by applying the appropriate reference wind pressures given in Table 1112.1 to the vertical projected area, normal to the wind direction of the vertical surfaces of the structure, plus the appropriate wind forces on the roof as specified in Section 1112.8. Consideration shall be given to wind acting in all directions.

1112.5.1 Simultaneous wind forces on orthogonal sides: For structures which are essentially rectangular in plan, or whose plan shape is made up of rectangular parts, only wind directions normal to the sides of the structure need be considered, provided that zero point seven (0.7) times the effects of the wind acting simultaneously normal to adjacent orthogonal sides shall also be considered when it produces more severe effects in the structural support system. Factors other than zero point seven (0.7) may be used if substantiated by appropriate wind tunnel tests.

1112.5.2 Wind force distribution: The total wind force on the vertical surfaces of a structure prescribed in Section 1112.5 shall be distributed six-tenths (6/10) to the windward surfaces (as a positive pressure) and four-tenths (4/10) to the leeward surfaces (as a suction). Other distributions may be used if substantiated by appropriate wind tunnel tests.

1112.6 Vertical parts of structures: Vertical parts of structures that are subjected directly to the wind, and their local supporting elements, shall be designed to resist the pressures listed in the following Table 1112.2, normal to the surface, inward or outward. The pressures listed in the table represent the combined internal and external pressures. A local supporting element of a vertical part subjected directly to the wind shall be defined as a wall assembly, a stud, a mullion, a girt, or a similar item which distributes the wind load from the vertical part to the principal structural system of the structure.

Table 1112.1
REFERENCE PRESSURE (POUNDS PER SQUARE FOOT)

H (feet) Height above grade	Zone 1			Zone 2			Zone 3		
	Exposure			Exposure			Exposure		
	A	B	C	A	B	C	A	B	C
0-50	11	12	12	11	17	17	14	21	21
50-100	11	12	18	11	17	24	14	21	31
100-150	11	16	22	14	21	29	18	26	37
150-200	13	18	25	17	24	33	22	30	41
200-250	15	20	27	20	27	36	25	34	45
250-300	17	22	29	22	30	39	28	37	48
300-400	19	25	31	25	33	42	32	41	52
400-500	22	28	34	29	37	46	26	46	57
500-600	24	30	37	33	41	49	41	51	61
600-700	27	33	39	36	44	52	45	55	65
700-800	29	35	41	39	47	55	48	58	68
800-900	31	37	43	41	49	57	52	62	72
900-1000	33	39	45	44	52	59	55	65	74

See Table 1112.1a, next page, for empirical wind pressure formulas.

Alternately, Empirical Wind Pressure Formulas presented in Table 1112.1a may be used in lieu of the reference pressures tabulated above, but not below one hundred (100) feet.

Table 1112.1a
EMPIRICAL WIND PRESSURE FORMULAS

Zone 1		
Exposure		
A	B	C
$p = 30\ (H/800)^{.55}$	$p = 36\ (H/800)^{.45}$	$p = 42\ (H/800)^{.35}$
Zone 2		
Exposure		
A	B	C
$p = 40\ (H/800)^{.55}$	$p = 48\ (H/800)^{.45}$	$p = 56\ (H/800)^{.35}$
Zone 3		
Exposure		
A	B	C
$p = 50\ (H/800)^{.55}$	$p = 60\ (H/800)^{.45}$	$p = 70\ (H/800)^{.35}$

Table 1112.2
WIND PRESSURES ON PARTS OF STRUCTURES AND LOCAL SUPPORTING ELEMENTS

Location of applied wind pressure	Tributary wind load area of part or local supporting element	Required design pressures		
		Ref. pressure of Sec. 1112.4 times[1]	But not less than	But need not be greater than
Within salient corner area[2]	Any	1.7	20 psf	70 psf
Beyond salient corner area	Less than or equal to 200 sq. ft.	1.2	20 psf	50 psf
Beyond salient corner area	Greater than 200 sq. ft.	0.8	15 psf	50 psf

Note 1. For partially enclosed structures, where any side is more than thirty-five (35) percent open, add a factor of zero point three (0.3) to the coefficients of this column of the table.

Note 2. The salient corner area shall be defined as the vertical surface located within a distance equal to one-tenth (1/10) the least width of the structure, but not more than ten (10) feet, from a prominent (salient) corner.

Table 1112.3
WIND PRESSURES ON ROOFS

External wind pressure - flat, gable, shed roofs (wind perpendicular to ridge)				
Roof pitch		Multiples of reference pressure of Section 1112.4		
Degrees	Rise/run	Windward slope		Leeward slope
		Positive pressure	Suction	Suction
0-20	Flat to 4/12	---	0.6	0.5
20-30	4/12 to 7/12	0.2	0.5	0.5
30-40	7/12 to 10/12	0.3	0.4	0.5
40-50	10/12 to 14/12	0.4	0.3	0.5
50-90	14/12 to vertical	0.6	0.0	0.5

External wind pressure - arch shaped roofs (wind perpendicular to ridge)				
Rise to span ratio	Multiples of reference pressure of Section 1112.4			
	Windward quarter		Center half	Leeward half
	Positive pressure	Suction	Suction	Suction
Less than 2/10	0.2	0.7	0.7	0.4
2/10 to 3/10	0.3	---	0.8	0.4
3/10 to 6/10	0.6	---	1.0	0.4

External wind pressure - flat, gable, shed or arched shaped roofs (wind parallel to ridge)
Suction of 0.6 times the reference pressure of Section 1112.4

1112.7 Wind loads on roofs: Roofs and their supporting structure shall be designed to resist the combined effects of the external and internal wind pressures specified in Sections 1112.8 through 1112.11. All pressures specified shall be considered to act normal to the roof surface. When applying the reference wind pressures of Section 1112.4 to the provisions of Sections 1112.8 through 1112.11, the reference wind pressures shall be for a height equal to the average height of the roof eave above grade.

1112.8 External wind pressures on roofs of enclosed structures: Except as specified otherwise in Section 1112.11, external wind pressures shall be as specified in the following Table 1112.3, or in Section 1112.8. Where both positive pressure and suction are specified, the effects of each shall be evaluated.

1112.8.1 Roof shapes not specified: For roof shapes not specified herein, external wind pressures shall be determined as specified in Section 1112.13 but the minimum suction effect shall be equal to zero point six (0.6) times the reference wind pressure of Section 1112.4.

1112.9 Internal wind pressures on roofs of enclosed structures: Except as specified otherwise in Section 1112.10, internal wind pressures shall be zero point two (0.2) times the reference wind pressure given in Section 1112.4. The internal pressure shall be applied as a positive pressure or a suction, whichever gives the greater structural effect when added to the external pressure, for the design of each structural component.

1112.10 Wind pressures on roofs over nonenclosed or partially enclosed structures: Except as specified otherwise in Section 1112.11, wind pressures for roofs of partially enclosed or nonenclosed structures shall be as follows:

1. When a structure is partially enclosed, with each side not more than thirty-five (35) per cent open, the wind pressures shall be the same as for an enclosed structure.

2. When a structure is partially enclosed, with openings essentially all on one (1) side, and when that side is more than thirty-five (35) percent open, external wind pressure shall be as specified in Table 1112.1 and internal wind pressures shall be as specified in Section 1112.9 except that the value of internal wind pressure shall be equal to zero point five (0.5) times the reference wind pressure given in Table 1112.3.

3. For all other cases of partially enclosed structures, or for nonenclosed structures, the combined effect of the wind pressures above and below roofs shall be equal to one point twenty-five (1.25) times the values specified in Table 1112.3 for the corresponding roof shapes and wind directions.

1112.11 Wind pressures for parts of roofs: Parts of roofs that are subjected directly to the wind, and their local supporting elements, shall be designed to resist the following pressures in an outward direction:

1. Where parts subjected directly to the wind are located within a distance of one-tenth (1/10) the least width of a structure, but not more than ten (10) feet, from a ridge, eave, or cornice, they shall resist a pressure one point seven (1.7) times the reference wind pressure given in Table 1112.1 (representing the combined internal and external pressures).

2. Where parts subjected directly to the wind are located outside the zones specified in Item 1 above, they shall resist pressures as specified in Sections 1112.8 through 1112.10 and Table 1112.3

A local supporting element of a part of a roof shall be defined as a roof deck element, purlin, rafter, or similar item which distributes the wind load from the roof part to the principal structural system of the structure.

1112.12 Wind load on signs, towers, exposed framing, tanks, stacks and chimneys: Signs, towers, exposed framing, tanks, stacks, chimneys, and similar structures, or parts thereof, shall be designed for wind forces determined by applying coefficients given in Sections 6.7, 6.8, 6.9 of ANSI A58.1 as listed in Appendix A for the
applicable structure using zero point seventy-five (0.75) times the applicable reference wind pressures given in Table 1112.1.

1112.12.1 Shielding: Shielding effect of one element by another shall not be considered when the distance between them exceeds four (4) times the projected smallest dimension of the windward element.

1112.12.2 Signs: For open or solid outdoor signs with ratios of dimensions with the limits stated below, a wind load applied uniformly over the area of the sign and determined by the lesser of one point two P (1.2P) on the gross area within the outside dimensions of the sign, or one point six P (1.6P) on the net projected area of the sign; whichever is less, may be used in lieu of the loads given in reference standard ANSI A58.1, where "P" is the reference wind pressure given in Table 1112.1 for a height equal to the average height of the sign above the ground.

1. Ground supported signs (whose bottom is .25 times the vertical height from the ground to the top of the sign): height to width ratio less than ten (10).

2. Above ground signs: largest to smallest dimension ratio less than twenty (20).

1112.13 Wind forces and pressures using wind tunnel tests: Design wind forces and pressures may be determined by appropriate wind tunnel tests on specific structures as stipulated by the responsible design engineer and approved by the building official. The wind tunnel test program shall adequately represent the relevant properties of the structure and its surroundings and the oncoming wind flow. The wind tunnel tests may be combined with a detailed statistical study of meteorological records, including high level wind velocity and direction, from stations near the proposed structure. The wind effects used for design of the structure shall be not less than those corresponding to an event having an annual probability of occurrence of one-hundredth (.01). In lieu of a detailed statistical study of meteorological records, the appropriate reference wind velocity stipulated in Section 1112.3 may be used.

The wind forces and pressures so determined, plus an appropriate allowance for stack effects and internal pressures, may be used for the design of the structure as a whole, and its individual parts. However, these values of forces and pressures shall not be less than eight-tenths (.8) of the values required by Sections 1112.5, 1112.7 and 1112.12, as applicable, for reference wind pressures for Exposure A and the appropriate wind zone specified in Table 1112.1.

1112.14 Uplift, overturning and sliding:

1112.14.1 Anchorage, roofs and walls: All parts of a structure subjected directly to the wind shall be anchored to the supporting structure, to resist specified wind loads inwardly or outwardly.

1112.14.2 Anchorage, structural system: The design of the structural system and its elements for uplift, overturning moment, or horizontal shear, or their combination, shall provide anchorage resistance required by the load combinations specified in Section 1114.0.

1112.15 Eccentricity of wind forces: Consideration shall be given to the effects of specified wind forces being applied eccentric to the center of rigidity of a structure.

SECTION 1113.0 EARTHQUAKE LOADS

1113.1 General: Provisions of this section reflect informed judgments regarding the probable intensities of future earthquake ground motions in this region, and their associated probabilities of occurrence. The objective of these provisions is to protect life safety by limiting structural failure.

1113.1.1 Every structure and every portion thereof, except detached one- and two-family dwellings and minor accessory buildings, shall be designed and constructed to resist stresses produced by lateral forces as provided in this section. Stresses shall be calculated as the effect of a force applied horizontally at each floor or roof level or to building parts above the foundation. The force shall be assumed to come from any horizontal direction.

1113.1.2 Every structure and every portion designed and constructed to resist stresses produced by lateral forces as provided in this section shall be constructed and inspected in accordance with the applicable provisions of this code.

1113.2 Definitions: (See Section 201.0)

1113.3 Symbols and notations: The following symbols and notations apply only to the provisions of Section 1113.0:

A_c , A_{ch} , A_g , A_{sh}	=	See Section 1113.5.1.3.c.
C	=	Numerical coefficient for base shear as specified in Section 1113.4.1.1.
C_p	=	Numerical coefficient as specified in 1113.4.5 and as set forth in Table 1113.2.
D	=	The dimension of the building in feet in a direction parallel to the applied forces.
D	=	Dead load or related internal moments and forces, when used in Section 1113.5.4.
D_s	=	The plan dimension of the vertical lateral force resisting system in feet.
E	=	Load effects of earthquake, or related internal moments and forces.

F_i , F_n , F_x	=	Lateral force applied to level i, n, or x, respectively.
F_p	=	Lateral force on the part of the structure and in the direction under consideration.
F_t	=	That portion of V considered concentrated at the top of the structure. The remaining portion of the total base shear V shall be distributed over the height of the structure including level according to Section 1113.4.2.
f_{yh}	=	See Section 1113.5.1.3.c
h_c	=	See Section 1113.5.1.3.c (2).
h_i , h_n , h_x	=	Height in feet above the base to level i, n, or x, respectively.
K	=	Numerical coefficient as set forth in Table 1113.1
L	=	Live loads or related internal moments and forces (see Section 1113.5.1.4).
Level i	=	Level of the structure referred to by the subscript "i".
Level n	=	that level which is uppermost in the main portion of the structure.
Level x	=	That level which is under design consideration.
M	=	Overturning moment at the base of the building or structure.
M_x	=	The overturning moment at level "x".
N	=	The total number of stories above the base to level "n".
S	=	Numerical coefficient as specified in Section 1113.4.1.

s_h = See Section 1113.5.1.3.c.(2).

T = Fundamental period of vibration of the building or structure in seconds in the direction under consideration.

U = Required strength to resist factored loads or related internal moments and forces (see Section 1113.5.1.4).

V = Total lateral load or shear at the base.

$$V = F_t + \sum_{i=1}^{n} F_i$$

where $i = 1$ designates first level above the base.

W = Total dead load including the partition loading where applicable plus fifty (50) per cent of the snow load.

Exception: W shall be equal to the total dead load plus twenty-five (25) per cent of the floor live load in storage and warehouse occupancies.

w_i , w_x = That portion of W which is located or is assigned to level "i" or "x", respectively.

W_p = The weight of a part or portion of a structure.

Y_t = Total unit weight.

1113.4 Minimum earthquake forces for structures: The provisions of Section 1113.4 are applicable only to structures meeting the requirements of Section 1113.5. All other structures shall be designed in accordance with Section 1113.7.

1113.4.1 Total lateral force: Every structure shall be designed and constructed to withstand minimum total lateral seismic forces assumed to act non concurrently in

the direction of each of the main axes of the structure in accordance with the following formula:

$$V = \frac{1}{3} KCSW$$

1113.4.1.1 C factor: The value of C shall be determined in accordance with the following formula:

$$C = \frac{0.05}{\sqrt[3]{T}}$$

For all one- and two-story buildings or structures the value of C shall be zero point one (0.1). The maximum value of C need not exceed zero point one (0.1).

T is the fundamental period of vibration of the structure in seconds in the direction under consideration. Properly substantiated technical data for establishing the period T may be submitted. In the absence of such data, the value for T for buildings shall be determined by the following formula:

$$T = \frac{0.05 h_n}{\sqrt{D}}$$

Exception: In all buildings which the lateral force resisting system consists of a moment-resisting space frame which resists one hundred (100) percent of the required lateral forces and which frame is not enclosed by or adjoined by more rigid elements would tend to prevent the frame from resisting lateral forces.

$$T = 0.010N$$

1113.4.1.2 K factor: The horizontal force factors K for structures meeting the requirements of Section 1113.5 are set forth in Table 1113.1.

Table 1113.1
HORIZONTAL FORCE FACTORS "K" FOR STRUCTURES

Type of arrangement of existing element	Value of K
Buildings with a box system as defined in Section 201.0	1.33
Buildings with a dual bracing system as defined in Section 201.0	0.80
Buildings with a moment-resisting space frame designed to resist the total required lateral force	0.67
Other buildings	1.00
Elevated tanks plus full contents on four (4) or more cross-braced legs and not supported by a building[2]	3.00[3]
Structures other than buildings and other than those set forth in Table 1113.1	2.00

Note 1. Where wind load would produce higher stresses, the wind load shall be used in lieu of the loads resulting from earthquake forces.
Note 2. The minimum value of KC shall be zero point twelve (0.12) and the maximum value of KC need not exceed zero point twenty-five (0.25).
Note 3. The tower shall be designed for accidental torsion of five (5) percent as specified in Section 1113.4.3. Elevated tanks which are supported by buildings or do not conform to type or arrangement of supporting elements as described above shall be designed in accordance with Section 1113.4.5 using $C_p = 0.2$.

1113.4.1.3 S Factor: The S Factor shall have the following values according to the types of soil sites as defined below.

Soil Site S_1, S = 1
Soil Site S_2, S = 1.2
Soil Site S_3, S = 1.5

Values other than those tabulated may be used provided they are based on studies by a registered professional engineer and are not less than 1.0. The values of CS need not exceed zero point twelve (0.12).

For the purposes of determining the S Factor, the following types of soils sites are defined according to the materials encountered below the foundation level.

Soil Site S_1: Bedrock of any type including material Classes 1 through 4 of Table 1201.

Stiff soil conditions where the soil depth below foundation level is less than 200 ft. and the soil types overlying bedrock consist of glacial till; gravel or well graded sand and gravel, sands that are not susceptible to liquefaction in accordance with Section 1113.8, clay having an undrained shear strength of at least one thousand (1,000) psf, dense silts and compacted granular fill provided that fill soils are compacted throughout as required in Section 1201.3.1.

Soil Site S_2: Soil sites that cannot be classified as Soil Sites S_1 or S_3.

Soil Site S_3: Soil profiles that contain 30 ft or more of soft clays having an undrained shear strength smaller than 1,000 psf, loose silts, organic soils, loose sands, or miscellaneous fill.

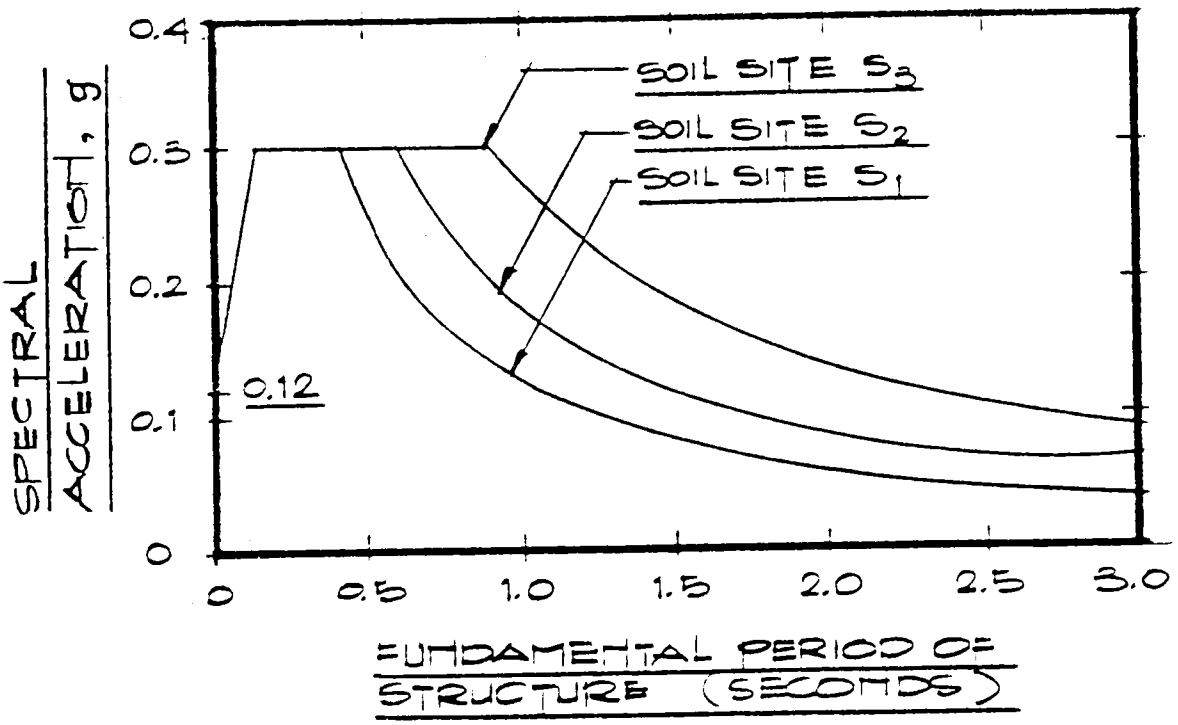


Figure 1113.1
DESIGN RESPONSE SPECTRUM

1113.4.2 Distribution of lateral force:

1113.4.2.1 With vertical distribution for structures having regular shapes or framing systems, the total lateral force V shall be distributed in the height of the structure in the following manner:

$$F_t = .004V\left(\frac{h_n}{D_s}\right)^2$$

F_t need not exceed zero point fifteen (0.15) V and may be considered as zero (0) for values (h_n/D_s) of three (3) or less, and:

$$F_x = \frac{(V - F_t)\, w_x h_x}{\sum_{i=1}^{n} w_i h_i}$$

Exception: one- and two-story buildings shall have uniform distribution. At each level designated as "x," the force F_x shall be applied over the building in accordance with the mass distribution on that level.

1113.4.2.2 Horizontal distribution: Total shear in any horizontal plane shall be distributed to the various elements of the lateral force resisting system in proportion to their rigidities considering the rigidity of the horizontal bracing system or diaphragm.

1113.4.2.3 Setbacks: Buildings having setbacks wherein the plan dimension of the tower in each direction is at least seventy-five (75) percent of the corresponding plan dimension of the lower part may be considered as a uniform building without setbacks for the purpose of determining seismic forces.

For other conditions of setbacks the tower shall be designed as a separate building using the larger of the seismic coefficients at the base of the tower determined by considering the tower as either a separate building for its own height or as part of the overall structure. The resulting total shear from the

tower shall be applied at the top of the lower part of the building which shall be otherwise considered separately for its own height.

Exception: Nothing in Section 1113.4.2.3 shall be deemed to prohibit the submission of properly substantiated technical data for establishing the lateral design forces by a dynamic analysis in accordance with Section 1113.4.2.4.

1113.4.2.4 Distribution of lateral forces for structures having irregular shapes or framing systems: The distribution of the lateral forces in buildings or structures which have highly irregular shapes, large differences in lateral resistance or stiffness between adjacent stories, or other unusual structural features affecting seismic response shall be determined considering the dynamic characteristics of the structure. The total base shear shall not be less than required by Section 1113.4.1. The analysis should be based either upon the modal analysis procedure using the appropriate response spectrum in Figure 1113.1 with reduced ordinates or upon time histories of base motion with a frequency content similar to that implied by the appropriate response spectrum in Figure 1113.1.

1113.4.3 Horizontal torsional moments: Provisions shall be made for the increase in shear resulting from the horizontal torsion due to an eccentricity between the center of mass and the center of rigidity. Negative torsional shears shall be neglected. Where the vertical resisting elements depend on diaphragm action for shear distribution at any level, the shear-resisting elements shall be capable of resisting a torsional moment assumed to be equivalent to the story shear acting with an eccentricity of not less than five (5) per cent of the maximum building dimension at that level.

1113.4.4 Overturning: Every structure shall be designed to resist the overturning effects caused by the wind forces and related requirements specified in Section 1112.14 or the earthquake forces specified in this section, whichever governs.

At any level, the incremental changes of the design overturning moment in the story under consideration shall be distributed to the various resisting elements in the same proportions as the distribution of the shears in the resisting system. Where other vertical members are provided which are capable of partially resisting the overturning moments, a redistribution may be made to these members if framing members of sufficient strength and stiffness to transmit the required loads are provided. Where a vertical resisting element is discontinuous, the overturning moment carried by the lowest story of that element shall be carried down as loads to the foundation.

1113.4.5 Lateral force on parts or portions of buildings or structures: Parts or portions of structures and their anchorage shall be designed for lateral forces in accordance with the following formula: (See formula next page)

$$F_t = \frac{1}{3} C_p W_P$$

The values of C_p are set forth in Table 1113.2. The distribution of these forces shall be according to the gravity loads pertaining thereto.

Table 1113.2
HORIZONTAL FORCE FACTOR "C_p" FOR PARTS OR PORTIONS OF STRUCTURES

Parts or portion of structure	Direction of force	Value of C_p
Exterior bearing and non-bearing walls, interior and partitions, interior non-bearing walls and partitions over ten (10) feet in height, masonry or concrete fences over six (6) feet in height.	Normal to flat surface	0.20[3]
Cantilever parapet and other cantilever walls, except retaining walls	Normal to flat surface	1.00
Exterior and interior ornamentations and appendages.	Any direction	1.00
When connected to, part of, or housed within a building: towers, tanks, towers and tanks plus contents, storage racks over six (6) feet in height plus contents, chimneys, smoke stacks, penthouses, equipment and machinery.	Any direction	0.20[1,2]
When resting on the ground, tank plus effective mass of its contents.	Any direction	0.12[6]
Floors and roofs acting as diaphragms[4].	Any direction	0.10
Connections for exterior panels or for elements complying with Section 1113.6.6.	Any direction	1.00
Connections for prefabricated structural elements other than walls, with force applied at center of gravity of assembly.	Any horizontal direction	0.30[5]
Connections for exterior panels or for elements complying with Section 1113.6.6.	Any direction	1.00
Connections for prefabricated structural elements other than walls, with force applied at center of gravity of assembly.	Any horizontal direction	0.30[5]

Notes to Table 1113.2

Note 1: When located in the upper portion of any building where the "h_n/D" ratio is five to one (5/1) or greater, the value shall be increased by fifty (50) percent.
Note 2: "W_P" for storage racks plus contents. The value of C_p for racks over two (2) storage support levels in height shall be zero point sixteen (0.16) for the levels below the top two levels.
Note 3: Exterior bearing and nonbearing walls, interior bearing walls and partitions, interior nonbearing walls and partitions over ten (10) feet in height shall be designed for a minimum value of C_p of 0.20 unless a greater value of C_p is required by the basic seismic formula V = 1/3 (KCSW) and the coefficient F_X w_x at the height h_x where the wall or partition is located.
Note 4: Floors and roofs acting as diaphragms shall be designed for a minimum value of "C_p" of ten (10) percent applied to loads tributary from that story unless a greater value of "C_p" is required by the basic seismic formula V = 1/3 (KCSW).
Note 5: The "W_p" shall be equal to the total load plus twenty-five (25) percent of the floor live load in storage and warehouse occupancies.
Note 6: When the soil Factor S is less than or equal to one point two (1.2), "C_p" may be taken as zero point one times S (0.1)(S).

1113.4.6 Lateral force on foundations: Consideration shall be given to the manner in which the earthquake lateral force, computed in accordance with Section 1113.4.6.1, will be transmitted from the soil or rock to the structure. Transmission of the lateral force will occur through one or more of the following foundation elements:

a. Lateral soil pressure against foundation walls, footings, grade beams, and pile caps;
b. Lateral soil pressure against piles, piers, or caissons;
c. Side or bottom friction on walls or footings;
d. Batter piles.

Bottom friction under pile caps should be assumed to be ineffective in transmitting horizontal forces.

The horizontal force shall be distributed among the various elements in the foundation in proportion to their estimated rigidities. Any element which will participate in the transfer of horizontal forces from the soil to the structure shall be designed to resist forces in such a way that its ability to sustain static loads will not be impaired.

1113.5 Design requirements:

1113.5.1 Concrete: Design and construction of earthquake resisting reinforced concrete structures shall conform to the provisions of Section 1506.0 and of reference standard ACI 318 (except Appendix A) as listed in Appendix A, and to the requirements of this section.

1113.5.1.1 Physical requirements for reinforced concrete materials: Concrete shall have an ultimate compressive strength at twenty-eight (28) days f'_c, of not less than three thousand (3,000) pounds per square inch. The maximum specified ultimate compressive strength at twenty-eight (28) days, f'_c, for lightweight concrete shall be limited to four thousand (4,000) pounds per square inch. Reinforcing steel shall comply with ASTM A615, Grade 40 or 60, as listed in Appendix A.

1113.5.1.2 Flexural members of moment-resisting space frames:

a. Throughout the length of flexural members, both top and bottom reinforcement shall consist of not less than two (2) bars and ratio provided shall not be less than 200/fy.

b. Positive moment strength of flexural members at column connections shall not be less than twenty-five (25) percent of the required negative moment strength.

c. All reinforcement shall be extended beyond the section at which it is required and developed by bond, hook, or mechanical device to develop the yield strength of the bar.
In confined regions, length of anchorage shall be not less than sixty (60) per cent of the development length but not less than twenty-four (24) inches.

d. Web reinforcement perpendicular to the longitudinal reinforcement shall be required throughout the length of each flexural member. The minimum area of such web reinforcement shall be zero point fifteen (0.15) percent of the product of the width of the web and the spacing of the web reinforcement along the longitudinal axis of the member. The maximum spacing shall be three-quarter (¾)d unless a smaller spacing is required by reference standard ACI 318.

Stirrup-ties shall be provided for a distance not less than one and one half (1½) d from the face of the support. The first stirrup-tie shall be not more than (3) inches from the face of the support and the remainder at a spacing not greater than d/4. A stirrup-tie is a closed stirrup which conforms to requirements set forth for hoops in tied columns in a following paragraph.

Lapped splices located in a region of tension or reversing stress shall be confined by at least two (2) stirrup-ties at each splice.

1113.5.1.3 Columns of moment-resisting space frames:

a. Special transverse reinforcement shall be provided in those portions of tied columns within a distance from the face of the joint equal to the maximum column dimension, one-sixth (1/6) of the clear height of the column, or eighteen (18) inches, whichever is the greatest. The first hoop shall be located two (2) inches from the face of the joint.

b. At exterior and corner columns, the open sides of the joint shall be confined by special transverse reinforcement throughout the height of the joint.

c. Where special transverse reinforcement is required, by the provisions of this section, it shall mean spirals, single hoops or overlapping hoops with supplementary cross ties, where required, in accordance with the following requirements:

1.) For spiral columns, the ratio of the volume of spiral reinforcement to the volume of the core, measured out-to-out of spiral, shall be not less than:

$$0.45\left(\frac{A_g}{A_c}-1\right)\frac{f'_c}{f_{yh}}$$

or:

$$0.12\left(\frac{f'_c}{f_{yh}}\right)$$

2.) For tied columns, transverse ties in the form of rectangular hoops and supplementary cross ties shall be provided in sets spaced vertically not more than four (4) inches apart. The total cross-sectional area, A_{sh}, of hoop reinforcement, included supplementary cross ties, shall be not less than: (See additional formula next page)

$$0.03\left(\frac{A_g}{A_{ch}}-1\right)s_h h_c\frac{f'_c}{f_{yh}}$$

or:

$$0.12 s_h h_c \left(\frac{f'_c}{f_{yh}} \right)$$

where:

A_c = Area of circular core, measured out-to-out of spiral, in square inches.
A_{ch} = Area of rectangular core of column measured out-to-out of hoops, in square inches.
A_g = Gross area of column, in square inches.
A_{sh} = Total cross-sectional area of hoop reinforcement, including supplementary cross ties having a spacing of s_h and crossing a section with a core dimension of h_c, square inches.
f_{yh} = Specified yield strength of spiral or hoops, psi.
h_c = Core dimension of tied column in inches.
s_h = Vertical spacing of hoops.

A hoop shall be a one-piece closed tie, #3 or larger, enclosing longitudinal bars, with a one hundred thirty-five (135) degree bend plus ten (10) tie-diameter extension at its ends, the bends being hooked around a single longitudinal bar.

Supplementary cross ties of the same size and longitudinal spacing as hoops, using one hundred eighty (180) degree standard hooks engaging the peripheral hoop and secured to a longitudinal bar, may be used. Supplementary cross-ties or legs of overlapping hoops shall be spaced not more than fourteen (14) inches on center transversely.

1113.5.1.4 Earthquake resisting shear walls and braced frames: Shear walls and braced frames shall be designed by the strength design method except that the alternate design method of reference standard ACI 318 may be used, provided that the factor of safety in shear is equivalent to that achieved with the strength design method. The formulas for required strength U, as provided in reference standard ACI 318 shall be modified to:

$$U = 1.4(D + L) + 1.4E$$

$$U = 0.9D + 1.4E$$

Except that 2E shall be used in the calculation of shear stresses in shear walls of buildings without a moment-resisting space frame capable of carrying all vertical loads and lateral forces.

Force E shall be determined from V in accordance with Section 1113.4.1.

a. Shear walls

1.) Special vertical boundary elements shall be provided at the edges of concrete shear walls in buildings with a dual bracing system as defined in Section 201.0. These elements shall be composed of concrete encased structural steel elements of A36, A440, A441, A572 (except Grades 60 and 65) or A588 steel, or shall be concrete reinforced as required for columns with special transverse reinforcement, as described above for the full length of the element. The boundary vertical elements and such other similar vertical elements as may be required shall be designed to carry all the vertical stresses resulting from the wall loads in addition to tributary dead and live loads and from the design lateral forces. Horizontal reinforcing in the walls shall be fully anchored to the vertical elements.

2.) Similar confinement of horizontal and vertical boundaries at wall openings also shall be provided unless it can be demonstrated that the unit compressive stresses at the opening have a load factor two (2) times that given by the formulae of Section 1113.5.1.4 for required strength U.

3.) Wall reinforcement required to resist wall shear shall be terminated with not less than a ninety (90) degree bend plus a twelve (12) bar diameter extension beyond the boundary reinforcing at vertical and horizontal end faces of wall sections. Wall reinforcement terminating in boundary column shall be fully anchored into the boundary elements.

1113.5.1.5 Braced frames:

a. Reinforced concrete members of braced frames subject primarily to axial stresses shall have special transverse reinforcement as specified

above, through the full length of the member. Tension members shall additionally meet the requirements for compressive members.

b. In buildings without a moment-resisting space frame capable of carrying all vertical loads and the total required lateral force, all members in braced frames shall be designed for one point twenty-five (1.25) times the force determined in accordance with Section 1113.4.1 Connections for these members are not permitted the thirty-three (33) per cent stress increase for earthquake.

1113.5.2 Steel: Design and construction of earthquake resisting structural steel framing members and their connections shall conform to the requirements of Section 1801.0 and of the Specification for the Design, Fabrication and Erection of Structural Steel for Buildings of the American Institute of Steel Construction and to the requirements of this section.

1113.5.2.1 Moment-resisting space frames:

a. General: Design and construction of steel framing in moment- resisting space frames shall conform to the provisions of Section 1801.0 and the requirements of this section.

b. Definitions:

1.) Joints: The joint is the entire assemblage at the intersections of the members.

2.) Connections: The connection consists of only those elements that connect the member to the joint.

c. Connections:

Each beam or girder moment connection to a column shall be capable of developing in the beam the full plastic capacity of the beam or girder.

Exception: The connection need not develop the full plastic capacity of the beam or girder if it can be shown that adequately ductile joint displacement is provided with a lesser connection.

d. Local buckling: Members in which hinges will form during inelastic displacement of the frames shall comply with the requirements for plastic design sections.

e. Slenderness ratios: The effective length kl used in determining the slenderness ratio of an axially loaded compression member in the moment-resisting space frame depends on its own bending stiffness for the lateral stability of the building, even if bracing or shear walls are provided.

f. Nondestructive welding testing: Welded connections between primary members of the moment-resisting space frame shall be tested by nondestructive methods for compliance with the code and job specifications. A program for this testing shall be established by the person responsible for structural design. As a minimum, this program shall include the following:

1.) All complete penetration groove welds contained in joints and splices shall be tested one hundred (100) per cent either by ultrasonic testing or by radiography.

Exception: The nondestructive testing rate for an individual welder may be reduced to twenty-five (25) percent subject to the concurrence of the design engineer of record, provided the reject rate is demonstrated to be five (5) percent or less of the welds tested for the welder. A sampling of at least forty (40) completed welds shall be made for such reduction evaluation. Reject rate is defined as the number of welds containing rejectable defects divided by the number of welds completed. For evaluating the reject rate of continuous welds over three (3) feet in length, each twelve (12) inch increment shall be considered as one weld. For evaluating the reject rate for continuous welds greater than one (1) inch thick, each six (6) inches of length shall be considered one (1) weld.

2.) Partial penetration groove welds when used in column splices shall be tested either by ultrasonic testing or radiography as required by the design engineer of record.

1113.5.2.2 Braced frames:

a. All members in braced frames of K = 1.0 and K = 1.33 buildings shall be designed for one point twenty-five (1.25) times the force determined in accordance with Section 1113.4.1. Connections for these members are not permitted the thirty-three (33) per cent stress increase for earthquake, unless designed for the full capacity of the members.

1113.5.3 Masonry:

1113.5.3.1. Walls: All bearing walls, shear walls, exterior walls, chimneys and parapets, which are constructed of masonry shall be reinforced in two (2) directions so as to qualify as reinforced masonry according to the provisions of the BIA or NCMA Standards listed in Appendix A.

In masonry bearing or shear walls, principal reinforcement shall be spaced a maximum of four (4) feet on center in either the horizontal or vertical direction. In the other direction, spacing or reinforcement may be increased to six (6) feet.

Nonstructural masonry walls which enclose stairwells or elevator shafts, other than exterior walls, shall be designed as partially reinforced masonry in accordance with the standards listed in Appendix A. The spacing of reinforcement is not to exceed six (6) feet.

1113.5.3.2 Columns: The size and spacing of ties at the ends of tied columns shall not be less than that required for concrete columns (See Section 1113.5.1.3).

1113.5.3.3 Anchorage: Masonry walls shall be anchored to all floors and roofs which provide lateral support for the wall. Such anchorage shall provide a positive direct connection capable of resisting the horizontal design forces or a minimum force of two hundred (200) pounds per lineal foot of wall, whichever is greater. Required anchors in masonry walls of hollow units or cavity walls shall be embedded in a reinforced grouted structural element of the wall.

1113.5.4 Timber:

1113.5.4.1. General: Design and construction of earthquake resisting timber structures shall conform to the requirements of Section 1701.0 and of the *Timber Construction Manual of the American Institute of Timber Construction* listed in Appendix A, and to the requirements of this section.

1113.5.4.2 Diaphragms: Lumber and plywood diaphragms may be used to resist wind or horizontal earthquake forces. The design of diaphragms shall conform to the accepted engineering practice as presented in the *Timber Construction Manual.*

1113.5.4.3 Connections: Axial and shear forces produced in wood members by wind or earthquake shall be transferred by positive connections and adequate anchorage. Uplift or horizontal displacement of seated connections shall be prevented by positive anchors. Toenailing or nails subject to withdrawal are not acceptable for connections resisting such forces or displacements.

1113.5.4.4 Sheathing: Sheathing materials may be used as tension ties provided the tension force does not produce cross-grain bending or cross-grain tension in the peripheral members or other framing members to which the sheathing connects.

1113.5.5 Prefabricated construction: All structural elements within the structure which are considered to resist seismic forces or movement and/or are connected so as to participate with the structural system shall be designed in accordance with the provisions of this code in accordance with accepted engineering practice standards (ACI 318 for precast concrete) as listed in Appendix A. Connections shall accommodate all design forces and movement without loss of load carrying capacity of the interconnected members and shall conform to Section 1113.5.7.

1113.5.6 Other materials or methods of construction: Materials other than concrete, structural steel, clay masonry, concrete block masonry and wood and structural systems other than structural steel, reinforced concrete, reinforced masonry, wood frame or heavy timber shall not be relied on to resist lateral forces and deformations in building structures unless it can be demonstrated to the building official that the structure can safely withstand lateral distortion eight (8) times that computed for the lateral forces specified in Section 1113.4.1. The building official shall require drawings and calculations submitted by a registered professional engineer to verify the requirements of this provision.

1113.5.7 Connections:

1113.5.7.1 Connections which transfer forces between members resisting seismic forces in flexure shall be designed for the required forces and also shall either:

a. Develop the full plastic moment of the member; or
b. Be capable of deforming to form a reversible plastic hinge.

1113.5.7.2 Members which are part of the lateral force resisting system and resist seismic motion by direct axial force shall have connections designed to develop the axial capacities of the members.

1113.5.7.3. Connections of structural members which are not part of the lateral force resisting system to supporting members shall be designed to resist the required seismic forces without reliance on frictional forces.

1113.5.7.4 Column splices, column base anchorages, and similar connections or anchorage elements in which forces induced by seismic loading counteract forces due to dead load shall, in addition to the other design requirements, be designed to resist the forces resulting from sixty-seven (67) percent of the dead load combined with forces of opposite sign resulting from the full seismic loading (0.67 D-E). For this loading combination the splice, anchorage or connection is not permitted the thirty-

three (33) percent increase in allowable stress otherwise permitted by the accepted engineering practice standards. The above provisions shall not apply to portions of the splice, anchorage or connection governed by reinforced concrete provisions of this code based on factored loads and ultimate strength design.

1113.5.7.5 Connections between diaphragms and resisting shear walls and bracing shall be designed for twice the computed force.

1113.6 Other design requirements:

1113.6.1 Lateral force resisting system: Rigid elements that are assumed not to be part of the lateral force resisting system may be incorporated into buildings provided that their effect on the action of the system is considered and provided for in the design.

1113.6.2 Moment resisting space frames: Moment resisting space frames may be enclosed by or adjoined by more rigid elements which would tend to prevent the space frame from resisting lateral forces where it can be shown that the action or failure of the more rigid elements will not impair the vertical and lateral load resisting ability of the space frame.

1113.6.3 Building separations: All portions of structures shall be designed and constructed to act as an integral unit in resisting horizontal forces unless separated structurally by a distance sufficient to avoid contact under deflection from seismic action or wind forces.

1113.6.4 Structural system anchorage: The design of the structural system and its elements for uplift, overturning moment, or horizontal shear, or their combination, shall not depend on more than sixty-seven (67) percent of the available resistance due to dead load effects, the additional required capacity shall be provided by suitable connections and anchorages.

1113.6.5 Combined vertical and horizontal forces: In computing the effect of seismic force in combination with vertical loads, gravity load stresses induced in members by dead load plus design live load, except roof live load, shall be considered.

1113.6.6 Exterior elements: Precast, nonbearing, nonshear wall panels, parapets, or other elements which are attached to, or enclose the exterior shall accommodate movements of the structure resulting from lateral forces or temperature changes. The concrete panels or other elements shall be supported by means of poured-in-place concrete or by mechanical fasteners in accordance with the following provisions:

1113.6.6.1 Connections and panel joints shall allow for a relative movement between stories of not less than two (2) times story drift caused by wind or (3.0/K) times the calculated elastic story drift caused by required seismic forces; or one-half (½) inch, whichever is greater. Values of K are set forth in Table 1113.1.

1113.6.6.2 Connections shall have sufficient ductility and rotation capacity so as to preclude fracture of the concrete or brittle failures at or near welds. Inserts in concrete shall be attached to, or hooked around reinforcing steel, or otherwise terminated so as to effectively transfer forces to the reinforcing steel.

1113.6.6.3 Connections to permit movement in the plane of the panel for story drift may be properly designed sliding connections using slotted or oversize holes, or may be connections which permit movement by bending of steel.

1113.6.7 Minor alterations: Minor structural alterations may be made in existing buildings and structures, but the resistance to lateral forces shall be not less than that before such alterations were made, unless the building as altered meets the requirements of this section of the code.

1113.6.8 Drift: Lateral deflections or drift of a story relative of its adjacent stories shall be considered in accordance with accepted practice. Lateral deflection of diaphragms shall be considered in addition to the deflection of vertical bracing elements.

Rigid elements that are assumed not to be part of the lateral force resisting system may be incorporated into buildings provided that the effect of the action of the system is considered and provided for in the design. In addition, the effects of the drift on such rigid elements themselves and on their attachment to the building structure shall be considered.

1113.6.9 Interconnections of foundations: Pile, pier and caisson caps shall be interconnected by ties. Each tie shall carry by tension or compression a horizontal force equal to ten (10) percent of the larger pile, pier or caisson cap loading, unless it can be demonstrated that equivalent restraint can be provided by other means. At sites where footings are used, adequate consideration shall be given to the lateral and vertical movements of footings that may occur during the design earthquake specified in Section 1113.7. Particular consideration shall be given to those sites where there are saturated, cohesionless, granular soils with blowcounts which only slightly exceed the criteria given in Figure 1113.2.

1113.6.10 Retaining walls: Retaining walls shall be designed to resist at least the superimposed effects of the total static lateral soil pressure, excluding the pressure caused by any temporary surcharge, plus an earthquake force of $0.045Y_tH^2$ (horizontal backfill surface). Surcharges which are applied over extended periods of time shall be included in the total static lateral soil pressure and their earthquake lateral force shall be computed and added to the force of $0.045Y_tH^2$. The earthquake force from the backfill shall be distributed as an inverse triangle over the height of the wall. The point of application of the earthquake force from an extended duration surcharge shall be determined on an individual case basis. If the backfill consists of loose saturated granular soil, consideration shall be given to the potential liquefaction of the backfill during the seismic loading.

1113.7 Dynamic analysis: Any building or structure is deemed to have complied with the provisions of Section 1113.0 if a qualified registered engineer determines that there is negligible risk to life safety if the building or structure experiences an earthquake with a peak acceleration of 0.12g and a frequency content similar to that implied by the appropriate response spectrum in Figure 1113.1. A copy of the studies upon which the determination may be based upon shall be filed with the building official. Such a determination may be based upon:

1. A dynamic analysis, based upon generally acceptable procedures, together with evidence that the building or structure can safely withstand the computed displacements and distortions:

2. A comparison of the building or structure with similar buildings or structures having similar foundations and subsoil conditions, that have withstood a similar actual earthquake; or

3. Other accepted procedures.

1113.8 Liquefaction: The earthquake liquefaction potential of saturated clean medium to fine sands shall be evaluated on the basis of Figure 1113.2 for cases where lateral sliding cannot occur. If the standard penetration resistances, N, in all strata of medium and fine sand lie above the applicable curve in Figure 1113.2 the sands at the site shall not be considered subject to liquefaction. Liquefaction below a depth of sixty (60) feet from final grade need not be considered for level ground. For pressure-injected footings, the ten (10) foot thickness of soil immediately below the bottom of the driven shaft shall not be considered subject to liquefaction.

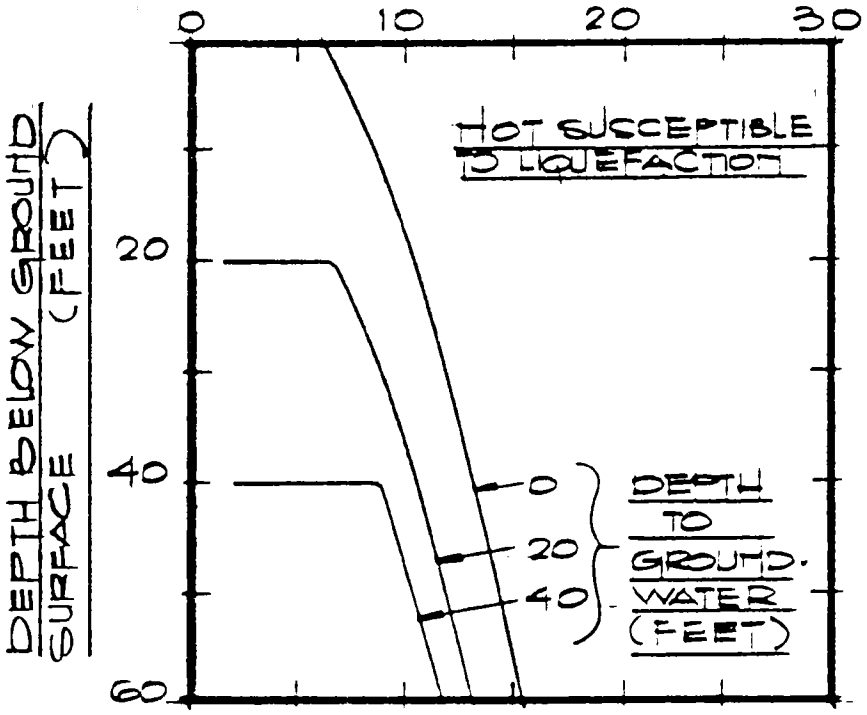


Figure 1113.2
STANDARD PENETRATION RESISTANCE (BLOWS/FT.)

Compacted granular fills shall not be considered subject to liquefaction provided they are systematically compacted to at least ninety-three (93) percent of maximum dry density as determined in accordance with laboratory test designation ASTM D1557, or a relative density of at least sixty (60) percent in the case of granular soils having less than ten (10) percent of weight passing the No. 200 sieve.

For sites not meeting the above criteria, studies by a registered professional engineer shall be made to determine that the structure loads can be safely supported. Such studies might include the following:

1. Investigations to establish that the soils at the site are not subject to liquefaction during the design earthquake as specified in Section 1113.7.
2. Design of foundations that will not fail either by loss of bearing capacity or excessive settlements if liquefaction occurs.

3. Replacement or densification of liquefaction-susceptible soils such that liquefaction will not occur.

For sites underlain by saturated sands where lateral sliding (slope instability) may occur, studies by a registered professional engineer shall be made to establish the safety against sliding during an earthquake with a peak acceleration of 0.12g and a frequency content similar to that implied by the appropriate response spectrum in Figure 1113.1.

For sites underlain by saturated silty sands and inorganic nonplastic silts, studies shall be made by a registered professional engineer to determine the susceptibility to liquefaction of these soils.

SECTION 1114.0 COMBINATION OF LOADS

1114.1 Load combinations:

a.) All structures shall be designed for the effects of at least the following combinations of loads:

(1.) D + L + S

(2.) D + L + S + .5W

(3.) D + L + .5S + W

(4.) D + L + S + E

b.) If the structure will be subjected to loads not included in the above combinations, such loads shall be added to the above combinations.

1114.2 Counteracting loads:

a.) When the inclusion of live, snow, wind, earthquake or other temporary loads will counteract the accumulation of the maximum or minimum total loads in the above load combinations, that load or those loads shall be assumed not to be acting so that only the maximum and the minimum total loads are considered.

b.) When dead load counteracts the maximum or minimum applied load, the dead load shall be reduced. In this case, the dead load shall be taken as 0.67D, unless such a reduction is accounted for by the use of

an ultimate or limit strength design procedure as permitted in this Code.

1114.3 Creep and volume change: When appropriate, the effects of creep or volume change due to temperature or moisture variations shall be considered.

SECTION 1115.0 LIVE LOAD REDUCTIONS

1115.1 General: The design live loads specified in Section 1106.0 may be reduced as permitted and specified herein, except that the design live load shall not be reduced on the following types of structural members:

1.) One-way precast or cast-in-place solid, ribbed, and hollow core concrete slabs.

Exception: Ribs of ribbed or hollow core slabs may be treated as individual beams, and live load may be reduced on the ribs the same as for beams.

2.) Two-way concrete flat slabs and grid slabs, with or without capitals or drop panels.

Exception: Live load may be reduced on slab panels if there are beams on all sides of the panels, and load is transferred to the columns from these beams entirely by "beam shear".

3.) Hangers

1115.2 Design live loads of 100 psf or less; Except for places of public assembly (as defined in Section 210.0) and for floors of garages and open parking structures, a structural member having a tributary area A_T that is greater than A_B may be designed for a reduced live load determined by the following formulas:

$L = NL_o$

N = the largest of the following:

1.) $1 - 0.0008(A_T - A_B)$
2.) $0.75 - 0.20(D_o/L_o)$
3.) 0.50 for members supporting load from more than one floor, or 0.60 for members supporting load from one floor only in which:

L = reduced design live load for the member
L_o = basic design live load
D_o = dead load on the member

A_T = loaded area tributary to the member, square feet
A_B = basic tributary area, square feet, defined as follows:

A_B = 100 square feet for members supporting load from more than one floor
A_B = 250 square feet for members supporting load from one floor only

1115.3 Design live loads greater than 100 psf: Structural members supporting load from more than one floor may be designed for a reduced live load equal to 80% of the design live load.

1115.4 For determination of the number of floors supported by a member in Sections 1115.2 and 1115.3, a roof may be considered to be a floor if the design live load of the roof is equal to or greater than the design live load of the floor below.

ARTICLE 12

FOUNDATION SYSTEMS AND RETAINING WALLS

(This Article is entirely unique to Massachusetts)

SECTION 1200.0 GENERAL

1200.1 Scope: The provisions of this article shall control foundation design and construction of all buildings and structures hereafter erected to insure adequate strength of all parts thereof for the safe support of all superimposed live and special loads, in addition to their own dead load, without exceeding the allowable stresses or design capacities.

SECTION 1201.0 BEARING PRESSURE ON FOUNDATION MATERIALS

1201.1 Soils report:- All applications for permits for the construction of new structures, and for the alteration of permanent structures which require changes in foundation loads and distribution, shall be accompanied by a report describing soil in all bearing strata, including sufficient records and data to establish character, nature and load bearing pressure. Such report shall be prepared and submitted by a registered professional engineer, except as otherwise specified in this article.

1201.2 Satisfactory foundation materials: Satisfactory bearing strata to provide structural support shall be considered to include the following, provided they are of a standard consistent with engineering specifications: natural strata of rock, gravel, sand, inorganic silt, inorganic clay, or combination of these materials. Compacted fills, when designed and monitored by a registered professional engineer, may be accepted by the building official. Other conditions of unsatisfactory bearing materials which are improved in accordance with the recommendations of, and monitored by, a registered professional engineer may be accepted by the building official. Sites involving medium and fine sands, inorganic silt and compacted fills are subject to the additional special requirements of Section 1113.8 (Liquefaction).

1201.2.1 Loading interaction: Wherever bearing strata are subject to interaction from other loadings or strata reactions, such conditions shall be incorporated in the evaluation of the design bearing capacity of the support strata.

1201.2.2 Bearing capacity for light weight structures: Light weight structures and accessory structures, such as garages and sheds, may be founded on normally unacceptable bearing strata, providing such material is determined by a qualified registered professional engineer as being satisfactory for the intended use.

1201.2.3 Protection of bearing strata: Bearing strata which may be adversely affected by conditions within the structure, such as evaporation and shrinkage due to excess heat or cold, shall be adequately protected.

1201.3 Allowable bearing pressures: The maximum pressure on soils under foundations shall not exceed values specified in Table 1201 except when determined in accordance with the provisions of Section 1203.0 or when modified by specific sections of this article. Higher allowable bearing pressures may be approved by the building official when substantiated by the results of investigations, analyses or testing prepared by a registered professional engineer.

1201.3.1 Classification of bearing materials: The terms used in this section shall be interpreted in accordance with generally accepted engineering nomenclature. Refer to commentary in Appendix D for guidelines regarding soil and rock classification and description.

1201.3.2 Compacted fills below foundations: Materials from Classes 6 through 8, Table 1201, or dense graded crushed stone or slag, and which contain no plastic fines, shall have a maximum allowable bearing pressure of up to five (5) tsf when compacted to ninety-five (95) percent or greater of the maximum dry density as determined by ASTM D1557.

For compacted fills which do not meet the above criteria or materials which cannot be tested as above, a registered professional engineer shall be engaged to provide recommendations for compaction and allowable bearing pressures.

The building official will require that a registered professional engineer or his representative be on the project at all times while fill is being placed and compacted. He shall make an accurate record of the types of materials used, including grain-size curves, thickness of lifts, densities, percent compaction, type of compacting equipment and number of coverages, the use of water and other pertinent data.

Table 1201
ALLOWABLE BEARING PRESSURES FOR FOUNDATION MATERIALS

Material Class	Description	Notes	Consistency in Place[1]	Allowable Net Bearing Pressure (tons/ft^2)
1a	Massive bedrock: Granite, diorite gabbro, basalt, gneiss	3	Hard, sound rock , minor jointing	100
1b	Quartzite, well cemented conglomerate	3	Hard, sound rock moderate jointing	60
2	Foliated bedrock: slate, schist	3	Medium hard rock, minor jointing	40
3	Sedimentary bedrock: cementation shale, siltstone, sandstone, limestone, dolomite, conglomerate	3,4	Soft rock, moderate jointing	20
4	Weakly cemented sedimentary bedrock: compaction shale or other similar rock in sound condition	3	Very soft rock	10
5	Weathered bedrock: any of the above except shale.	3,5	Very soft rock, weathered and/or major jointing and fracturing	8
6	Slightly cemented sand and/or gravel, glacial till (basal or lodgement), hardpan	7,8	Very dense	10

Material Class	Description	Notes	Consistency in Place[1]	Allowable Net Bearing Pressure (tons/ft^2)
7	Gravel, widely graded sand and gravel; and granular ablation till	6,7,8	Very dense Dense Medium dense Loose Very loose	8 6 4 2 Note 11
8	Sands and nonplastic silty sands with little or no gravel (except for Class 9 materials)	6,7,8,9	Dense Medium dense Loose Very loose	4 3 2 Note 11
9	Fine sand, silty fine sand, and nonplastic inorganic silt	6,7,9	Dense Medium dense Loose Very loose	3 2 1 Note 11
10	Inorganic sandy or silty clay, clayey sand, clayey silt, clay, or varved clay; low to high plasticity	5,6,10	Hard Stiff Medium Soft	4 2 1 Note 11
11	Organic soils: peat, organic silt, organic clay	11	--------	Note 11

Notes on Table 1201:

1. Refer to commentary in Appendix D regarding typical index test values that may be helpful as guides for evaluation of consistency in place.
2. Refer to Section 1206.0 for determination of design loads and for special cases.
3. The allowable bearing pressures may be increased by an amount equal to ten (10) percent for each foot of depth below the surface of sound rock; however, the increase shall not exceed two (2) times the value given in the table.
4. For limestone and dolomite, the bearing pressures given are acceptable only if an exploration program performed under the direction of a registered professional engineer demonstrates that there are no cavities within the zone of influence of the foundations. If cavities exist, a special study of the foundation conditions is required.
5. Weathered shale and/or weathered compaction shale shall be included in Material Class 10. Other highly weathered rocks and/or residual soils shall be treated as soil under the appropriate description in Material Classes 6 to 10. Where the transition between residual soil and bedrock is gradual, a registered professional engineer shall make a judgment as to the appropriate bearing pressure.

6. Settlement analyses in accordance with Section 1204.5 should be performed if the ability of a given structure to tolerate settlements is in question, particularly for, but not limited to, soft or very soft clays and silts and loose granular materials.
7. Allowable bearing pressures may be increased by an amount equal to five (5) percent for each foot of depth of the bearing area below the minimum required in Section 1205.0; however, the bearing pressure shall not exceed two (2) times the value given in the table. For foundation bearing areas having a least lateral dimension smaller than three (3) feet, the allowable bearing pressure shall be one-third (1/3) of the tabulated value times the least dimension in feet.
8. Refer to Section 1201.3.2 when these materials are used as compacted fills.
9. These materials are subject to the provisions in Section 1113.8 (Liquefaction).
10. Alternatively, the allowable bearing pressure may be taken as 1.5 times the peak unconfined compressive strength of undisturbed samples for square and round footings or 1.25 times that strength for footings with length to width ratio of 4 or greater. For intermediate cases, interpolation may be used.
11. A registered professional engineer shall be engaged to provide recommendations for these special cases. Direct bearing on organic soils is not permitted. Organic soils are allowed under foundations for those cases defined in Section 1201.3.3, Preloaded materials.

1201.3.3 Preloaded materials: The building official may allow the use of certain otherwise unsatisfactory natural soils and uncompacted fills for support of one (1) story structures after these materials have been preloaded to effective stresses not less than one hundred and fifty (150) percent of the effective stresses which will be induced by the structure.

The building official may require the loading and unloading of a sufficiently large area, conducted under the direction of a registered professional engineer, approved by the building official, who shall submit a report containing a program which will allow sufficient time for adequate consolidation of the material based on an analysis of the preloaded material and of the probable settlements of the structure.

1201.4 Light weight structures: One story structures without masonry walls and not exceeding eight hundred (800) square feet in area may be founded on a layer of satisfactory bearing material not less than three (3) feet thick, which is underlain by highly compressible material, provided that the stresses induced in the unsatisfactory material by the live and dead loads of the structure, and the weight of any new fill within or adjacent to the building area, will not exceed two hundred and fifty (250) pounds per square foot (psf).

SECTION 1202.0 SUBSURFACE EXPLORATIONS

1202.1 Where required: Borings, test pits or other soil investigations shall be required for all structures except the following, unless specifically required by the building official:

1. one- and two-family dwellings and their accessory buildings;
2. structures less than 35,000 cubic feet in gross volume; or
3. structures used for agricultural purposes.

The borings, test pits or other soil investigations shall be adequate in number and depth and so located to accurately define the nature of the subsurface materials necessary for the support of the structure. When it is proposed to support the structure directly on bedrock, the building official shall require core borings to be made into the rock; or shall require other satisfactory evidence to prove that the structure shall be adequately founded on bedrock.

1202.2 Soil samples and boring reports: Samples of the strata penetrated in test borings or test pits, representing the natural disposition and conditions at the site, shall be available for examination by the building official. Wash or bucket samples shall not be accepted. Duplicate copies of the results obtained from all borings, plotted to a true relative elevation and to scale, and of all test results or other pertinent soil data, shall be filed with the building official.

SECTION 1203.0 SOIL BEARING TESTS

1203.1 General: Whenever the allowable bearing pressure on bearing materials is in doubt, the building official may require soil bearing tests. The tests shall be performed under the direction of a registered professional engineer. A complete record of the test results together with a soil profile shall be filed by the registered professional engineer who shall have a representative on the site during all test operations.

1203.2 Loaded areas: The loaded area shall be approximately 4 square feet for all bearing materials; except that when the footing overlies wet clay or other soft materials, the test load shall be applied to an area of not less than 10 square feet.

Bearing tests shall be applied at the elevations of the proposed bearing surfaces of the structure; except that the load may be applied directly on the surface of compacted granular material. The excavation immediately surrounding an area to be tested shall be made not deeper than one (1) foot above the plane of application of the test. The test plate shall be placed with uniform bearing.

1203.3 Loading procedure: The application of the test load shall be in steps equal to not more than one-half (½) the contemplated design load, to at least twice the contemplated design load. The unloading shall be at least two (2) steps, to the design load and then to zero (0) load. The contemplated design load and twice the contemplated design load shall be maintained constant for at least twenty-four (24) hours and until the movement does not exceed two hundredths (.02) of an inch during a twenty-four hour period. The load for all other load and unload steps

including the zero (0) load at the end of the test shall be maintained constant for a period of not less than four (4) hours. Sufficient readings for each load step shall be made to define properly the time-deflection curve.

1203.4 Accuracy of loading: Test loads applied by mechanical devices shall be automatically controlled so as to insure not more than 5 percent variation in applied load. Such devices shall be calibrated prior to the test.

1203.5 Determination of design load: The proposed design load shall be allowed provided that the requirements of Section 1204.5 are fulfilled and the settlements under the design load and twice the design load do not exceed three-eighths (3/8) of an inch and one (1) inch, respectively.

SECTION 1204.0 ALLOWABLE FOUNDATION LOADS

1204.1 General: The maximum allowable pressures on foundation materials shall be in accordance with Section 1201.0 and as modified herein.

1204.2 Foundations on rock: Where subsurface explorations at the project site indicate variations or doubtful characteristics in the structure of the rock upon which it is proposed to construct foundations, a sufficient number of borings shall be made to a depth of not less than ten (10) feet below the level of the footings to provide assurance of the soundness of the foundation bed and its bearing capacity. Refer to Table 1201 for allowable bearing pressures and special conditions.

1204.3 Foundations on soil: Refer to Table 1201 for allowable bearing pressure and special conditions.

1204.4 Vertical pressure: The computed vertical pressure at any level beneath a foundation shall not exceed the allowable bearing pressure for the material at that level. Computation of the vertical pressure in the bearing materials at any depth below a foundation shall be made on the assumption that the load is spread uniformly at an angle of thirty (30) degrees with the vertical; but the area considered as supporting the load shall not extend beyond the intersection of thirty (30) degree planes of adjacent foundations.

1204.5 Settlement analysis: Whenever a structure is to be supported by medium or soft clay (materials of Class 10) or other materials which may be subject to settlement or consolidation, the settlements of the structure and of neighboring structures due to consolidation shall be given careful consideration, particularly if the subsurface material or the loading is subject to significant variation. The building official may require a settlement analysis to be made by a registered professional engineer when the live and dead loads of the structure, as specified in this article,

minus the weight of the excavated material, induce a maximum stress greater than three hundred (300) pounds per square foot at mid-depth of the underlying soft clay layer.

Settlement analysis will be based on a computation of the new increase in stress that will be induced by the structure and realistically appraised live loads, after deducting the weight of excavated material under which the soil was fully consolidated. The effects of fill loads within the building area or fill and other loads adjacent to the building shall be included in the settlement analysis. The appraisal of the live loads may be based on surveys of actual live loads of existing buildings with similar occupancy. The soil compressibility shall be determined by a registered professional engineer.

1204.6 Disturbance of bearing materials: Whenever the bearing materials are disturbed from any cause, for example, by the inward or upward flow of water and/or by construction activities, the extent of the disturbance shall be evaluated by a registered professional engineer and appropriate remedial measures taken satisfactory to the building official.

SECTION 1205.0 DEPTH OF FOOTING

1205.1 Frost protection: All permanent supports of buildings and structures shall extend a minimum of four (4) feet below finished grade except when erected upon sound bedrock or when protected from frost, or when the foundation grade is established by a registered professional engineer and as approved by the building official. The engineer shall show supporting data including the type and extent of free-draining foundation material, ground water levels, and climatic records.

1205.2 Isolated footing: Footings on granular soil of Classes 7 to 9 of Table 1201 and compacted fill shall be so located that the line drawn between the lower edges of adjoining footings shall not have a steeper slope than thirty (30) degrees with the vertical, unless the material supporting the higher footing is braced or retained or otherwise laterally supported in an approved manner.

1205.3 Depth of spread foundations: The bottom surface of any footing resting on material of Classes 5 to 10 of Table 1201, inclusive, shall be at least eighteen (18) inches below the lowest ground surface or the surface of a floor slab bearing directly on the soil immediately adjacent to the footing.

SECTION 1206.0 FOOTING DESIGN

1206.1 Design loads: The loads to be used in computing the pressure upon bearing materials directly underlying foundations shall be the live and dead loads of the structure, as specified in Section 1115.0 including the weight of the foundations and

of any immediately overlying material, but deducting from the resulting pressure per square foot the total weight of a one-(1) foot-square column of soil, including the water in its voids, which extends from the lowest immediately adjacent surface of the soil to the bottom of the footing, pier or mat. Foundations shall be constructed so as to resist the maximum probable hydrostatic pressures.

1206.2 Pressure due to lateral loads: Where the pressure on the bearing material due to wind or other lateral loads is less than one-third (⅓) of that due to dead and live loads, it may be neglected in the foundation design. Where this ratio exceeds one-third (⅓), foundations shall be so proportioned that the pressure due to combined dead, live, wind loads, and other lateral loads shall not exceed the allowable bearing pressures by more than one-third (⅓).

1206.3 Earthquake loads: Special provisions shall be made in the foundation design to comply with the provisions of Section 1113.0.

1206.4 Vibratory loads: Where machinery or other vibrations may be transmitted through the foundations, consideration shall be given in the design of the footings to prevent detrimental disturbances of the soil.

1206.5 Varying unit pressures: Footings shall be so designed that the unit soil pressure under the dead load shall be as uniform as possible under all parts of the building structure. When necessary for stability in the structure due to settlement or varying soil conditions, approved variations are permitted in the unit pressure under different footings.

1206.6 Eccentric loads: Eccentricity of loadings in foundations shall be fully investigated, and the maximum pressure on the basis of straight-line distribution shall not exceed the allowable bearing pressures.

SECTION 1207.0 TIMBER FOOTINGS AND WOOD FOUNDATIONS

1207.1 Timber footings: Timber footings are permitted for buildings of Type 5 construction and as otherwise approved. Such footings shall be treated in accordance with AWPA C2 or C3 listed in Appendix A. Treated timbers are not required when placed entirely below permanent water level, or when used as capping for wood piles which project above the water level over submerged or marsh lands. The compressive stresses perpendicular to grain in untreated timber footings supported upon piles shall not exceed 70 percent of the allowable stresses for the species and grade of timber as specified in the NFoPA *National Design Specification for Wood Construction* listed in Appendix A.

1207.2 Pole buildings: Pole-type buildings shall be designed and erected in accordance with AWPI *Pole Building Design* listed in Appendix A. The poles shall be treated in accordance with AWPA C2 or C4 listed in Appendix A.

1207.3 Wood foundations: Wood foundation systems shall be designed and installed in accordance with NFoPA TR7 listed in Appendix A. All lumber and plywood shall be treated in accordance with AWPB-FDN listed in Appendix A and shall be identified as to conformance with such standards by an approved agency.

SECTION 1208.0 STEEL GRILLAGES

1208.1 General: All steel grillage beams shall be separated with approved steel spacers and shall be entirely encased in at least 3 inches of concrete and the spaces between the beams shall be completely filled with concrete or cement grout. When used on yielding soils, steel grillages shall rest on approved concrete beds not less than 6 inches thick.

SECTION 1209.0 CONCRETE FOOTINGS

1209.1 Concrete strength: Concrete in footings shall have a specified compressive strength of not less than 2,500 psi at 28 days.

1209.2 Design: Concrete footings shall comply with Article 15 and ACI 318 listed in Appendix A.

1209.3 Thickness: The thickness of concrete footings shall comply with Section 1209.3.1 and 1209.3.2.

1209.3.1 Plain concrete: In plain concrete footings, the edge thickness shall be not less than 8 inches for footings on soil; except that for buildings of Use Group R-3 and buildings less than two stories in height of Type 5 construction, the required edge thickness shall be reduced to 6 inches provided the footing does not extend beyond 4 inches on either side of the supported wall.

1209.3.2 Reinforced concrete: In reinforced concrete footings, the thickness above the bottom reinforcement shall be not less than 6 inches for footings on soil, nor less than 12 inches for footings on piles. The clear cover on reinforcement where the concrete is cast against the earth shall not be less than 3 inches. Where concrete is exposed to soil after it has been cast, the clear cover shall be not less than 1½ inches for reinforcement of No. 5 bars or ⅝ inch diameter wire or smaller, nor less than 2 inches for larger reinforcement.

1209.4 Deposition: Concrete footings shall not be poured through water unless otherwise approved. When poured under or in the presence of water, the concrete

shall be deposited by approved means which insure minimum segregation of the mix and negligible turbulence of the water.

1209.5 Protection of concrete: Concrete footings shall be protected from freezing during depositing and for a period of not less than 5 days thereafter. Water shall not be allowed to flow through the deposited concrete.

1209.6 Forming of concrete: Concrete footings shall not be cast against the earth where, in the opinion of the building official, soil conditions warrant forming. When forming is required, it shall be in accordance with Chapter 6 of ACI 318 listed in Appendix A.

SECTION 1210.0 MASONRY UNIT FOOTINGS

1210.1 Dimensions: Masonry unit footings shall be laid in Type M or S mortar complying with Section 1409.0, and the depth shall be not less than twice the projection beyond the wall, pier or column. The width shall be not less than 8 inches wider than the wall supported thereon.

1210.2 Offsets: The maximum offset of each course in brick foundation walls stepped up from the footings shall be 1½ inches if laid in single courses, and 3 inches if laid in double courses.

SECTION 1211.0 MAT, RAFT AND FLOAT FOUNDATIONS

1211.1 General: Mat, raft and float foundations shall be used only when the applied loads of the building or structure are so arranged as to result in practically uniformly balanced loading, and the soil immediately below the mat is of uniform bearing capacity. The characteristics of the soil under the mat or raft shall be considered in the analysis of loading on mats and other continuous footings, and due allowance shall be made for possible concentrated soil pressures under heavily loaded columns.

1211.2 Settlement analysis: The design of floating foundations shall include a settlement analysis in accordance with the provisions of Section 1204.5.

SECTION 1212.0 PIER FOUNDATIONS

1212.1 General: A foundation pier is here defined as a structural member which extends to satisfactory bearing materials to develop support by end bearing and/or friction in those materials. The pier shall be constructed by advancing a hole to the required depth using non-displacement methods and filling the hole with reinforced

or plain concrete. This section includes foundation types also referred to as drilled piers, drilled shafts, caissons and piles installed by hollow-stem auger methods.

The diameter of the pier shall be no less than 12 inches. The base may be enlarged by belling to increase the bearing area. Small diameter grouted piles are covered in Section 1217.2.

1212.2 Installation: In unstable soils, a temporary casing or slurry shall be used to stabilize the excavation. When a slurry is used to stabilize the excavation, the level and quality of the slurry shall be monitored and controlled to maintain stability of the shaft.

1212.3 Enlarged bases: Bell-shaped bases shall have a minimum edge thickness of 4 inches. The bell roof shall slope not less than sixty (60) degrees with the horizontal unless the base is designed in accordance with Sections 1500.2 and 1506.0.

1212.4 Placement of concrete: Concrete may be dropped into the pier from the ground surface provided no more than three (3) inches of water remains in the bottom and the concrete will free-fall vertically without obstruction. The concrete shall be placed in a rapid, continuous operation and controlled such that the concrete does not segregate.

1212.4.1 No piers shall be installed near a concreted pier until the concrete has set sufficiently to avoid damage to the concreted pier.

1212.4.2 For piers without enlarged bases, concrete or grout may be placed through still water or slurry. A properly operated tremie or pumping method shall be used. Samples of the slurry shall be tested to determine the properties prior to placing concrete in each pier. The quality, consistency, and density of the slurry shall be controlled to ensure that there will be free-flow of concrete from the tremie pipe. The concrete must be placed such that all water, slurry and contaminated concrete below design cutoff level is displaced.

1212.4.3 For piers with enlarged bases, the concrete may be placed under slurry, based upon the recommendations of a registered professional engineer and with the approval of the building official. The specific soil or rock conditions, equipment and procedures used shall be taken into account.

1212.4.4 A suitable method shall be employed to verify that the entire length of the shaft is completely filled with concrete or grout. Such means shall include the ability to determine the incremental volumes of concrete or grout installed in relation to calculated drilled shaft volume.

1212.5 Design stresses: Foundation piers may be designed as concrete columns with continuous lateral support below the soil level. The unit compressive stress in the concrete shall not exceed thirty-three (33) percent of the twenty-eight-(28) day strength of the concrete or sixteen hundred (1600) pounds per square inch, whichever is less. The unit compressive stress in the steel reinforcement or the permanent steel casing shall not exceed forty (40) percent of the yield strength of the steel or twenty-four thousand (24,000) pounds per square inch, whichever is less. Permanent steel casing which is used as structural reinforcement shall be protected against corrosion in accordance with Section 1213.3.2.

1212.6 Alignment: When the center of the cross section of a foundation pier at any level deviates from the resultant of all forces more than one-fiftieth (1/50) of its height, or more than one-tenth (1/10) of its diameter, it shall be reinforced as provided in Section 1506.0. The restraining effect of the surrounding soil may be taken into account.

1212.7 Allowable bearing pressure: The allowable bearing pressure on the bottom of the pier shall be in accordance with Section 1201. Additional load may be carried by using higher bearing pressures than allowed by Section 1201 and/or by friction on the sides of the pier embedded in suitable bearing material based on recommendations by a registered professional engineer, and subject to the approval of the building official. Such recommendations shall be based on the results of load tests or other suitable tests or analyses carried out to measure side friction and/or end bearing of piers installed in the same bearing stratum.

1212.8 Minimum spacing: The minimum center-to-center spacing between adjacent piers designed for friction support shall be not less than two (2) times the shaft diameter.

1212.9 Special provisions: For piers with shaft diameter less than 24 inches, the following special provisions shall apply:

1212.9.1 For piers with temporary casing extending to the bottom, the concrete may be poured from the top in accordance with Section 1212.4. For all other cases, piers shall be filled from the bottom upward through a tremie, concrete pump tube, or hollow stem auger in accordance with Section 1212.4.2.

1212.10 Records: The owner shall engage a registered professional engineer to monitor the installation of the piers. The engineer or his representative, qualified by training and experience, shall be present at all times while foundation piers are being installed, to observe and test the bearing material in place, to verify the pier dimensions and to observe concrete placement. When direct inspection of the bearing surface is impossible, a suitable method shall be employed to verify the

condition of the bearing material and to make the measurements and tests. Records of all observations, tests and dimensions shall be signed by the engineer and a copy shall be filed in the office of the building official.

SECTION 1213.0 PILE FOUNDATIONS

1213.1 Site investigation: In addition to the provisions for subsurface explorations, Section 1202.0, the building site shall be investigated for all conditions which might promote deterioration of pile foundations, and approved protective measures meeting the requirements of Section 1213.3 shall be taken to prevent corrosion or other destructive action from deleterious conditions.

When it is intended that a structure be supported on end-bearing piles, a sufficient number of borings shall be cored into bedrock or shall extend into the bearing stratum to such depths that satisfactory evidence is provided to demonstrate that there are not compressible soil deposits below the bearing stratum which would adversely affect the structure.

1213.2 Special piles and caissons: Types of piles or caissons not specifically covered by the provisions of this code may be permitted, subject to the approval of the building official, upon the submission of acceptable test data and design and construction information prepared by a registered professional engineer stating that the pile or caisson installation is adequate to fulfill the design requirements.

1213.3 Protection of pile materials: Where boring records, previous experience, or site investigations indicate any condition which might promote deterioration or possible deleterious action on pile materials due to soil constituents, changing water levels or other causes, such pile materials shall be adequately protected as stated herein.

1213.3.1 Preservative treatments: The preservative treatment of timber piles shall comply with provisions of Section 1219.5 and the reference standards as listed in Appendix A.

1213.3.2 Steel and steel-concrete piles: At locations where steel and steel-concrete piles will be in contact with any material which is corrosive to the steel, one (1) of the following procedures shall be used for protection, or any other method which will satisfy the requirements of the building official:

1. Remove all objectionable material.

2. Effectively protect the steel surface from pile cutoff grade to a grade fifteen (15) feet below the bottom of the objectionable material by means of:

a. cathodic protection as approved by the building official; or

b. an approved encasement of not less than three (3) inches of dense concrete; or

c. an effective protective coating subject to the approval of the building official; or

d. providing an excess steel thickness of one-eight (⅛) inch beyond design requirements on all exposed steel surfaces.

1213.4 Lateral support: Any soil other than fluid soil, including strata of soil not meeting the criterion in Figure 1113.2, shall be deemed to afford sufficient lateral support to permit the design of any type of pile as a short column. When piles are driven through soil which will be removed subsequent to the completion of the foundation, the resistance offered by such material shall not be considered to contribute to the lateral supporting capacity.

1213.4.1 Column action: The portion of a pile or pier that is not laterally supported shall be designed as a column in accordance with Section 1507.0 and taking into consideration the conditions of end fixity.

1213.5 Group action: In cohesive soils, the compressive load capacity of a group of friction piles shall be analyzed in accordance with the requirements of Section 1214.3.2.

1213.6 Stability:

Wall foundations: All piles in wall foundations shall be staggered about the center line of the wall at a minimum distance of one-half (½) the top diameter therefrom. A foundation wall restrained laterally so as to ensure stability both during and after construction may be supported by a single row of piles.

Columns: Individual columns supported on piles shall be designed for eccentricity between the column and the centroid of the supporting piles equal to a minimum of three (3) inches or the actual eccentricity, whichever is greater. The design shall account for such eccentricity through one of the following methods:

a.) By supporting the column on a minimum of three (3) piles in a triangular pattern.

b.) By designing walls, grade beams or structural floors to resist the bending moment induced by the eccentricity.

c.) By designing the piles, column or both to resist the bending moment induced by the eccentricity and providing adequate lateral restraint at the top of the piles to resist the lateral thrust due to the bending moment.

1213.7 Structural integrity: Piles shall be installed in such a manner and sequence as to prevent distortion or damage to piles being installed or already in place, to the extent that such distortion or damage affects the structural integrity of the piles.

When piles have been damaged in driving, or have been driven in locations and alignment other than those indicated on the plans, or have capacities less than required by the design, the affected pile groups and pile caps shall be investigated, and if necessary, the pile groups or pile caps shall be redesigned or additional piles shall be driven to replace the defective piles.

1213.8 Spacing: The minimum center-to-center spacing of piles shall be not less than twice the average diameter of a round pile, nor less than one and three-quarter (1¾) times the diagonal dimension of a rectangular pile. When driven to or penetrating into rock, the spacing shall be not less than 24 inches. When receiving principal support from end-bearing on materials other than rock or through frictional resistance, the spacing shall be not less than thirty (30) inches.

1213.9 Splices: Splices shall be avoided insofar as practicable. Where used, splices shall be sufficiently strong to withstand stresses induced during handling and driving without failure. Splices shall be so constructed as to provide and maintain true alignment and position of the component parts of the pile during installation and subsequent thereto. Splices shall be capable of transmitting all stresses at the location of the splice under design load without exceeding the allowable stresses for specific pile types in this code. Splices shall develop not less than fifty (50) percent of the capacity of the pile in bending.

1213.10 Pile caps: Pile caps shall be of reinforced concrete. The minimum distance from the edge of the cap to the nearest pile surface shall be six (6) inches and there shall be at least two (2) inches of concrete between the top of the pile and the steel reinforcement of the cap. The pile caps shall extend not less than three (3) inches below the pile cutoff.

1213.11 Pre-excavation: Jetting, augering and other methods of pre-excavation must be approved by the building official and carried out in a manner which will not impair the carrying capacity of the piles already in place or the safety of existing adjacent structures. Immediately after completion of jetting or augering, the pile shall be advanced to the maximum depth of pre-excavation and driven below this depth to the required load resistance.

1213.12 Inspection: The owner shall engage a registered professional engineer who shall submit his qualifications in writing to the building official. This engineer, or his representative, who must be qualified by experience and training, shall be present at all times while piles are being driven to observe all work in connection with the piles. The engineer or his representative shall make an accurate record of the material and the principal dimensions of each pile, of the weight and fall of the ram, the type, size and make of hammer, cushion blocks, the number of blows per minute, the energy per blow, the number of blows per inch for the last six (6) inches of driving, together with the grades at point and cutoff and any other pertinent details. A copy of these records shall be signed by the registered professional engineer, and filed in the office of the building official.

1213.13 Identification: All pile materials shall be identified for conformity to the specified grade with this identification maintained continuously from the point of manufacture to the point of installation or shall be tested by an approved agency to determine conformity to the specified grade and the approved agency shall furnish an affidavit of compliance to the building official.

1213.14 Pile location plan: A plan showing the location and designation of all piles by an identification system shall be filed with the building official prior to installation of such piles. All detailed records for individual piles shall bear an identification corresponding to that shown on the plan.

1213.15 Use of existing piles: Piles left in place where a structure has been demolished shall not be used for the support of new construction unless satisfactory evidence is submitted to the building official indicating that the piles are sound and meet the requirements of this code. Such piles shall be load tested or re-driven to verify their capacities. The design load applied to such piles shall be the lowest allowable load as determined by tests or redriving data.

1213.16: Pile driveability: Pile cross sections shall be of sufficient size and strength to withstand driving stresses without damage to the pile and to provide sufficient stiffness to transmit the required driving forces.

Driven piles of uniform cross section or tapered piles shall have a minimum nominal diameter of eight (8) inches except as provided in Section 1219.0 for timber piles or Section 1218.0 for precast concrete piles. Tapered shoes or points of lesser dimensions may be attached to the pile unit.

1213.17 Pile heave: Adequate provision shall be made to observe pile heave. Accurate reference points shall be established on each pile immediately after installation; for cast-in-place piles with unfilled corrugated shells, the reference point shall be at the bottom of the pile. If, following the installation of other piles in the

vicinity, heaving of one-half (½) inch or more occurs, corrective measures shall be taken to ensure that the pile has adequate capacity.

1213.18 Settlement analysis: Pile foundations shall be subject to the requirements of Section 1204.5.

1213.19 Use of vibratory drivers: Vibratory drivers shall only be used to install piles where the pile load is verified by load tests in accordance with Section 1214.4. The installation of production piles shall be controlled according to power consumption and rate of penetration, or other approved means that assure pile capacities equal or exceeding that of the test piles.

1213.20 Installation sequence: Piles shall be installed in such sequence as to avoid compacting the surrounding soil to the extent that other piles cannot be installed properly and to prevent ground movements that could damage adjacent structures.

SECTION 1214.0 ALLOWABLE PILE LOADS

1214.1 General: The allowable load on piles shall be determined by the applicable formulas complying with accepted engineering practice or load tests as stated herein. The maximum load capacity shall be limited by the supporting capacity as obtained from bearing upon or embedment in bearing materials as defined in Sections 1201.0 and 1204.0, but the load shall not exceed the capacity of the pile designed in accordance with the provisions of this Section and the requirements of Article 13 for the construction materials involved.

The allowable load on a pile shall not be limited to load obtained by multiplying its point area by the allowable bearing pressure given in Section 1201.0.

1214.2 Negative friction: Where a pile or a group of piles is placed in subsiding fill or soil, the effect of the downward frictional forces shall be given consideration in the design.

1214.3 Determination of allowable load: In the absence of pile load tests, the load on a single pile, except for the pile types covered in Section 1217.4 (pressure injected footings) and Section 1221.0 (drilled-in caissons), shall not exceed the higher of the two (2) values determined in accordance with Section 1214.3.1 (driving formula) or Section 1214.3.2 (friction formula in clay). Loads on jacked piles shall be determined in accordance with 1214.3.3.

1214.3.1 Driving formula:

1. Where the design load capacity of the pile does not exceed fifty (50) tons, the allowable load may be computed by means of the following driving formula:

$$R = \frac{2E}{S+C}$$

where

R = allowable pile load in pounds;

E = energy per blow in foot-pounds;

S = penetration of last blow or average penetration of last few blows expressed in inches; and

C = constant equal to 1.0 for drop hammer and 0.1 for steam or air hammer.

2. When the design load capacity of a pile exceeds fifty (50) tons the required driving resistance shall be increased above that required by the driving formula in Item 1 above based on load tests or past experience under similar conditions.

3. The value of S must be determined with the hammer operating at one hundred (100) per cent of the rated number of blows per minute for which the hammer is designed.

4. Any driving resistance developed in strata overlying the bearing material shall be discounted.

5. If the driving of the pile has been interrupted for more than one (1) hour, the value of S shall not be determined until the pile is driven at least an additional twelve (12) inches, except when it encounters refusal on or is in a material of Classes 1 to 6 inclusive.

6. When any pile is driven through a layer of gravel, sand or hard clay exceeding five (5) feet in thickness, and through an underlying soft stratum, the bearing capacity shall not be determined in accordance with the driving formula, unless jetting is used during the entire driving of the pile through the layer of gravel, sand or hard clay or unless a hole is pre-excavated through said layer for each pile.

1214.3.2 Friction formula in clay: The allowable load on a pile stopped in inorganic clay may be based on a friction value of five hundred (500) pounds per

square foot of embedded pile surface for a design load not to exceed twenty-two (22) tons, or on a friction value and design load determined from pile load tests. The embedded length shall be the length of the pile below the surface of the inorganic clay or below the surface of immediately overlying satisfactory bearing material. The area of embedded pile surface shall be computed by multiplying the embedded length by the perimeter of the smallest circle or polygon that can be circumscribed around the average section of the embedded length of the pile. The method of determining the allowable load described in this paragraph shall not be used for a pile in which the drive pipe is withdrawn or for piles which are driven through the clay to or into firmer bearing materials.

In case these piles are in clusters, the allowable load shall be computed for the smaller of the following two (2) areas: the sum of the embedded pile surfaces of individual piles; or the area obtained by multiplying the perimeter of the polygon circumscribing the cluster at the surface of the satisfactory bearing material by the average embedded length of pile.

1214.3.3 Jacked piles:

1. Not less than ten (10) per cent of jacked piles shall be load-tested to twice the design load (load test piles). All other jacked piles shall be founded in the same bearing stratum as the load test piles and shall be proof-loaded to one hundred and twenty-five (125) percent of design load (production piles).

2. For production piles, the one hundred and twenty-five (125) percent of design load shall be maintained for at least thirty (30) minutes. Acceptability criteria: during final fifteen (15) minutes of load, the rate is not progressive (plot is linear or decreasing when settlement is plotted against logarithm of time); and the rate of settlement is equal to or less than that observed for load test piles during the corresponding time period under one hundred and twenty-five (125) per cent of design load.

3. Settlement readings shall be plotted after 1, 2, 4, 8, and 15 minutes, and at 15-minute intervals thereafter. Load shall be maintained on production piles until acceptability criteria are met.

4. For load test piles, the load shall be applied directly to one hundred and twenty-five (125) per cent of design load and maintained for not less than thirty (30) minutes, but until the settlement rate is not progressive (as defined above). Load shall then be increased to twice the design load and maintained constant for not less than four (4) hours. Settlement during the four (4) hour period shall not exceed point zero fifty (.050) inches.

In the event that settlement exceeds point zero fifty (.050) inches in four (4) hours, the pile shall be deemed unacceptable for one half (½) of the final load. The allowable load on the rejected pile may be established by performing an additional load test at the lesser design load. The design load shall not exceed one half (½) the load maintained for a four (4) hour period during which time settlement did not exceed point zero fifty (.050) inches.

1214.4 Compression load test: Where the proposed design load for any pile, including pressure injected footings, exceeds fifty (50) tons or exceeds the value determined in accordance with Section 1214.3.2 (friction formula in clay), or where the design load for any pile is in doubt, one or more pile load tests shall be performed in accordance with Section 1214.4 on representative piles.

The results of the load test can be applied to other piles within the area of substantially similar subsoil conditions as that for the test pile, providing the performance of the test pile has been satisfactory and the remaining piles are of the same type, shape and size as the test pile and are installed using the same methods and equipment and are driven into the same bearing strata as the load-tested pile to an equal or greater penetration resistance.

For design loads between fifty (50) and one hundred-twenty (120) tons, pile load tests may be waived by the building official, where justified, upon submittal of substantiating data prepared by a registered professional engineer which include experience and/or performance records for the proposed pile installation under similar soil and loading conditions.

1214.4.1 Required test load: A single pile shall be load-tested to not less than twice the allowable design load. When two (2) or more piles are to be tested as a group, the total load shall be not less than one and one-half (1½) times the allowable design load for the group.

In no case should the load reaching the top of the bearing stratum under maximum test load for a single pile or pile group be less than the following:

Case A - piles designed as end-bearing piles, 100% of the allowable design load.

Case B - piles designed as friction piles, 150% of the allowable design load. For piles designed as combination end-bearing and friction piles, Case A applies, if the pile is designed to support more than fifty (50) percent of its design in bearing; otherwise, Case B applies.

1214.4.2 Internal instrumentation: The test pile shall be instrumented in accordance with the requirements in paragraph 4.4.1 of ASTM D1143 to enable measurement or computation of the load in the pile where it enters the bearing stratum. For piles containing concrete, instrumentation shall be installed in the test pile to permit direct measurement of the elastic modulus of the pile.

This requirement is waived for the following cases:

1. The test pile is installed within a casing that extends to within 10 feet above the bearing stratum.
2. The pile to be tested has been functioning satisfactorily under load for a period of one year or more.
3. The pile is 30 feet long or less and no appreciable load will be supported above the bearing stratum.

1214.4.3 Loading procedure: Pile load tests shall be conducted in accordance with ASTM D1143, Standard Method of Testing Piles under Static Axial Compressive Load, except that Section 5, Loading procedures, shall be deleted and replaced by the following provisions:

1. Apply 25% of the allowable design load every one-half (½) hour. Longer time increments may be used, but each time increment should be the same.
2. At 200% of the allowable design load (or 150% for pile groups), maintain the load for a minimum of one hour and until the settlement (measured at the lowest point on the pile at which measurements are made) over a one-hour period is not greater than 0.01 in.
3. Remove 50% of the design load every fifteen (15) minutes until zero load is reached. Longer time increments may be used, but each should be the same.
4. Measure rebound at zero load for a minimum of one hour.

In no case shall a load be changed if the rate of settlement is not decreasing with time. For each load increment or decrement, take readings at the top of the pile and on the internal instrumentation at 1, 2, 4, 8 and 15 minutes and at 15-minute intervals thereafter.

A load greater than 200% of the allowable design load (or 150% of the allowable design load for pile groups) may be applied at the top of the pile, using the above loading procedure, to ensure that Section 1214.4.1 is fulfilled. Other optional methods listed in ASTM D1143 may be approved by the building official upon submittal in advance of satisfactory justification prepared by a registered professional engineer who is qualified in this field.

1214.4.4 Selection of design load: Provided that the allowable design load does not exceed the load allowed in this section for the type of pile and provided that the allowable design load does not exceed 100% of the load supported in the bearing stratum (or ⅔ of the load supported in the bearing stratum for friction piles or pile groups) when the maximum test load is applied, then the allowable design load shall be the greater of the following:

1. Allowable design load based on settlement during loading:
   Fifty (50) percent of the applied test load which causes a gross settlement at the pile cutoff grade equal to the sum of: a) the theoretical elastic compression of the pile in inches assuming all the load on the butt is transmitted to the tip, plus b) 0.15 inch, plus c) one (1) percent of the pile tip diameter or pile width in inches. If the settlements are so small that the load-settlement curve does not intersect the failure criterion, the allowable design load shall be fifty (50) percent of the maximum test load.
2. Allowable design load based on the net settlement after rebound:
   Fifty (50) percent of the applied test load which results in a net settlement at the top of the pile of one-half (½) inch, after rebound for a minimum of one hour at zero load.

1214.5 Use of allowable higher stresses: Higher stresses than those permitted in this code for various pile materials may be approved by the State Board of Building Regulations and Standards based upon the submission of substantiating data and analyses which justify such higher stresses. The data shall be presented in a report prepared by a registered professional engineer and shall include, as applicable: the results of the soil investigation, dynamic analyses of the pile behavior, pile load tests, analyses of load transfer during testing and prediction of pile performance during long term service.

1214.6 Lateral load tests: The allowable load on piles subject to lateral load shall be verified by test unless it is waived by the building official. Pile load tests may be waived by the building official, where justified, upon submittal of substantiating data which include experience and/or performance records for pile installations under similar soil and loading conditions prepared by a registered professional engineer experienced in geotechnical aspects of foundation design.

1214.6.1 Required test load: A single pile shall be load tested to not less than 200 percent of the design load.

1214.6.2 Test setup and loading procedure: The load test setup instrumentation and loading procedure shall be in accordance with ASTM D3966.

1214.6.3 Selection of design load: The design load shall be selected by the responsible registered professional engineer, based upon his interpretation of the load-deflection data from the load test.

1214.7 Tension load tests: The allowable load on piles in tension shall be verified by test unless it is waived by the building official. Pile load test may be waived by the building official, where justified, upon submittal of substantiating data which includes experience and/or performance records for pile installations under similar soil and loading conditions prepared by a registered professional engineer experienced in the geotechnical aspects of foundation design.

1214.7.1 Required load test: A single pile or a pile group shall be load tested to not less than 200 percent of the design load for transient loads (ie: earthquake and wind) and 250 percent for sustained loads.

1214.7.2 Test setup and loading procedure: The load test setup, instrumentation and loading procedure shall be in accordance with ASTM D3689.

1214.7.3 Selection of design load: Provided the allowable design load does not exceed the allowable stresses in the pile materials, the allowable design load shall be the lower of the following:

1. Fifty (50) percent (for transient loads) or forty (40) percent (for sustained loads) of the applied test load which results in a net upward movement of one-half (½) inch at the top of the pile after removal of the maximum test load (The gross upward movement minus the rebound movement).

2. Fifty (50) percent (for transient loads) or forty (40) percent (for sustained loads) of the applied test load which results in continuous upward movement with no increase in load.

1214.8 Bearing capacity: Individual piles and groups of piles shall develop ultimate load capacities of at least twice the design working loads in the designated bearing layers.

Where weaker materials underlie the bearing material into which the piles are driven, the allowable pile load shall be limited by the provision that the vertical pressures in such underlying materials produced by the loads on all piles in a foundation shall not exceed the allowable bearing pressures of such materials as established by analysis, applying accepted principles of soil mechanics. Piles or pile groups shall be assumed to transfer their loads to the underlying materials by spreading the load uniformly at an angle of sixty (60) degrees with the horizontal, starting at a polygon circumscribing the piles at the top of the satisfactory bearing material in which they are embedded; but the area considered as supporting the load

shall not extend beyond the intersection of the sixty (60) degree planes of adjacent piles or pile groups.

1214.9 Bent piles: The load carrying capacity of piles discovered to have a sharp or sweeping bend shall be determined by an approved method of analysis or by load testing a representative pile.

1214.10 Overloads on piles: The maximum compressive load on any pile due to mislocation shall not exceed 110 percent of the allowable design load.

1214.11 Liquefaction during earthquakes: The requirements of Section 1113.8 shall be considered in design of pile foundations. If pile tips lie above soil which does not meet the criteria in Figure 1113.2 special studies shall be made by a registered professional engineer to ensure safety during the design earthquake specified in Section 1113.7.

SECTION 1215.0 STRUCTURAL STEEL PILES

1215.1 Steel: Steel sections may be of any type of steel permitted by the provisions of the reference standards of this article.

1. Rolled structural steel piles shall be of H form, with flange projection not exceeding fourteen (14) times the minimum thickness of metal in either flange or web and with total flange width at least eighty-five (85) per cent of the depth of the section. A section shall not have a nominal thickness of metal less than four-tenths (4/10) inch, nor a nominal depth in the direction of the web of less than eight (8) inches.

2. The use of built-up sections or sections of other than H form will be permitted if the several components of the section are adequately connected to develop the strength of the adjacent components and if the ratio of width to thickness of the component parts does not exceed the values for conventional H sections.

3. The tips of all steel H piles having a thickness of metal less than five-tenths (5/10) inches which are driven to end bearing on rock of Classes 1 through 3 by an impact hammer shall be reinforced. The installation of all steel H piles by impact hammer to end bearing on rock of Classes 1 through 3 shall be conducted so as to terminate driving when the pile reaches refusal on the rock surface.

4. Structural caps shall be rigidly attached to the pile section and shall be designed to transfer the full load into the piles; except that when the pile

extends into the footing sufficiently to develop the full load by bond, or to permit the use of mechanical devices to develop the full load by shear, structural caps shall not be required.

1215.2 Splices: All splices shall comply with Section 1213.9.

1215.3 Protection: Structural steel piles shall be protected under the conditions specified in Section 1213.3 or due allowance shall be made for corrosion as therein specified.

1215.4 Allowable load: Except as provided in Section 1214.5, the load on such piles shall not exceed the allowable load determined in accordance with Section 1214.0, nor shall the stress exceed thirty-five (35) per cent of the minimum specified yield strength or twelve thousand six hundred (12,600) pounds per square inch (psi) on the cross section.

SECTION 1216.0 CONCRETE-FILLED PIPE AND TAPERED TUBULAR PILES

1216.1 Installation: Immediately before filling with concrete, the inside of the casing shall be thoroughly cleaned to the bottom and subjected to a visual inspection. The casing shall be subject to the following limitations:

1. The diameter shall not vary more than twenty (20) per cent from the specified value.

2. The bottom of the casing shall not deviate more than ten (10) per cent of the length of the pile from the design alignment.

3. The casing shall not deviate by more than six (6) per cent of the length of the casing from the straight line connecting the mid-points of the ends of the casing. Any other conditions which may affect the design performance shall be duly noted and evaluated subject to the requirements of the building official.

Concrete shall not be placed through water; except that the building official may approve the use of a properly-operated tremie or pumped concrete in still water, provided the pipe is proven to be free of other material.

1216.2 Steel pipe: All steel pipe shall conform to the applicable standards listed in the reference standards in the appendices for welded and seamless steel pipe and tubes, and for hot-rolled carbon steel sheets. The yield point used in the design of steel casings shall be that of the fabricated element as determined by test.

1216.3 Design: Except as provided in Section 1214.5, the load on concrete-filled pipe piles shall not exceed the allowable load determined in accordance with Section 1214.0, nor shall a load computed on the basis of stress in the concrete exceed twenty-five (25) per cent of the twenty-eight (28) day strength, or eleven hundred (1100) pounds per square inch (psi) and stress in the steel exceed nine thousand (9000) pounds per square inch; nor shall the load carried by the steel on this basis exceed one-half (1/2) the total load on the pile.

1216.4 Minimum thickness: The minimum wall thickness of all load-bearing pipes, tubes and shells shall be one-tenth (1/10) inches. When requiredby soil conditions, allowance shall be made for corrosion as specified in Section 1213.3.

1216.5 Splices: All splices of the steel section shall comply with Section 1213.9.

SECTION 1217.0 CAST-IN-PLACE CONCRETE PILES

1217.1 General: This section includes small diameter grouted piles (drilled or driven), pressure injected footings (enlarged base piles) and cased poured concrete piles. There are distinct differences among these types as noted.

All cast-in-place concrete piles shall be made and placed to ensure the exclusion of all foreign matter and to secure a well-formed unit of full cross-section. The minimum strength of concrete for cast-in-place piles shall be three thousand (3,000) pounds per square inch (psi). While placing the concrete, in other than grouted piles, the casing or drive-pipe shall contain not more than three (3) inches of water.

The maximum size of coarse aggregate for all concrete shall be three-quarter- (3/4) inch, and the concrete shall have a slump of four (4) to seven (7) inches. If placed from the top of the pile, all concrete shall be poured in a rapid, continuous operation through a funnel hopper centered at the top of the pile and having a discharge diameter less than the smallest diameter of the pile. After filling with concrete, the top ten (10) feet shall be thoroughly rodded.

1217.2 Small diameter grouted piles:

1217.2.1 General: This section covers grouted cast-in-place piles which are less than twelve (12) inches in diameter and in which all or a portion of the pile is cast directly against the soil without permanent casing.

1217.2.2 Installation: The pile may be formed in a hole advanced by rotary or rotary percussive drilling methods (with or without temporary casing), by a hollow-stem auger, or by driving a temporary casing. The pile shall be grouted with a fluid

cement grout. The grout shall be pumped through a tremie pipe extending to the bottom of the pile until grout of suitable quality returns at the top of the pile.

The following requirements apply to specific installation methods:

1. Piles grouted with temporary casing: For piles grouted inside a temporary casing, the reinforcing steel shall be inserted prior to withdrawal of the casing. The casing shall be withdrawn in a controlled manner with the grout level maintained at the top of the pile, to ensure that the grout completely fills the drill hole. During withdrawal of the casing, the grout level inside the casing shall be monitored to check that the flow of grout inside the casing is not obstructed.

2. Piles grouted without temporary casing: For a pile or portion of a pile grouted in an open drill hole in soil without temporary casing, the minimum design diameter of the drill hole shall be verified by a suitable device immediately prior to grouting. The reinforcing steel shall be inserted prior to grouting.

3. Piles grouted with hollow-stem augers: For piles installed with a hollow-stem auger, the grout shall be pumped under continuous pressure, and the rate of withdrawal of the auger shall be carefully controlled to ensure that the hole is completely filled with grout as the auger is withdrawn. The actual volume of grout pumped for each one (1) foot of withdrawal of the auger shall be recorded and must be equal to or greater than the theoretical volume. The reinforcing steel shall be inserted prior to withdrawal of the auger.

Piles designed for end bearing: For piles designed for end bearing, a suitable means shall be employed to verify that the bearing surface is properly cleaned prior to grouting.

Protection of grouted piles: Subsequent piles shall not be drilled or driven near piles that have been grouted until the grout has had sufficient time to harden.

1217.2.3 Pile diameter: The design pile diameter shall be taken as:

1. The outside diameter of the temporary casing; or

2. The diameter of a full circumferential drill bit attached to the bottom of the temporary casing; or

3. The outside diameter of the hollow-stem auger; or

4. The borehole diameter verified by suitable measurements made immediately prior to grouting.

1217.2.4 Allowable design stresses: Except as provided in Section 1214.5, the design stresses shall not exceed the following values:

1. For compression loads: The allowable stress on the cement grout shall be thirty-three (33) percent of the twenty-eight (28) day unconfined compressive strength, but not exceeding sixteen hundred (1600) pounds per square inch (psi). The allowable stress on the steel reinforcing, including permanent steel casing, shall be forty (40) percent of the minimum specified yield strength, but not exceeding twenty-four thousand (24,000) pounds per square inch (psi).

2. For tension loads: The allowable stress on the steel reinforcing shall be sixty (60) percent of the minimum specified yield strength. The allowable stress on the cement grout shall be zero.

1217.2.5 Minimum reinforcing: The steel reinforcing shall be designed to carry the following minimum percentage of the design compression load:

1. For a pile or a portion of a pile grouted inside a temporary casing, grouted inside a hole drilled into rock, or grouted with a hollow-stem auger, the reinforcing steel shall be designed to carry not less than forty (40) percent of the design compression load.

2. For a pile or a portion of a pile grouted in an open drill hole without temporary or permanent casing, the pile shall be designed to carry the entire design compression load on the reinforcing steel. If a steel pipe section is used for reinforcing, any portion of the cement grout enclosed within the pipe may also be included at the allowable stress for the grout.

1217.2.6 Corrosion protection:

1. Minimum grout cover: Where steel reinforcing is not enclosed inside a permanent casing, centralizers shall be provided on the reinforcing to ensure a minimum grout cover of one (1) inch in soil and one-half (½) inch in rock. Grout cover requirements may be reduced when the reinforcing steel is provided with a suitable protective coating.

2. Permanent steel casing that is used as structural reinforcing shall be protected in accordance with the provisions of Section 1213.3.2.

3. For piles subjected to sustained tension loading in corrosive environments, the reinforcing steel shall be protected by a suitable protective coating or encapsulation method.

1217.2.7 Allowable load: The load on small diameter grouted piles shall not exceed the allowable load computed on the basis of the allowable stresses given in Section 1217.2.4 and minimum reinforcing requirements given in Section 1217.2.5, nor shall the load exceed the allowable load determined by load test in accordance with Section 1214.4. Load tests may be waived by the building official based on substantiating data and analyses prepared by a registered professional engineer.

1217.2.8 Alternative load test procedure for friction piles: For piles designed as friction piles, the friction capacity in compression may be verified by load testing in tension. The tension load test shall be performed in accordance with Section 1214.7, with the following exceptions:

1. The test pile must be cased or left ungrouted down to the top of the bearing stratum in a manner which will ensure that no friction resistance is developed above the bearing stratum.

2. The maximum design load shall be taken as fifty (50) percent of the applied test load which results in a movement under load of one-half (½) inch at the pile tip. The movement at the pile tip shall be a.) measured directly by a tell-tale or b.) computed by deducting the theoretical elastic elongation of the pile from the displacement measured at the top of the pile.

1217.2.9 Records: The owner shall engage a registered professional engineer to observe the installation of the piles in accordance with Section 1213.12. The engineer or his representative shall make an accurate record of the installation equipment used, pile dimensions, grouting volumes and procedures used and all other pertinent installation data.

1217.3 Driven uncased piles: (omitted)

1217.4 Pressure-injected footings: (Enlarged base piles)

1217.4.1 Loading: The load on pressure-injected footings shall be limited by the provisions of Section 1214.8 except that the circumscribing polygon shall start at the junction of the shaft and the enlarged base, and the bearing area shall be taken at planes six (6) feet or more below the junction.

1217.4.2 Installation: The installation of pressure-injected footings shall fulfill the following requirements:

1. The drive pipe used for installing the piles shall not be less than twenty (20) inches outside diameter for piles which have an allowable load of one hundred (100) tons or greater, and not less than sixteen (16) inches outside diameter for piles which have an allowable load between fifty (50) and one hundred (100) tons. For loads less than fifty (50) tons, smaller drive casing may be used subject to the approval of the building official.

2. The enlarged base of the pressure-injected footings shall be formed on or in bearing materials of Classes 1 to 9 inclusive. The Class 9 material (fine sand) shall have a maximum of fifteen (15) percent by weight finer than the No. 200 mesh sieve and shall be non-plastic, unless satisfactory load test results or other substantiating data are submitted to, and approved by, the building official.

3. The concrete in the base shall have a minimum compressive strength at twenty-eight (28) days of four thousand (4,000) psi; shall be of zero (0) slump, and shall be placed in batches not to exceed five (5) cubic feet in volume.

4. The last batch of concrete shall be driven into the enlarged base with not fewer than twenty-five (25) blows, each of not less than one hundred and forty thousand (140,000) foot pounds. On the basis of test data, and subject to approval by the building official, the hammer blow energy may be reduced, in which case the number of blows on the last batch shall vary inversely with the energy delivered per blow.

5. During injection of the last five (5) cubic feet, the level of concrete in the drive pipe shall not be more than six (6) inches above the bottom of the pipe.

6. As the drive pipe is being withdrawn, not less than two (2) blows of at least twenty-five thousand (25,000) foot-pounds each shall be applied to compact each batch of concrete in an uncased shaft.

7. An uncased shaft shall not be formed through inorganic clay or inorganic silt unless a hole is made through such soil by a nondisplacement method, at least equal to the inside diameter of the drive pipe, unless the individual piles are located more than nine (9) feet apart and outside the heave range. Pressure-injected footings shall have cased shafts when spaced closer than nine (9) feet apart and when installed through inorganic clay or inorganic silt.

8. An uncased shaft shall not be formed through peat or other organic soils.

9. The permanent metal casing shall be fastened to the enlarged base in such a manner that the two will not separate. The concrete may be placed in the metal casing in the same manner as for poured-concrete piles. A metal casing shall not be filled with concrete until after all pressure injected footings within a radius of at least nine (9) feet have been driven.

1217.4.3 Allowable stresses: In metal-cased shafts the stresses in the concrete shall not exceed thirty-three (33) percent of the twenty-eight-(28) day strength, but not exceeding sixteen hundred (1600) psi. If non-corrugated steel casing is at least two-tenths (0.2) inch thick, the stress in the steel shall not exceed thirty-five (35) percent of the minimum specified yield strength, but not exceeding twelve thousand six hundred (12,600) psi. When required by soil conditions, allowance shall be made for corrosion as specified in Section 1213.3.

1217.4.4 Spacing: The center-to-center spacing of the piles shall be not less than three (3) times the shaft diameter and not less than three and one-half (3½) feet.

1217.5 Cased poured concrete piles:

1217.5.1 Design: The shape of the pile may be cylindrical, or conical, or a combination thereof, or it may be a succession of cylinders of equal length, with the change in diameter of adjoining cylinders not exceeding one (1) inch.

1217.5.2 Loading: Except as provided in Section 1214.5, the load on poured concrete piles shall not exceed the allowable load specified in Section 1214.0, nor shall a load computed on the basis of stress exceed thirty-three (33) percent of the twenty-eight-(28) day strength of the concrete, nor sixteen hundred (1,600) psi when applied to the cross-sectional area computed on the following basis:

1. For metal-cased piles driven to and into materials of Classes 1 to 4 inclusive, using the diameter measured one (1) foot above the point, except that when the rock is immediately overlain by a bearing stratum consisting of one or a combination of bearing materials of Classes 5, 6, and 7, using the diameter at the surface of the bearing stratum.

2. For metal-cased piles, driven through compressible materials including Classes 10 and 11 and into a bearing stratum consisting of one or a combination of bearing materials of Classes 5-9 inclusive, using the diameter at the surface of the bearing stratum.

1217.5.3 Installation: Immediately before filling with concrete, the inside of the casing shall be thoroughly cleaned to the bottom and subjected to a visual examination. The casing shall be subject to the following limitations:

1. The diameter shall not vary more than twenty (20) percent from the specified value.

2. The point of the casing shall not deviate more than ten (10) percent of the length of the pile from the design alignment.

3. The casing shall not deviate by more than four (4) percent of the length of the casing from the straight line connecting the midpoints of the ends of the casing. Any other condition which may affect the design performance shall be duly noted and evaluated subject to the requirements of the building official. A casing or drive-pipe shall not be filled with concrete until all casings or drive-pipes within a radius of seven (7) feet, or within the heave range, whichever is greater, have been driven to the required resistance.

SECTION 1218.0 PRECAST CONCRETE PILES

1218.1 Concrete strength: A precast concrete pile shall not be driven before the concrete has attained a compressive strength of not less than four thousand (4,000) pounds per square inch (psi) based on tests of cylinders cast from the same batches and cured under the same conditions as the pile concrete. These piles shall be so proportioned, cast, cured, handled and driven as to resist without significant cracking the stresses induced by handling and driving as well as by loads.

1218.2 Design: The piles shall be designed and reinforced in accordance with the applicable reinforced concrete regulations cited in Section 1506.0. If for any reason the pile is damaged, or the reinforcement is exposed, its use shall be condemned. The lateral reinforcement at both ends of the pile shall be spaced sufficiently close to resist impact stresses due to driving and not more than three (3) inches on center. When driven to or into bearing materials of Classes 1 to 6 inclusive, or through materials containing boulders, they shall have metal tips of approved design. The minimum lateral dimension of a precast concrete pile shall be ten (10) inches.

1218.3 Limitation of load: Except as provided in Section 1214.5, the load on precast concrete piles shall not exceed the allowable load specified in Section 1214.0, thirty-three (33) percent of the twenty-eight (28) day strength of the concrete, nor sixteen hundred (1600) psi. For prestressed concrete piles, thirty-three (33) percent of the effective prestress load in the concrete after losses shall be deducted from thirty-three (33) percent of the twenty-eight (28) day strength of the concrete or sixteen hundred (1600) psi, whichever is less, in computing the maximum allowable load.

1218.4 Protection: A minimum covering of two (2) inches of concrete shall be provided over all reinforcements, except that for piles to be exposed to sea water

and other severe environments, a three-(3) inch protective covering shall be furnished in the zone of such exposure.

1218.5 Minimum spacing: The minimum center-to-center spacing of precast concrete piles shall be two and one-half (2½) times the square root of the cross-sectional area at the butt.

1218.6 Splices: All splices shall comply with Section 1213.9.

SECTION 1219.0 TIMBER PILES

1219.1 Species: Piles shall be of Type I species, Type II species or other species approved for such use by the building official.

1. Type I species shall include southern yellow pine, oak, Douglas fir and other woods of similar strength and physical characteristics.

2. Type II species shall include Norway pine, spruce and other woods of similar strength and physical characteristics.

1219.2 Quality: Timber piles shall conform to the applicable provisions of the Standard for Round Timber Piles, ASTM D25.

1219.3 Minimum Dimensions:

1. Piles shall be of adequate size to resist the applied loads without having to endure compressive stress parallel with the grain in excess of the following:

   a. Eight hundred (800) pounds per square inch (psi) for Type I species of wood or five hundred (500) pounds per square inch for Type II species of wood on the pile cross section located at the surface of the bearing stratum for piles driven into materials of Classes 6 through 10.

   b. Five hundred (500) pounds per square inch (psi) for Type I species of wood or three hundred (300) pounds per square inch for Type II species of wood on the pile cross section at the tips of piles driven to bearing on materials of Classes 1 through 5.

2. The piles shall measure at least six (6) inches in diameter at the tip and at least ten (10) inches in diameter at the cutoff, with these measurements being taken under the bark.

3. All piles shall be driven in one (1) piece except as provided in Section 1220.0 for composite piles.

1219.4 Cutoff: The tops of all timber piles shall be cut off in a horizontal plane; and if not treated by an approved preservative process, the cutoff shall be below mean low water level or lowest ground water level, and shall be subject to the building official's approval. He may require the owner to install and maintain in good condition at least one (1) ground water observation well within the building, which shall be accessible to the building official.

1219.5 Treated piles: Timber piles pressure-treated with creosote or creosote-coal-tar solution, and conforming to the requirements of this section, may be cut off above permanent ground water level when used for the support of buildings not exceeding two (2) stories in height.

1219.5.1 Treatment: Preservative and final retention shall be in accordance with AWPA Standard C-3. When exposed to salt water, the treatment shall conform to the AWPB Standard MP-1 or MP-2 or MP-4. Pile cutoffs shall be treated in accordance with AWPI Standard M-4.

1219.5.2 Certification: Before any treated piles are driven, the building official shall be furnished with certification by a licensed testing laboratory, certifying that piles were free of decay, were properly peeled and otherwise prepared before treatment; and that the method of treatment, the chemical composition and the amount of retention of the preservative conform to the requirements of this section.

1219.6 Maximum load on wood piles: Except as provided in Section 1214.0, the load on a wood pile shall not exceed the allowable load specified in Section 1214.0, nor thirty-five (35) tons. For timber piles driven into material of Classes 6 through 10, the area of the pile at the surface of bearing stratum shall be used to compute the allowable load.

1219.7 Precautions in driving: To avoid damage to the pile, the size of the hammer shall be such that the driving energy in foot-pounds per blow shall not exceed numerically the point diameter of the pile in inches multiplied by fifteen hundred (1,500). The total driving energy in foot-pounds for six (6) inches of penetration shall for all types of hammers be numerically not greater than the point diameter in inches times thirty-two thousand (32,000) for Type I species of wood or times twenty-two thousand (22,000) for Type II species of wood. For the last inch of penetration, the energy in foot-pounds shall not exceed numerically the point diameter in inches multiplied by six thousand (6,000). In any case, driving shall be stopped immediately when abrupt high resistance to penetration is encountered. Any sudden decrease in driving resistance shall be investigated with regard to the

possibility of breakage of the pile; and if such sudden decrease in driving resistance cannot be correlated to boring data, and if the pile cannot be removed for inspection, it shall be considered adequate reason for rejection of the pile.

SECTION 1220.0 COMPOSITE PILES

1220.1 Design: A composite pile shall consist of a combination of not more than two (2) of any of the different types of piles provided for in this article. The pile shall fulfill the requirements for each type, and in addition the provisions of this Section. The requirements of Section 1217.5.3 shall apply to the entire length of a pipe-shell composite pile.

1220.2 Limitation of load: The allowable load on composite piles shall be that allowed for the weaker of the two sections. Except as provided in Section 1214.5, the allowable load on wood composite piles shall not exceed eighty (80) per cent of that allowed for the wood section alone. Wood-shell composite piles shall not be used for support of buildings exceeding two (2) stories in height.

1220.3 Splices: Splices between concrete sections and steel or wood sections shall be designed to prevent separation of the sections both before and after the concrete portion has set, and to insure the alignment and transmission of the total pile load. Splices shall be designed to resist uplift due to heave during driving of adjacent piles and shall develop the full compressive strength and not less than fifty (50) percent of the strength in tension and bending of the weaker section.

1220.4 Minimum Spacing: The center-to-center spacing shall be governed by the larger of the spacings required in this article for the types composing the pile.

SECTION 1221.0 CONCRETE-FILLED PIPE WITH STEEL CORE CAISSONS

1221.1 Construction: These units shall consist of a shaft section of concrete-filled pipe extended to and firmly seated in bedrock of Classes 1 or 2 with an uncased socket drilled into the bedrock which is filled with cement grout. The steel core shall be centered in the shaft and shall extend through the cement grout to the bottom of the socket.

1221.2 Steel shell: The steel shell shall be seamless or welded steel pipe with a minimum yield point of thirty-three thousand (33,000) pounds per square inch (psi), fitted with an approved cutting shoe and structural cap, or with other approved means of transmitting the super-structure load. The minimum diameter for drilled caissons shall be twenty-four (24) inches and minimum shell thickness five-sixteenths (5/16) inch. Steel shall be protected under the conditions specified in Section

1213.3.2. Splices shall be welded to develop one hundred (100) per cent of the strength of the pipe.

1221.3 Concrete fill: The concrete fill of caissons shall be controlled concrete with a minimum compressive strength of four thousand (4,000) psi at twenty-eight (28) days. It shall be so placed that it shall fill completely the space between the steel core and the pipe. In case the socket cannot be kept free from inflow of water, the pipe shall be filled to its top with clean water before placing the cement grout. The details of the design and installation, including the cleaning and inspection of the socket, the placement of concrete under water or in the dry, the method of centering the steel core, and all other phases of the work shall be submitted to the building official for approval.

1221.4 Rock socket: A socket, approximately the inside diameter of the pipe, shall be made in bedrock of Classes 1 or 2 to a depth that will assure load transfer when computed for bearing on the bottom surface of the socket in accordance with Sections 1203.0, 1206.0 and 1214.0 acting together with a bond stress on the perimeter surface of the socket of two hundred (200) psi. The minimum socket depth shall be at least equal to the diameter of the pipe. Before placement of concrete, the socket and pipe shall be thoroughly cleaned and the rock inspected by a registered professional engineer or his qualified representative.

1221.5 Steel core: The steel core shall consist of a structural steel member. The mating ends of the sections shall be spliced so as to safely withstand the stresses to which they may be subjected. The minimum clearance between structural core and shell shall be two (2) inches. When such cores are installed in more than one (1) length, they shall be assembled to develop the full compressive strength of the section.

1221.6 Driving precautions: Drilled caissons shall not be driven out of plumb by more than two (2) per cent of the length of the caissons.

1221.7 Spacing: The minimum center-to-center spacing shall be not less than two and one-half (2½) times the outside diameter of the steel shell.

1221.8 Allowable load: Except as provided in Section 1214.5, the load on concrete-filled pipe with steel core shall not exceed the allowable load determined in accordance with the provisions of Section 1221.4; nor that computed on the basis of stress in concrete at thirty-three (33) per cent of the twenty-eight (28) day strength, but not exceeding sixteen hundred (1,600) psi; plus stress in the steel at thirty-five (35) per cent of the minimum specified yield strength but not exceeding twelve thousand six hundred (12,600) psi on the net area of the steel pipe plus fifty

(50) per cent of the minimum specified yield strength but not exceeding eighteen thousand (18,000) psi on the area of the core steel.

SECTION 1222.0 FOUNDATION WALLS

1222.1 Design: Foundation walls shall be designed to resist frost action and to support safely all vertical and lateral loads as provided in Article 11. The maximum stresses due to combined loads shall be within the values specified for the materials used in the construction. Unless properly reinforced, tensile stresses shall not exceed those permitted in plain masonry.

1222.2 Minimum thickness: The thickness of foundation walls shall be not less than the thickness of the wall supported, and the minimum thickness shall be limited for the various materials of construction as herein specified. Eight-inch foundation walls shall be permitted under brick veneered frame and under 10-inch cavity walls when the total height of the wall supported, including gables, is not more than 20 feet.

1222.2.1 Reinforced concrete: When reinforced concrete is required to resist all stresses, foundation walls shall be not less than 8 inches thick.

1222.2.2 Hollow and solid unreinforced masonry and plain concrete: The thickness of unreinforced masonry foundation walls shall not be less than shown in Table 1222.2.2 for the type of foundation and superstructure construction used. The maximum depth below grade shall be increased up to that indicated in parentheses in Table 1222.2.2 where such increase is warranted by soil conditions and local experience, and is approved. Where height of unbalanced fill (height of finish grade above basement floor or inside grade) exceeds 7 feet foundation wall thickness shall be determined by structural analysis as required in Section 1223.2.

Table 1222.2.2
THICKNESS OF FOUNDATION WALLS

Foundation wall construction		Maximum depth below grade (feet) (See Section 1222.2.2) Supported wall construction		
Type	Thickness (inches) (See Section 1222.2.2)	Frame	Masonry veneer	Masonry
Hollow masonry (unreinforced)	8	4(6)	4.5 (6)	5 (7)
	10	5(7)	5.5 (7)	6 (7)
	12	7	7	7
Solid masonry (unreinforced)	8	5 (7)	5.5 (7)	6 (7)
	10	6 (7)	6 (7)	6.5 (7)
	12	7	7	7
Plain concrete	8	7	7	7

1222.2.3 Hollow unit walls: Foundation walls of approved hollow masonry units shall be provided with not less than 4 inches of solid masonry at girder bearings, or shall be strengthened with buttresses.

1222.2.4 Rubble stone: Foundation walls of rough or random rubble stone shall not be less than 16 inches thick.

1222.2.5 Bonding: All foundation walls shall be bonded as required for superstructure walls in Section 1411.0.

1222.3 Increased thickness with depth: When any foundation wall, other than a wall that is designed as a retaining wall, extends more than 12 feet below the top of the first floor beams, the thickness of the wall shall be increased 4 inches for each additional 12 feet or fraction thereof in depth.

1222.4 Corbels on 8-inch walls: Where an 8-inch wall is corbeled, the top corbel shall be a full course of headers at least 6 inches in length, extending not higher than the bottom of the floor framing. The maximum projection of one unit shall exceed neither one-half the depth of the unit nor one-third its width at right angles to the face which is offset.

1222.5 Lateral stability: Foundation walls of buildings and structures which serve as retaining walls shall conform to the applicable requirements of Section 1223.0,

and shall be strengthened with buttresses or additional wall thickness to resist lateral soil and hydrostatic pressure when subjected thereto.

SECTION 1223.0 RETAINING WALLS

1223.1 General: Walls built to retain or support the lateral pressure of earth or water or other superimposed loads shall be designed and constructed of approved masonry, reinforced concrete, steel sheet piling or other approved materials within the allowable stresses specified in this code (see Section 1712.3.3).

1223.2 Design: Retaining walls shall be designed to resist the pressure of the retained material, including both dead and live load surcharges to which they are subjected, and to insure stability against overturning, sliding, excessive foundation pressure and water uplift.

1223.3 Hydrostatic pressure: Unless drainage is provided, the hydrostatic head of water pressure shall be assumed equal to the height of the wall.

1223.4 Coping: All masonry retaining walls other than reinforced concrete walls shall be protected with an approved coping.

1223.5 Guardrails: When retaining walls with a difference in grade level on either side of the wall in excess of 4 feet are located closer than 2 feet to a walk, path, parking lot or driveway on the high side, such retaining walls shall be provided with a guard constructed in accordance with Section 827.0 or other approved protective measures.

SECTION 1224.0 WATERPROOFING AND DAMPPROOFING

1224.1 Where required: Walls or portions thereof, retaining earth and enclosing interior spaces and floors below grade shall be waterproofed and dampproofed according to this section except those spaces containing uses other than residential and institutional where such omission is not detrimental to the building or occupancy.

1224.1.1 Story above grade: Where a basement is considered a story above grade and the ground level adjacent to the basement wall is below the floor elevation for not less than 25 percent of the perimeter, the floor and walls shall be dampproofed in accordance with Section 1224.3 and a foundation drain shall be installed in accordance with Section 1224.5.2. The foundation drain shall be installed around the portion of the perimeter where the basement floor is below ground level. The provisions of Sections 1224.2, 1224.4, and 1224.5.1 shall not apply in this case.

1224.1.2 Underfloor space: The finished ground level of an underfloor space such as a crawl space shall not be located below the bottom of the footings. Where there is evidence that the ground water table can rise to within 6 inches of the ground level at the outside building perimeter or where there is evidence that the surface water does not readily drain from the building site, the ground level of the underfloor space shall be as high as the outside finished ground level, unless an approved drainage system is provided. The provisions of Sections 1224.2, 1224.3, 1224.4, 1224.5, and 1224.6 shall not apply in this case.

1224.2 Ground water table investigation: The owner or applicant shall perform a subsurface soil investigation to determine the possibility of the ground water table rising above the proposed elevation of the floor or floors below grade.

Exception: A subsurface soil investigation shall not be required when:
1. Waterproofing is to be provided.
2. Satisfactory data from adjacent areas is available which demonstrates that ground water has not been a problem.
3. Floodproofing is to be provided in accordance with Section 2102.0.

1224.2.1 Ground water control: Where the ground water table is lowered and maintained at an elevation not less than 6 inches below the bottom of the lowest floor, the floor and walls shall be dampproofed in accordance with Section 1224.3. The design of the system to lower the ground water table shall be based upon accepted principles of engineering which shall consider, but not necessarily be limited to: permeability of the soil, rate at which water enters the drainage system, rated capacity of pumps, head against which pumps are to pump and the rated capacity of the disposal area of the system. The design shall also take into account any adverse impacts on utilities, structures or other facilities in the vicinity which would result from the lowering of groundwater levels.

1224.3 Dampproofing required: Where hydrostatic pressure will not occur as determined by Section 1224.2, floors and walls for other than wood foundation systems shall be dampproofed in accordance with this section. Wood foundation systems shall be constructed in accordance with NFoPA TR7 listed in Appendix A.

1224.3.1 Floor applications: The required dampproofing materials shall be installed between the floor and the base as provided by Section 1224.5.1, except where a separate floor is provided above a concrete slab.

1224.3.1.1 Floor dampproofing materials: Where installed beneath the slab, dampproofing shall consist of not less than 6-mil (.006 inch) polyethylene with joints lapped not less than 6 inches, or other approved methods or materials. Where permitted to be installed on top of the slab, dampproofing shall consist of

mopped-on bitumen, not less than 4-mil (.004 inch) polyethylene, or other approved methods or materials. Joints in the membrane shall be lapped and sealed in accordance with the manufacturer's recommendations.

1224.3.2 Walls: Dampproofing materials shall be installed on the exterior surface of walls, and shall extend from the top of the footing to above ground level.

1224.3.2.1 Surface preparation of walls: Prior to application of dampproofing materials on concrete walls, all holes and recesses resulting from the removal of form ties shall be sealed with a bituminous material or other approved methods or materials. Unit masonry walls shall be parged on the exterior surface below ground level with not less than ⅜ inch of portland cement mortar. The parging shall be coved at the footing.

> **Exception**: Parging of unit masonry walls is not required where a material is approved for direct application to the masonry.

1224.3.2.2 Wall dampproofing materials: Dampproofing shall consist of a bituminous material, any of the materials permitted for waterproofing by Section 1224.4.2.2, or other approved methods or materials.

1224.4 Waterproofing required: Where the ground water investigation required by Section 1224.2 indicates that a hydrostatic pressure condition exists, walls and floors shall be waterproofed in accordance with this section.

1224.4.1 Floors: Floors required to be waterproofed shall be of concrete, designed and constructed to withstand the hydrostatic pressure to which they will be subjected.

1224.4.1.1 Floor waterproofing materials: Waterproofing shall be accomplished by placing a membrane of rubberized asphalt, butyl rubber, neoprene, or not less than 6-mil (006 inch) polyvinyl chloride or polyethylene with joints lapped not less than 6 inches, or other approved materials under the slab. Joints in the membrane shall be lapped and sealed in accordance with the manufacturer's recommendations.

1224.4.2 Walls: Walls required to be waterproofed shall be of concrete or masonry designed and constructed to withstand the hydrostatic pressure and other lateral loads to which they will be subjected.

1224.4.2.1 Surface preparation of walls: Prior to the application of waterproofing materials on concrete or masonry walls, the walls shall be prepared in accordance with Section 1224.3.2.1.

1224.4.2.2 Wall waterproofing materials: Waterproofing shall be applied from the bottom of the wall to not less than 12 inches above the maximum elevation of the ground water table. The remainder of the wall shall be dampproofed in accordance with Section 1224.3.2.2. Waterproofing shall consist of two-ply hot mopped felts, not less than 6-mil (.006 inch) polyvinyl chloride or other approved methods or materials capable of bridging nonstructural cracks. Joints in the membrane shall be lapped and sealed in accordance with the manufacturer's recommendations.

1224.4.3 Joints and penetrations: Joints in walls and floors, and between the wall and floor, and penetrations of the wall and floor, shall be made watertight utilizing approved methods and materials.

1224.5 Subsoil drainage system: Where a hydrostatic pressure condition does not exist, dampproofing shall be provided and a base shall be installed under the floor and a drain installed around the foundation perimeter. A subsoil drainage system designed and constructed in accordance with Section 1224.2.1 shall be deemed adequate for lowering the ground water table.

1224.5.1 Floor base: Floors of basements except as provided in Section 1224.1.1 shall be placed over a base course not less than 4 inches in thickness consisting of gravel or crushed stone containing not more than 10 percent of material that passes a No. 4 sieve.

1224.5.2 Foundation drain: A drain shall be placed around the perimeter of a foundation consisting of gravel or crushed stone containing not more than 10 percent material that passes a No. 4 sieve. The drain shall extend a minimum of 12 inches beyond the outside edge of the footing. The thickness shall be such that the bottom of the drain is not higher than the bottom of the base under the floor, and the top of the drain is not less than 6 inches above the top of the footing. The top of the drain shall be covered with an approved filter membrane material. Where a drain tile or perforated pipe is used, the invert of the pipe or tile shall be not higher than the floor elevation. The top of joints or the top of perforations shall be protected with an approved filter membrane material. The pipe or tile shall be placed on not less than 2 inches of gravel or crushed stone complying with Section 1224.5.1 and covered with not less than 6 inches of the same material.

1224.5.3 Drainage disposal: The floor base and foundation perimeter drain shall discharge by gravity or mechanical means into an approved drainage system complying with the Massachusetts State Plumbing Code (248 CMR 2.00) listed in Appendix G.

> **Exception**: Where a site is located in well-drained gravel or sand-gravel mixture soils, a dedicated drainage system is not required.

1224.6 Placement of backfill: The excavation outside the foundation shall be backfilled with soil which is free of organic material, construction debris, and large rocks. The backfill shall be placed in lifts and compacted in a manner which does not damage the waterproofing or dampproofing material.

1224.7 Site grading: The ground immediately adjacent to the foundation shall be sloped away from the building at a slope of not less than one unit vertical in twelve units horizontal (1:12) for a minimum distance of 8 feet measured perpendicular to the face of the wall or an approved alternate method of diverting water away from the foundation shall be used. Consideration shall be given to possible additional settlement of the backfill when establishing the final ground level adjacent to the foundation.

1224.8 Erosion protection: Where water impacts the ground from the edge of the roof, downspout, scupper, or other rain water collection or diversion device, provisions shall be made to prevent soil erosion and direct the water away from the foundation.

ARTICLE 13

MATERIALS AND TESTS

SECTION 1300.0 GENERAL

1300.1 Scope: The provisions of this article shall govern the quality, workmanship and requirements for all materials and methods hereafter used in the construction of buildings and structures. All materials and methods of construction and tests shall conform to the applicable standards listed in this code.

1300.2 New materials and methods of construction: The provisions of this code are not intended to prevent the use of any material, system or method of construction not specifically prescribed by this code. All new building materials, equipment, appliances, systems or methods of construction not provided for in this code, and any material of questioned suitability proposed for use in the construction of a building or structure, shall be subjected to the tests prescribed in this article and in the approved rules to determine character, quality and limitations of use.

1300.3 Used materials and equipment: Used materials and equipment and devices which meet the requirements of this code for new materials, equipment and devices shall be permitted.

SECTION 1301.0 ALTERNATIVE TEST PROCEDURE

1301.1 General: In the absence of approved rules or other approved standards, the building official shall make or cause to be made the necessary tests and investigations; or the building official shall accept duly authenticated reports from approved agencies in respect to the quality and manner of use of new materials or assemblies as provided in Section 110.0. The cost of all tests and other investigations required under the provisions of this code shall be borne by the applicant.

SECTION 1302.0 TEST SAFE LOAD

1302.1 When required: When not capable of design by accepted engineering analysis, any system of construction or structural unit and its connections shall be subjected to the tests prescribed in this article and Articles 14, 15, 16, 17, 18, 19 or 20, or to such other approved tests that simulate the actual loads and conditions of application that occur in normal use; or the building official shall accept certified

reports of such tests conducted by an approved testing agency, providing such tests meet the requirements of this code and the approved rules.

1302.2 Test load: When approved by test, every structural assembly shall sustain without failure minimum superimposed loads equal to two and one-half times the required live load; and under the approved working load, the deflection shall not exceed the limits prescribed in Section 1305.0.

SECTION 1303.0 TESTS

1303.1 Test standards: All structural units and assemblies shall be tested in accordance with the standards listed in Appendix A. In the absence of test procedures governing any specific material or method of construction, the building official shall accept authenticated reports from approved agencies which meet the requirements of this code.

1303.2 Strength tests: To determine the safe uniformly distributed working load when not capable of design by approved engineering analysis, or to check the adequacy of the structural design of an assembly when there is reasonable doubt as to its strength or stability, every system of construction, subassembly or assembled unit and its connections shall be subjected to strength tests prescribed in this code, or to such other approved tests that simulate the loads and conditions of application that the completed structure will be subjected to in normal use. Structural load determinations shall include transverse floor and roof, wall compression and racking, concentrated load, plaster bond, puncture penetration and soil tests.

1303.2.1 Strength test for glass: The working strength of glass for any location in which it is required to withstand wind or impact loads shall be determined according to Section 2202.0 for wind loads and Section 2203.0 for impact loads.

1303.3 Durability and endurance tests: Whenever required by the code official or specified herein or in the approved rules, the material or construction shall be subjected to sustained and repetitive loading to determine its resistance to fatigue, and to test for durability and weather resistance.

1303.4 Maintenance test: In addition to durability and endurance tests, tests of all materials shall be made to assure the maintenance of the standards of approved materials when reasonable doubt exists as to quality and when required by the code official.

1303.5 Performance test: All work shall be conducted and completed in an approved manner, so as to secure the results intended in all sections of this code. Whenever there is reasonable doubt as to the stability or structural safety of a completed building or structure or part thereof for the intended use, the code

official is authorized to require a load test of the building unit or portion of the structure in question. The load test shall be conducted in accordance with Section 1303.5.1 or 1303.5.2.

1303.5.1 Load test procedure specified: When a standard listed in Appendix A governing a specific material or method of construction has load test procedures and acceptance criteria, the test procedure and acceptance criteria of the standard shall apply.

1303.5.2 Load test procedure not specified: In the absence of load test procedures and acceptance criteria for a specific material or method of construction, such existing structure shall be subjected to a superimposed load equal to two times the design live load. The test load shall be left in place for a period of 24 hours. If during the test, or upon removal of the test load, the structure shows evidence of failure, the building official shall order such reinforcement or modifications deemed necessary to insure adequacy of the structure for the rated capacity; or in lieu thereof, the building official shall specify a reduced working load to which the structure shall be limited. The structure shall be considered to have successfully met the test requirements if the total deflection does not exceed the theoretical deflection computed by approved engineering formulae. When the total deflection is greater than such theoretical value, the structure shall be considered safe for the design load if it recovers 75 percent of the maximum deflection within 24 hours after the removal of the test load.

1303.6 Tests of service equipment and devices: Tests of service equipment and accessories shall include proscenium curtain and stage ventilation in accordance with Sections 615.2.6 and 615.2.8; structural load tests in accordance with Section 1302.0; flues, chimneys and boilers in accordance with the BOCA National Mechanical Code listed in Appendix A; electric installations in accordance with Section 2702.0; escalators, elevator interlocks and safety devices in accordance with Section 2602.0; refrigerating equipment and other mechanical and plumbing systems and devices as required by the mechanical and plumbing codes listed in Appendix G, and all other service tests required by the approved rules.

1303.7 Fire tests: In the determination of flash points, combustibility, flameresistance and fireresistance rating of construction materials and methods, all tests shall be conducted in conformity to Sections 902.0, 903.0 and 904.0.

1303.8 Prefabricated construction tests: Prefabricated assemblies or subassemblies not capable of design by approved engineering analysis shall meet all the requirements and tests for at-site construction. The floor panels and other prefabricated units shall be assembled to form an integrated test specimen constructed as in practice, of not less than three units in width with two longitudinal joints; and when designed on the assumption of a simple span, such units shall be tested with flat end supports.

1303.9 Test specimens: The selection and construction of all test specimens and the details of test procedures herein required shall conform to the requirements of the specific test standard being followed. All test specimens and constructions shall be truly representative of the materials, workmanship and details to be normally applied in practice. When structural or fireresistance rated properties of the material are dependent upon adequate curing, the age of the specimen shall be not less than that required to reach the specified design strength or other condition regulated by the applicable test standard.

> **Note: Test procedures.** Test requirements constitute fundamental performance standards and therefore come within the scope of this code. The detail test specifications and procedures are formulated and defined in the approved rules or by reference to test standards of approved testing agencies and organizations. Details of test procedures have been omitted from this code, except for essential basic requirements when deemed necessary.

SECTION 1304.0 DESIGN STRENGTHS OF MATERIALS

1304.1 Conformance to standards: The design strengths and permissible stresses of any structural material that is identified as to manufacture and grade by mill tests, or the strength and stress grade is otherwise confirmed to the satisfaction of the building official, shall conform to the specifications and methods of design of accepted engineering practice or the approved rules in the absence of applicable standards.

1304.2 New materials: For materials which are not specifically provided for in this code, the design strengths and permissible stresses shall be established by tests as provided in Sections 1302.0 and 1303.0.

SECTION 1305.0 CONDITIONS OF ACCEPTANCE

1305.1 General: In evaluating the physical properties of materials and methods of construction when not subject to design by approved engineering analysis, the structural requirements shall be based on the criteria established by the following Sections 1305.2 through 1305.7.

1305.2 Test load factor: The test assembly shall sustain without failure superimposed loads equal to two and one-half times the design live load.

1305.3 Working load deflection: Under the approved working load, the deflection of floor and roof assemblies shall not be greater than 1/360 of the span for plastered construction; 1/240 of the span for unplastered floor construction; and 1/180 of the span for unplastered roof construction.

1305.4 Wall and partition assemblies: Bearing wall and partition assemblies shall sustain the load test both with and without window framing.

1305.5 Comparative tests: When not available from existing approved test data, the building official is authorized to require comparative tests of assemblies of standard traditional forms of construction used for similar purposes to assist in determining the adequacy of the new construction.

1305.6 Concentrated load tests: When not capable of design, all floor assemblies in the use classification groups specified in Table 1106 shall be subjected to the concentrated loads therein prescribed when such loading exceeds in stress effect the uniformly distributed load specified for such uses in Table 1106.

1305.7 Puncture penetration tests: All finish floor assemblies in which light gage metal or other thin materials are used as the structural floor shall withstand the application of a 200-pound concentrated load applied to the top surface on an area of 1 square inch at any point or points of the assembly designated by the code official.

SECTION 1306.0 APPROVALS

1306.1 Written approval: Any material, appliance, equipment, system or method of construction meeting the requirements of this code shall be approved in writing within a reasonable time after satisfactory completion of all required tests and submission of required test reports.

1306.2 Approved record: Whenever any material, appliance, equipment, system or method of construction shall have been approved, a record of such approval, including all the conditions and limitations of its permitted use, shall be kept on file in the building official's office and shall be open to public inspection during business hours.

1306.3 Labeling: Products and materials required to be labeled shall be labeled in accordance with the procedures set forth in Sections 1306.3.1 through 1306.3.3.

1306.3.1 Testing: An approved agency shall test a representative sample of the product or material being labeled to the relevant standard or standards. The approved agency shall maintain a record of all the tests performed. The records shall provide sufficient detail to verify compliance with the test standard.

1306.3.2 Inspection and identification: The approved agency shall periodically perform an inspection, which shall be in-plant if necessary, of the product or material that is to be labeled. The inspection shall verify that the labeled product or material is representative of the product or material tested.

1306.3.2.1 Independent: The agency to be approved shall be objective and competent. The agency shall also disclose all possible conflicts of interest so that its objectivity can be confirmed.

1306.3.2.2 Equipment: An approved agency shall have adequate equipment to perform all required tests. The equipment shall be periodically calibrated.

1306.3.2.3 Personnel: An approved agency shall employ experienced personnel educated in conducting, supervising and evaluating tests.

1306.3.3 Label information: The label shall contain the manufacturer's and/or distributor's identification, model number, serial number, or definitive information describing the product or material's performance characteristics and approved agency's identification.

1306.4 Heretofore approved materials: The use of any material already fabricated or of any construction already erected, which conformed to requirements or approvals heretofore in effect, shall be permitted to continue, if not detrimental to life, health or safety of the public.

ARTICLE 14

MASONRY

SECTION 1400.0 GENERAL

1400.1 Scope: The provisions of this article shall govern the materials, design, construction and quality of masonry.

SECTION 1401.0 MASONRY CONSTRUCTION UNITS

1401.1 Nominal dimensions: Dimensions and thicknesses of masonry construction units specified in this code are nominal dimensions. Actual dimensions shall not vary from the prescribed minimum except in accordance with approved tolerances in the building industry.

1401.2 Second-hand units: Brick and other second-hand masonry units which are to be reused, shall be approved as to quality, condition and compliance with the requirements for new masonry units. The unit shall be of whole, sound material, free from cracks and other defects that would interfere with its proper laying or use, and shall be cleaned free from old mortar before reuse.

SECTION 1402.0 BRICK UNITS

1402.1 General: Brick of clay, shale and calcium silicate (sand/ lime) shall conform to ASTM standards listed in Appendix A as follows: C216 for solid units of face brick; C62 for solid units of building brick; C652 for hollow brick; and C73 for calcium silicate brick. Grade requirements for clay and shale brick units in contact with the ground or subject to water, frost and freezing action shall be governed by the applicable provisions of the ASTM standards listed above.

SECTION 1403.0 STRUCTURAL CLAY TILE UNITS

1403.1 General: Structural clay wall tile shall conform to ASTM standards for structural clay tile units listed in Appendix A as follows: C34 for loadbearing wall tile; C212 for structural clay facing tile; C56 for structural clay nonloadbearing wall tile. Grade requirements for units subjected to the weather or contact with the ground shall be governed by the applicable provisions of the ASTM standards listed above.

1403.2 Fireproofing tile: Structural clay tile for nonstructural use in fireproofing of structural members and in wall furring shall not be required to meet compressive strength specifications. The fireresistance rating shall be determined by standard test procedure to comply with the requirements of Table 401.

SECTION 1404.0 GLAZED MASONRY UNITS

1404.1 General: Glazed masonry building units shall be of a quality equal to that required by ASTM C126 listed in Appendix A.

SECTION 1405.0 CONCRETE UNITS

1405.1 Quality: Cast concrete units shall be of sound, compact structure, uniform in shape and free from cracks, warpage or other defects that would impair their serviceability or strength when laid in the wall.

1405.2 Hollow loadbearing units: Approved hollow loadbearing concrete units for use below grade or unprotected against the weather by stucco, brick or other approved facings or veneers shall have a minimum compressive strength on the gross area of 1,000 pounds per square inch (psi) and for protected exterior use and general interior construction not less than 700 psi.

1405.3 Hollow nonloadbearing units: Approved hollow nonloadbearing concrete units shall have a minimum compressive strength on the average gross area of 350 psi.

1405.4 Solid loadbearing units: Approved solid loadbearing concrete masonry units, when unprotected against the weather or subject to frost and water action, shall have a minimum compressive strength of 1,800 psi, and for protected exterior or general interior use not less than 1,200 psi.

1405.5 Concrete brick: Approved concrete brick for use when exposed to freezing in the presence of moisture shall have a minimum compressive strength of 2,500 psi; and where used as a backup in exterior walls or for general interior construction, a compressive strength of not less than 1,250 psi.

1405.6 Concrete fireproofing and furring units: Approved concrete block or tile used in fireproofing or furring when not exposed to the weather shall have a minimum compressive strength of 300 psi of net area tested as laid in practice. Where exposed to the weather, the compressive strength shall be not less than 700 psi of gross area. All nonbearing units shall be clearly marked to distinguish them from loadbearing units.

1405.6.1 Fireresistance ratings: Fireresistance ratings for concrete masonry walls of various equivalent thicknesses shall be in accordance with Table 1405.6.1. Thicknesses shown are equivalent thicknesses and include the thickness of portland cement plaster, 1.5 times the thickness of gypsum plaster, lath and gypsum wallboard where mentioned and grout when cells are solidly grouted. Where combustible members are framed into the wall, the wall shall be of such thickness or be so constructed that the thickness of solid material between the end of each member and the opposite face of the wall, or between members set in from opposite sides, will be not less than 93 percent of the thickness shown in Table 1405.6.1

Table 1405.6.1
MINIMUM EQUIVALENT THICKNESS, INCHES, FOR RATINGS OF:
(See Section 1405.6.1)

	4 hrs.	3 hrs.	2 hrs.	1 1/2 hrs.	1 hr.	3/4 hr.	1/2 hr.
Calcareous and siliceous gravel	6.2	5.3	4.2	3.6	2.8	2.4	2.0
Expanded clay, shale or slate	5.1	4.4	3.6	3.3	2.6	2.2	1.8
Expanded slag or pumice	4.7	4.0	3.2	2.7	2.1	1.9	1.5
Limestone cinders or slag	5.9	5.0	4.0	3.4	2.7	2.3	1.9

1405.6.2 Increasing ratings: Walls composed of hollow concrete masonry units having a nominal thickness of 8 inches or greater and having a fireresistance rating of at least 2 hours shall be classified as 4 hours where the hollow spaces are completely filled with insulation, grout or a dry granular material, such as expanded slag, clay, shale or sand.

SECTION 1406.0 ARCHITECTURAL TERRA COTTA

1406.1 General: All approved architectural terra cotta units shall be formed with a strong, homogeneous body of hardburned, weather-resisting clay which gives off a sharp, metallic ring when struck and shall meet the strength and durability requirements of this code. All units shall be formed to engage securely with, and anchor to, the structural frame or masonry wall.

SECTION 1407.0 NATURAL STONE

1407.1 General: Natural stone for masonry shall be sound and free from loose or friable inclusions. It shall meet the strength, fireresistance, durability and impact resistance required for the intended use.

SECTION 1408.O CAST STONE

1408.1 General: All approved cast stone shall be fabricated of concrete or other approved materials of required strength, durability and fireresistance for the intended use and shall be reinforced where necessary to comply with Article 15.

SECTION 1409.0 MORTAR AND GROUT FOR MASONRY

1409.1 General: Mortar and grout for use in reinforced and nonreinforced masonry construction shall meet the requirements of this section and ASTM C270 or C476 listed in Appendix A.

1409.2 Mortar and grout types: Mortar and grout for masonry construction shall conform to the requirements of this section.

1409.2.1 Mortar types: Mortar shall conform to the proportion specification of Table 1409.2.1 or the property specification of ASTM C270 listed in Appendix A. Aggregate for use in mortar shall comply with ASTM C144 listed in Appendix A. Mortar conforming to the proportion specification mixed to an initial flow of 100 to 115 percent, shall have a flow after suction of not less than 70 percent.

1409.2.2 Grout types: Grout for reinforced and nonreinforced masonry shall conform to Table 1409.2.2. Aggregate for use in grout shall comply with ASTM C404 listed in Appendix A.

1409.3 Types of mortar permitted: Unit masonry shall be laid in mortar of the types listed in Table 1409.3.

1409.4 Special mortars: The building official shall approve other special masonry mortars in place of the mortar types listed in Table 1409.3, provided they develop the minimum compressive strengths specified for the respective mortars they replace. The strength classification of a special mortar or special mix shall be determined by compressive strength tests with the materials and in the proportions representative of those to be used in actual practice or by other approved methods. The allowable unit working stresses in the masonry shall not be more than one-fourth the average ultimate compressive strength of the assembled test samples.

Table 1409.2.1
MORTAR PROPORTION SPECIFICATION REQUIREMENT
(PARTS BY VOLUME)

Mortar type	Portland cement	Masonry cement	Hydrated lime or lime putty		Damp loose aggregate
			Min.	Max.	
M	1 1	--- 1	--- ---	¼ ---	Not less than 2¼ and not more than 3 times the sum of the volume of the cement and lime used.
S	1 ½	--- 1	¼ ---	½ ---	
N	1 ---	--- 1	½ ---	1 ¼ ---	
O	--- 1	1 ---	--- 1 ¼	--- 2 ½	

Table 1409.2.2
GROUT PROPORTIONS FOR REINFORCED AND NONREINFORCED MASONRY (PARTS BY VOLUME)

Type	Portland cement or portland blast-furnace slag cement	Hydrated lime or lime putty	Aggregates, measured in a damp loose condition	
			Fine	Coarse
Fine grout	1	0 to 1/10	2 ¼ to 3 times the sum of the volumes of the cementitious materials	-----
Course grout	1	0 to 1/10	2 ¼ to 3 times the sum of the volumes of the cementitious materials	1 to 2 times the sum of the volumes of the cementitious materials

Table 1409.3
MASONRY AND MORTAR TYPES

Types of masonry	Types of mortar permitted
Fire brick	R fractory air setting mortar
Glass block masonry	S or N
Grouted and filled cell masonry	M or S
Linings of existing masonry, above or below grade	M or S
Masonry above grade or interior masonry	
Cavity walls and masonry bonded hollow walls:	
Design wind pressure exceeds 20 psf	M or S
Design wind pressure 20 psf or less	M, S or N
Piers of hollow units	M or S
Piers of solid units	M, S or N
Walls of hollow units	M, S or N
Walls of solid units	M, S, N or O
Masonry in contact with earth	M or S
Masonry other than above	M, S or N
Nonloadbearing partitions and fireproofing	M,S,N, O or gypsum

Table 1409.5
CERAMIC TILE MORTAR COMPOSITIONS

Walls:	Scratchcoat	1 cement; 1/5 hydrated lime; 4 dry or 5 damp sand
	Setting bed and leveling coat	1 cement; ½ hydrated lime; 5 damp sand to 1 cement; 1 hydrated lime; 7 damp sand
Floors:	Setting bed	1 cement; 1/10 hydrated lime; 5 dry or 6 damp sand; or 1 cement; 5 dry or damp sand
Ceilings:	Scratchcoat and setting bed	1 cement; ½ hydrated lime; 2½ dry sand or 3 damp sand

1409.5 Mortars for ceramic wall and floor tile: Portland cement mortars for installing ceramic wall and floor tile shall be of the compositions indicated in Table 1409.5.

1409.5.1 Dry-set portland cement mortars: Premixed, prepared portland cement mortars requiring only the addition of water used in the installation of ceramic tile shall comply with ANSI A118.1 and ANSI A118.2 listed in Appendix A. Dry-set mortars which are for use with a particular type of tile, such as glazed wall tile, ceramic mosaics, pavers, and quarry tile, shall not be used to set other types of tile for which they are not intended. The shear bond strength for tile set in such mortar shall be as required for the kind of mortar used when tested in accordance with that standard. Mortars which are not restricted to particular types of tile shall pass all of the shear tests listed in the standard. Tile set in dry-set portland cement mortar shall be installed in accordance with ANSI A108.5 and ANSI A108.7 listed in Appendix A.

1409.5.2 Latex portland cement mortars: Latex-modified portland cement thin-set mortar to which latex is added as a replacement for all or part of the gauging water, used in the installation of ceramic tile shall comply with ANSI A 118.4 listed in Appendix A. Tile set in latex portland cement mortar shall be installed in accordance with ANSI A108.5 and A108.7 listed in Appendix A.

1409.6 Organic adhesives: Water-resistant organic adhesives used in the installation of ceramic tile shall comply with ANSI A136.1 listed in Appendix A. The shear bond strength shall be not less than 40 psi for Type I adhesive, and not less than 20 psi for Type II adhesive, when tested in accordance with ANSI A136.1 listed in Appendix A. Tile set in organic adhesives shall be installed in accordance with ANSI A108.4 listed in Appendix A.

1409.7 Epoxy mortar: Epoxy used in the installation of ceramic tile shall comply with ANSI A118.3 listed in Appendix A. Tile set in epoxy shall be installed in accordance with ANSI A108.6 listed in Appendix A.

SECTION 1410.0 MASONRY WALL CONSTRUCTION

1410.1 Design: All masonry construction shall comply with the provisions of this article governing quality of materials and manner of construction; and shall be of adequate strength and proportions to support all superimposed loads within working stresses prescribed in Table 1410, NBS H74, BIA *Building Code Requirements for Engineered Brick Masonry*, NCMA TR75-B or ACI 531 (with the exception of Section 12.2.2 on fired clay masonry) listed in Appendix A.

1410.1.1 Hollow walls: The allowable compressive stresses for hollow walls are based on the gross cross-sectional area of wall minus area of cavity between wythes. The allowable compressive stresses for cavity walls are based upon the assumption that the floor loads bear upon but one of the two wythes. Where hollow walls are loaded concentrically, the maximum allowable stresses shall be increased by 25 percent.

1410.2 Wetting of brick: Brick (clay or shale) at the time of laying, shall require wetting if the unit's initial rate of water absorption exceeds 30 grams per 30 square inches per minute or 0.035 ounces per square inch, as determined by ASTM C67 listed in Appendix A.

1410.3 Cold weather construction: Masonry laid in temperatures of the outside air below 40 degrees F. (4 degrees C.) shall be protected in accordance with the provisions of the IMIAWC *Recommended Practices and Guide Specifications for Cold Weather Masonry* listed in Appendix A. Frozen materials shall not be used, nor shall frozen masonry be built upon.

1410.4 Incorporation of combustibles: Lumber or other combustible materials, except nailing blocks and ornamental timber to an extent permitted by the chasing restrictions of Section 1413.0 and the provisions of Section 900.3, shall not be incorporated in masonry walls, except as approved for combustible aggregates or component materials after fire tests.

SECTION 1411.0 BONDING OF WALLS

1411.1 General: Walls of solid, composite and hollow masonry and cavity and other hollow walls shall be bonded in accordance with this section, ACI 531, NCMA TR75-B or NBS H74 listed in Appendix A.

1411.2 Rubble stone walls: All stones in rubble masonry shall be laid on their natural bed and the walls shall be bonded with not less than one through-bond stone for each 9 superficial square feet of area.

1411.3 Buttresses and piers: All buttresses shall be bonded into the wall by a masonry bond. The piers and buttresses shall have sufficient strength and stability with sufficient bonding or anchorage between the walls and the supports to resist wind pressure and suction.

1411.4 Intersecting walls and partitions: Where required by design or Section 1412.0, masonry walls and partitions shall be securely anchored or bonded at points where they intersect by one of the following methods indicated in Sections 1411.4.1 through 1411.4.3.

1411.4.1 True masonry bond or metal ties: Walls shall be bonded by laying at least 50 percent of the units at the intersection in true masonry bond with alternate units having a bearing of not less than 3 inches upon the unit below, or they shall be anchored with not less than 3/16 inch diameter corrosion-resistant metal wire ties or joint reinforcement at vertical intervals not to exceed 2 feet, or by other equivalent approved anchorage.

Table 1410
ALLOWABLE COMPRESSIVE STRESSES: GROSS CROSS-SECTIONAL AREA, IN PSI
(Except as noted)

Type of masonry and grade of masonry unit (psi gross area)	Type of mortar			
	M	S	N	O
Grouted masonry of solid masonry units:				
from 4,500 to 8,000 psi	350	275	200	---
from 2,500 to 4,500 psi	275	215	155	---
from 1,500 to 2,500 psi	225	175	125	---
Hollow walls (cavity or masonry bonded):				
See Section 1410.1.1				
Solid masonry units:				
2,500 plus psi	140	130	110	---
from 1,500 to 2,500 psi	100	90	80	---
Hollow masonry units:	70	60	55	---
Masonry of hollow units:	85	75	70	---
Piers of hollow units, cellular spaces filled:	105	95	90	---
Solid masonry of brick and other solid units of clay or shale; sand lime or concrete:				
8,000 plus psi	400	350	300	200
from 4,500 to 8,000 psi	250	225	200	150
from 2,500 to 4,500 psi	175	160	140	110
from 1,500 to 2,500 psi	125	115	100	75
Solid masonry of solid concrete masonry units:				
1,800 plus psi	175	160	140	100
from 1,200 to 1,800 psi	125	115	100	75
Stone ashlar masonry:				
Granite	800	720	640	500
Limestone or marble	500	450	400	325
Rubble stone, course, rough or random	140	120	100	80
Sandstone or cast stone	400	360	320	250

1411.4.2 Offsets and anchors: Where walls are carried up separately, the intersection shall be toothed or blocked with 8-inch maximum offsets and shall be provided with approved metal anchors at vertical intervals of not more than 4 feet or, when approved, blocking is not required where rigid steel anchors are provided and spaced not more than 2 feet apart vertically.

1411.4.3 Interior nonloadbearing walls: Interior nonloadbearing walls shall be bonded or anchored as required by Sections 1411.4.1 or 1411.4.2 or they shall be anchored at their intersection at vertical intervals of not more than 2 feet with at least 0.034 inch nominal thickness corrosion-resistant corrugated metal ties 7/8 inch in width, or other equivalent approved method of anchorage.

1411.5 Change in thickness: Where hollow walls decrease in thickness, a course of solid masonry or concrete-filled units, or a continuous bearing plate shall be interposed between the thicker and thinner sections.

1411.6 Erecting precautions: A wall shall not be built up more than 25 feet in advance of other walls of the same building or structure unless supported independently at each floor, and all walls shall be temporarily braced during erection.

SECTION 1412.0 LATERAL BRACING OF WALLS

1412.1 General: All masonry walls shall be laterally supported by horizontal bracing of floor and roof framing, or vertical bracing of columns, buttresses or cross walls at vertical or horizontal intervals as specified in NBS 211, NBS H74, ACI 531, NCMA TR75-B or BIA *Building Code Requirements for Engineered Brick Masonry* listed in Appendix A. Provisions shall be made in the structure to transfer wind pressures and other lateral forces to the foundation.

SECTION 1413.0 CHASES AND RECESSES IN BEARING WALLS

1413.1 Where permitted: Chases and recesses shall be prohibited in any wall less than 12 inches thick and in the required area of piers and buttresses; except that in 8-inch walls, where permitted in residential buildings, and in the apron under window openings, the maximum depth of chases shall be 4 inches.

1413.2 Maximum size: The maximum permitted depth of a chase in any wall shall be not more than one-third the wall thickness, and the maximum length of a horizontal chase or the maximum horizontal projection of a diagonal chase shall not exceed 4 feet except as provided in Section 1413.5; and except further that the maximum length of the apron below window sills in all walls shall not exceed the width of the window opening. Waterproofed chases in such aprons in 8-inch walls shall not exceed 4 inches in depth. The aggregate area of recesses and chases in any

wall shall be not more than one-fourth of the area of the face of the wall in any one story.

1413.3 Fireresistive limitations: Chases or recesses shall not reduce the thickness of material below the minimum specified in Article 9 for fire walls, fire separation walls or required fireresistive covering of structural members.

1413.4 Hollow walls: Where chases and recesses are permitted in hollow walls and walls constructed of hollow blocks or tile, they shall be built in with the wall. Chases shall not be cut in hollow walls after erection.

1413.5 Continuous chases: Where horizontal chases for the bearing of reinforced concrete floor and roof slabs are continuous, anchors shall be installed above and below the floor construction to resist the bending and uplifts in the wall due to flexure of the slab.

SECTION 1414.0 WATERPROOFING CHASES

1414.1 Chases: The backs and sides of all chases in exterior walls with less than 8 inches of approved masonry to the exterior surface shall be insulated and waterproofed.

SECTION 1415.0 CORBELED AND PROJECTED MASONRY

1415.1 Limitations: In nonreinforced masonry, the maximum horizontal projection of corbeling from the plane of the wall shall not exceed one-half (½) of the wall thickness of solid walls or one-half (½) of the wythe thickness for cavity walls. The maximum projection of one unit shall not exceed one-half (½) the height of the unit, nor one-third (⅓) of its bed depth.

1415.2 Hollow walls: Corbeling of hollow masonry or masonry built of hollow units shall be supported on at least one full course of solid masonry.

1415.3 Molded cornices: Unless structural support and anchorage is provided to resist the overturning moment, the center of gravity of all projecting masonry or molded cornices shall lie within the middle third of the supporting wall. Terra cotta and metal cornices shall be provided with a structural frame of approved noncombustible material anchored in an approved manner.

SECTION 1416.0 BEARING ON HOLLOW UNIT WALLS

1416.1 Bearing area: Beam, girder and other concentrated loads shall be provided with a bearing of solid masonry or filled cores of hollow unit masonry at least 4

inches in height, or with a bearing plate of adequate design and dimensions to distribute the load safely on the wall or pier.

1416.2 Closure tile: All open cells in tile or blocks at wall ends and at openings shall be filled solidly with grout for a length of not less than 12 inches, or reversed closure tile shall be used.

SECTION 1417.0 ENGINEERED UNREINFORCED MASONRY

1417.1 General: This section shall govern wall thicknesses and lateral support requirements for unreinforced masonry determined by a structural analysis based upon standards referenced in this section.

1417.2 Brick masonry: Walls designed and constructed of brick masonry using solid clay shale units shall conform to the provisions of the BIA *Building Code Requirements for Engineered Brick Masonry* listed in Appendix A.

1417.3 Concrete block masonry: Walls designed and constructed of concrete block masonry units shall conform to the provisions of ACI 531 listed in Appendix A.

SECTION 1418.0 REINFORCED MASONRY

1418.1 General: All reinforced masonry, except for reinforced solid clay brick masonry and reinforced concrete block masonry, shall conform to the provisions of NBS H74 or NCMA TR75-B listed in Appendix A. Reinforced solid clay brick masonry shall conform to the BIA *Building Code Requirements for Engineered Brick Masonry* listed in Appendix A. Reinforced concrete block masonry shall conform to the provisions of NCMA TR75-B or ACI 531 listed in Appendix A.

1418.2 Tests: When required, testing of masonry assemblies designed and constructed under this section for strength, material compatibility, and quality control shall be in accordance with ASTM E72, ASTM E447, ASTM E518 or ASTM E519 listed in Appendix A.

SECTION 1419.0 UNREINFORCED MASONRY

1419.1 General: All unreinforced masonry except for engineered unreinforced masonry shall conform to NBS 211 listed in Appendix A. Engineered unreinforced masonry shall conform to Section 1417.0.

1419.2 Tests: When required, testing of masonry assemblies designed and constructed under this section for strength, material compatibility, and quality

control shall be in accordance with ASTM E72, ASTM E447, ASTM E518, and ASTM E519 listed in Appendix A.

SECTION 1420.0 STRUCTURAL GLASS BLOCK WALLS

1420.1 Exterior wall panels: The maximum dimensions of glass block wall panels in exterior walls, when used singly or in multiples forming continuous bands of structural glass blocks between structural supports, shall be 25 feet in length and 20 feet in height between structural supports and expansion joints; and the area of each individual panel shall be not more than 250 square feet. Intermediate structural supports shall be provided to support the dead load of the wall and all other superimposed loads. Where individual panels are more than 144 square feet in area, a supplementary stiffener shall be provided behind the panels, anchored thereto and to the structural supports.

1420.2 Joint materials: Glass blocks shall be laid up in Type S or N mortar with approved galvanized or other noncorrosive metal wall ties in the horizontal mortar joints of exterior panels. The sills of glass block panels shall be coated with approved asphaltic emulsion, or other elastic waterproofing material, previous to laying the first mortar course, and the perimeter of the panels shall be caulked to a depth of not less than ½ inch with nonhardening caulking compound on both faces, or other approved expansion joints shall be provided. Where laid up in joint materials other than mortars herein defined, a single panel shall not be more than 100 square feet in area, nor more than 10 feet in either length or height.

1420.3 Wind and earthquake loads: Exterior wall panels shall be held in place in the wall opening to resist both the internal and external pressures due to wind and earthquake loads specified in Sections 1112.0 and 1113.0.

1420.4 Interior wall panels: Solid or hollow approved structural glass blocks shall not be used in fire walls, party walls or fire separation walls, or for loadbearing construction. Such blocks shall be erected with mortar in metal frames or reinforcement as provided in this section for exterior walls, or other approved joint materials. All mortar-bearing surfaces of the glass block shall be precoated or prepared to insure adhesion between mortar and glass. Wood strip framing shall not be used in partitions which are required to be fireresistance rated.

> **Exception:** Glass block assemblies having a 3/4-hour fireresistance rating shall be permitted in accordance with the listing as opening protectives in fire separation walls which have a fireresistance rating of 1 hour or less and do not enclose exit stairways or exit corridors.

SECTION 1421.0 ISOLATED PIERS

1421.1 General: Isolated masonry piers shall be bonded as required for solid walls of the same thickness and shall be provided with adequate means for distributing the load at the top of the pier.

SECTION 1422.0 DRY-STACKED,SURFACE-BONDED MASONRY WALLS

1422.1 General: Dry-stacked, surface-bonded masonry walls shall comply with the requirements of this code for masonry wall construction, except where noted otherwise in this section.

1422.2 Materials: Surface-bonding mortar shall comply with ASTM C887 listed in Appendix A. Concrete masonry units shall comply with ASTM C946 listed in Appendix A.

1422.3 Design: Dry-stacked, surface-bonded masonry walls shall be of adequate strength and proportions to support all superimposed loads without exceeding the allowable stresses of Table 1422.3. Allowable stresses not specified in Table 1422.3 shall comply with the requirements of Table 1410, NCMA TR75-B or ACI 531 listed in Appendix A.

Table 1422.3
ALLOWABLE STRESSES
GROSS CROSS-SECTIONAL AREA (psi)

Description	Maximum allowable stress (psi)
Compression	
Standard block	45
Shear	10
Flexural tension	
Vertical span	18
Horizontal span	30

1422.4 Construction: Construction of dry-stacked, surface-bonded masonry walls, including stacking and leveling of units, mixing and application of mortar, curing and protection, shall comply with ASTM C946 listed in Appendix A.

ARTICLE 15

CONCRETE

SECTION 1500.0 CONCRETE DESIGN STANDARDS

1500.1 Reinforced and prestressed concrete: Structural members of reinforced concrete, including prestressed concrete, shall be designed and constructed in accordance with the provisions of this article and ACI 318 listed in Appendix A, hereafter referred to in this article as ACI 318.

1500.2 Plain concrete: Structural members of plain concrete shall be designed and constructed in accordance with the provisions of this article and ACI 318.1 listed in Appendix A. Concrete that is either unreinforced or contains less reinforcement than the minimum specified for reinforced concrete by ACI 318 shall be classified as plain concrete. Plain concrete shall not be used for structural members where special design considerations are required for earthquake or blast forces, unless specifically approved.

SECTION 1501.0 SEISMIC DESIGN PROVISIONS

See Section 1113.0 for all seismic design criteria.

SECTION 1502.0 MATERIALS

1502.1 General: Materials used to produce concrete and admixtures for concrete shall comply with the requirements of this section and ACI 318.

1502.2 Cements: Cement shall conform to ASTM C 150 listed in Appendix A, or to such other cements listed in ACI 318.

1502.3 Aggregates: Concrete aggregates shall conform to ASTM C33 or to ASTM C330 listed in Appendix A.

1502.3.1 Special tests: Aggregates failing to meet the specifications listed in Section 1502.3 shall not be used unless approved and shown by special test or actual service to produce concrete of adequate strength and durability.

1502.3.2 Nominal size: Nominal maximum size of coarse aggregate shall be not larger than:

1. One-fifth the narrowest dimension between sides of forms, nor
2. One-third the depth of slabs, nor
3. Three-fourths (¾) the minimum clear spacing between individual reinforcing bars or wires, bundles or bars, or prestressing tendons or ducts.

Exception: These limitations shall not apply when information which shows that the workability and methods of consolidation are such that concrete can be placed without honeycomb or voids is submitted by the engineer and is approved.

1502.4 Water: Water used in mixing concrete shall be clean and free from injurious amounts of oils, acids, alkalis, salts, organic materials, or other substances that are deleterious to concrete or reinforcement.

1502.4.1 Chloride ions: Mixing water for prestressed concrete or for concrete that will contain aluminum embedments, including that portion of mixing water contributed in the form of free moisture on aggregates, shall not contain deleterious amounts of chloride ion (see Section 1503.3.4).

1502.4.2 Potability: Nonpotable water shall not be used in concrete unless specific requirements of ACI 318 allowing the use of nonpotable water are satisfied.

1502.5 Metal reinforcement: Reinforcement and welding of reinforcement to be placed in concrete construction shall conform to the requirements of this section.

1502.5.1 Reinforcement type: Reinforcement shall be deformed reinforcement, except for plain reinforcement used for spirals or tendons; and reinforcement consisting of structural steel, steel pipe, or steel tubing as specified in ACI 318. Reinforcement shall conform to the applicable ASTM standards listed in ACI 318.

1502.5.2 Welding: Reinforcing bars to be welded shall be indicated on the drawings, and welding procedure to be used shall be specified. ASTM reinforcing bar specifications, except for ASTM A706 listed in Appendix A, shall be supplemented to require a report of material properties necessary to conform to welding procedures specified in AWS D1.4 listed in Appendix A.

1502.6 Admixtures: Admixtures used in concrete shall comply with Sections 1502.6.1 through 1502.6.3.

1502.6.1 Chloride: Calcium chloride or admixtures containing chloride from other than impurities from admixture ingredients shall not be used in prestressed concrete, in concrete containing embedded aluminum, in concrete cast against stay-in-place galvanized metal forms, or in concrete to be exposed to severe or very severe sulfate-containing solutions as defined in ACI 318 (see Section 1503.3.4).

1502.6.2 Standards: Air-entraining admixtures shall conform to ASTM C260 listed in Appendix A. Water-reducing admixtures, retarding admixtures, accelerating admixtures, water-reducing and retarding admixtures, and water-reducing and accelerating admixtures shall conform to ASTM C494 listed in Appendix A.

1502.6.3 Pozzolans: Fly ash or other pozzolans used as admixtures shall conform to ASTM C618 listed in Appendix A.

1502.7 Tests of materials: Tests of concrete and the materials used in concrete shall be in accordance with ACI 318.

SECTION 1503.0 CONCRETE QUALITY

1503.1 General: Concrete shall be proportioned to provide an average compressive strength as prescribed by ACI 318. Concrete shall be produced to minimize frequency of strengths below f'_c as prescribed in Section 1503.4.2. The specified compressive strength f'_c for concrete designed and constructed in accordance with this article shall be not less than 2,500 psi.

Unless otherwise specified, f'_c shall be based on 28-day strength. If other than 28 days is used in the design, the length of time to reach f'_c shall be indicated on the design drawings and in the specifications.

1503.2 Selection of concrete proportions: Concrete proportions shall be determined in accordance with ACI 318 and as modified in this section.

1503.2.1 Proportioning by water-cement ratio: If data based on field experience or trial mixture as required by ACI 318 is not available, concrete proportions shall be based on water-cement ratio limits shown in Table 1503.2.1 subject to approval. The specified compressive strengths in Table 1503.2.1 are 28-day strengths for cements meeting strength limits of ASTM C150 listed in ACI 318, Types I, IA, II or IIA and seven-day strengths for Types III and IIIA. For strengths above 3,500 psi, concrete proportioned by water-cement ratio shall be established by methods in ACI 318.

1503.2.2 Limitation on use:Table 1503.2.1 shall be used only for concrete to be made with cements meeting strength requirements for Types I, IA, II, IIA, III, IIIA, or V of ASTM C150 listed in Appendix A, or Types IS, IS-A, IS(MS), IS-A(MS),

I(SM), I(SM)-A, IP, IP-A, I(PM), I(PM)-A, IP(MS), IP-A(MS), or P of ASTM C595 listed in Appendix A, and shall not be applied to concrete containing lightweight aggregates or admixtures other than those for entraining air.

Table 1503.2.1
MAXIMUM WATER-CEMENT RATIOS
AND MINIMUM CEMENT CONTENTS

Specified compressive strength (psi)	Minimum sacks of cement per cubic yard of concrete	Maximum permissible water-cement ratios			
		Non air-entrained concrete		Air-entrained concrete	
		Absolute ratio by weight	US gal per 94 lb bag of cement	Absolute ratio by weight	US gal per 94 lb bag of cement
2,500	5	0.67	7.6	0.54	6.1
3,000	5 ½	0.58	6.6	0.46	5.2
3,500	6	0.51	5.8	0.40	4.5

1503.2.3 Special exposure: Concrete proportioned by water-cement ratio limits prescribed in Table 1503.2.1 shall also conform to special exposure requirements of Section 1503.3 and to compressive strength test criteria of Section 1503.4.

1503.3 Special exposure requirements: When concrete is exposed to special conditions described in Sections 1503.3.1 through 1503.3.5, the requirements set forth in those sections shall be met.

1503.3.1 Freezing and thawing and deicer chemicals: Normal-weight and lightweight concrete exposed to freezing and thawing or deicer chemicals shall be air-entrained with air content indicated in Table 1503.3.1. Tolerance on air content as delivered psi, shall be ± 1.5 percent. For specified compressive strength f'_c greater than 5,000 the required air content indicated in Table 1503.3.1 shall be reduced 1 percent. When finely divided materials of fly ash or natural pozzolans are used as mineral admixtures (see Section 1502.6.3) in air-entrained portland cement concrete, air content tests shall be made in accordance with ASTM C23 1 listed in Appendix A, to assure compliance with air content requirements of Table 1503.3.1. The frequency of air-content tests shall be the same as that for strength tests required by Section 1503.4.1.

1503.3.2 Water-cement ratio and strength: Normal-weight aggregate concrete used in buildings or their appurtenances of Use Group R-3 or Use Group R-2 less than four stories in height, and subject to weathering (i.e., freezing and thawing) and/or deicer chemicals, shall comply with the requirements of Table 1503.3.2.2. In

all other buildings, concrete that is intended to be water-tight or concrete that will be subject to freezing and thawing in a moist condition shall conform to requirements of Table 1503.3.2.1.
Data needed to determine the weathering index for any locality can be found ofr estimated from the *Tables of Local Climatological Data*, published by the National Oceanic & Atmoshperic Administration, U.S. Department of Commerce. Massachusetts is considered to lie within the Severe region (Over 500°) of the Weathering Probability Map for Concrete.

Table 1503.3.1
TOTAL AIR CONTENT FOR FROST-RESISTANT CONCRETE

Nominal maximum aggregate size, in.[b]	Air content, percent	
	Severe[a] exposure	Moderate[a] exposure
3/8	7½	6
½	7	5½
¾	6	5
1	6	4½
1½	5½	4½
2[c]	5	4
3[c]	4½	3½

Note a. For the purpose of this section, severe and moderate exposures shall be defined as follows: Severe exposure occurs when concrete will be in almost continuous contact with moisture prior to freezing, or where deicing salts are used. Examples are pavements, bridge decks, sidewalks, parking garages, and water tanks.
Moderate exposure occurs when concrete will be only occasionally exposed to moisture prior to freezing, and where no deicing salts are used. Examples are certain exterior walls, beams, girders, and slabs not in direct contact with soil.
Note b. See ASTM C33 listed in Appendix A for oversize tolerances for various nominal maximum size designations.
Note c. These air contents apply to total mix, as for the preceding aggregate sizes. When testing these concretes, however, aggregate larger than 1½ inch is removed by handpicking or sieving and air content is determined on the minus -1½ inch fraction of mix. (Tolerance on air content as delivered applies to this value.) Air content of total mix is computed from value determined on the minus -1½ inch fraction.

1503.3.3 Protection from sulfate: Concrete which will be exposed to sulfate-containing solutions shall conform to requirements for such exposure in ACI 318.

1503.3.4 Corrosion-resistance: The maximum water soluble chloride ion concentrations in concrete shall not exceed the limits established in ACI 3I8.

1503.3.5 Protection from salt: When reinforced concrete will be exposed to deicing salts, brackish water, seawater, or spray from these sources, the requirements of Table 1503.2.1 for water-cement ratio or concrete strength and minimum concrete cover requirements of Section 1506.6 shall be satisfied.

1503.4 Evaluation for acceptance of concrete: For evaluation and acceptance of concrete the procedures established in Sections 1503.4.1 through 1503.4.4 shall be followed.

Table 1503.3.2.1
REQUIREMENTS FOR SPECIAL EXPOSURE CONDITIONS

Exposure condition	Maximum water-cement ratio, normal-weight aggregate concrete	Minimum f'_c lightweight aggregate concrete (psi)
Concrete intended to be water-tight: a. Concrete exposed to fresh water b. Concrete exposed to brackish water or sea water	0.50 0.45	3,750 4,250
Concrete exposed to freezing and thawing in a moist condition: a. Curbs, gutters, guardrails, or thin sections b. Other elements c. In presence of deicing chemicals	0.45 0.50 0.45	4,250 3,750 4,250
For corrosion protection for reinforced concrete exposed to deicing salts, brackish water, seawater or spray from these sources	0.40[a]	4,750[a]

Note a. If minimum concrete cover required by Section 1506.6 is increased by 0.5 in., the maximum water-cement ratio shall be increased to 0.45 for normal weight concrete, or the minimum f'_c reduced to 4250 psi for lightweight concrete.

Table 1503.3.2.2
MINIMUM SPECIFIED COMPRESSIVE STRENGTH (f'_c)
OF CONCRETE SUBJECT TO Weathering[b]
AND/OR DEICER CHEMICALS

Type or location of concrete construction	Minimum specified compressive strength (f'_c at 28 days, psi)		
	Negligible exposure	Moderate exposure	Severe exposure
Basement walls and foundations not exposed to the weather	2,500	2,500	2,500[a]
Basement slabs and interior slabs on grade, except garage floor slabs	2,500	2,500	2,500[a]
Basement walls, foundation walls, exterior walls, and other vertical concrete surfaces exposed to the weather	2,500	3,000[b]	3,000[b]
Driveways, curbs walks, patios, porches, carport slabs, steps, and other flat-work exposed to weather, and garage floor slabs	2,500	3,000[b]	3,500[b]

Note a. Concrete in these locations which can be subjected to freezing and thawing during construction shall be air-entrained concrete in accordance with Table 1503.3.1
Note b. Concrete shall be air-entrained in accordance with Table 1503.3.1.

1503.4.1 Frequency of testing: Testing shall be conducted as required by the following:

1. Samples for strength tests of each class of concrete placed each day shall be taken not less than once a day, nor less than once for each 150 cubic yards of concrete, nor less than once for each 5,000 square feet of surface area for slabs or walls.
2. On a given project, if total volume of concrete is such that frequency of testing required by Section 1503.4.1, item 1, would provide less than five strength tests for a given class of concrete, tests shall be made from at least five randomly selected batches or from each batch if fewer than five batches are used.
3. When total quantity of a given class of concrete is less than 50 cubic yards, strength tests are not required when approved and when evidence of satisfactory strength is provided. Satisfactory evidence shall

include, but not be limited to, certification from the concrete supplier that the concrete to be provided will be proportioned to achieve the strength specified based on "field experience and/or "trial batches" in accordance with ACI 318. In the absence of satisfactory evidence, concrete shall be proportioned in accordance with Table 1503.2.1.

4. A strength test shall be the average of the strengths of two cylinders made from the same sample of concrete and tested at 28 days or at test age designated for determination of f'_c.

1503.4.2 Laboratory-cured specimens: Laboratory-cured specimens shall conform to the following:

1. Samples for strength tests shall be taken in accordance with ASTM C172 listed in Appendix A.
2. Cylinders for strength tests shall be molded and laboratory-cured in accordance with ASTM C31 listed in Appendix A, and tested in concordance with ASTM C39 listed in Appendix A.
3. Strength level of an individual class of concrete shall be considered satisfactory if both of the following requirements are met:
   a. Average of all sets of three consecutive strength tests equal or exceed f'_c.
   b. All individual strength tests (average of two cylinders) shall not fall below f'_c by more than 500 psi.
4. If either of the requirements of Section 1503.4.2, item 3, is not met, steps shall be taken to increase the average of subsequent strength test results. Requirements of Section 1503.4.4 shall apply if the requirement in Section 1503.4.2, item 3(b), is not met.

1503.4.3 Field-cured specimens: When the building official requires strength tests of cylinders cured under field conditions to check adequacy of curing and protection of concrete in the structure, the field-cured specimens shall conform to the following:

1. Field-cured cylinders shall be cured under field conditions in accordance with Section 7.4 of ASTM C31 listed in Appendix A.
2. Field-cured test cylinders shall be molded at the same time and from the samples as laboratory-cured test cylinders.
3. Procedures for protecting and curing concrete shall be improved when strength of field-cured cylinders at test age designated for determination of f'_c is less than 85 percent of that of companion laboratory-cured cylinders. The 85 percent is not required when field-cured strength exceeds f'_c by more than 500 psi.

1503.4.4 Investigation of low strength test results: If the investigation of concrete indicates low strength conditions, the following procedures shall apply:

1. If any strength test (Section 1503.4.1, item 4) of laboratory-cured cylinders falls below specified value of f'_c by more than 500 psi (Section 1503.4.2, item 3b) or if tests of field-cured cylinders indicate deficiencies in protection and curing (Section 1503.4.3, item 3) steps shall be taken to assure that all load-carrying capacity of the structure is not jeopardized.
2. If the likelihood of low-strength concrete is confirmed and computations indicate that load-carrying capacity would be significantly reduced, tests of cores drilled from the area in question shall be made in accordance with ACI 318.
3. Concrete in an area represented by core tests shall be considered structurally adequate if the average of three cores is not less than 85 percent of f'_c and if a single core is not less than 75 percent of f'_c. When necessary to check testing accuracy, locations represented by erratic core strengths shall be retested.
4. If criteria of Section 1503.4.4, item 3, are not met, and if structural adequacy remains in doubt, load tests shall be ordered at the discretion of the engineer or the building official as outlined in Chapter 20 of ACI 318 for the questionable portion of the structure, or other appropriate action taken.

SECTION 1504.0 MIXING AND PLACING OF CONCRETE

1504.1 General: The preparation, handling and curing of concrete shall be performed in accordance with the requirements of Sections 1504.2 through 1504.8.

1504.2 Preparation of equipment and place of deposit: Preparation before concrete placement shall include the following:

1. All equipment for mixing and transporting concrete shall be clean.
2. All debris and ice shall be removed from spaces to be occupied by concrete.
3. Forms shall be properly coated.
4. Masonry filler units that will be in contact with concrete shall be well drenched.
5. Reinforcement shall be thoroughly clean of ice or other deleterious coating.
6. Water shall be removed from place of deposit before concrete is placed unless a tremie is to be used or unless otherwise permitted by the building official.
7. All laitance and other unsound material shall be removed before additional concrete is placed against hardened concrete.

1504.3 Mixing: All concrete shall be mixed until there is a uniform distribution of materials, and shall be discharged completely before the mixer is recharged.

1504.3.1 Ready-mixed concrete: Ready-mixed concrete shall be mixed and delivered in accordance with the requirements of ASTM C94 or ASTM C685 listed in Appendix A.

1504.3.2 Job-mixed concrete: Job-mixed concrete shall be mixed in accordance with ACI 318.

1504.4 Conveying: Concrete shall be conveyed from mixer to place of final deposit by methods that will prevent separation or loss of materials. Conveying equipment shall be capable of providing a supply of concrete at site of placement without separation of ingredients and without interruptions sufficient to permit loss of plasticity between successive increments.

1504.5 Depositing: Concrete shall be deposited as nearly as practicable in its final position to avoid segregation due to rehandling or flowing.

1504.5.1 Placement timing: Concrete shall be carried on at such a rate that concrete is at all times plastic and flows readily into spaces between reinforcement.

1504.5.2 Unacceptable concrete: Concrete that has partially hardened or been contaminated by foreign materials shall not be deposited in the structure.

1504.5.3 Retempering: Retempering concrete or concrete that has been remixed after initial set shall not be used unless approved by the engineer.

1504.5.4 Continuous concreting: After concreting is started, it shall be carried on as a continuous operation until placing of a panel or section, as defined by its boundaries or predetermined joints, is completed except as permitted or prohibited by Section 1505.4.

1504.5.5 Placement in walls: Top surfaces of vertically formed lifts shall be generally level.

1504.5.6 Construction joints: When construction joints are required, joints shall be made in accordance with Section 1505.4.

1504.5.7 Consolidation: All concrete shall be thoroughly consolidated by suitable means during placement and shall be thoroughly worked around reinforcement and embedded fixtures and into corners of forms.

1504.6 Curing: Concrete (other than high-early-strength) shall be maintained above 50 degrees F. (10 degrees C.) and in a moist condition for at least the first seven days after placement, except when cured in accordance with Section 1504.6.2.

1504.6.1 High-early-strength concrete: High-early-strength concrete shall be maintained above 50 degrees F. (10 degrees C.) and in a moist condition for at least the first three days, except when cured in accordance with Section 1504.6.2.

1504.6.2 Accelerated curing: If curing is to be accelerated, it shall be done in accordance with ACI 318.

1504.7 Cold weather requirements: Adequate equipment shall be provided for heating concrete materials and protecting concrete during freezing or near freezing weather.

1504.7.1 Frost: All concrete materials and all reinforcement, forms, fillers and ground with which concrete is to come in contact shall be free from frost.

1504.7.2 Ice: Frozen materials or materials containing ice shall not be used.

1504.8 Hot weather requirements: During hot weather, attention shall be given to ingredients, production methods, handling, placing, protection, and curing to prevent excessive concrete temperatures or water evaporation that would impair required strength or serviceability of the member or structure.

SECTION 1505.0 FORMWORK, EMBEDDED PIPES, AND CONSTRUCTION JOINTS

1505.1 Design of formwork: The design, fabrication and erection of forms shall result in a final structure that conforms to shapes, lines, and dimensions of the members as required by the design drawings and specifications.

1505.1.1 Form strength: Forms shall be substantial and sufficiently tight to prevent leakage of mortar.

1505.1.2 Form bracing: Forms shall be properly braced or tied together to maintain position and shape.

1505.1.3 Form placement: Forms and their supports shall be designed so as not to damage previously placed structure.

1505.2 Removal of forms and shores: Construction loads shall not be supported on, nor any shoring removed from, any part of the structure under construction except when that portion of the structure, in combination with the remaining forming

and shoring system, has sufficient strength to support safely its weight and loads placed thereon.

1505.2.1 Structural analysis: Sufficient strength shall be demonstrated by structural analysis considering proposed loads, strength of forming and shoring system, and concrete strength data. Concrete strength data shall be based on tests of field-cured cylinders or, when approved, on other procedures to evaluate concrete strength. Structural analysis and concrete strength test data shall be furnished to the building official when so required.

1505.2.2 Construction loads: Construction loads exceeding the combination of superimposed dead load plus specified live load shall not be supported on any unshored portion of the structure under construction, unless analysis indicates adequate strength to support such additional loads.

1505.2.3 Safety: Forms shall be removed in such manner as not to impair safety and serviceability of the structure. All concrete to be exposed by form removal shall have sufficient strength not to be damaged thereby.

1505.2.4 Prestressed members: Form supports for prestressed concrete members shall not be removed unless sufficient prestressing has been applied to enable prestressed members to carry their dead load and anticipated construction loads.

1505.3 Conduits and pipes embedded in concrete: Where conduits, pipes and sleeves of any material not harmful to concrete and within limitations of this section are embedded in concrete with approval of the engineer, they shall not be considered to replace structurally the displaced concrete, except as provided in Section 1505.3.5.

1505.3.1 Aluminum conduit and pipe: Conduits and pipes of aluminum shall not be embedded in structural concrete unless effectively coated or covered to prevent aluminum-concrete reaction or electrolytic action between aluminum and steel.

1505.3.2 Structural effect: Conduits, pipes, and sleeves passing through a slab, wall, or beam shall not impair significantly the strength of the construction.

1505.3.3 Columns: Conduits and pipes, with their fittings, embedded within a column shall not displace more than 4 percent of the area of cross section on which strength is calculated or which is required for fire protection.

1505.3.4 Slabs, walls or beams: Except when plans for conduits and pipes are approved by the engineer and the building official, conduits and pipes embedded within a slab, wall or beam (other than those merely passing through) shall satisfy the following:

1. They shall not be larger in outside dimension than one-third the overall thickness of slab, wall, or beam in which they are embedded.
2. They shall not be spaced closer than three diameters or widths on center. 3. They shall not impair significantly the strength of the construction.

1505.3.5 Displaced concrete: Conduits, pipes, and sleeves shall not be considered as replacing structurally in compression the displaced concrete unless:

1. They are not exposed to rusting or other deterioration.
2. They are of uncoated or galvanized iron or steel not thinner than standard Schedule 40 steel pipe.
3. They have a nominal inside diameter not over 2 inches and are spaced not less than three diameters on center.

1505.3.6 Additional considerations: In addition to other requirements of Section 1505.3, pipes that will contain liquid, gas or vapor which are embedded in structural concrete shall conform to the following conditions:

1. Pipes and fittings shall be designed to resist effects of the material, pressure, and temperature to which they will be subjected.
2. Temperature of liquid, gas, or vapor shall not exceed 150 degrees F. (66 degrees C.).
3. Maximum pressure to which any piping or fittings shall be subjected shall not exceed 200 psi above atmospheric pressure.
4. All piping and fittings shall be tested as a unit for leaks before concrete placement. Testing pressure above atmospheric pressure shall be 50 percent in excess of pressure to which piping and fittings will be subjected, but minimum testing pressure shall not be less than 150 psi above atmospheric pressure. Pressure test shall be held for 4 hours without a drop in pressure except that caused by changes in air temperature.

Exception: Drain pipes and other piping designed for pressures of not more than 1 psi above atmospheric pressure need not be tested.

5. Pipes carrying liquid, gas, or vapor that is explosive or injurious to health shall again be tested as specified in Section 1505.3.6, item 4, after concrete has hardened.
6. Liquid, gas, or vapor, except water not exceeding 90 degrees F. degrees C.) or 50 psi pressure, shall not be placed in the pipes until the concrete has attained its design strength.
7. In solid slabs, piping, unless it is for radiant heating or snow melting, shall be placed between top and bottom reinforcement.

8. Concrete cover for pipes and fittings shall not be less than 1½ inches for concrete exposed to earth or weather, or ¾ inches for concrete not exposed to weather or in contact with ground.
9. Reinforcement with an area of not less than 0.002 times area of concrete section shall be provided normal to piping.
10. Piping shall be fabricated and installed so that cutting, bending or displacement of reinforcement from its proper location will not be required.

1505.4 Construction joints: Construction joints shall be created using the procedures set forth in Sections 1505.4.1 through 1505.4.6.

1505.4.1 Surface cleaning: Surface of concrete construction joints shall be cleaned and laitance removed.

1505.4.2 Preparation of joint: Immediately before new concrete is placed, all construction joints shall be wetted, and standing water shall be removed.

1505.4.3 Effect on strength: Construction joints shall be so made and located as not to impair the strength of the structure. Provisions shall be made for transfer of shear and other forces through construction joints.

1505.4.4 Location of joints: Construction joints in floors shall be located within the middle third of spans of slabs, beams, and girders. Joints in girders shall be offset a minimum distance of two times the width of intersecting beams.

1505.4.5 Support conditions: Beams, girders, or slabs supported by columns or walls shall not be cast or erected until concrete in the vertical support members is no longer plastic.

1505.4.6 Monolithic pours: Beams, girders, haunches, drop panels and capitals shall be placed monolithically as part of a slab system, unless otherwise shown in design drawings or specifications.

SECTION 1506.0 DETAILS OF REINFORCEMENT

1506.1 General: Details of reinforcement shall comply with the requirements of this section and ACI 318.

1506.2 Bending reinforcement: All reinforcement shall be bent cold, unless permitted by the engineer and approved. Reinforcement partially embedded in concrete shall not be field bent except as shown on the design drawings or permitted by the engineer and approved.

1506.3 Surface conditions of reinforcement: At the time concrete is placed, metal reinforcement shall be free from mud, oil, or other nonmetallic coatings that adversely affect bonding capability.

1506.3.1 Rust or mill scale: Metal reinforcement, except prestressing tendons, with rust, mill scale, or a combination of both shall be considered satisfactory, provided the minimum dimensions (including height of deformations) and weight of a hand-wire-brushed test specimen are not less than the specification requirements of the applicable ASTM standard referenced by ACI 318.

1506.3.2 Prestressing tendons: Prestressing tendons shall be clean and free of oil, dirt, scale, pitting and excessive rust. A light oxide is permissible.

1506.4 Placing reinforcement: Reinforcement, prestressing tendons and ducts shall be accurately placed and supported before concrete is placed, and shall be secured against displacement within tolerances permitted in Sections 1506.4.1 through 1506.4.3.

> **Exception:** Embedded items (such as dowels or inserts) of precast concrete members that either protrude from concrete or remain exposed for inspection shall not be embedded while the concrete is in a plastic state unless approved by the engineer and the following conditions are met:
>
> 1. Embedded items shall not be required to be hooked or tied to reinforcement within plastic concrete.
> 2. Embedded items shall be maintained in correct position while concrete remains plastic.
> 3. Embedded items shall be properly anchored to develop required factored loads.

1506.4.1 Reinforcement, prestressing tendons and prestressing ducts: Unless otherwise specified by the engineer, reinforcement, prestressing tendons, and prestressing ducts shall be placed within the following tolerances:

1. Tolerance for depth *d*, and minimum concrete cover in flexural members, walls and compression members shall be as specified in Table 1506.4.1, except that tolerance for the clear distance to formed soffits shall be minus ¼ inch and tolerance for cover shall not exceed minus one-third the minimum concrete cover required in the design drawings or specifications.
2. Tolerance for longitudinal location of bends and ends of reinforcement shall be ± 2 inches except at discontinuous ends of members where tolerance shall be ± ½ inch.

Table 1506.4.1
TOLERANCES

Depth *d*	Tolerance on *d*	Tolerance on minimum concrete cover
d less than or equal to 8 in.	± 3/8 in.	-3/8 in.
d greater than 8 in.	± 1/2 in.	-1/2 in.

1506.4.2 Welded wire fabric: Where welded wire fabric (with wire size not greater than W5 or D5) used in slabs not exceeding 10 feet in span is curved from a point near the top of slab over the support to a point near the bottom of slab at midspan, such reinforcement shall be either continuous over, or securely anchored at the support.

1506.4.3 Welding: Welding of crossing bars shall not be permitted for assembly of reinforcement unless approved by the engineer.

1506.5 Spacing limits for reinforcement: The clear distance between reinforcing bars, bundled bars, prestressing tendons and ducts shall be in accordance with the limitations of ACI 318.

1506.6 Concrete protection for reinforcement: Reinforcement shall be provided with the protection required by Sections 1506.6.1 through 1506.6.5.

1506.6.1 Cast-in-place concrete: In cast-in-place concrete (nonprestressed), the minimum concrete cover for reinforcement shall be as indicated in Table 1506.6.1.

1506.6.2 Precast concrete: The minimum cover for reinforcement in precast concrete manufactured under plant control conditions, and for prestressed concrete shall be in accordance with ACI 318.

1506.6.3 Corrosive environments: In corrosive environments or other severe conditions, amount of concrete protection shall be suitably increased, and denseness and nonporosity of protection concrete shall be considered, or other protection shall be provided.

1506.6.4 Future extensions: Exposed reinforcement, inserts and plates intended for bonding with future extensions shall be protected from corrosion.

1506.6.5 Fire protection: When this code requires a thickness of cover for fire protection greater than the minimum concrete cover specified in Section 1506.6.1 or ACI 318, such greater thickness shall be used.

Table 1506.6.1
MINIMUM COVER

Structural element and condition	Minimum cover, in.
1. Concrete cast against and permanently exposed to earth	3
2. Concrete exposed to earth or weather:	
#6 through #18 bars	2
#5 bar, W31 or D31 wire, and smaller	1½
3. Concrete not exposed to weather or in contact with ground	
Slabs, walls, joists:	
#14 and #18 bars	1 ½
#11 bar and smaller	¾
Beams, columns:	
Primary reinforcement, ties, stirrups, spirals	1 ½
Shells, folded plate members:	
#6 bar and larger	¾
#5 bar, W31 or D31 wire, and smaller	½

SECTION 1507.0 CONCRETE-FILLED PIPE COLUMNS

1507.1 General: Concrete-filled pipe columns shall be manufactured from standard, extra-strong, or double-extra-strong steel pipe and tubing, filled with concrete so placed and manipulated as to secure maximum density and to insure complete filling of the pipe without voids.

1507.2 Design: The safe supporting capacity of concrete-filled pipe columns shall be computed in accordance with the approved rules or as determined by a test.

1507.3 Connections: All caps, base plates and connections shall be of approved types and shall be positively attached to the shell and anchored to the concrete core. Welding of brackets without mechanical anchorage shall be prohibited. When the pipe is slotted to accommodate webs of brackets or other connections, the integrity of the shell shall be restored by welding to insure hooping action of the composite section.

1507.4 Reinforcement: To increase the safe load-supporting capacity of concrete-filled pipe columns, the steel reinforcement shall be in the form of rods, structural shapes or pipe embedded in the concrete core with sufficient clearance to insure the composite action of the section, but not nearer than 1 inch to the

exterior steel shell. All structural shapes used as reinforcement shall be milled to insure bearing on cap and base plates.

1507.5 Fireresistance rating protection: Pipe columns shall be of such size or so protected as to develop the required fireresistance ratings specified in Table 401. When an outer steel shell is used to enclose the fireproof covering, it shall not be included in the calculations for strength of the column section. The minimum diameter of pipe columns shall be 4 inches except that in Type 5 structures not exceeding 3 stories or 40 feet in height, pipe columns used in the basement and as secondary steel members shall have a minimum diameter of 3 inches.

1507.6 Approvals: All details of column connections and their splices shall be shop-fabricated by approved methods and shall be approved only after tests in accordance with the approved rules. Shop-fabricated concrete-filled pipe columns shall be inspected by the building official or by an approved representative of the manufacturer at the plant.

SECTION 1508.0 SHOTCRETE

1508.1 General: Except as specified in the following sections, shotcrete shall conform to the requirements for plain concrete or reinforced concrete. Shotcrete is mortar or concrete pneumatically projected at high velocity onto a surface.

1508.2 Proportioning: Shotcrete proportions shall be selected that allow suitable placement procedures using the delivery equipment selected, and that results in in-place hardened shotcrete meeting the strength requirements of this code.

1508.3 Aggregate: Coarse aggregate, if used, shall not exceed ¾ inch in size.

1508.4 Reinforcement: Reinforcement shall comply with Sections 1508.4.1 through 1508.4.3.

1508.4.1 Size: The maximum size of reinforcement shall be No. 5 bars. The building official shall permit the use of larger bars when it is demonstrated that adequate encasement of the larger bars can be achieved.

1508.4.2 Spacing: The minimum clearance between parallel reinforcing bars shall be 2½ inches. Welded wire fabric shall have a minimum wire spacing of 2 inches by 2 inches.

1508.4.3 Splices: Lap splices in reinforcing bars shall be by the noncontact lap splice method with at least 2 inches clearance between bars. The building official shall permit the use of contact lap splices where necessary for the support of the

reinforcing and when it is demonstrated that adequate encasement of the bars at the splice can be achieved.

1508.5 Rebound: Any rebound or accumulated loose aggregate shall be removed from the surfaces to be covered prior to placing the initial or any succeeding layers of shotcrete. Rebound shall not be reused as aggregate.

1508.6 Joints: Except where permitted herein, unfinished work shall not be allowed to stand for more than 30 minutes unless all edges are sloped to a thin edge. For structural elements which will be under compression and for construction joints shown on the approved plans, square joints are permitted. Before placing additional material adjacent to previously applied work, sloping and square edges shall be cleaned and wetted.

1508.7 Damage: Any in-place shotcrete which exhibits sags or sloughs, segregation, honeycombing, sand pockets or other obvious defects shall be removed and replaced.

1508.8 Curing: During the curing periods specified herein, shotcrete shall be maintained above 40 degrees F. (4 degrees C.) and in a moist condition.

1508.8.1 Initial curing: Shotcrete shall be kept continuously moist for 24 hours after shotcreting is completed or shall be sealed with an approved curing compound.

1508.8.2 Final curing: Final curing shall continue seven days after shotcreting, or for three days if high-early-strength cement is used, or until the specified strength is obtained. Final curing shall consist of either the initial curing process or the shotcrete shall be covered with an approved moisture-retaining cover.

1508.8.3 Natural curing: Natural curing shall not be used in lieu of that specified above unless the relative humidity remains at or above 85 percent, and is authorized by the design architect/engineer, and approved by the building official

1508.9 Strength test: Strength test of shotcrete shall be made in accordance with the quality assurance provisions of ACI 506.2 listed in Appendix A.

SECTION 1509.0 MINIMUM SLAB THICKNESS

1509.1 General: The thickness of concrete floor slabs supported directly on the ground shall be not less than 3 ½ inches. An approved vapor barrier with joints lapped not less than 6 inches shall be placed between the base course or subgrade and the concrete floor slab.

Exception: A vapor barrier is not required:

1. For detached structures accessory to Use Group R-3, such as garages, utility buildings or other unheated facilities;
2. For buildings of other uses when migration of moisture through the slab from below will not be detrimental to the intended use of the building;
3. For driveways, walks, patios and other flatwork which will not be enclosed at a later date; or
4. Where approved based upon local site conditions.

ARTICLE 16

GYPSUM AND PLASTER

1600.0 GENERAL

1600.1 Scope: The provisions of this article shall govern the materials, design, construction and quality of gypsum and plaster.

SECTION 1601.0 INTERIOR LATHING AND GYPSUM PLASTERING

1601.1 General: All lathing and gypsum plaster materials and accessories shall be marked with appropriate standards referenced in this section and stored in such manner as to protect them from the weather.

1601.2 Standards: All interior lathing and gypsum plastering materials shall conform to the standards listed in Table 1601 and Appendix A and, when required for fire protection, shall also conform to the provisions of Article 9.

1601.3 Installation: Installation of these materials shall conform to Section 1604.0.

SECTION 1602.0 PORTLAND CEMENT STUCCO LATH AND PLASTER

1602.1 General: All exterior and interior portland cement stucco lathing and plastering shall be done with appropriate materials listed in Table 1601 and Appendix A.

1602.2 Weather protection: All materials shall be stored in such a manner as to protect them from the weather.

1602.3 Installation: Installation of these materials shall be in conformance with ASTM C926 listed in Appendix A and Section 1602.4.

1602.4: Protection after application: At all times during application and for a period of not less than 48 hours after application of each coat, provisions shall be made to keep stucco work above 40 degrees F. (4 degrees C).

Table 1601
PLASTER MATERIALS AND ACCESSORIES

Material	Standard
Exterior plaster bonding compounds	ASTM C932
Gypsum base for veneer plasters	ASTM C588
Gypsum casting and molding plaster	ASTM C59
Gypsum Keene's cement	ASTM C61
Gypsum lath	ASTM C37
Gypsum plaster	ASTM C28
Gypsum veneer plaster	ASTM C587
Interior bonding compounds, gypsum	ASTM C631
Lime plasters	ASTM C5; C206
Metal lath	ASTM C847
Plaster aggregates	
Sand	ASTM C35; C897
Perlite	ASTM C35
Vermiculite	ASTM C35
Portland cement	ASTM C150
Steel studs and track	ASTM C645; C955
Steel screws	ASTM C1002; C954
Welded wire lath	ASTM C933

SECTION 1603.0 GYPSUM BOARD MATERIALS

1603.1 General: All gypsum board materials and accessories shall be marked with appropriate standards referenced in this section and stored so as to protect them from the weather.

1603.2 Standards: All gypsum board materials shall conform to the appropriate standards listed in Table 1603 and Appendix A.

1603.3 Installation: Installation of these materials shall conform to Section 1604.0 and, when required for fireresistance, to Article 9.

1603.4 Water-resistant gypsum backer board: In all areas subjected to repeated damp conditions and moisture accumulation such as bathtub and shower compartments, water-resistant gypsum backer board complying with ASTM C630 listed in Appendix A shall be used as a substratum unless protected with a moisture-proof and vapor-proof covering.

Table 1603
GYPSUM BOARD MATERIALS AND ACCESSORIES

Material	Standard
Gypsum sheathing	ASTM C79
Gypsum wallboard	ASTM C36
Joint reinforcing tape and compound	ASTM C474; C475
Nails for gypsum boards	ASTM C514
Steel screws	ASTM C1002; C954
Steel studs, nonloadbearing	ASTM C645
Water-resistant gypsum backing board	ASTM C630

SECTION 1604.0 GYPSUM CONSTRUCTION

1604.1 General: Gypsum board and plaster construction shall be of the materials listed in Table 1603. These materials shall be assembled and installed in conformance with appropriate standards listed in Table 1604 and Appendix A.

1604.2 Limitations: Gypsum construction shall not be used in any exterior location where it would be directly exposed to the weather.

1604.3 Inspection: The building official shall be notified not less than 24 hours in advance of all plastering work or installation of any gypsum board except gypsum lath. Plaster shall not be applied until after the lathing or other plaster base has been inspected and approved by the building official.

1604.4 Weather protection: When plastering work is in progress, the building or structure shall be enclosed and conditioned to provide proper ventilation and temperatures not less than 40 degrees F. (4 degrees C.) nor more than 80 degrees F. (27 degrees C.) from one week prior to the plastering operation and until one week following or until the plaster is dry.

Table 1604
INSTALLATION OF GYPSUM CONSTRUCTION

Material	Standard
Gypsum plaster	ASTM C842
Gypsum veneer base	ASTM C844
Gypsum veneer plaster	ASTM C843
Gypsum wallboard	GA-216
Interior lathing and furring	ASTM C841
Steel framing for gypsum boards	ASTM C754; C1007

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ARTICLE 17

WOOD

SECTION 1700.0 GENERAL

1700.1 Scope: "The provisions of this article shall govern the materials, design, construction and quality of wood.

SECTION 1701.0 LUMBER AND TIMBER CONSTRUCTION

1701.1 Design: All structural wood members and connections shall be of sufficient size or capacity to carry all design loads without exceeding the allowable design values specified in the NFoPA *National Design Specification for Wood Construction* listed in Appendix A.

1701.1.1 Identification: All lumber used for load-supporting purposes, including end-jointed or edge-glued lumber, shall be identified by the grade mark of an approved lumber grading or an approved inspection agency. Grading practices and identification shall be in accordance with rules published by an approved agency. In lieu of a grade mark on the material, a certificate of inspection as to species and grade issued by an approved lumber grading or an approved inspection agency shall be accepted for precut, remanufactured, or rough-sawn lumber, and for sizes larger than 3-inch nominal thickness.

1701.1.2 Native lumber: **Native lumber, as defined in this code shall be acceptable for use in one and two story dwellings, barns, sheds, agricultural and accessory structures. Native lumber shall also be acceptable for use in other structures of less than three stories as columns when the design loads are 25 percent greater than required elsewhere by this code; as joists, principal beams, and girders in floor constructions when the design loads are 15 percent greater than required elsewhere by this code; and as other elements when the design loads are as required elsewhere by this code.**

Each piece of native lumber produced shall be stamped with the name and registration number off the producer in accordance with the rules and regulations of the State Board of Building Regulations and Standards. In addition, all native lumber shall bear an approved mark identifying the species of wood. In lieu of the stamp bearing the name and registration number and species identification, a

certification bearing the same information may be provided by the producer for precut or remanufactured lumber in accordance with the rules and regulations of the Board. When native lumber is used, it shall be subject to the following requirements:

1. Sizing criteria: For lumber, sized in accordance with the *American Softwood Lumber Standard PS-20-70*, figures for maximum fiber stress and modulus of elasticity for framing grade No. 2 will be used in establishing span and spacing characteristics for all structural members.

2. Stress ~~criteria:~~ increase Lumber which is sized in excess of the dimensions established by the *American Softwood Standard PS-20-70* for the given nominal size referenced shall be allowed to have a maximum fiber stress increase above that provided in Item 1 above in proportion to the increased bearing capacity of the cross section as provided in Table 1701 or as calculated.

1701.2 Minimum dimensions: Dimensions of lumber and timber construction shall comply with Sections 1701.2.1 and 1701.2.2.

1701.2.1 Sizes of structural members: All lumber sizes specified in this code are nominal sizes. Nominal sizes or actual sizes shall be shown on the plans. Computations to determine the required size of members shall be based on the net dimensions (actual sizes).

1701.2.2 Structural posts: All isolated structural posts shall have a minimum dimension of 4 inches.

1701.3 Fabrication: Fabrication of lumber and timber construction shall comply with Sections 1701.3.1 through 1701.3.3.

1701.3.1 Connections: All connections shall be fabricated with approved timber connectors, bolts, lag screws, spikes, nails or gluing or other approved connecting devices. Bolted connections shall be snugged up tightly without crushing wood fibers under the washers. All nailed connections shall meet the minimum requirements of Appendix C.

1701.3.2 Cambering: Trusses and long-span girders shall be designed with sufficient camber, or other provision shall be made to counteract any deflection other than that permitted in Section 1305.3.

1701.3.3 Cutting and notching: It shall be unlawful to notch, cut or pierce wood beams, joists, rafters or studs in excess of the limitations herein specified, unless proven safe by structural analysis or suitably reinforced to transmit all calculated loads.

Table 1701
NATIVE LUMBER ALLOWABLE STRESS

Nominal Size	Actual lumber size. (Closest size which does not exceed the number shown)	Multiplier factor lumber based on width	Factor to be added to column 3 factor for lumber oversized in thickness.	
	Actual Size (thickness, width)		Thickness increase of 1/4" to 1/2"	Thickness increase of over 1/2" to 1"
3 x 8	2 1/2 x 7 1/2 x 7 3/4 x 8	1.0 x F_s 1.07 1.14	+0.10	+0.20
3 x 10	2 1/2 x 9 1/2 x 9 3/4 x 10	1.0 1.05 1.11		
3 x 12	2 1/2 x 11 1/2 x 11 3/4 x 12	1.0 1.04 1.09		
3 x 14	2 1/2 x 13 1/2 x 13 3/4 x 14	1.0 1.04 1.07		
4 x 10	3 1/2 x 9 1/2 x 9 3/4 x 10	1.0 1.05 1.11	+0.07	+0.14
4 x 12	3 1/2 x 11 1/2 x 11 3/4 x 12	1.0 1.04 1.09		
4 x 14	3 1/2 x 13 1/2 x 13 3/4 x 14	1.0 1.04 1.08		

1701.3.3.1 Notches: Notch depth in the top or bottom of the joist, rafters and beams shall not exceed one-sixth the depth of the members and shall not be located in the middle one-third of the span. Notch depth at the ends of the member shall not exceed one-fourth the depth of the member. The tension side of beams, joists and rafters of 4-inch or greater nominal thickness shall not be notched, except at ends of members.

1701.3.3.2 Holes: Holes bored or cut into joists for piping or electrical cables shall not be closer than 2 inches to the top or bottom of the joist and the diameter of the hole shall not exceed one-third the depth of the joist. In studs of bearing walls or partitions, notches or bored holes made to receive piping, electrical conduit, air conditioning or heating ductwork or for other fabricating purposes shall not be cut or bored more than one-third the depth of the stud.

1701.3.3.3 Reinforcement: Where the stud is cut or bored in excess of one-third its depth, the stud shall be reinforced to be equal in load-carrying capacity to a stud notched not more than one-third its depth.

1701.4 Trimmer and header beams: Where determined necessary by stress analysis, trimmer and header beams shall be hung in approved stirrups or hangers, unless supported on a wall, girder or column. All multiple-member beams shall be spiked or bolted together.

1701.5 Bearing and anchorage on girders: All members framing into girders shall be anchored or tied to secure continuity. The ends of all wood beams or joists resting on girders shall bear not less than 4 inches or shall be supported in approved metal stirrups, hangers or on wood clips or ribbon strips. Beams framing from opposite sides shall lap at least 6 inches and be bolted or spiked together; and when framing end-to-end, the beams shall be secured together by approved ties, straps, dogs, plates or sheathing.

1701.6 Maintenance: All connections in the joints of timber trusses and structural frames shall be inspected periodically. Bolts and other connectors shall be maintained tight.

SECTION 1702.0 HEAVY TIMBER CONSTRUCTION

1702.1 Wood: All structural wood members, sawn or glued-laminated, used in Type 4 construction shall be stress-grade timbers identified as to grade and strength by approved manufacturing, testing or inspection agencies or bureaus. All structural timber members shall have the minimum dimensions specified in Section 405.0 for Type 4 construction and shall be designed, fabricated and installed in accordance with the NFoPA *National Design Specification for Wood Construction* AITC 108, AITC 112, AITC 117, AITC 119, and AITC A 190.1 listed in Appendix A.

1702.2 Other structural materials: Structural steel or reinforced concrete members shall not be substituted for timber in any part of the structural frame unless protected to develop the required fireresistance rating specified in Table 401 , but not less than 1-hour fireresistance rating. Structural members supporting walls shall be protected to afford the same fireresistance rating as the wall supported.

1702.3 Columns: Columns shall be continuous or superimposed throughout all stories by means of reinforced concrete or metal caps with brackets, or shall be connected by properly designed steel or iron caps, with pintles and base plates, or by timber splice plates affixed to the columns by means of metal connectors housed within the contact faces, or by other approved methods. Girders or trusses supporting columns shall have at least 1-hour fireresistance rating.

1702.4 Floors: The planks shall be laid so that a continuous line of joints will not occur except at points of support and so that they are not spiked to supporting girders which are parallel to the lamination of the floor. Flooring shall not extend closer than ½ inch to walls to provide an expansion joint, but the joint shall be covered at top or bottom to avoid flue action.

1702.5 Beams and girders: Beam and girder supports and connections shall comply with Sections 1702.5.1 and 1702.5.2.

1702.5.1 Wall and girder supports: Wall plate boxes of a self-releasing type, or approved hangers, shall be provided where beams and girders enter masonry. An air space of 1/2 inch shall be provided at the top, end and sides of the member unless approved durable or treated wood is used. Where intermediate beams are used to support a floor, the beams shall rest on top of the girders, or shall be supported by ledgers or blocks securely fastened to the sides of the girders, or they shall be supported by approved metal hangers into which the ends of the beams shall be closely fitted. Wood beams and girders supported by walls required to have a fireresistance rating of 2 hours or more shall have not less than 4 inches of solid masonry between their ends and the outside face of the wall and between adjacent beams. Approved roof anchorage shall be provided.

1702.5.2 Column connections: Girders and beams shall be closely fitted around columns and adjoining ends shall be cross-tied to each other, or inter-tied by caps or ties, to transfer horizontal loads across the joint. Wood bolsters shall not be placed on tops of columns unless the columns support roof loads only.

SECTION 1703.0 DESIGN AND CONSTRUCTION

1703.1 General: The exterior walls, interior partitions, floors and roofs of wood construction shall be designed and constructed to develop adequate strength to resist all vertical and lateral forces due to both dead and live loads. Standard balloon, braced, platform, and post-and-beam types of construction shall be acceptable framing methods.

1703.2 Beam separation in Types 3A and 3B construction: All wood and other combustible floor, roof and other structural members framing into masonry walls

shall be cut to a bevel of 3 inches in the depth and shall project not more than 4 inches into the wall. The distance between embedded ends of adjacent beams or joists entering into the wall from opposite sides shall be not less than 4 inches.

1703.3 Framing around flues and chimneys: Combustible framing shall be trimmed not less than 2 inches from all flues, chimneys and fireplaces, and 6 inches away from flue openings.

SECTION 1704.0 WALL CONSTRUCTION

1704.1 Bearing walls: Posts and studs in bearing walls and partitions shall be designed as columns, with due allowance for lateral support furnished by sheathing, intermediate bracing, horizontal bridging, wall coverings and the floor and roof assemblies. The walls shall be fabricated in such a manner as to provide adequate support for the material used to enclose the building and to provide for transfer of all lateral loads to the foundation in accordance with Section 1305.4.

A single top plate shall not be used unless the plate is adequately tied at joints, corners, and intersecting walls by at least the equivalent of 3 inch by 6 inch by 0.036 inch thick galvanized steel that is nailed to each wall or segment of wall by three 8d nails or equivalent, and the rafters, joists, or trusses are centered over the studs with a tolerance of not more than 1 inch.

1704.2 Nonbearing walls: Studs in nonbearing walls and partitions shall not be spaced more than 48 inches on center, and are permitted to be erected with the long dimension parallel to the wall, unless otherwise approved after test as an integrated assembly. A single top plate shall not be used unless it is installed in accordance with Section 1704.1.

1704.3 Bracing: In buildings more than one story in height and where necessary for strength in one-story buildings, the corner posts shall be the equivalent of not less than two pieces of 2-inch by 4-inch studs, braced by not less than one piece of 1 -inch by 4-inch continuous diagonal brace let into the studs. Bracing is not required where diagonal wood sheathing, plywood or particle board panels are used, or other sheathing specified in Section 1704.7 is applied vertically in panels of not less than 4 feet by 8 feet with approved fasteners complying with Appendix C. Other sheathing materials shall be permitted when tested in accordance with ASTM E72 listed in Appendix A and meeting the following criteria.

Dry tests with load increments of 400 pounds. Maximum load 5,200 pounds or 650 pounds per foot.

1. At load of 1,200 pounds, average total deflection of 0.2 inch and residual deflection of 0.1 inch.

2. At load of 2,400 pounds, average total deflection of 0.6 inch and residual deflection of 0.3 inch.

Wet tests with load increments of 400 pounds. Maximum load 4,000 pounds.

1. At load of 1,200 pounds, average total deflection of 0.28 inch and residual deflection of 0.14 inch.
2. At load of 2,400 pounds, average total deflection of 0.4 inch and residual deflection of 0.8 inch.

1704.4 Mortise-and-tenon framing: Where mortise-and-tenon framing is used, the vertical members of the frame shall be not less than 4 inches by 6 inches in size and shall be designed as a column.

1704.5 Multiple stories: Where the frame is more than one story in height and studs and posts are not continuous from sill to roof, the members shall be secured together with approved clips, splices or other connections to insure a continuous, well-integrated structure. Sheet metal clamps, ties or clips shall be formed of galvanized steel or other approved corrosion-resistive materials equivalent to 0.040 inch nominal thickness steel sheets for 2-inch framing members and not less than 0.052 inch nominal thickness.s steel sheets for 3-inch structural members. For 4-inch and larger members, column splices and beam and girder supports shall comply with Section 1702.0.

1704.6 Framing over openings: Headers, double joists, trusses or other approved assemblies of adequate size to transfer all superimposed loads to the vertical members shall be provided over all window and door openings in bearing walls and partitions.

1704.7 Wall sheathing: Except as provided in Section 2104.1 for weather boarding or when stucco construction complying with Section 1602.0 is used, all enclosed buildings shall be sheathed with one of the materials of the nominal thickness specified in Table 1704.7 or any other approved material of equal strength and durability.

1704.7.1 Paper-backed lath sheathing: In buildings of Use Group R-3 and one-story commercial buildings with brick or similar veneers, the sheathing shall conform to Section 1704.7 or shall consist of a layer of paper-backed lath complying with Section 1601.0 and a 1-inch intermediate space which shall be mortar-filled as each course of veneering is applied.

Table 1704.7
Minimum Thickness of Wall Sheathing

Sheathing type	Minimum thickness
Fiber board	½ inch
Gypsum sheathing	½ inch
Particle board	See Section 1711.5
Plywood	5/16 inch
Reinforced cement mortar	1 inch (See Section 1704.7.1)
Wood sheathing	⅝ inch

1704.8 Foundation anchorage: Wall sill plates, minimum of 2-inch by 4-inch members, shall be sized and anchored to foundation walls or piers and at intermediate intervals as required to resist wind uplift. Anchor bolts shall be a minimum of ½ inch diameter. The bolts shall be embedded in foundations to a depth of not less than 8 inches of poured in place concrete, and not less than 15 inches in grouted unit masonry. There shall be a minimum of two anchor bolts per section of plate and anchor bolts shall be placed 12 inches from the end of each section of plate with intermediate bolts spaced a maximum of 8 feet on center.

1704.9 At-grade protection: All exterior wood framework of buildings, whether structural or nonloadbearing, shall be supported on approved foundation walls at least 8 inches above the finished grade, and higher when necessitated by a greater average snowfall. Where climatic conditions or the geographical location require additional control measures to protect buildings and structures against decay and termite attack, the provisions of Section 1712.0 shall apply.

SECTION 1705.0 FLOOR CONSTRUCTION

1705.1 Flooring: The flooring of wood frame construction shall be of adequate strength and stiffness to support required loads and, where necessary for strength and for lateral support of the building, subflooring shall be provided.

1705.2 Floor spans: Except when otherwise substantiated by approved structural design methods, floor joist spans shall comply with the NFoPA Span Tables for Joists and Rafters listed in Appendix A. Design stresses shall be those indicated in the NFoPA Design Values for Joists and Rafters listed in Appendix A. Metal plate connected floor trusses shall be designed in accordance with TPI Design Specifications for Metal Plate Connected Parallel Chord Wood Trusses and the NFoPA National Design Specifications for Wood Construction listed in Appendix A.

1705.3 Bridging: Except as hereinafter noted, in all floor, attic and roof framing, there shall be not less than one line of bridging for each 8 feet of span. The bridging shall consist of not less than 1-inch by 3-inch lumber, double-nailed at each end, or of equivalent metal bracing of equal rigidity. A line of bridging shall also be required at supports where adequate lateral support is not otherwise provided. Midspan bridging is not required for floor, attic or roof framing in buildings of Use Groups R-2 and R-3, except when the joist depth exceeds 12 inches nominal or when the minimum uniformly distributed live load exceeds 40 psf.

SECTION 1706.0 ROOF CONSTRUCTION

1706.1 Roof spans: Except when otherwise substantiated by approved structural design methods, rafter spans shall comply with the NFoPA *Span Tables for Joists and Rafters* listed in Appendix A. Design stresses shall be those indicated in the NFoPA *Design Values for Joists and Rafters* listed in Appendix A. Metal plate connected roof trusses shall be designed in accordance with the TPI *Design Specifications for Metal Plate Connected Wood Trusses* and the NFoPA *National Design Specifications for Wood Construction* listed in Appendix A and shall be braced to prevent rotation and provide lateral stability.

1706.2 Roof decking and sheathing: Roof deck sheathing shall consist of not less than ⅝-inch boards, plywood of the thickness specified in Section 1710.3, particle board of the grade and thickness specified in Section 1711.4, or other approved materials of equivalent strength and rigidity. When open deck sheathing is used on pitch roofs, it shall consist of not less than 1-inch by 4-inch roofers spaced not more than 6 inches on center, or material of equivalent strength and rigidity.

SECTION 1707.0 STRESS SKIN PANELS 1707.1

1707.1 Integrated assemblies: Approved panels or other integrated assemblies fabricated of dimension lumber with wood stress coverings glued thereto, or consisting of structural units of metal-covered or molded plywood or other approved plastics formed and molded into prefabricated loadbearing members, shall be permitted for use in floors, roofs, walls, partitions and ceilings when designed in accordance with APA S812, S812, U315C, U813 and U814 listed in Appendix A or meeting the test requirements of Sections 1303.0, 1305.0 and 1306.0.

1707.2 Splices: Splices and connections between panels shall be weather-tight and of sufficient strength to resist two and one-half times the design live load to which they will be subjected in normal use. The fastenings of covering assemblies to structural studs, ribs or joists shall provide rigidity equivalent to approved gluing. Nailing shall not be acceptable for that purpose.

1707.3 Molded plywood units: Structural units of plywood or other approved plastics of similar combustible characteristics formed and molded into prefabricated loadbearing members shall conform to the approved rules and shall be identified by the approved label. The design shall be based on approved engineering analysis, confirmed by the tests prescribed in Sections 1303.0 and 1305.0.

SECTION 1708.0 STRUCTURAL GLUED-LAMINATED TIMBER AND BUILT-UP WOOD CONSTRUCTION

1708.1 General: Buildings and structures designed and erected of glued-laminated structural members, or of composite members of plywood and dimension lumber, or of composite members of wood veneer facings laminated to a flakeboard core shall comply with this section.

1708.2 Exposed structural glued-laminated timber: Those portions of glued-laminated timbers which form the structural supports of a building or other structure and are exposed to weather and not properly protected by a roof, eave overhangs, or similar coverings shall be treated in accordance with AITC 109 listed in Appendix A or be manufactured from approved durable woods.

1708.3 Glued-laminated members and plywood components: Built-up beam and column sections consisting of one or more webs with glued lumber flanges and stiffeners shall be designed in accordance with APA S811, S812, U315C, U813 and U814 listed in Appendix A. Plywood beams consisting of plywood alone bonded together with adhesives shall be designed and fabricated in accordance with APA H815 listed in Appendix A. Other plywood components consisting of plywood alone or plywood in combination with sawn or glued-laminated lumber and bonded together with adhesives shall be designed, fabricated and identified in accordance with APA S811, S812, U315C, U813 and U814 listed in Appendix A.

1708.3.1 Gluing surfaces: In glued-lumber constructions, the surfaces to be glued shall be worked to a smooth, flat surface without sanding and free from wax, grease or oil to insure a complete glue bond over the entire contact. Factory-sanded plywood shall be permitted.

1708.4 Wood veneer and flakeboard core composite framing: Composite framing consisting of wood veneer facings laminated to a flakeboard core shall conform to the SFES standard *Performance and Quality Control Standards for Composite Floor, Wall and Truss Framing* listed in Appendix A.

SECTION 1709.0 FIBER BOARDS

1709.1 General: Insulating boards manufactured with wood or other vegetable fibers used as building boards for sheathing, roof decks, interior wall and ceiling finish, roof insulation or sound deadening, shall be vermin-proof resistant to rot-producing fungi, water-repellant and shall meet the strength and durability tests specified in ASTM C208, AHA 194.1, ASTM D2277 and C532 listed in Appendix A. Sheathing, when used structurally, shall be so identified by an approved agency. Where required under the provisions of Article 9, the boards shall be protected or treated to develop the required fireresistance rating or flameresistance as determined by test.

1709.2 Jointing: To insure tight-fitting assemblies, edges shall be manufactured square or shiplapped, beveled, tongue-and-groove or U-jointed.

1709.3 Roof insulation: When used as roof insulation in all types of construction, fiber boards shall be protected with an approved roof covering.

1709.4 Wall insulation: Where installed and firestopped to comply with Article 9, fiber boards are permitted as wall insulation in all types of construction. In fire wall and fire separation wall construction, unless treated to be fire-retardant as provided in Section 904.0 for Class I materials, the board shall be cemented directly to the masonry or other noncombustible base and shall be protected with an approved noncombustible veneer anchored to the base without intervening air spaces.

1709.5 Drywall construction: Where fireresistance ratings are required, provision shall be made for interlocking, lapping or otherwise protecting the joints between adjacent boards to insure smoke and flame tightness.

1709.6 Insulating roof deck: Where used as roof decking in open beam construction, fiber board insulating roof deck shall have a nominal thickness not less than 1 inch.

1709.7 Siding: Hardboard siding shall comply with AHA A135.6 listed in Appendix A.

SECTION 1710.0 PLYWOOD

1710.1 Quality: All plywood, when used structurally, shall meet the performance standards and all other requirements of DOC PS 1 and HPMA PS 51 listed in Appendix A for the type, grade and span rating or species group of plywood involved and shall be so identified by an approved agency. Working stresses shall conform to APA E30, APA Y510 and HPMA HP-SG listed in Appendix A.

1710.2 Types: Plywood for interior use shall be either of the interior type, moisture-resistant type, or exterior type. Plywood for exterior use shall be of the exterior waterproof type, except that plywood roof sheathing exposed to the outdoors on the underside is permitted to be interior type bonded with exterior glue. Exterior plywood shall not be applied directly to the framing as a siding unless it has a minimum nominal thickness of ⅜ inch. Joints shall occur over framing members, unless wood or plywood sheathing is used or joints are lapped horizontally a minimum of ½ inches or otherwise made waterproof in an approved manner. Where plywood is used as lapped siding without sheathing, the wall framing to which it is attached shall be diagonally braced.

1710.3 Spans: The maximum spans for plywood sheathing shall be limited by the allowable stresses and deflections for the design live load, but shall not be greater than the spans specified in Tables 1710.3.1, 1710.3.la, 1710.3.2 and 1710.3.3.

1710.3.1 Floor and roof sheathing: Allowable spans for floor and roof sheathing shall be as specified in Tables 1710.3.1 and 1710.3.la. The values in Table 1710.3.1 apply to Structural I and II, C-D and C-C grades only and are limited to spans shown because of possible effect of concentrated loads.

1710.3.1.1 Floor sheathing: Edges of plywood floor sheathing shall have approved tongue-and-groove joints or shall be supported with blocking, unless ¼ inch minimum thickness underlayment or 1½ inches of approved cellular or lightweight concrete is installed, or finish floor is 25/32 inch wood strip. Allowable uniform load based on deflection of 1/360 of the span is 165 pounds per square foot (psf).

1710.3.2 Plywood combination subfloor underlayment: Allowable spans for combination subfloor underlayment shall be as specified in Table 1710.3.2.

Table 1710.3.1 ALLOWABLE SPANS FOR PLYWOOD FLOOR AND ROOF SHEATHING CONTINUOUS OVER TWO OR MORE SPANS AND FACE GRAIN PERPENDICULAR TO SUPPORTS[a] (SPAN IN INCHES)

Panel span rating,[b] roof/floor span	Roof					Floor
	Maximum span (inches)			Load (psf)		Maximum Span[e] (inches)
	Thickness (Inches)	Edges Blocked[c]	Edges Unblocked	Total load	Live load	
12/0	5/16	12	12	135	130	0
16/0	5/16, 3/8	16	16	80	65	0
20/0	5/16, 3/8	19.2	19.2	70	55	0
24/0	3/8	24	20	60	45	0
24/0	15/32, 1/2	24	24	60	45	0
32/16	15/32, 1/2 5/8	32	28	50	35	16[f]
40/20	19/32, 5/8, 3/4	40	32	40[d]	35[d]	20[f,g]
48/24	23/32, 3/4, 7/8	48	36	40	35	24

Note a. For limitations on the applicability of this table to grades of plywood, see Section 1710.3.1.
Note b. Span rating appears on all panels in the construction grades listed in Section 1710.3.1.
Note c. Edges shall be blocked with lumber or other approved type of edge support.
Note d. For roof live load of 40 psf or total load of 55 psf, decrease spans by 13 percent or use panel with next greater span rating.
Note e. For requirements for edge support and allowable uniform load, see Section 1710.3.1.1
Note f. Maximum shall be 24 inches if 25/32-inch wood strip flooring is installed at right angles to joists.
Note g. For joists spaced 24 inches on center. plywood sheathing with span rating numbers 40/20 or greater shall not be used for subfloors except when supporting 1½ inches of lightweight concrete.

Table 1710.3.1a
ALLOWABLE LOADS FOR PLYWOOD ROOF SHEATHING CONTINUOUS OVER TWO OR MORE SPANS AND FACE GRAIN PARALLEL TO SUPPORTS[a] (SPAN IN INCHES)

	Thickness (inches)	No. of Piles	Span (Inches)	Total load (psf)	Live load (psf)
Structural I	15/32	4	24	30	20
	15/32	5	24	45	35
	1/2	4	24	35	25
	1/2	5	24	55	40
Other grades Covered in PS 1	15/32	5	24	25	20
	1/2	5	24	30	25
	19/32	4	24	35	25
	19/32	5	24	50	40
	5/8	4	24	40	30
	5/8	5	24	55	45

Note a. Uniform load deflection limitation: 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 support.

1710.3.2.1 Limitations: Table 1710.3.2 is applicable to underlayment grade, C-C (plugged) and all grades of sanded exterior type plywood. For panels with a span rating of other than 48 o.c., the allowable uniform load based on deflection of 1/360 of span is 125 psf 2). Panels with a span rating of 48 o.c. are limited to 65 psf total load at maximum span. Plywood edges shall have approved tongue-and-groove joints or shall be supported with blocking, unless ¼ inch minimum thickness underlayment is installed, or finish floor is 25/32-inch wood strip. If wood strips are perpendicular to supports, thicknesses or span ratings shown for 16-inch and 20-inch spans shall be used on 24-inch spans. Spans are limited to values shown in Table 1710.3.2 because of possible effects of concentrated loads.

1710.3.3 Vertical maximum stud spacing: Stud spacing for vertical sheathing shall be as specified in Table 1710.3.3.

1710.4 Stress skin panel: For use in stress skin or other prefabricated construction, plywood design shall be determined by approved engineering analysis or by the tests prescribed for prefabricated assemblies in Section 1303.0.

Table 1710.3.2
ALLOWABLE SPANS FOR PLYWOOD COMBINATION SUBFLOOR UNDERLAYMENT[a], PLYWOOD CONTINUOUS OVER TWO OR MORE SPANS AND FACE PERPENDICULAR TO SUPPORT (THICKNESS IN INCHES)

Identification	Maximum spacing of joists (inches)			
Species group[b]	16	20	24	48
1 2,3 4	1/2 5/8 3/4	5/8 3/4 7/8	3/4 7/8 1	--- --- ---
Span rating	16 o.c.	20 o.c.	24 o.c.	48 o.c.

Note a. For limitations on the use of Table 1710.3.2, see Section 1710.3.2.1
Note b. Applicable to all grades of sanded exterior type plywood.
Note c. Applicable to underlayment grade and C-C (plugged).

TABLE 1710.3.3
ALLOWABLE STUD SPACING FOR PLYWOOD WALL SHEATHING

Panel span rating	Panel thickness (inches) and construction	Maximum stud spacing (inches) Exterior coverings nailed to:	
		Stud	Sheathing
12/0, 16/0, 20/0	5/16	16	16
16/0, 20/0, 24/0, 32/16	3/8, 15/32 and 1/2 (3 ply)	24	16 24
24/0, 32/16	15/32 and 1/2 (4 & 5 ply)	24	24

Note a. Blocking of horizontal joints not required.
Note b. Apply plywood sheathing with face grain perpendicular to studs.

SECTION 1711.0 PARTICLE BOARD

1711.1 Quality: Particle board shall conform to ANSI A208.1 listed Appendix A. Particle board shall be identified by the grade mark or certificate of inspection issued by an approved agency.

1711.2 Floor underlayment: Underlayment shall conform to Type 1-M-1 or sanded Type 2-M-W of ANSI A208.1 listed in Appendix A. Underlayment shall not be less than 1/4 inch in thickness and shall be installed as recommended by the manufacturer.

1711.3 Subfloor or combination subfloor underlayment: Allowable spans and grades for combination subfloor underlayment shall be as specified in Table 1711.3. All panels shall be continuous over two or more spans and the tongue-and-groove panels shall be installed with the long dimension perpendicular to supports. Uniform deflection limitation shall be 1/360th of the span under 100 psf minimum load. Edges shall have 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.

Table 1711.3
ALLOWABLE SPANS FOR PARTICLE BOARD SUBFLOOR AND COMBINATION SUBFLOOR UNDERLAYMENT[a]

Grade	Thickness (inches)	Maximum spacing of supports (inches)	
		Subfloor	Combination subfloor underlayment
2-M-W	1/2	16	--
	5/8	20	16
	3/4	24	24
2-M-F	3/4	20	20
2-M-3	3/4	20	20

Note a. For limitations on the use of Table 1711.3, See Section 1711.3.

Table 1711.4
ALLOWABLE LIVE LOADS FOR PARTICLE BOARD ROOF SHEATHING[a]

Grade	Thickness (inches)	Maximum on-center spacing of supports (inches)	Live load (pounds per square foot)	Total load (pounds per square foot)
2-M-W and 2-M-F	3/8	16	45	65
	7/16	16	105	105
	7/16	24	30	40
	1/2	16	110	150
	1/2	24	40	55

Note a. For limitations on the use of Table 1711.4, see Section 1711.4.

1711.4 Roof sheathing: Allowable loads for roof sheathing shall be in accordance with the spans and grades specified in Table 1711.4. Panels shall be continuous over two or more spans. Uniform load deflection limitations shall be 1/180th of the span under live load plus dead load and 1/240th of the span under live load only. Edges of all 3/8 inch panels and edges of 7/16-inch panels with 24 o.c. spacing shall be supported with blocking or edge clips.

1711.5 Siding and sheathing: Allowable spans and grades of particle board siding and sheathing shall be as specified in Tables 1711.5a and 1711.5b.

Table 1711.5a
ALLOWABLE SPANS FOR EXPOSED PARTICLE BOARD PANEL SIDING

Grade	Stud spacing (inches)	Minimum thickness (inches)		
		Siding		Exterior ceiling
		Direct to studs	Continuous support	Direct to supports
2-M-W and 2-M-F	16 24	3/8 1/2	5/16 5/16	5/16 3/8
2-M-1 and 2-M-2	16 24	5/8 3/4	3/8 3/8	--- ---

Table 1711.5b
ALLOWABLE SPANS FOR PARTICLE BOARD WALL SHEATHING[a]

Grade	Thickness (inches)	Stud spacing (inches)	
		Siding nailed to studs	Sheathing under coverings parallel or perpendicular to studs
2-M-W and 2-M-F	5/16 3/8 7/16	16 24 24	-- 16 24
2-M-1 and 2-M-2	3/8 1/2	16 16	-- 16

Note a. Not exposed to the weather, long dimension of the panel parallel or perpendicular to studs.

SECTION 1712.0 PROTECTION AGAINST DECAY AND TERMITES

1712.1 General: Wood construction shall conform to provisions of this section in order to prevent decay and termite attack.

1712.2 Protection: Where protection of wood members is required by this section, protection shall be provided by using naturally-durable or pressure treated wood.

1712.2.1 Naturally-durable wood: The term "naturally-durable wood" refers to the heartwood of the following species with the exception that an occasional piece with corner sapwood is permitted if 90 percent or more of the width of each side on which it occurs is heartwood.

Decay-resistant:	Redwood, cedars, black locust, bald cypress (tidewater red), and black walnut.
Termite-resistant:	Redwood, bald cypress (tidewater red), and Eastern red cedar.

1712.2.2 Pressure-treated wood: The term "pressure-treated wood" refers to wood, including plywood, meeting the retention, penetration and other requirements applicable to the species, product, treatment and conditions of use in AWPA C1, C2, C9, and AWPB LP2, LP22, LP33, LP44, LP55, and LP77 listed in Appendix A. Preservatives shall conform to the AWPA P1, P2, P5, P8, and P9 listed in Appendix A.

1712.2.3 Identification: All lumber and plywood required to be pressure treated shall bear the quality mark of an approved agency which maintains continuing supervision, testing and inspection over the quality of the product. Quality control inspection agencies for preservative pressure-treated wood shall be certified as to competency and performance by an approved organization. Said mark shall include the following information in a legible format: identification of the inspection agency, the standard to which treated, the identification of the treating plant, and the purpose for which the product has been treated. The mark shall be permanently affixed to each piece unless specifically waived by the building official.

1712.2.4 Moisture content: When wood pressure-treated with a water-borne preservative is used in enclosed locations where drying in service cannot readily occur, such wood shall be at a moisture content of 19 percent or less before being covered with insulation, interior wall finish, floor coverings or other material.

1712.3 Conditions favorable to decay: Where conditions are favorable to decay, wood shall comply with Sections 1712.3.1 through 1712.3.3.

1712.3.1 Wood used above ground: Wood used above ground in the locations specified in Sections 1712.3.1.1 through 1712.3.1.5 shall be naturally-durable or

pressure-treated wood using water-borne preservatives and treated in accordance with AWPB LP 2 listed in Appendix A.

1712.3.1.1 Joists and girders: When wood joists or the bottom of a wood structural floor without joists are closer than 18 inches, or wood girders are closer than 12 inches to the exposed ground in crawl spaces or unexcavated areas located within the perimeter of the building foundation, the floor assembly, including posts, girders, joists and subfloor shall be of approved naturally-durable or pressure-treated wood.

1712.3.1.2 Sills: All sills which rest on concrete or masonry exterior walls and are less than 8 inches from exposed earth shall be of approved naturally-durable or pressure-treated wood.

1712.3.1.3 Sleepers and sills: Sleepers and sills on a concrete or masonry slab which is in direct contact with earth shall be of approved naturally-durable or pressure-treated wood.

1712.3.1.4 Girder ends: The ends of wood girders entering exterior masonry or concrete walls shall be provided with a ½ inch air space on top, sides and end, unless approved naturally-durable or pressure-treated wood is used.

1712.3.1.5 Clearance: Clearance between wood siding and earth on the exterior of a building shall be not less than 6 inches except where siding, sheathing and wall framing are of approved pressure-treated wood.

1712.3.2 Wood in contact with the ground: All wood in contact with the ground (exposed earth) and which supports permanent structures intended for human occupancy shall be approved pressure-treated wood using waterborne preservatives and treated in accordance with AWPB LP22 listed in Appendix A when used in the locations specified in Sections 1712.3.2.1 through 1712.3.2.4.

> **Exception:** Untreated wood is permitted where entirely below ground water level or continuously submerged in fresh water.

1712.3.2.1 Columns embedded in concrete: Sawn posts and columns supporting permanent structures intended for human occupancy which are embedded in concrete in direct contact with earth or embedded in concrete exposed to the weather shall be of approved pressure-treated wood.

1712.3.2.2 Other columns: Posts or columns exposed to the weather or in basements and cellars, and which support permanent structures, shall be supported by concrete piers or metal pedestals projecting at least 1 inch above concrete or

masonry floors or decks and 6 inches above exposed earth and separated therefrom by an impervious moisture barrier, except where approved naturally-durable or pressure-treated wood is used.

1712.3.2.3 Columns in crawl spaces: Posts or columns supporting permanent structures which are closer than 8 inches to exposed ground in enclosed crawl spaces or unexcavated areas located within the perimeter of the building shall be of approved naturally-durable or pressure-treated wood.

1712.3.2.4 Wood structural members: Wood structural members supporting moisture-permeable floors or roofs which are exposed to the weather, such as concrete or masonry slabs, shall be of approved naturally-durable or pressure-treated wood unless separated from such floors or roofs by an impervious moisture barrier.

1712.3.3 Wood used in retaining walls: Wood used in retaining or crib walls shall be of approved pressure-treated wood, treated in accordance with AWPB LP22, LP33, LP44, LP55 or LP77 listed in Appendix A, except as indicated in Sections 1712.3.3.1 through 1712.3.3.3.

1712.3.3.1 Untreated wood: Where the wall is not more than 2 feet in height and is separated from the lot line or a permanent building by a minimum distance equal to the height of the wall, the wall is permitted to be of untreated wood.

1712.3.3.2 Naturally-durable wood on the lot line: Where the wall is not more than 2 feet in height and is located on the lot line, approved naturally-durable wood is permitted.

1712.3.3.3 Naturally-durable wood separated: Where the wall is not more than 4 feet in height and is separated from the lot line or a permanent building by a minimum distance equal to the height of the wall, **when such a wall is orientated parallel to the foundation wall,** approved naturally-durable wood is permitted.

1712.4 Geographical areas: In geographical areas where experience has demonstrated a specific need, approved naturally-durable or pressure-treated wood shall be used for those portions of wood members which form the structural supports of buildings, balconies, porches or similar permanent building appurtenances when such members are exposed to the weather without adequate protection from a roof, eave, overhang or other covering to prevent moisture or water accumulation on the surface or at joints between members. Depending on local experience, such members include, but are not limited to, the following:

1. Horizontal members such as girders, joists and decking;
2. Vertical members such as posts, poles and columns; or
3. Both horizontal and vertical members.

ARTICLE 18

STEEL

SECTION 1800.0 GENERAL

1800.1 Scope: The provisions of this article shall govern the materials, design, construction and quality of steel structural members.

SECTION 1801.0 STRUCTURAL STEEL CONSTRUCTION

1801.1 General: Structural steel construction used in all buildings and structures shall be fabricated from materials of uniform quality, free from defects that would vitiate the strength or stability of the structure. All structural steel shall be designed and constructed in accordance with either the AISC *Specification for the Design, Fabrication and Erection of Structural Steel for Buildings* or the AISC *Load and Resistance Factor Design Specification for Structural Steel Buildings* listed in Appendix A.

1801.2 Temporary and special stresses: Due provision shall be made in the design for temporary stresses occurring during erection, and for the influence of special loads producing impact or vibrations as provided in Article 11. Stresses caused by eccentric loading shall be fully provided for and eccentric details shall be shown on the design and shop drawings.

1801.3 Shop drawings: Complete shop drawings shall be prepared in conformance with the best modern practice in advance of the actual fabrication. Such drawings shall clearly distinguish between shop and field rivets, bolts and welds in all connections and details.

1801.4 Painting and special protection: All painting shall comply with the requirements contained in either of the AISC design specifications referenced in Section 1801.1. When exposed to highly corrosive fumes or vapors, or subject to destruction from other highly hazardous industrial processes, all structural steelwork shall be protected by an approved method.

SECTION 1802.0 FORMED STEEL CONSTRUCTION

1802.1 Design: The design of all cold-formed steel members and assembled wall, floor and roof panels, used alone or in combination with other structural members, or with component materials, shall be based on allowable unit stresses and maximum deflections in accordance with the AISI *Specification for Design of Cold-Formed Steel Structural Members* and AISI *Specification for Design of Cold-Formed Stainless Steel Structural Members* listed in Appendix A. Metal building systems shall conform to the provisions of this code and the MBMA *Low Rise Building Systems Manual* listed in Appendix A.

1802.2 Secondary structural systems: Formed steel floor, wall and roof systems are permitted to be designed and constructed to resist all vertical and horizontal moments and shears resulting from lateral forces. Such members, when designed to transmit horizontal shears due to wind or other lateral forces, shall be connected to the supporting structure so as to adequately resist all primary and secondary stresses. Where concrete topping or other approved decking is installed and strength of the composite member is included in the calculations, the concrete topping or decking shall be installed in a manner that insures composite action of the assembly.

1802.3 Protection: Formed steel shall be protected in accordance with Sections 1802.3.1 through 1802.3.4.

1802.3.1 Shop coat: All individual structural members and assembled panels of light gage and formed steel construction, except where fabricated of approved corrosion-resistive metallic steel or of steel having a corrosion-resistive or other approved coating, shall be protected against corrosion with an approved shop coat of paint, enamel, or other approved protection.

1802.3.2 Field coat: After erection where directly exposed to the weather, except when encased in concrete made of noncorrosive aggregates, or where fabricated of approved corrosion-resistive steel, or of galvanized or otherwise adequately-protected steel, individual structural members and assembled panels of light gage and formed steel construction shall be given an additional coat of approved protection.

1802.3.3 Siding: Exposed siding or sheathing shall be fabricated of approved corrosion-resistive steel or otherwise protected at the ground level for sufficient height above grade as determined by the depth of average snowfall in the locality, but not less than 8 inches.

1802.3.4 Protection at exterior walls: Floor or roof construction which extends into an exterior wall shall be adequately waterproofed and protected from the weather to prevent corrosion.

1802.4 Tests: When not capable of design by approved engineering analysis, the building official shall require tests of the individual or assembled structural units and their connections as prescribed in Sections 1303.0 and 1305.0. At least three specimens truly representative of the construction to be used in practice shall be subjected to the prescribed test and the mean of the results shall determine the safe working value; provided that any individual test varying more than 10 percent from the mean value shall cause rejection of the series.

1802.5 Identification: Each structural member, siding panel and roof panel of a metal building system, other than hardware items such as bolts, nuts, washers, shims and rivets, shall be identified by the manufacturer. The identification shall include manufacturers's name or logo, and part name consistent with assembly instructions.

SECTION 1803.0 OPEN WEB STEEL JOIST CONSTRUCTION

1803.1 General: Steel joists and joist girders used as structural members in floor and roof construction shall be designed and constructed in accordance with SJI *Standard Specifications, Load Tables and Weight Tables for Steel Joists and Joist Girders* listed in Appendix A.

1803.2 Partitions: The joists shall be designed to support the dead load of partitions, wherever they occur, in addition to all other imposed dead and live loads.

1803.3 Protection: Painting of steel joists shall be in accordance with the requirements of Section 1802.3 for formed steel construction.

1803.4 Tests: Where not subject to approved engineering analysis as regulated by Section 1803.1, the assembly shall meet the load test requirements specified in Sections 1303.0 and 1305.0.

SECTION 1804.0 REINFORCING STEEL

1804.1 General: Metal reinforcement for reinforced gypsum concrete, and reinforced masonry shall comply with ACI 531, NBS H74, NCMA TR75-B or BIA *Requirements for Engineered Brick Masonry* listed in Appendix A.

1804.2 Tests: Where unidentified reinforcement is approved for use, not less than three tension and three bending tests shall be made on representative specimens of the reinforcement from each shipment and grade of reinforcing steel proposed for use in the work.

SECTION 1805.0 CAST STEEL CONSTRUCTION

1805.1 Materials: Carbon steel casting for building construction shall be cast from steel conforming to the AISC specifications listed in Section 1801.1. All castings shall be free from injurious blow holes or other defects which would impair the structural strength.

1805.2 Higher strength cast steel: Higher strength cast steel shall not be used unless approved.

1805.3 Welding cast steel: Cast steel designed for use in welding shall be of weldable grade.

SECTION 1806.0 CAST IRON CONSTRUCTION

1806.1 Materials: Cast iron for building construction shall be a good foundry mixture providing clean, tough, gray iron, free from serious blow holes, cinder spots and cold shuts, and conforming to ASTM A48 and ASTM A256 listed in Appendix A for medium gray iron castings.

1806.2 Limitations of use: Cast iron columns shall not be used where subject to eccentric loads which produce a net tension in the section, nor in any part of a structural frame which is required to resist stress due to wind. The maximum stresses for cast iron shall be as indicated in Table 1806.

Table 1806
CAST IRON STRESSES

Types of stress	Maximum stress in pounds per square inch
Extreme compression (fiber stress in bending)	16,000
Extreme tension (fiber stress in bending)	3,000
Column compression	9,000 minus 40 l/r
Shear	3,000
Tension	3,000
Ratio l/r not to exceed 70	

1806.3 Multi-story columns: Cores of superimposed columns shall be of the same dimensions above and below a splice. When a column of smaller diameter is superimposed over one of larger diameter, the larger column shall be tapered down to the smaller diameter over a length of not less than 6 inches.

1806.4 Thickness of metal: The minimum thickness of cast iron shall be not less than specified in Sections 1806.4.1 through 1806.4.3.

1806.4.1 Columns: In columns, the metal shall be not less than one-twelfth the smallest dimension of the cross-section and not less than 3/4-inch.

1806.4.2 Bases and brackets: In bases and flanges, the metal shall be not less than 1 inch thick reinforced with fillets and brackets.

1806.4.3 Lintels: In lintels, the metal shall be not less than 3/4 inch thick and shall be limited to use on spans of not more than 6 feet.

1806.5 Inspection: A cast iron column shall not be erected in place before it has been inspected and approved. The use of any cast iron column in which blow holes or imperfections reduce the effective area of the cross-section more than 10 percent shall be prohibited. Where required by the building official, 3/8-inch round inspection holes shall be drilled in the section to expose the thickness of metal for inspection purposes.

SECTION 1807.0 SPECIAL STEEL AND STEEL CABLE STRUCTURAL SYSTEMS

1807.1 Special steels: Alloy, high-carbon or other special high-strength steels not covered in this article, where used in the design and construction of buildings and structures, shall conform to Section 1304.0.

1807.2 Structural steel cable systems: The design, fabrication and erection of steel cables used as load-carrying members in buildings and structures shall be in accordance with the AISI *Criteria for Structural Applications of Steel Cables for Buildings* listed in Appendix A.

SECTION 1808.0 EXTERIOR STEEL FRAME CORROSION PROTECTION UNDER MASONRY

1808.1 Required: Exterior steel columns and girders, before embedment in masonry of the required fireresistance rating specified in Table 401, shall be protected from moisture by approved waterproofing material, a parging coat of cement mortar or by a minimum of 8 inches of weather-tight masonry.

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ARTICLE 19

LIGHTWEIGHT METAL ALLOYS

SECTION 1900.0 GENERAL

1900.1 Scope: The provisions of this article shall govern the materials, design, construction and quality of aluminum and other lightweight metal alloys.

SECTION 1901.0 MATERIALS

1901.1 General: Aluminum used for structural purposes in buildings and structures shall comply with AA-SAS 30 and AA-ASM 35 listed in Appendix A. Other lightweight metals and alloys used for structural purposes in buildings and structures shall be of approved materials.

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ARTICLE 20

PLASTIC

SECTION 2000.0 GENERAL

2000.1 Scope: The provisions of this article shall govern the quality and methods of application of plastics for use as light-transmitting materials in buildings and structures. When used as interior finish, plastic materials shall meet the requirements of Section 922.0. In the application of this article, foam plastics shall only be subject to the provisions of Section 2002.0.

2000.2 Approved materials: The use of all plastics which meet the strength, durability, sanitary and fireresistive requirements of this code, ASTM D635, ASTM D1929, ASTM D2843 and ASTM E84 listed in Appendix A shall be permitted subject to the limitations of this article.

2000.3 Application for approval: Applicants for approval of a plastic material shall furnish, in accordance with Section 1306.0, all necessary technical data required by the building official. The data shall include, if necessary, the chemical composition; pertinent physical, mechanical and thermal properties such as fireresistance, flammability, and flame spread; weather resistance; electrical properties; products of combustion and coefficients of expansion.

2000.4 Identification: All plastic materials approved for use under this code shall be identified by the trade formula number or name or other acceptable identification. Each unit or package shall bear the approval number or other identification mark of the approving authority.

2000.5 Use: Section 2001.0 shall apply to plastics used in light-transmitting applications such as glazing, skylights, lighting lenses, luminous ceilings, signs and similar purposes. Section 2002.0 shall apply to foam plastics.

SECTION 2001.0 LIGHT-TRANSMITTING PLASTICS

2001.1 Approved light-transmitting plastics: An approved light-transmitting plastic shall be any thermoplastic, thermosetting, or reinforced thermosetting plastic material which has a self-ignition temperature of 650 degrees F. or greater when tested in accordance with ASTM D1929 listed in Appendix A, a smoke density rating

not greater than 450 when tested in the manner intended for use by ASTM E84 listed in Appendix A or not greater than 75 when tested in the thickness intended for use according to ASTM D2843 listed in Appendix A, and which meets one of the following combustibility classifications:

Class C 1: Plastic materials which have a burning extent of 1 inch or less when tested in nominal .060 inch thickness, or in the thickness intended for use, by ASTM D635 listed in Appendix A;

or

Class C 2: Plastic materials which have a burning rate of 2.5 inches per minute or less when tested in nominal .060 inch thickness, or in the thickness intended for use, by ASTM D635 listed in Appendix A.

2001.2 Structural requirements: All plastic materials and their assemblies shall be of adequate strength and durability to withstand the loads and forces specified in Articles 11 and 12 for their approved use.

2001.3 Connections and supports: All fastenings, connections and supports shall be proportioned to safely transmit two and one-half times the design live load. Adequate allowance shall be made in the fastenings and supports for differential expansion and contraction of the connected materials.

2001.4 Other applicable requirements: Light-transmitting plastics used in glazing applications and skylight assemblies shall conform to Section 2204.0. Light-transmitting plastics used as exterior wall panels shall conform to Section 2105.2. Light-transmitting plastics used as roof panels shall conform to Section 2306.0.

2001.5 Light-diffusing systems: Light-diffusing systems shall not be installed in buildings of Use Groups H, I-2 or I-3, nor in exits unless the building is protected throughout by an approved automatic fire suppression system. Plastic diffusers shall be supported directly or indirectly from ceiling or roof construction by use of noncombustible hangers. Hangers shall be at least No. 12 Steel Wire Gage galvanized wire or equivalent.

2001.5.1 Installation: Approved light-transmitting plastic diffusers shall comply with Section 922.0 unless the plastic panels will fall from their mountings before igniting and at an ambient temperature of at least 200 degrees F. below their ignition temperature. The panels shall remain in place at an ambient room temperature of 175 degrees F. for a period of not less than 15 minutes.

2001.5.2 Size limitations: Individual panels or units shall not exceed 10 feet in length nor 30 square feet in area.

2001.5.3 Fire suppression system: In buildings having an approved automatic fire suppression system throughout, plastic light-diffusing systems shall be protected both above and below unless the system has been specifically approved for installation only above the system. Areas of light-diffusing systems shall not be limited when protected in accordance with this section.

2001.5.4 Electrical lighting fixtures: Plastic light-transmitting panels and light diffuser panels installed in approved electrical lighting fixtures shall comply with Section 922.0 unless the plastic panels meet the requirements of Section 2001.5.1. The area of approved plastic materials when used in required exits or corridors shall not exceed 30 percent of the aggregate area of the ceiling in which they are installed, unless the building is equipped throughout with an approved automatic fire suppression system.

2001.6 Partitions: Approved light-transmitting plastics used in or as partitions shall comply with the requirements of Sections 922.0 and 905.3.

2001.7 Bathroom accessories: Approved plastics shall be permitted as glazing in shower stalls, shower doors, bathtub enclosures and similar accessory units.

2001.8 Awnings and similar structures: Approved light-transmitting plastics used on awnings and similar structures shall comply with the general performance provisions of other sections of the code.

2001.9 Greenhouses: Approved light-transmitting plastics may be used in lieu of plain glass in greenhouses.

SECTION 2002.0 FOAM PLASTICS

2002.1 General: The provisions of this section shall govern the requirements and uses of foam plastic in buildings or structures.

2002.1.1 Surface burning characteristics: Unless otherwise indicated in this section, all foam plastics and foam plastic cores of manufactured assemblies shall have a flame spread rating of not more than 75 and shall have a smoke developed rating of not more than 450 when tested in the maximum thickness intended for use in accordance with ASTM E84 listed in Appendix A.

2002.1.2 Labeling: Foam plastics or their packages, and containers of foam-in-place plastic system ingredients shall be labeled in conformance with Section 1306.3.

2002.2 Thermal barrier: Unless otherwise indicated in this section, all foam plastic shall be separated from the interior of a building by an approved thermal barrier of 1/2 inch gypsum wallboard or equivalent thermal barrier material which will limit the average temperature rise of the unexposed surface to not more than 250 degrees F. after 15 minutes of fire exposure complying with the standard time-temperature curve of ASTM E119 listed in Appendix A. The thermal barrier shall be installed in a manner that assures it will stay in place for a minimum of 15 minutes under the same test conditions.

2002.3 Prescriptive installations: The requirements of Sections 2002.3.1 through 2002.3.10.7 shall apply to all uses of foam plastics unless specifically approved according to Section 2002.4.

2002.3.1 Masonry or concrete construction: The thermal barrier described in Section 2002.2 is not required when the foam plastic is protected by a minimum 1-inch thickness of masonry or concrete.

2002.3.2 Cold storage construction: Where foam plastic is tested in a thickness of 4 inches and is used in a thickness up to 10 inches, the building shall be equipped throughout with an approved automatic fire suppression system.

2002.3.3 Walk-in coolers: When foam plastic is used in a maximum thickness of 4 inches in freestanding walk-in coolers or freezer units less than 400 square feet in floor area without a thermal barrier and without an automatic fire suppression system, the foam plastic shall be covered by a metal facing not less than 0.032 inch thick aluminum or corrosion-resistant steel having a minimum base metal thickness of 0.016 inches. The maximum thickness shall be 10 inches when the foam plastic is protected by a thermal barrier.

2002.3.4 Roofing: Foam plastic used in a roof covering assembly without the thermal barrier shall have the foam separated from the interior of the building by plywood sheathing not less than 15/32 inch in thickness bonded with exterior glue, with edges supported by blocking, tongue-and-groove joints or other approved type of edge support, or an equivalent material. The requirements of Sections 2002.1.1 and 2002.2 are not applicable to foam plastic roof insulation which complies with FM 4450 or UL 1256 listed in Appendix A. For all roof applications, the smoke developed rating shall not be applicable.

2002.3.5 Attics and crawl spaces: Within an attic or crawl space where entry is made only for service of utilities, foam plastics shall be protected against ignition by 1 1/2 inch thick mineral fiber insulation, 1/4 inch thick plywood, particle board or hardboard or 3/8 inch gypsum wallboard, corrosion-resistant steel having a base metal thickness of 0.016 inch, or other approved material installed in such a manner

that the foam plastic is not exposed. The protective covering shall be consistent with the requirements for the type of construction.

2002.3.6 Doors: Where doors are permitted without a fireresistance rating and foam plastic is used as a core material, the door facing shall be of metal having a minimum thickness of 0.032-inch aluminum or 0.016-inch steel. The thermal barrier requirement of Section 2002.2 shall not apply.

> **Exception:** In buildings of Use Group R-3, foam-filled exterior entrance doors not requiring a fireresistance rating shall be faced with wood or other approved materials.

2002.3.7 Siding backer board: Foam plastic to be used as siding backer board shall have a maximum thickness of 1/2 inch and be separated from the interior of the building by not less than 2 inches of mineral fiber insulation or equivalent in lieu of the thermal barrier or when applied as insulation with residing over existing exterior wall construction.

2002.3.8 Interior trim: Foam plastic used as interior trim shall comply with Sections 2002.3.1 through 2002.3.8.4.

2002.3.8.1 Density: The minimum density is 20 pounds per cubic foot.

2002.3.8.2 Thickness: The maximum thickness of the trim is 1/2 inch and the maximum width is 4 inches.

2002.3.8.3 Area limitation: The trim constitutes not more than 10 percent of the aggregate wall and ceiling area of any room or space.

2002.3.8.4 Flame spread: The flame spread rating does not exceed 75 when tested according to ASTM E84 listed in Appendix A. The smoke developed rating is not limited.

2002.3.9 One-story buildings: Foam plastic insulation, having a flame spread rating of not more than 25 used without a thermal barrier in or on exterior walls of one-story buildings, shall not have a thickness more than 4 inches and the foam plastic shall be covered by a thickness of not less than 0.032-inch aluminum or corrosion-resistant steel having a base metal thickness of 0.016 inch and the building area shall be equipped throughout with an automatic fire suppression system.

2002.3.10 Exterior walls: Foam plastics used in or on the exterior side of exterior walls in Types 1, 2, 3 or 4 construction shall comply with the requirements of Sections 2002.3.10.1 through 2002.3.10.7.

2002.3.10.1 Use: Foam plastics are permitted within exterior walls provided the wall assembly affords the required fireresistance rating.

2002.3.10.2 Thickness: The foam plastic shall be limited to a maximum thickness of 4 inches.

2002.3.10.3 Flame spread: The foam plastic core, coatings and facings, each when tested individually, shall have a flame spread rating of 25 or less when tested in accordance with ASTM E84 listed in Appendix A.

2002.3.10.4 Fastening: Facing, coating and core materials shall be fastened to each other, and the overall assembly shall be fastened to the building frame to prohibit failure in bond as a result of temperatures which occur in a building fire, from wind load or other conditions.

2002.3.10.5 Full-scale tests: Results of full-scale fire tests reflecting an end-use configuration shall be submitted to the building official demonstrating that the assembly in its final form does not show any tendency to propagate flame over the surface or through the core when exposed on the exterior face to a fire source. Such testing shall be performed on the finished manufactured foam plastic assemblies and on the maximum thickness intended for use.

2002.3.10.6 Thermal barrier: Any foam plastic insulation shall be separated from the building interior by a thermal barrier unless specific approval is obtained on the basis of Section 2002.4.

2002.3.10.7 Identification: The edge or face of each piece of foam plastic insulation shall be labeled in accordance with Section 1306.3.

2002.4 Diversified tests: Foam plastic is not required to comply with Sections 2002.2 and 2002.3 when specifically approved based on diversified tests such as FM Procedure 4880, UL Subject 1040 or UL Subject 1715 listed in Appendix A. Such approvals shall also be based on tests conducted in accordance with ASTM E84 and ASTM D1929 listed in Appendix A. Such testing shall be performed on the finished manufactured foam plastic assemblies and on the maximum thickness intended for use. Foam plastics which are used as interior finish on the basis of diversified tests shall also meet the flame spread requirements of Section 922.0.

2002.5 Urea based foamed-in-place insulation: Use of this material has been banned by the Massachusetts Department of Public Health.

ARTICLE 21

EXTERIOR WALLS

SECTION 2100.0 GENERAL

2100.1 Scope: The provisions of this article shall govern the minimum specifications for exterior walls and wall thickness hereafter used in the construction of buildings and structures. All materials and methods of construction shall conform to the applicable standards listed in this code.

SECTION 2101.0 GENERAL CONSTRUCTION REQUIREMENTS

2101.1 General: All buildings, except as provided in Section 906.1.1, shall be enclosed on all sides with independent or party walls of approved construction. Such walls shall be constructed to afford the fireresistance rating specified in Table 401 and as required in this code for location, use and type of construction.

2101.2 Projections: Exterior enclosure walls shall be constructed entirely within lot lines or building lines when established by law, except for authorized projections beyond the street lot line in accordance with Section 506.0.

2101.3 Fireresistance rated openings: Openings in exterior walls, when required to be fireresistance rated, shall comply with the provisions of Article 9.

2101.4 Structural strength against wind forces: In all buildings required to resist wind pressure under the provisions of Article 11, exterior window openings shall be designed to resist the specified wind load when such protectives are more than 100 square feet in area in the first story or more than 50 square feet in the upper stories.

2101.5 Structural strength of sash or frames: The glass or other approved glazing material shall be of adequate thickness or shall be provided with steel frames or otherwise reinforced to resist the wind loads specified in Article 11, acting both inwardly and outwardly.

SECTION 2102.0 FLOOD RESISTANT CONSTRUCTION

2102.1 Definitions: The following definitions shall apply only for Section 2102.0

1. "Lowest Floor": The lowest floor of the lowest enclosed area (including basement or cellar). An unfinished or flood resistant enclosure, usable solely for parking of vehicles, building access or storage, in an area other than a basement or cellar area, is not considered a building's lowest floor, provided that such enclosure is not built so as to render the structure in violation of the applicable non-elevation design requirements of this building code.

2. "Manufactured Home": A building transportable in one or more sections which is built on a permanent foundation when connected to the required utilities. The term "Manufactured Home" includes park trailers, travel trailers and other similar vehicles placed on a site for greater than 180 consecutive days.

3. "One-Hundred (100) Year Flood ": The flood having a one (1) percent chance of being equalled or exceeded in any given year. Also referred to as the "Base Flood".

4. "Start of Construction": The date the building permit was issued, provided the actual start of construction, repair, reconstruction, placement, or other improvements was within 180 days of the permit date. The actual start means the first placement of permanent construction of a structure on a site, such as the pouring of slab or footings, the installation of piles, the construction of columns, or any work beyond the stage of excavation or the placement of a manufactured home on a foundation.

5. "Breakaway Wall": A wall that is not part of the structural support of the building and intended through its design and construction to collapse under specific lateral loading forces, without causing damage to the elevated portion of the building or supporting foundation system.

6. "Substantial Improvements": Any repairs, reconstruction, or improvements, the cost of which exceeds fifty (50) percent of the market value of the structure before repairs of damages.

2102.2 Designated areas and projects: Plans for all structures and gas storage tanks, including new construction and substantial improvements to existing structures, and the placement of manufactured buildings and manufactured homes, shall be subject to review by the building official to determine if the location is within any areas of special flood hazards as designated by the Federal Insurance

Administration (FIA), through issuance of a Flood Hazard Boundary Map or through a scientific and engineering report entitled "Flood Insurance Study" with accompanying Flood Insurance Rate Maps and Flood Boundary and Floodway Maps. The building Official shall determine if the structure is within the one-hundred (100) year Floodplain area designated (as zones A, A1-30, AE, AH, AO, V1-30 or AE) on the community's flood hazard boundary map or flood insurance rate map published by FIA. If the structure is not located in a one-hundred (100) year flood zone as identified by FIA, and the building official has information indicating that the structure would be flooded during a one-hundred (100) year flood event, then the requirements of this section shall apply.

The one-hundred (100) year flood elevation shall be determined by the building official as follows:

(I) In A1-30, AH, AE, V1-30 and VE zones the one-hundred year flood elevation is provided on the community's Flood Insurance Study (FIS) and accompanying Flood Insurance Rate Map (FIRM).

(II) In AO zones add the depth provided on the Flood Insurance Rate Map to the highest adjacent grade. If no depth is provided add at least two (2) feet to the highest adjacent grade.

(III) In A and V zones the building official shall obtain, review and reasonably utilize any Base Flood Elevation Data available from a federal, state or other source.

2102.3 Structural Requirements in Floodplains: If a structure is to be constructed or substantially improved within flood zones (A, A1-30, AE, AO, AH), it shall be designed and constructed to minimize flood damage. Plans for such construction shall be submitted and certified by a registered professional engineer or architect to ensure that the following requirements are met:

1. The building is designed (or modified) and adequately anchored to prevent flotation, collapse or lateral movement

2. The building is constructed with materials and utility equipment resistant to flood damage.

3. The building is constructed by methods and practices that minimize flood damages;

4. Electrical, heating, ventilation, plumbing and air conditioning equipment and other service facilities are designed and/or located so as to prevent

water from entering or accumulating within the components during conditions of flooding;

5. New construction and substantial improvements of any residential structure shall have the lowest floor, including basement or cellar, elevated to or above the base flood elevation;

Exception: If the addition complies with the National Flood Insurance Provisions (that is, if it is elevated to or above the base flood elevation), the existing structure need not be elevated. However, second story additions which rely upon the support of an existing structure not in compliance with this section are not eligible for this exception.

6. New construction and substantial improvements of any non-residential structure shall either have the lowest floor, including basement or cellar, elevated to or above the base flood elevation; or, together with attendant utility and sanitary facilities, shall:

(I) Be floodproofed so that below the base flood elevation the structure is watertight with walls substantially impermeable to the passage of water; and

(II) Have structural components capable of resisting hydrostatic and hydrodynamic loads and effects of buoyancy; and

(III) Be certified by a registered professional engineer or architect that the design plan specifications and methods of construction are in accordance with accepted standards of practice for meeting the provisions of this section.

7. Enclosure of space below the base flood elevation of all new construction and substantial improvements is permitted provided that the following conditions are met: (1) the space is used for parking of vehicles, building access or storage, (2) the space is not a basement or cellar and (3) the enclosure be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing for the entry and exit of flood waters. Designs to meet this requirement must either be so certified by a registered professional engineer or architect or must meet or exceed the following minimum criteria: A minimum of two openings having a total net area of not less than one square inch for every square foot of enclosed area subject to flooding shall be provided. The bottom of all openings shall be no higher than one foot above grade. Openings may be equipped with screens, louvers or other coverings or devices provided that they permit the automatic entry and exit of floodwaters.

8. All manufactured homes must be elevated on permanent foundations such that the lowest floor of the manufactured home is above the one-hundred (100) year flood elevation and is securely anchored to resist flotation, collapse or lateral movement by providing over-the-top and frame ties to ground anchors in the following manner:

   a. Over-the-top ties shall be provided at each of the four corners of manufactured homes; with two (2) additional ties per side at intermediate locations for manufactured homes greater or equal to fifty (50) feet long, and one (1) additional tie per side for manufactured homes less than (50) feet long;

   b. Frame ties shall be provided at each corner of the manufactured home with five additional ties per side at intermediate locations for manufactured homes greater or equal to fifty (50) feet long and four additional ties per side for manufactured homes less than fifty (50) feet long;

   c. All components of the anchoring system be capable of carrying a force of four thousand eight hundred (4,800) pounds: and

   d. Any additions to the manufactured home shall be similarly anchored.

2102.4 Structural requirements in coastal high hazard areas: If a structure is to be constructed or substantially improved within a coastal high hazard area (land subject to high velocity waters, including hurricane wave wash identified as Zones V1-30 and VE on the community FIRM), as determined by the building official, the structural design specification and plans for such building shall be reviewed and certified by a registered professional engineer or architect that the design and methods of construction to be used are in accordance with accepted standards of practice for meeting the following provisions:

1. The structure is elevated on adequately anchored pilings or columns, and securely anchored to such piles or columns so that the lowest portion of the structural members of the lowest floor (excluding the pilings or columns) is elevated to or above the one-hundred (100) year level;

   Exception: If the addition complies with National Flood Insurance Provisions (that is, if it is elevated to or above the base flood elevation), the existing structure need not be elevated. However, second story additions which rely upon the support of an existing structure not in compliance with this section are not eligible for this exception.

2. The structure is securely anchored, as provided above, in order to withstand velocity waters and hurricane wave wash;

3. Fill is not used for structural support; and

4. The space below the lowest floor is either free of obstruction or constructed with non-supporting breakaway walls, open wood lattice--work, or insect screening intended to collapse, under wind and water loads without causing collapse, displacement or other structural damage to the elevated portion of the building or supporting foundation system. The space below the base flood level must not be used for human habitation. Such enclosed space shall be usable solely for parking off vehicles, building access and storage. For the purposes of this section a breakaway wall shall be designed in accordance with the following conditions:

   (I) Breakaway wall collapse shall result from a water load less than that which would occur during the base flood; and,

   (II) The elevated portion of the building and supporting foundation system shall not be subject to collapse, displacement or other structural damage due to the effects of wind and water loads acting simultaneously on all building components (structural and non-structural). Maximum wind and water loading values to be used in this determination shall each have a one percent chance of being equalled or exceeded in any given year (100 year mean recurrence interval).

5. New construction and substantial improvements of any residential structure shall have the lowest floor, including basement or cellar, elevated to or above the base flood elevation;

   Exception: If the addition complies with the National Flood Insurance Provisions (that is, if it is elevated to or above the base flood elevation), the existing structure need not be elevated. However, second story additions which rely upon the support of an existing structure not in compliance with this section are not eligible for this exception.

6. Electrical, heating, ventilation, plumbing, air conditioning and other service facilities are designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding.

2102.5 Records: The building official shall obtain (or have the applicant provide) and maintain for public inspection a record of:

1. **The as-built elevations, of the lowest floor, including basement or cellar, in relation to the national geodetic vertical datum. These elevations must be certified by a registered land surveyor or professional engineer;**

2. **The as-built elevations, in relation to the national geodetic vertical datum, to which a building has been floodproofed. These elevations must be certified by a registered land surveyor or professional engineer;**

3. **The date when such construction commenced.**

SECTION 2103.0 RATPROOFING

2103.1 General: All buildings or structures and the walls enclosing habitable or occupiable rooms and spaces in which persons live, sleep or work, or in which feed, food or foodstuffs are stored, prepared, processed, served or sold, shall be constructed in accordance with the provisions of this section.

2103.2 Grade protection: Buildings not provided with a continuous foundation shall be provided with protection against rodents at grade in accordance with either Section 2103.2.1 or 2103.2.2.

2103.2.1 Apron: When an apron is provided, the apron shall be not less than 8 inches above, nor less than 24 inches below grade. In all cases the apron shall not terminate below the lower edge of the siding material. The apron shall be constructed of an approved nondecayable, water-resisting and ratproofing material of required strength and shall be installed around the entire perimeter of the building. When constructed of masonry or concrete materials, the apron shall be not less than 4 inches in thickness.

2103.2.2 Grade floors: Where continuous concrete grade floor slabs are provided, open spaces shall not be left between slab and walls, and all openings in the slab shall be protected.

2103.3 Opening protection: Openings shall be protected in accordance with Sections 2103.3.1 through 2103.3.3.

2103.3.1 Wall openings: Openings in the wall or apron required for ventilation or other purposes shall be guarded with corrosion-resistive ratproof shields of not less than nominal 0.034-inch perforated steel sheets, or No. 20 B&S Gage aluminum or nominal 0.064-inch expanded steel or wire mesh screens, with not more than 1/2-inch mesh openings.

2103.3.2 Slab openings: Access openings in grade floor slabs shall be protected with concrete, masonry, metal or other corrosion-resistive noncombustible covers of adequate strength to support the floor loads.

2103.3.3 Pipe and conduit openings: All openings for pipe, conduit, cable and similar purposes at or near grade shall have snugly-fitted collars to eliminate all open spaces.

SECTION 2104.0 WEATHER PROTECTION

2104.1 General: To secure weather-tightness in framed walls and other unoccupied spaces, the exterior walls shall be faced with an approved weatherresisting covering properly attached to resist wind and rain. The cellular spaces shall be so ventilated as not to vitiate the firestopping at floor, attic and roof levels, or shall be provided with approved interior noncorrodible vapor type barriers, or other means shall be used to avoid condensation and leakage of moisture. The materials indicated in Table 2104.1 shall be acceptable as approved weather coverings of the minimum nominal thickness specified.

2104.1.1 Basic hardboard: Basic hardboard shall meet the requirements AHA A135.4 listed in Appendix A.

2104.1.2 Siding: Hardboard siding shall meet the requirements of AHA A 135.6 listed in Appendix A, and when used structurally, shall be so identified by an approved agency.

2104.2 Backing surfaces for veneers: Veneers for other than buildings of Type 5 construction shall be attached only to substantial, rigid and noncombustible surfaces which are plumb, straight and of true plane. Wood backing surfaces shall not be used, except in buildings of Type 5 construction. The backing shall provide sufficient rigidity, stability and weather resistance, and the veneer shall be installed and anchored as required in this code for the specific material.

2104.2.1 Wood siding: Wood siding of thicknesses less than ½ inch shall be placed over sheathing which conforms to Section 1704.7.

2104.3 Building paper: When veneers of brick, clay tile, concrete, or natural or artificial stone are used, 14-pound felt or paper shall be attached to the sheathing with flashing wherever necessary to prevent moisture penetration behind the veneer.

2104.4 Nailing: All weather boarding and wall coverings shall be securely nailed with aluminum, copper, zinc, zinc-coated or other approved corrosion-resistive nails in accordance with the nailing schedule in Appendix C or the approved manufacturer's recommendations. Shingles and other weather coverings shall be

attached with appropriate standard shingle nails to furring strips securely nailed to studs, or with approved mechanically bonding nails, except when sheathing is wood not less than 1-inch nominal thickness or plywood not less than 5/16, inch thick. Where wood shingles or shakes are applied over fiber board shingle backer and fiber board sheathing, they shall be attached with approved corrosion-resistive annular grooved nails and the installation shall be done in accordance with the approved manufacturer's recommendations. Where wood shingles or shakes and asbestos shingles or siding are nailed directly to nail base fiber board sheathing, the sheathing shall be not less than ½-inch nominal thickness, the shingles, shakes and siding shall be attached with approved corrosion-resistive annular grooved nails, and the installation shall be done in accordance with the approved manufacturer's recommendations.

2104.5 Metal siding: Exposed metal siding or sheathing shall be protected from corrosion at the ground level by supporting the foundation channel at sufficient height above grade on the concrete apron or other approved waterresisting foundation.

2104.6 Exterior wall pockets: In exterior walls of all buildings or structures, wall pockets or crevices in which moisture can accumulate shall be avoided or protected with adequate caps or drips, or other approved means shall be provided to prevent water damage.

2104.7 Flashings: Approved corrosion-resistive flashing shall be provided at top and sides of all exterior window and door openings in such manner as to be leakproof. Similar flashings shall be installed at the intersection of chimneys or other masonry construction with frame or stucco walls, with projecting lips on both sides under stucco copings; under and at the ends of masonry, wood or metal copings and sills; continuously above all projecting wood trim; at wall and roof intersections and at built-in gutters. (See exception next page)

> **Exception:** When approved by the building official, flashing is not required when an approved water-resistant sheathing is used and an approved water-resistant caulking is used at the top and sides of all window and door openings in such a manner to be leakproof.

Table 2104.1
MINIMUM THICKNESS OF WEATHER COVERINGS

Covering type	Minimum thickness
Aluminum siding[b]	0.019 inch
Asbestos cement boards	1/8 inch
Asbestos shingles	5/32 inch
Brick and concrete masonry veneers	2 inches
Ceramic veneer (architectural terra cotta, anchored type)	1 inch
~~anchored type~~)	1/4 to 1 inch
Clay tile (flat slab) ↑ move each up one space	1 3/4 inches
Clay tile (structural)	5/16 inch
Exterior plywood (with sheathing)	See Section 1710.2
Exterior plywood (without sheathing)	3/8 inch
Glass fiber reinforced concrete panels	1/4 inch
Hardboard siding	1 inch
Marble slabs	See Section 1711.5
Particle board (with sheathing)	See Section 1711.5
Particle board (without sheathing)	5/8 inch
Precast stone facing	1/2 inch
Protected fiber board siding	0.035 inch
Rigid PVC siding[c]	0.017 inch
Steel (approved corrosion-resistive)	1 1/2 inches
Stone (cast artificial)	2 inches
Stone (natural)	11/32 inch
Structural glass	3/4 inch
Stucco or exterior plaster	3/8 inch
Wood shingles	1/2 inch
Wood siding (without sheathing)[a]	

Note a. For wood siding of a lesser thickness, see Section 2104.2.1.
Note b. See AAMA 1402.3 listed in Appendix A.
Note c. See ASTM D3679 listed in Appendix A.

SECTION 2105.0 WALL PANELS

2105.1 Solid panel walls: Panel, apron or spandrel walls as defined in this code shall not be limited in thickness, provided they meet the fireresistance rating requirements of Article 9 and Table 401, and are constructed of approved noncombustible weather-resisting materials of adequate strength to resist the wind loads specified in Section 1112.0.

2105.2 Light-transmitting plastic: Approved light-transmitting plastic materials shall not be used as wall panels in exterior walls in buildings of Use Groups A-1, A-2, H, I-2 and I-3. In all other uses, approved light transmitting plastic materials shall not be used as wall panels in exterior walls unless the walls are not required to have a fireresistance rating and the installation conforms to the requirements of Sections 2105.2.1 through 2105.2.7. Such panels shall be erected and anchored on a foundation coat, waterproofed or otherwise protected from moisture absorption and sealed with a coat of mastic or other approved waterproof coating. Refer to Section 2001.1 for requirements for approved light-transmitting plastics.

2105.2.1 Installation: Exterior wall panels installed as provided herein shall not alter the type of construction classification of the building.

2105.2.2 Height limitation: Approved light-transmitting plastics shall not be installed more than 70 feet above grade level, except as allowed by Section 2105.2.6.

2105.2.3 Area limitation and separation: Area limitation and separation requirements of exterior wall panels shall be as provided in Table 2105.

> **Exception:** Veneers of approved weather-resisting plastics used as exterior siding as an element of Type 5 construction in compliance with Section 926.2.1.

2105.2.4 Spandrel separation: Vertical spandrel wall separation between stories shall be 3 feet for Class C1 light-transmitting plastic wall panels and 4 feet for Class C2 light-transmitting plastic wall panels. See Section 2001.1 for definition of C1 and C2 light-transmitting plastic

2105.2.5 Fire canopies: In structures which are provided on any floor above the first with continuous architectural projections constituting an effective fire canopy extending at least 36 inches from the surface of the wall in which plastic wall panels are installed, vertical separation at that floor is not required except that provided by the vertical thickness of the projection.

2105.2.6 Automatic fire suppression: When an approved automatic fire suppression system is provided throughout the building, the maximum percent area of exterior wall in plastic panels and the maximum square feet of single area given in Table 2105 shall be increased 100 percent, but the area of plastic wall panels shall not exceed 50 percent of the wall area. These uses shall be exempt from height limitations.

Table 2105
AREA LIMITATION AND SEPARATION REQUIREMENTS FOR PLASTIC WALL PANELS[a]

Fire separation distance	Class of plastic	Maximum % area of exterior wall in plastic panels	Maximum sq. ft. single area	Minimum separation of panels (ft.)	
				Vert.	Horz.
Less than 6 ft.	---	NP[c]	NP	---	---
6 ft. or more but less than 11 ft.	C1 C2	10 NP	50 NP	8 ---	4 ---
11 ft. or more but less than 30 ft.	C1 C2	25 15	90 70	6 8	4 4
Over 30 ft.	C1 C2	50 50	Not limited 100	3 6	0 3

Note a. For combination of glazing and wall panel areas permitted, see Section 2105.2.7.
Note b. For reductions in vertical separation allowed, see Section 2105.2.5.
Note c. Not permitted.

2105.2.7 Combinations of glazing and wall panels: Combinations of plastic glazing and plastic wall panels shall be subject to the area, height, percentage limitations and separation requirements applicable to the class of plastic as prescribed for wall panel installations.

SECTION 2106.0 METAL VENEERS

2106.1 Materials: Veneers of metal shall be fabricated from approved corrosion-resistive materials or shall be protected front and back with porcelain enamel or shall be otherwise treated to render the metal resistant to corrosion. Such veneers shall be not less than 0.017-inch nominal thickness galvanized sheet steel mounted on wood or metal furring strips or approved sheathing on the wood construction.

2106.2 Construction: Metal veneer for buildings of other than Type 5 construction shall be securely attached to masonry; supported on approved metal framing protected by painting, galvanizing or other approved protection; or supported by wood furring strips treated with an approved preservative process complying with Section 1712.2.

2106.3 Waterproofing: All joints and edges exposed to the weather shall be caulked with approved durable waterproofing material or by other approved means to prevent penetration of moisture.

2106.4 Grounding metal veneers: Grounding of metal veneers on all buildings shall comply with the requirements of Article 27 and NFiPA 70 listed in Appendix A.

SECTION 2107.0 MASONRY VENEERS

2107.1 General: Veneers of unit masonry shall be attached to the wood frame with at least 0.034-inch nominal thickness corrosion-resistive, corrugated, galvanized steel ties not less than 7/8 inch in width at vertical interval: of not more than 16 inches and horizontal intervals of not more than 32 inches.

2107.2 Nonstructural: Masonry or other approved noncombustible materials used as facing on bearing walls or partitions shall not be considered to have structural value, and shall be excluded in the determination of required wall thickness.

2107.3 Height of veneers: The average height of 4-inch masonry veneer shall be not more than 25 feet above its supports on a foundation wall or on corbels of masonry or steel; and not more than 18 feet in height for 2-inch veneers.

SECTION 2108.0 THIN STONE AND TILE VENEERS

2108.1 Size of units: In localities subject to frost and freezing temperatures, tile and terra cotta units shall be frostproof and shall not be more than 288 square inches in area. Where not subject to frost action, the maximum size of the tile shall be 432 square inches.

2108.2 Construction: One-inch thick marble, granite, terra cotta and similar materials, or ceramic tile facing ¼ to 1 inch in thickness shall be installed in an approved manner.

SECTION 2109.0 STRUCTURAL GLASS VENEERS

2109.1 Dimensions: The minimum thickness of glass veneer shall be 11/32 inch and the area of individual panels shall not exceed 10 square feet, with a maximum length of 4 feet. The edge of each unit shall be ground square with a slight arris. All exposed external corners and angles shall be rounded to a radius of not more than 3/16 inch.

2109.2 Construction: Structural glass veneer construction shall comply with Sections 2109.2.1 and 2109.2.2.

2109.2.1 Backing surface: The glass veneer shall be set in mastic cement on a float coat of 1-inch thick cement mortar reinforced with wire lath attached to noncombustible furring spaced not more than 12 inches on center.

2109.2.2 Support of veneer: The base course of glass units shall be supported on a corrosion-resistive metal frame anchored to the backing and caulked with a waterproof compound at grade.

2109.3 Reinforcement: Metal reinforcing of cold-formed corrosion-resistive angles of not less than 0.064-inch nominal thickness galvanized sheet steel or other approved reinforcement shall be provided in all horizontal joints anchored into the masonry wall with expansion or toggle bolts.

2109.4 Expansion joints: Expansion joints shall be provided at ends and intermediate sections caulked with an approved waterproofing compound. Where necessary for water-tightness, exposed edges shall be protected with corrosion-resistive metal or other approved noncombustible flashing.

2109.5 Other loads: Signs, awning brackets or other loads shall not be hung directly from glass veneers, but shall be supported on framing anchored to or otherwise supported by the masonry wall, free from contact with the glass.

ARTICLE 22

VERTICAL AND SLOPED GLASS AND GLAZING

SECTION 2200.0 GENERAL

2200.1 Scope: The provisions of this article shall govern the materials, design, construction and quality of glass and glazing in vertical and sloped applications. For the definition of approved light-transmitting plastic, see Section 2001.1.

SECTION 2201.0 GENERAL REQUIREMENTS FOR GLASS

2201.1 Labeling: Each light shall bear the manufacturer's label designating the type and thickness of glass. Labels shall not be omitted unless approved and an affidavit is furnished by the glazing contractor certifying that each light is glazed in accordance with approved plans and specifications. Labels shall not be omitted from tempered glass.

Each unit of tempered glass shall be permanently identified by the manufacturer. The identification shall be etched or ceramic-fired on the glass and be visible when the unit is glazed. Tempered spandrel glass is exempted from permanent labeling, but shall be labeled with a removable paper label by the manufacturer.

Safety glazing materials shall conform to the requirements of the Annotated Laws of Massachusetts Chapter 143, Sections 3T, 3U, and 3V, as amended.

2201.2 Glass supports: Where one or more sides of any light of glass is not firmly supported, or is subjected to unusual load conditions, detailed shop drawings, specifications and analysis or test data assuring safe performance for the specific installation shall be prepared by engineers experienced in this work and approved by the building official. **Analysis shall be based on the wind loads required by Section 1112** for components and cladding. The elevation of the glazed openings shall be computed by adding the distances from grade to the head and sill, respectively, and dividing the sum by two.

2201.3 Glass dimensional tolerance: Glass thickness tolerances shall comply with those established in the Table 2201.3. Where thickness is to be controlled, nominal values are stated subject to the tolerances shown in Table 2201.3.

Table 2201.3
MINIMUM GLASS THICKNESS

Nominal Thickness (inches)	Plate Glass Minimum Thickness (inches)	Sheet Glass Minimum Thickness (inches)
SS	--	0.085
DS	--	0.115
1/8	0.094	--
3/16	0.156	0.182
13/64	0.172	--
7/32	--	0.205
1/4	0.218	0.236
5/16	0.281	--
3/8	0.343	0.357
1/2	0.468	0.478
5/8	0.562	--
3/4	0.689	--
7/8	0.750	--
1	0.875	--
1 1/4	1.125	--

2201.4 Louvered windows or jalousies: Regular plate, sheet or patterned glass in jalousies and louvered windows shall not be thinner than nominal 7/32 inch and not longer than 48 inches. When other glass types are used, detailed shop drawings, specifications and analysis or test data assuring safe performance for the specific installation shall be prepared by engineers experienced in this work and approved by the building official.
Exposed glass edges shall be smooth.
Wired glass with wire exposed on longitudinal edges shall not be used in jalousies or louvered windows.

SECTION 2202.0 WIND LOADS FOR GLASS

2202.1 Wind loads: Glass in windows, curtain and window walls, skylights, doors, and other exterior applications shall be chosen to resist the wind loads in Section 1112.3.1 for components and cladding. Maximum sizes of single regular (annealed) glass shall be determined **in accordance with Section 2202.1.1**. Maximum sizes of other glass types shall be determined by first dividing the design wind load, **developed per Section 1112**, by the factor in Table 2202.1a.
Section 2202.1.1 is applicable for rectangular glass firmly supported on all four edges. When approved, alternative means for selecting glass shall be permitted in place of Table 2202.1a and **Section 2202.1.1** requirements.

Table 2202.1a
RELATIVE RESISTANCE TO WIND LOAD

Glass Type	Factor
Fully-Tempered	4.00
Heat-Strengthened	2.00
Insulating Glass[b] 2 panes	1.70
Insulating Glass[b] 3 panes	2.55
Laminated[a]	0.75
Patterned[c]	1.00
Regular (annealed)	1.00
Sandblasted[d]	0.40
Wired	0.50

Note a. Applies when two plies are identical in thickness and type; use total glass thickness, not thickness of one ply.
Note b. Applies when each glass pane is the same thickness and type; use thickness of one pane; for asymmetrical insulating glass units, consult glass supplier for specific information.
Note c. Use minimum glass thickness, that is, measured at the thinnest part of the pattern; wind load chart shall be interpolated if necessary.
Note d. Factor varies depending upon depth and severity of sand blasting; value shown is minimum.

Section 2202.1.1 The required nominal thickness of float glass: The required nominal thickness of float glass shall be based on the minimum thickness allowed in Fed. Spec. DD-G-451D, utilizing a design factor of 2.5 **and employing the wind loading criteria of Article 11, Section 1112.0.**

SECTION 2203.0 SAFETY GLAZING

2203.1 Human impact loads: Individual glazed areas in hazardous locations such as those indicated in Section 2203.2 shall **conform to the requirements of the Annotated Laws of Massachusetts Chapter 143, Sections 3T, 3U, and 3V, as amended, and shall comply with the ANSI Z97.1 Standard listed in Appendix A.** The requirements of this Section and Sections 2203.2 and 2207.0 shall apply equally to replacement glass and new glass installation. Additional requirements as specified in Section 2207.2 are to be satisfied for glass used in locations where the hazard is of a continuous nature, such as glass enclosures for sporting activities as identified in Section 2207.1.

Polished wired glass used in required fireresistance rated assemblies shall also comply with ANSI Z97.1, listed in Appendix A.

Plastic glazing shall meet the weathering requirements of ANSI Z97.1 listed in Appendix A.

2203.2 Specific hazardous locations: The following shall be considered specific hazardous locations for purposes of glazing.

1. Glazing in ingress and egress doors except jalousies (see Section 2201.4 for jalousies).
2. Glazing in fixed, sliding or swinging panels of sliding or swinging-type doors (patio and mall type).
3. Glazing in storm doors.
4. Glazing in all unframed swinging doors.
5. Glazing, operable or nonoperable, in shower and bathtub doors and enclosures with a horizontal edge less than 6 feet above the room floor level or less than 70 inches above the compartment floor.
6. Glazing, operable or nonoperable, adjacent to a door and within the same wall plane as the door and; whose nearest vertical edge is within 12 inches of the door in a closed position and; whose bottom edge is less than 60 inches above the floor or walking surface, unless an intervening interior permanent wall is between the door and the glazing.

7. Glazing in fixed panels having a glazed area in excess of 9 square feet with the lowest edge less than 18 inches above the finish floor level or walking surface within 36 inches of such glazing. In lieu of safety glazing, such glazed panels shall be protected with a horizontal member not less than 1 1/2 inches in width when located between 24 inches and 36 inches above the walking surface.

8. All glazing in railings regardless of area or height above a walking surface. Included are structural baluster panels and nonstructural in-fill panels.

Exceptions: The following products, materials and uses are exempt from the above hazardous locations:

1. Openings in doors through which a 3-inch sphere is unable to pass.
2. Assemblies of leaded glass or faceted glass and items of carved glass when used for decorative purposes in locations described in Section 2203.2, items 1,6 or 7.
3. Glazing materials used as curved glazed panels in revolving doors.
4. Commercial refrigerated cabinet glazed doors.

SECTION 2204.0 SLOPED GLAZING AND SKYLIGHTS

2204.1 Sloped glazing: Any installation of glass or other transparent, translucent, or opaque glazing material installed at a slope of 15 degrees or more from the vertical plane including skylights, roofs, and sloped walls shall comply with this section.

2204.2 Allowable glazing materials: Sloped glazing shall be any of the following materials, subject to the limitations specified in Section 2204.3 and the exceptions specified in Section 2204.4:

1. For monolithic glazing systems, the glazing material of the single light or layer shall be laminated glass with a minimum 30-mil polyvinyl butyral interlayer, wired glass, approved plastic materials, heat-strengthened glass, or fully-tempered glass;

2. For multiple layer glazing systems, each light or layer shall consist of any of the glazing materials specified in item 1 above.

For additional requirements for plastic skylights, see Section 2204.6. Glass block construction shall conform to the requirements of Section 1420.0.

2204.3 Limitations: Heat-strengthened glass and fully-tempered glass when used in monolithic glazing systems shall have screens installed below the glazing material, subject to exceptions in Section 2204.4, to protect building occupants from falling glass should breakage occur. The screens shall be capable of supporting the weight of the glass and shall be substantially supported below and installed within 4 inches of the glass. The screens shall be constructed of a noncombustible material not thinner than No. 12 B&S Gage (O.0808 inch) with a mesh not larger than 1 inch by 1 inch. In a corrosive atmosphere, structurally equivalent noncorrosive screening materials shall be used. Heat-strengthened glass, fully tempered glass, and wired glass when used in multiple layer glazing systems as the bottom glass layer over the walking surface shall be equipped with screening meeting the requirements specified for monolithic glazing systems.

2204.4 Exceptions: In monolithic and multiple layer sloped glazing systems, the following exceptions apply:

1. Fully-tempered glass installed without protective screens when glazed between intervening floors at a slope of 30 degrees or less from the vertical plane shall have the highest point of the glass 10 feet or less above the walking surface;

2. Any glazing material, including annealed glass, installed without screens shall have the walking surface below the glazing material permanently protected from the risk of falling glass or the area below the glazing material shall not be a walking surface; and

3. Any glazing material, including annealed glass, is permitted to be installed without screens in the sloped glazing systems of commercial or detached greenhouses used exclusively for growing plants and not accessible to the public, provided the height of the greenhouse at the ridge does not exceed 20 feet above grade. Greenhouse frames shall be noncombustible if the height of the sloped glazing exceeds 20 feet above grade.

2204.5 Framing: In Types 1 and 2 construction, all sloped glazing and skylight frames shall be constructed of noncombustible materials. In buildings where acid fumes deleterious to metal are incidental to the use of the buildings, approved pressure-treated woods or other approved noncorrosive materials shall be permitted for sash and frames. All sloped glazing and skylights shall be designed to meet all structural requirements for roofs specified in Article 11. All skylights set at an angle of less than 45 degrees from the horizontal plane shall be mounted at least 4 inches above the plane of the roof on a curb construction as required for the frame. Skylights shall not be installed in the plane of the roof where the roof pitch is less than 45 degrees from the horizontal.

Exception: Curbs for skylights are not required on roofs with a minimum slope of three units vertical in 12 units horizontal (3:12) in buildings of Use Group R-3.

2204.6 Light-transmitting plastic glazing of skylight assemblies: Skylight assemblies glazed with approved light-transmitting plastic materials shall conform to the provisions of Sections 2204.6.1 through 2204.6.7.

Exceptions:

1. These provisions shall not apply to a skylight of approved light-transmitting plastic on a building which is not more than one story in height, has a fire separation distance of at least 30 feet and the room or space sheltered by the roof is not classified as Use Group H, I-2 or I-3 or a means of egress.
2. These provisions shall not apply to skylights in which the approved light-transmitting plastic meets the required roof covering class according to Section 2301.0.

2204.6.1 Mounting: The plastic shall be mounted above the plane of the roof on a curb constructed consistent with the requirements for the type of construction classification, but at least 4 inches above the plane of the roof. Edges of plastic skylights or domes shall be protected by metal or other noncombustible material, or the plastic dome or skylight shall be shown to be able to resist ignition when exposed at the edge to a flame from a Class B brand as described in ASTM E108 listed in Appendix A.

Exceptions:

1. Curbs for skylights are not required when used on roofs with a minimum slope of 3 units vertical in 12 units horizontal (3:12) in buildings of Use Group R-3 and on buildings with an unclassified roof covering.

2. The metal or noncombustible edge material is not required where unclassified roof coverings are permitted.

2204.6.2 Slope: Flat or corrugated plastic skylights shall slope at least 4 units vertical in 12 units horizontal (4:12). Dome-shape skylights shall rise above the mounting flange a minimum distance equal to 10 percent of the maximum span of the dome, but not less than 3 inches.

Exception: Skylights which pass the Class B Burning Brand Test specified in ASTM E108 listed in Appendix A.

2204.6.3 Maximum area of skylight units: Each skylight unit shall have a maximum area within the curb of 100 square feet except that the area of skylight units shall not be limited in buildings equipped throughout with an approved automatic fire suppression system.

2204.6.4 Aggregate area of skylights: The aggregate area of skylights shall not exceed 33 percent of the floor area of the room or space sheltered by the roof in which they are installed when Class C1 materials are used, and 25 percent when Class C2 materials are used.

Exception: The aggregate area limitations of approved plastic skylights shall be increased 100 percent beyond the limitations set forth above where the building is equipped throughout with an approved automatic fire suppression system.

2204.6.5 Separation: Skylights shall be separated from each other by a distance of not less than 4 feet measured in a horizontal plane, except that the separation shall not be required where the building is equipped throughout with an approved automatic fire suppression system.

2204.6.6 Location: Where exterior wall openings are required to be fireresistance rated by Section 907.0, a skylight shall not be installed within 6 feet of such exterior wall.

2204.6.7 Combinations of roof panels and skylights: Combinations of plastic roof panels and skylights shall be subject to the area and percentage limitations and separation requirements applicable to roof panel installations.

SECTION 2205.0 LIGHT-TRANSMITTING PLASTIC GLAZING OF UNPROTECTED OPENINGS

2205.1 Use in Type 5B construction: In buildings of type 5B construction, doors, sashes and framed openings shall not be glazed with approved plastic materials unless such openings are not required to be fireresistance rated.

2205.2 Use Group F: In buildings of all types of construction of Use Group F, doors, sashes and framed openings shall not be glazed with approved plastic materials unless such openings are not required to be fireresistance rated.

2205.3 Other types of construction and use groups: In other types of construction and use groups, doors, sashes and framed openings shall not be glazed or equipped with approved plastic materials unless such openings are not required to be fireresistance rated according to Section 907.0 and the installation conforms to the requirements of Sections 2205.3.1 through 2205.3.4.

2205.3.1 Area: The area of such glazing shall not exceed 25 percent of the wall face of the story in which it is installed (see Section 2205.4).

2205.3.2 Size: The area of a unit or pane of glazing installed above the first story shall not exceed 16 square feet and the vertical dimension of a unit or pane shall not exceed 4 feet. There shall be a minimum 3 feet vertical spandrel wall between stories.

2205.3.3 Height: Approved plastics shall not be installed more than 70 feet above grade level.

2205.3.4 Protection: Approved thermoplastic materials installed in areas up to 50 percent of the wall area of each story in structures less than 150 feet in height shall be provided on each floor above the first floor with continuous architectural projections constituting an effective fire canopy extending at least 3 feet from the surface of the wall in which the glazing is installed. The size and the dimensions of individual units shall not be limited in such installations except as required to meet structural loading requirements.

2205.4 Automatic fire suppression: Where an approved automatic fire suppression system is provided throughout the building, the permissible area of glazing permitted by Section 2205.3.1 shall be increased 100 percent.

SECTION 2206.0 GLASS IN HANDRAILS AND GUARDRAILS

2206.1 Materials: Glass used as structural balustrade panels in railings shall be constructed of either single fully-tempered glass, laminated fully-tempered glass, or laminated heat-strengthened glass. Glazing in railing in-fill panels shall conform to ANSI Z97.1 listed in Appendix A or shall be an approved safety glazing material meeting the provisions of Section 2203.1. For all glazing types, the minimum nominal thickness shall be 1/4 inch. Fully tempered glass and laminated glass shall comply with Category 11 of CPSC 16 CFR Part 1201 listed in Appendix B. Wired glass shall comply with ANSI Z97.1 listed in Appendix A.

2206.1.1 Loads: The panels and their support system shall be designed to withstand the loads specified in Section 1109.7, **or Section 1109.8, as applicable**. A safety factor of four shall be used.

2206.1.2 Support: Each handrail or guardrail section shall be supported by a minimum of three glass balusters or be otherwise supported so that it remains in place should one baluster panel fail. Glass balusters shall not be installed without an attached handrail or guardrail.

2206.1.3 Parking garages: Glazing materials shall not be installed in railings in parking garages except for pedestrian areas not exposed to impact from vehicles.

SECTION 2207.0 GLAZING IN RACQUETBALL AND SQUASH COURTS

2207.1 Continuously hazardous locations: The following shall be considered continuously hazardous locations for purposes of glazing:

1. Glazing in squash and racquetball courts forming whole or partial wall sections.

2. Glazing in squash and racquetball courts used as a door or part of a door.

2207.2 Testing: Test methods and loads for individually glazed areas such as those described in Section 2207.1 shall conform to those of CPSC 16 CFR Part 1201 listed in Appendix B, with impacts being applied at a height from ground level of 59 inches to an actual or simulated glass wall installation with fixtures, fittings and methods of assembly identical to those used in practice. In order to be deemed acceptable, the following conditions shall be achieved for glass walls:

1. Any glass wall in a squash or racquetball court shall remain intact following a test impact.

2. The relative deflection of such walls shall not be greater than 1 1/2 inches at the point of impact.

In order to be deemed acceptable, the following conditions shall be achieved for glass doors:

1. Glass doors shall remain intact following a test impact at the prescribed height in the center of the door.

2. The relative deflection between the edge of a glass door and the adjacent wall shall not exceed the following values for the impact test bag drop heights specified below:
   a. The thickness of the wall plus 1/8 inch for a drop height of 24 inches.
   b. The thickness of the wall plus 1/4 inch for a drop height of 36 inches.
   c. The thickness of the wall plus 1/2 inch for a drop height of 48 inches.

ARTICLE 23

ROOFS AND ROOF COVERINGS

SECTION 2300.0 GENERAL

2300.1 Scope: The provisions of this article shall govern the materials, design, construction and quality of roofs and roof coverings. For the definition and requirements of approved light-transmitting plastics, see Section 2001.1.

SECTION 2301.0 FIRE CLASSIFICATION

2301.1 Classification: Roof covering materials shall be classified in accordance with Section 2301.3 when tested in accordance with ASTM E108 listed in Appendix A.

2301.2 Existing roofs: The repair of existing roofs shall comply with the provisions of Section 103.0, but more than 25 percent of the roof covering of any building shall not be replaced in a period of 12 months unless the entire roof covering is made to conform to the requirements for new roofing.

2301.3 Classification of use: Roof coverings shall be classified according to Sections 2301.3.1 through 2301.3.4.

2301.3.1 Class A roof coverings: Class A roof coverings are those which are effective against severe fire test exposure. Class A roof coverings shall include the following: masonry, concrete, slate, tile, or assemblies listed and identified as Class A by an approved testing agency. Class A roof coverings shall be permitted for use in buildings or structures of all types of construction.

2301.3.2 Class B roof coverings: Class B roof coverings are those which are effective against moderate fire test exposure. Class B roof coverings shall include metal sheets and shingles or assemblies listed and identified as Class B by an approved testing agency. Class B roof coverings shall be permitted as the minimum for use in buildings or structures of Type 1 construction.

2301.3.3 Class C roof coverings: Class C roof coverings are those which are effective against light fire test exposure. Class C roof coverings shall include assemblies listed and identified as Class C by an approved testing agency. Class C

roof coverings shall be permitted as the minimum for use in buildings or structures of Types 2, 3, 4 and 5A construction.

2301.3.4 Nonclassified roof coverings: Nonclassified roof coverings shall not be permitted.

Exceptions:
1. Buildings and structures of Type 5B construction with a fire separation distance of not less than 30 feet from the leading edge of the roof.
2. Detached buildings of Use Group R-3, and accessory buildings thereto, which have a fire separation distance of not less than 6 feet from the leading edge of the roof.

2301.4 Roof Insulation: The use of cork, fiber board and other combustible roof insulation shall be permitted, provided it is covered with approved roof coverings directly applied thereto (see Section 2002.3.4).

2301.5 Grounding of metal roofs: Whenever, because of hazard resulting from electrical equipment or apparatus located thereon, or because of proximity to power lines, or for any other reason, it is deemed necessary by the building official, metal roofs shall be grounded by bonding together each course or strip. The bonding conductor or conductors shall be extended to and attached in an approved manner to the grounding electrode used to ground the electrical system within the building on which such metal roofing is applied. The conductors used to bond courses or strips of metal roofing together, or any conductor extended for grounding to the grounding electrode, shall not have greater resistance than the conductor used to ground the electrical system within the building.

2301.5.1 Alternative methods of grounding metal roofing: Alternate methods of grounding metal roofing shall not be used unless they are at least equal in performance to the methods described herein and are approved.

SECTION 2302.0 WOOD SHINGLES

2302.1 General: Wood shingles, handsplit shakes and taper-sawn shakes used for roof covering where permitted in Section 2301.0 shall comply with the RCSHSB *Grading Rules for CertiGrade Red Cedar* or the TFS *Grading Rules for Pressure Treated Southern Pine Taper-Sawn Shakes* listed in Appendix A, and shall be installed on tight decking or on spaced roof boards.

2302.2 Reroofing: Not more than one overlay of wood shakes shall be applied over an existing asphalt shingle or wood shingle roof. One layer of 18-in Type 30 felt shall be interlaced between each layer of shakes.

2302.3 Application over shakes: New roof covering shall not be applied over existing shake roof.

SECTION 2303.0 ASPHALT SHINGLES

Note: The term "asphalt shingle" includes shingles made with a felt(cellulose) and/or fiberglass base.

2303.1 General: Asphalt shingle roofs with a slope of four units vertical in 12 units horizontal (4:12) or more shall have an underlay consisting of Type 15 saturated felt, adequately attached. Where January daily average temperature is 25 degrees F. (-4 degrees C.) or less, or where there is possibility of ice forming along the eaves and causing a backup of water, an eaves flashing strip of mineral surfaced roll roofing shall be applied to extend to a point 12 inches minimum inside the interior wall line of the building. Asphalt shingles laid shall not be installed on slopes below 4:12 to as low as 2:12 unless the shingles are laid with double coverage, are self-sealing shingles or are hand-sealed and are installed with an underlayment consisting of two layers of Type 15 felt applied shingle fashion. In areas where the January daily average temperature is 25 degrees F. (-4 degrees C.) or less, or where there is a possibility of ice forming along the eaves and causing a backup of water, the two layers of felt shall be cemented together from the eaves up the roof to overlie a point 24 inches inside the interior wall line of the building.

2303.2 Reroofing: Not more than two overlays of asphalt shingles shall be applied over an existing asphalt shingle roof. Not more than two overlays of asphalt shingles shall be applied over wood shingles. Asphalt shingles applied over wood shingles shall have an underlay of not less than Type-30 nonperforated felt.

SECTION 2304.0 FLASHINGS

2304.1 General: Flashings shall be installed at the intersection of chimneys or other masonry construction with frame or stucco walls, with projecting lips on both sides under stucco copings; under and at the ends of masonry, wood or metal copings and sills; continuously above all projecting wood trim; at wall and roof intersections; built-in gutters; at junctions of chimneys and roofs; and in all roof valleys and around all roof openings.

SECTION 2305.0 FASTENING

2305.1 General: All roof coverings shall be securely nailed with aluminum, copper, zinc, zinc-coated or other approved corrosion-resistive nails in accordance with the nailing schedule in Appendix C or the approved manufacturer's recommendations.

Wood shingles or shakes shall not be applied over fiber board shingle backer or fiber board sheathing unless the installation is in accordance with the approved manufacturer's recommendations and the shingles or shakes are attached with approved corrosion-resistive annular grooved nails. Where wood shingles or shakes are nailed directly to nail base fiber board sheathing not less than ½ inch nominal thickness, approved corrosion-resistive annular grooved nails shall be used and the installation shall be in accordance with the approved manufacturer's recommendations.

SECTION 2306.0 LIGHT-TRANSMITTING PLASTIC ROOF PANELS

2306.1 General: Approved light-transmitting plastic roof panels shall not be installed in buildings of Use Groups H, I-2 and I-3. In all other uses, approved light-transmitting plastic roof panels shall not be installed unless one of the following conditions applies:

1. The building is equipped throughout with an approved automatic fire suppression system;
2. The roof construction is not required to have a fireresistance rating by Table 401; or
3. The roof panels meet the requirements for roof coverings.

2306.2 Separations: Individual roof panels shall be separated from each other by a distance of not less than 4 feet measured in a horizontal plane, except that the separation between roof panels is not required in a building equipped throughout with an approved automatic fire suppression system.

2306.3 Location: Where exterior wall openings are required to be fireresistance rated by Section 907.0, a roof panel or unit shall not be installed within 6 feet of such exterior wall.

2306.4 Area limitations: Roof panels or units shall be limited in area and the aggregate area of panels shall be limited by a percentage of the floor area of the room or space sheltered in accordance with Table 2306.

Exceptions:

1. The area limitations of Table 2306 shall be increased 100 percent in buildings equipped throughout with an approved automatic fire suppression system.
2. Low hazard use buildings such as swimming pool shelters and greenhouses are exempt from the area limitations of Table 2306 provided the buildings do not exceed 5,000 square feet in area and have a minimum fire separation distance of 4 feet.

3. Roof coverings over terraces and patios of buildings of Use Group R-3 are exempt from the area limitations of Table 2306 and shall be permitted with approved plastics.

Table 2306
AREA LIMITATIONS FOR ROOF PANELS

Class of plastic	Maximum area Individual Unit of panel (sq. ft.)	Maximum aggregate Area (% of floor area)
C1	300	30
C2	100	25

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ARTICLE 24

MASONRY FIREPLACES

SECTION 2400.0 GENERAL

2400.1 Scope: The provisions of this article shall govern the design, installation, maintenance, repair, and approval of all masonry fireplaces.

2400.2 Mechanical code: All masonry fireplaces shall conform to the pertinent requirements of the BOCA National Mechanical Code listed in Appendix A.

SECTION 2401.0 PLANS AND SPECIFICATIONS

2401.1 General: The plans and specifications shall describe in sufficient detail the location, size, and construction of all masonry fireplaces. The thickness and character of all material and the clearances from walls, partitions and ceiling shall be clearly shown and described.

SECTION 2402.0 CONSTRUCTION REQUIREMENTS

2402.1 Dimensions: The firebox of a masonry fireplace shall have a minimum depth of 20 inches. The size of the chimney connection shall be a minimum cross-sectional area of 50 square inches. The minimum cross-sectional area of the fireplace shall equal the cross-sectional area of the chimney connection.

> **Exception: When the functional design of a fireplace requires a firebox depth of less than twenty (20) inches, hearth extensions as outlined in Section 2402.3.1 shall be increased. The combined dimension of the firebox and hearth extension shall not be less than thirty-six (36) inches.**

2402.2 Wall construction: Fireplace walls lined with a minimum of 2 inches of low-duty refractory brick conforming to ASTM C64 listed in Appendix A shall be a minimum total thickness of 8 inches solid masonry. Medium-duty fire clay mortar conforming to ASTM C105 listed in Appendix A or equivalent shall be used with the low-duty refractory brick. Unlined fireplace walls shall be solid masonry having a minimum total thickness of 12 inches.

2402.2.1 Extension of liners: The liner of the fireplace walls shall extend a minimum of 4 inches into the throat of the fireplace.

2402.2.2 Throat and smoke chamber: The walls of the throat and smoke chamber shall be solid masonry having a minimum thickness of 8 inches.

2402.2.3 Heat exchanger: Gravity-fed heat exchangers installed in the walls of masonry fireplaces shall not reduce the total thickness of solid masonry.

2402.3 Foundation and hearth: The foundation of a fireplace shall be constructed with noncombustible material and shall conform to the requirements of Article 10. The hearth and hearth extension shall be a minimum of 4 inches solid masonry.

2402.3.1 Hearth extension: The hearth shall extend a minimum of 16 inches beyond the face of the fireplace opening and a minimum of 8 inches on each side of the fireplace opening for fireplaces having an opening of less than 6 square feet. The hearth of larger size fireplaces shall extend a minimum of 20 inches beyond the face of the fireplace opening and a minimum of 12 inches on each side of the fireplace opening.

2402.4 Clearance to combustibles: The exterior surface of fireplace walls shall have a minimum 4 inches clearance to combustibles. The opening of fireplaces shall have a minimum 6 inches clearance to combustible.

2402.5 Opening to the chimney: Means shall be provided to shut off the opening to the chimney when the fireplace is not in operation.

2402.5.1 Dampers: Dampers shall be constructed of metal having a minimum thickness of No. 12 Manufacturer's Standard Gage.

2402.6 Chimneys with metal hoods: Metal hoods shall extend a minimum of 6 inches beyond the firebox. The hoods shall comply with the requirements for metal chimneys.

ARTICLE 25

MECHANICAL EQUIPMENT AND SYSTEMS

SECTION 2500.0 GENERAL

2500.1 Scope: The provisions of this article shall control the construction, inspection and maintenance of all mechanical equipment and systems in respect to structural strength, fire safety and operation. **For the purposes of this article, mechanical equipment shall also include solid fuel burning heating appliances and power venters.**

2500.2 Mechanical code: All mechanical equipment and systems shall be constructed, installed and maintained in accordance with **this code and** the BOCA National Mechanical Code listed in Appendix A.

2500.3 Commonwealth of Massachusetts requirements: All installations of gas appliances shall comply with the Massachusetts Fuel Gas Code, 248 CMR 3.00-8.00, as listed in Appendix G. The construction, installation and operation of oil burning equipment is subject to the provisions of 527 CMR 4.00. The construction, installation, testing and inspection of boilers, unfired pressure vessels, air tanks, ammonia compressor valves and refrigeration and air-conditioning systems of twenty (20) tons or more capacity are subject to the provisions of 522 CMR 2.00-12.00, and chapter 146 of the Massachusetts General Laws Annotated, as amended.

SECTION 2501.0 PLANS AND SPECIFICATIONS

2501.1 General: Plans and specifications for the installation, repair, extension or removal of any mechanical equipment or system shall be submitted in accordance with the BOCA National Mechanical Code listed in Appendix A, and a permit shall be secured prior to the commencement of any work.

2501.2 Matter covered: The plans and specifications shall show in sufficient detail all pertinent features and clearances of the appliances and systems, including: size and type of apparatus; construction of flue, stack or chimney; stack connections; type of fuel; method of operation; and the method of compliance with all regulations for the class and type of equipment installed.

2501.3 Details: An application for permit shall be accompanied by specifications and diagrammatic mechanical drawings in sufficient detail, complying with the provisions of the BOCA National Mechanical Code listed in Appendix A, before a permit shall be issued for the mechanical equipment and/or system. The plans shall be drawn to a scale of not less than 1/8 inch to the foot and shall show the location and arrangement of all equipment and distribution elements including safeties and pressure-controlling devices.

SECTION 2502.0 INSPECTIONS AND TESTS

2502.1 Inspection: All mechanical equipment and systems requiring a permit shall, **when applicable,** be inspected in accordance with the BOCA National Mechanical Code listed in Appendix A and shall not be placed in operation until having been tested and approved.

2502.2 Concealment: It shall be unlawful for owners, contractors or workers to lath over or in any way to conceal any piping, outlet boxes or other parts of the mechanical equipment or system requiring a permit until an inspection has been made thereof and due notice given that the work has been approved.

2502.3 Defects and repairs: Upon inspection or reinspection of a mechanical system, any defects or deficiencies which require repair to insure safe operation shall be rectified before the system is placed in use.

2502.4 Power to deem unsafe: When a system or any part thereof is found unsafe to life or property, it shall be deemed unsafe and such system shall not be restored to use until it has been made safe and approved.

SECTION 2503.0 EXISTING BUILDINGS

2503.1 Unsafe orders: All existing mechanical equipment and systems shall be maintained and operated in accordance with the requirements of this code and the BOCA National Mechanical Code listed in Appendix A. Any such equipment which does not comply with the requirements, and the operation of which is deemed unsafe to the building occupants, shall be altered as ordered by the code official to secure adequate safety.

SECTION 2504.0 FEES

2504.1 General: A permit to begin work for new construction or alteration shall not be issued until the prescribed application and permit fees have been paid, nor shall an amendment to a permit necessitating an additional fee because of the additional work involved be issued until the additional fee has been paid.

SECTION 2505.0 DRYING ROOMS

2505. 1 General: A drying room or dry kiln installed within a building shall be constructed entirely of approved noncombustible materials or assemblies of such materials with the required fireresistance rating based on the fire hazard of the contents and the process, as regulated by the approved rules or as required in Article 6 for special uses.

2505.2 Piping clearance: All overhead heating pipes shall have a clearance of not less than 2 inches from combustible contents of the dryer.

2505.3 Insulation: When the operating temperature of the dryer is 175 degrees F. or more, metal enclosures shall be insulated from adjacent combustible materials by not less than 12 inches of air space, or the metal walls shall be lined with 1/4-inch asbestos mill board or other approved equal insulation.

2505.4 Fire protection: Drying rooms designed for high hazard materials and processes, including special uses provided for in Article 6, shall be protected by an approved automatic fire suppression system conforming to the provisions of Article 10.

SECTION 2506.0 WASTE AND LINEN HANDLING SYSTEMS

2506.1 General: Waste and linen handling systems shall be installed in accordance with the provisions of Chapters 3 and 4 of NFiPA 82 listed in Appendix A.

SECTION 2507.0 REFUSE VAULTS

2507.1 Refuse vault enclosures: A vault for receiving combustible refuse from an exhaust system shall be constructed of not less than 3-hour fireresistance rated assemblies.

2507.2 Openings to boiler rooms: The opening between a vault and a boiler room shall not exceed 9 square feet in area and shall be located at least 8 feet from the firing door of the boiler, and the bottom of the opening shall be not less than 6 inches above the boiler room floor. All openings shall be equipped with fire doors of not less than 1 1/2-hour fireresistance rating complying with Section 916.0.

2507.3 Location: When located within a building, a refuse vault shall extend above the roof or shall be directly vented to the outer air with ducts complying with the BOCA National Mechanical Code listed in Appendix A.

2507.4 Fire protection: A vault for combustible refuse which exceeds 360 cubic feet in volume shall be protected by an approved automatic fire suppression system conforming to Article 10.

SECTION 2508.0 DUST, STOCK AND REFUSE CONVEYOR SYSTEMS

2508.1 Power transmission: Power for fans located in rooms from which flammable dust is being removed shall be transmitted by means of a shaft passing through a bushed hole, or by a belt, chain or similar driving mechanism which is encased in a metal or other noncombustible dust-tight enclosure, both within and without the room.

2508.2 Collectors and separators: Cyclone collectors and separators and their supports shall be constructed of noncombustible materials and shall be located whenever possible on the exterior of the building or structure. A collector or separator shall not be located nearer than 10 feet to combustible construction or to an unprotected wall or floor opening, unless the collector is provided with a metal vent pipe which extends above the highest part of any roof within a distance of 30 feet.

2508.3 Discharge pipes: Discharge pipes shall conform to all the requirements for ducts, including clearances required for high heat appliances, as contained in the BOCA National Mechanical Code listed in Appendix A. A delivery pipe from a cyclone collector shall not convey refuse directly into the firebox of a boiler, furnace, dutch oven, refuse burner, incinerator or other appliance.

2508.4 Vents for exhaust conveyor systems: An exhaust system shall be vented to the outside of the building either directly by flue, or indirectly, through the separator, bin, or vault into which it discharges.

2508.5 Spark protection: The outlet of an open air vent shall be protected with an approved metal or other noncombustible screen or by other equally efficient means to prevent the entry of sparks.

2508.6 Explosion relief vents: A safety or explosion relief vent shall be provided on all systems which convey combustible refuse or stock of an explosive nature, in accordance with the requirements of Section 618.0.

2508.6.1 Screens: When a screen is used in a safety relief vent, it shall be so attached as to permit ready release under emergency pressure.

2508.6.2 Hoods: The relief vent shall be provided with an approved noncombustible cowl or hood, or with a counterbalanced relief valve or cover arranged to prevent the escape of hazardous materials, gases or liquids.

SECTION 2509.0 MEDICAL GASES

2509.1 Nonflammable medical gases: Nonflammable medical gas systems shall be designed and installed in accordance with NFiPA 56F listed in Appendix A.

2509.2 Anesthetic systems: Inhalation anesthetic systems shall be designed and installed in accordance with Chapters 3 and 4 of NFiPA 99 listed in Appendix A.

SECTION 2510.0 OXYGEN SYSTEMS

2510.1 General: Nonmedical oxygen systems shall be designed and installed in accordance with NFiPA 50 and NFiPA 51 listed in Appendix A.

SECTION 2511.0 BOILER ROOMS

2511.1 Boiler room: Every boiler or combination boiler and cooling unit shall be installed in a space which allows a minimum clearance of twenty-four (24) inches on all service sides. Such room shall be constructed of at least one (1) hour fireresistance rated construction, and the door shall be a Class C fire door or a one and three-quarter (1 3/4) inch solid wood core door. Such door shall be equipped with an automatic self-closer. Combustion air shall be provided to such room in conformance with the BOCA National Mechanical Code listed in Appendix A. Storage or living quarters shall not be permitted in any boiler or similar heating equipment room.

> **Exception: One- and two-family dwellings, except for combustion air requirements as set forth in the BOCA National Mechanical Code listed in Appendix A.**

2511.2 Boiler room location: Boiler rooms shall not be located immediately below exitways; nor shall any space heater, floor furnace or other similar equipment be located in any aisle or passageway used as an element of a required means of egress from the building or structure.

SECTION 2512.0 SOLID FUEL BURNING HEATING APPLIANCES

2512.1 General: The design, installation, construction and repair of solid fuel burning heating appliances shall be in accordance with the BOCA National Mechanical Code listed in Appendix A, and by any applicable sections of this, the Building Code.

2512.1.1 Installation clearances: Clearance shall be provided from combustible construction in accordance with manufacturers' recommendations, or in accordance with Table 2512.1.1 (for solid fuel burning room heaters only) when manufacturers' recommendations are not available.

Table 2512.1.1
INSTALLATION CLEARANCES, SOLID FUEL BURNING HEATING APPLIANCES

Type of vent	Above top of casing or appliance (inches)	From front (inches)	From back (inches)	From sides (inches)	Chimney connector (inches)
Circulating type, vented or unvented	36	24	12	12	18
Radiant or other type, vented or unvented	36	36	36	36	18

Note 1: The floor shall be of masonry or other noncombustible construction with not less than a one (1) hour fire resistance rating and shall extend twelve (12) inches beyond the appliance on all sides and at least eighteen (18) inches on the fuel and ash access side. Solid fuel heaters may be installed on a combustible floor if the appliance is listed for such installation or if the floor is protected in an approved manner.

2512.1.2 Reduced clearances: Installation clearances may be decreased according to Table M-1101.2 of Article 11 of the BOCA Mechanical Code listed in Appendix A.

2512.2 Central heating appliance installation: Solid or solid/liquid fueled heating (central heating) appliances installed into an existing liquid or gas-fueled central heating system shall be positioned downstream of the existing appliance, and in accordance with the manufacturer's instructions.

2513.0 Power Venters (Power Exhausters)

2513.1 Power Venters used for the direct venting of comfort heating and/or comfort cooling appliances: The direct venting (through-the-sidewall combustion product exhaust venting) of comfort heating and/or comfort cooling appliances may be accomplished via the use of direct venting systems that are listed or are part of the listed appliances. A listed direct venting system or comfort heating or comfort cooling appliances that are listed are equipment that have been tested for the intended design conditions by established and recognized agencies regularly engaged in conducting tests or furnishing inspection services. Such listed equipment will

typically bear a plate, label or other means of identification indicating the listing agency and other pertinent information.

2513.2 Automatic safe shutoff: Power venters shall operate in such a manner and be electrically connected to the comfort heating and/or comfort cooling appliances in such a way as to prevent the operation of such appliances when the power venter is not in operation or is not providing sufficient draft for the appliance being vented.

2513.3 Installation of direct venting equipment: Direct venting equipment shall be installed in accordance with the manufacturer's installation manual and instructions (typically, only personnel trained in the installation of such equipment are accepted by the manufacturer as qualified to install). Power venters shall be selected to match the venting requirements of the equipment being vented in accordance with the manufactureer's requirements.

2513.4 Termination: The vent system shall terminate so that proper clearances are maintained in accordance with the National Fuel Gas Code, ANSI Z223.1 or in accordance with the manufacturer's recommendations - the more stringent of such requirements shall apply.

2513.5 Other applications of power exhausters: For applications of power exhausters for other than the venting of comfort heating appliances and/or comfort cooling appliances, the requirements of the BOCA Mechanical Code, listed in Appendix A, shall apply.

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ARTICLE 26

ELEVATOR, DUMBWAITER AND CONVEYOR EQUIPMENT INSTALLATION AND MAINTENANCE

SECTION 2600.0 GENERAL

2600.1 Scope: Except as otherwise provided by statute, the provisions of this article shall control the design, construction, installation, maintenance and operation of all elevators, dumbwaiters, escalators, moving walks and special hoisting and conveying equipment hereafter operated, installed, relocated or altered in all buildings and structures. The design, construction, installation, maintenance and operation of all miscellaneous hoisting and elevating equipment and amusement devices shall be subject to such special requirements as are deemed necessary by the **authority having jurisdiction** to secure their safe operation. The provisions of this article shall not apply to portable elevating devices used to handle materials only, and located and operated entirely within one story. The construction, alteration, maintenance, operation, inspection and tests of manlifts **are prohibited.**

2600.2 Referenced standard: Except as otherwise provided in this code, and except where more restrictive provisions govern, the construction, alteration, maintenance, operation, inspections and tests of elevators, dumbwaiters, moving walks and escalators shall conform to ASME A17.1 listed in Appendix A and 524 CMR and Modifications listed in Appendix G.

2600.3 Purpose and exceptions: The purpose of this code is to provide reasonable safety for life and limb. In case of practical difficulty or unnecessary hardship, the **state elevator inspector** shall grant exceptions from the literal requirements or permit the use of other methods, but only when it is clearly evident that reasonable safety is thereby secured.

SECTION 2601.0 PLANS, SPECIFICATIONS AND PERMITS

2601.1 Application: The person responsible for the installation, relocation, or alteration of any equipment covered by this article shall file an application for permit with the **state elevator section**, accompanied by governing specifications and scaled or fully-dimensioned plans with sufficient clarity and detail showing: the location of the installation in relation to the plans and elevation of the building; the

location of the machinery room and equipment to be installed, relocated or altered; and all structural supporting members thereof, including foundations. Such plans and specifications shall specify all materials to be employed and all loads to be supported or conveyed and shall be sufficiently complete to illustrate all details of construction and design.

2601.2 Permits: Equipment or devices subject to the provisions of this code shall not be constructed, installed, relocated or altered unless a permit has been received from the **state elevator inspector** before the work is commenced. A copy of such permit shall be kept at the construction site at all times while the work is in progress.

2601.3 Identification of equipment: In buildings containing more than one elevator or device and where such devices are subject to **annual** inspections, each such elevator or device shall be identified by a serial number, in figures not less than 1 inch high, attached to, painted, stenciled or otherwise registered on the crosshead of the elevator car and on the motor or machine; and on devices other than elevators, on the motor or machine. After such devices have been so designated, their numbers shall not be changed, except by permission of the **state elevator inspector**, and all correspondence in regard to such device shall refer to said number.

SECTION 2602.0 TESTS AND INSPECTIONS

2602.1 General: All equipment and devices covered by the provisions of this code shall be subjected to acceptance and maintenance tests and **annual** inspections as required herein.

2602.2 Acceptance tests: Acceptance tests and inspections shall be required on all new, relocated and altered equipment subject to the provisions of this article. Tests and inspections shall be of such nature as to determine whether the entire installation is designed, constructed and installed in compliance with this code, and shall include all parts of the equipment and machinery. All such tests shall be made in conformance with the requirements of Section 2602.5, in the presence of the **state elevator inspector**, by the person installing such equipment.

2602.3 Annual tests and periodic inspections: **Annual** tests shall be required on all new and existing power elevators, and periodic inspections shall be made of all new and existing equipment subject to the provisions of this article.

2602.3.1 Annual tests: **Annual** tests shall be made by the **state elevator inspector**, or by an approved agency, and shall be made at the expense and responsibility of the owner. Where such tests are not made by the **state elevator inspector**, the approved

agency shall submit a detailed report of the tests to the **state elevator inspector** on approved forms not more than 30 days following the completion of the tests.

2602.3.2 Periodic inspections: Periodic inspections **may** be made by the **state elevator inspector**, or by an approved agency. Where such inspections are not made by the **state elevator inspector**, the approved agency shall submit a detailed report of the inspection to the **state elevator inspector** on approved forms not more than 30 days following the completion of the inspection.

2602.4 Frequency of tests and inspections: Tests and inspections shall be conducted at frequencies specified in **524 CMR and Modifications.**

2602.4.1 Periodic inspection intervals: Miscellaneous hoisting and elevating equipment, conveyors and amusement devices shall be inspected at such intervals as are deemed necessary by the **authority having jurisdiction** to insure safety of operation.

2602.4.2 Annual tests: **Annual** tests shall be made as set forth in **524 CMR and Modifications.**

2602.5 Minimum requirements for tests and inspections: The minimum requirements for the inspection and test of the devices subject to this article shall conform to this section.

2602.5.1 Elevators, dumbwaiters and escalators: The equipment and machinery of elevators, dumbwaiters and escalators shall be inspected and tested to the requirements of **524 CMR and Modifications.**

2602.5.2 Freight lifts, conveyors and amusement devices: Freight lifts, conveyors and amusement devices shall be inspected and subjected to tests **by the authority having jurisdiction** to insure the load capacity and safety of operation. The tests shall cover all operating protectives and safety devices, structural adequacy of the supports, and anchorage to floors, walls, ceilings and foundations.

2602.5.3 Manlifts: **Manlifts are prohibited.**

2602.5.4 Miscellaneous hoisting and elevating equipment: All miscellaneous hoisting and elevating equipment shall be subjected to such tests and inspections as required by the **authority having jurisdiction** to insure safe operation.

SECTION 2603.0 CERTIFICATE OF COMPLIANCE

2603.1 General: The operation of all equipment governed by the provisions of this article and **524 CMR and Modifications** and hereafter installed, relocated or altered shall be unlawful by persons other than **a licensed** installer thereof until such equipment has been inspected and tested as herein required and a final or limited certificate of compliance has been issued therefor by the **authority having jurisdiction**.

2603.2 Final certificate of compliance: The **state elevator inspector, or other authority having jurisdiction,** shall issue a final certificate of compliance for each unit of equipment which has satisfactorily met all the inspections and tests required by this article. Such final certificate shall designate the rated load and speed, the date of the acceptance tests and inspections, and the name of the **state elevator inspector** who made or witnessed such tests and inspections.

2603.3 Limited certificate of compliance: The **state elevator inspector** is authorized to issue a limited certificate of compliance for any equipment covered by this article, which is hereafter being installed, relocated or altered, to permit its limited use by the person designated therein during the period of such installation, relocation or alteration. Such certificate shall be signed by the **state elevator inspector, or other authority having jurisdiction,** shall bear the dates of issue, renewal and expiration, and shall designate the class of service allowed.

2603.3.1 Tests and minimum safeguards required: A limited certificate shall not be issued for an elevator until such elevator has satisfactorily passed tests for rated load, car and counterweight safety, and terminal stopping devices. Permanent or temporary guards and enclosures shall be installed on the car, around the hoistway and at the landing entrances. Equipment other than elevators shall be tested and protectives provided as deemed necessary by the **state elevator inspector** to insure safe operation for the limited service specified.

2603.3.2 Special conditions: Automatic and continuous-pressure operation elevators shall not be placed in temporary operation from the landing pushbuttons unless the door locking device and interlocks required by ASME A17.1 listed in Appendix A are installed and operative. When the car can be operated only from the inside, landing entrance guards shall be provided with locks that can be released from the hoistway side only.

2603.3.3 Time limitation: Limited certificates of operation shall be issued for periods of not more than 30 days. The **state elevator inspector, or other authority having jurisdiction,** is authorized to renew the limited certificates of operation for additional periods of not more than 30 days each.

2603.4 Posting certificates of compliance: The owner or lessee shall post the last-issued certificate of compliance in a conspicuous place available to the **state elevator inspector.**

SECTION 2604.0 MAINTENANCE AND ACCIDENTS

2604.1 Owner responsibility: The owner or the owner's legal agent for the building in which the equipment is located shall be responsible for the care, maintenance and safe operation of all equipment covered by this article after the installation thereof and its acceptance by such owner or agent. The owner or legal agent shall make or cause to be made all periodic tests and inspections, and shall maintain all equipment in a safe operating condition, as required by this article **and MGL Chapter 143, Section 62A.**

2604.2 Contractor responsibility: The person installing any device covered by this article shall make all acceptance tests **in the presence of a state elevator inspector, or other authority having jurisdiction, until certified** and be responsible for the care and safe operation of such equipment during its construction and until accepted by the building owner or the owner's legal agent.

2604.3 Maintenance items: All operating and electrical parts and accessory equipment or devices subject to this article shall be maintained in safe operating condition. The maintenance of elevators, dumbwaiters and escalators shall conform to ASME A17.1 listed in Appendix A **and 524 CMR and Modifications listed in Appendix G.**

2604.4 Unsafe conditions: If upon inspection any equipment covered in this article is found in an unsafe condition, or not in accordance with the provisions of this code, the **state elevator inspector, or other authority having jurisdiction,** shall thereupon serve a written notice of such finding upon the building owner or lessee, stating the time when recommended repairs or changes shall be completed. After the service of such notice, it shall be the duty of the owner to proceed within the time allowed to make such repairs or changes as are necessary to place the equipment in a safe condition. It shall be unlawful to operate such equipment after the date stated in the notice unless such recommended repairs or changes have been made and the equipment has been approved, or unless an extension of time has been secured from the **state elevator inspector, or other authority having jurisdiction,** in writing.

2604.4.1 Power to seal equipment: The **state elevator inspector** in addition to any other penalties herein provided, shall have the power to seal out of service any device or equipment **under his jurisdiction** covered by this article when in case of emergency in the opinion of the **state elevator inspector**, such device is in a condition to render it unsafe for operation; or for willful failure to comply with recommendations and orders.

2604.4.2 Notice of sealing out of service: Before sealing any device out of service, the **state elevator inspector**, except in case of emergency, shall serve written notice upon the building owner or lessee stating intention to seal the equipment out of service and the reasons therefor.

2604.4.3 Unlawful to remove seal: Any device sealed out of service by the **state elevator inspector** shall be plainly marked with a sign or tag indicating the reason for such sealing. Any tampering with, defacing or removal of the sign, tag or seal without approval shall constitute a violation of this article.

2604.5 Accidents reported and recorded: The owner of the building shall immediately notify the **state elevator inspector** of every accident involving personal injury or damage to apparatus on, about or in connection with any equipment covered by this article, and shall afford the **state elevator inspector** every facility for investigating such accident. When an accident involves the failure, breakage, damage or destruction of any part of the apparatus or mechanism, it shall be unlawful to use such device until after an examination by the **state elevator inspector** is made and approval of the equipment for continued use is granted. It shall be the duty of the **state elevator inspector** to make a prompt examination into the cause of the accident and to enter a full and complete report thereof in the records of the **state elevator section**. Such records shall be open for public inspection at all reasonable hours.

2604.6 Removal of damaged parts: It shall be unlawful to remove from the premises any part of the damaged construction or operating mechanism of elevators, or other equipment subject to the provisions of this article, until permission to do so has been granted by the **state elevator inspector.**

SECTION 2605.0 EXISTING INSTALLATIONS

2605.1 Retroactive provisions: The provisions of this article are not retroactive except as specifically provided hereunder; and except further that if, upon inspection of any device covered by this code, the equipment is found in a dangerous condition, or there is an immediate hazard to those riding on or using such equipment, or if the design or the method of operation in combination with devices used is considered inherently dangerous in the opinion of the **state elevator inspector, ~~the authority having jurisdiction, the state elevator inspector~~, or the authority having jurisdiction,** shall notify the owner or lessee in writing of the existing condition and shall recommend such alterations or additions as are deemed necessary to eliminate the dangerous situation.

2605.2 Projections into hoistway: All ledges, floor beams, saddles, timbers and other projections that project more than 2 inches from the inside of the general surface of the hoistway enclosure shall be fitted with smooth beveled guards set directly over the entire length of the projection, except door interlocks and contacts,

door closers, door tracks and hangers, and door operating or signal devices in front of car openings, landing sills and separator beams between adjacent elevators. The angle of the bevels or guard plates shall be not less than 60 degrees from the horizontal **(not applicable prior to July 7, 1989).**

2605.3 Emergency interlock release switch: Emergency interlock release switches are prohibited.

2605.4 Lighting: The cars and entrances of all elevators shall be properly lighted at all times when in service. Minimum illumination shall be not less than 5 foot candles at the landing edge of the platform.

2605.5 Belt and chain-driven machines: Single-belted and chain-driven machines are permitted only on freight elevators, and only when equipped with electrically-released spring-applied brakes and with terminal-stopping and electrical safety devices required for new electric elevators. The brakes shall be applied directly to the hoisting machine and shall be arranged to operate automatically if the driving belt or chain breaks or comes off. Doublebelted elevator are permitted only on freight elevators and when driven by a line shafting which is used to apply power for other purposes.

2605.6 Replacement or relocation of gate switches or interlocks: The **state elevator inspector** shall require the replacement or relocation of car gate electric contacts, safety cutout switches or interlocks where such devices are found to be tied or blocked so as to render them inoperative.

2605.7 Removal of pipes from hoistway: The **state elevator inspector** shall order the removal from existing elevator hoistways of any pipe conveying gases, vapors or liquids which would endanger life if discharged into the hoistway or ignited.

2605.8 Existing passenger elevators: In addition to other provisions of this section, existing passenger elevators shall comply with Sections 2605.8.1 through 2605.8.5, **where applicable.**

2605.8.1 Hoistway enclosure: All existing passenger hoistways shall be fully enclosed from floor to ceiling on all floors to comply with Section 2608.0.

2605.8.2 Hoistway doors and interlocks: All existing electric and electrically controlled and operated hydraulic passenger elevators equipped with mechanical locks and electrical contacts in good operating condition are not required to be removed or altered. If not so equipped, such passenger elevators shall be provided with hoistway landing doors equipped with approved interlocks conforming to the requirements for new elevators; except that where approved interlock switches are installed in connection with existing hoistway door closers, the combination door

closer and interlocks shall conform to all the requirements for approved interlocks, except as to the required tests.

2605.8.3 Car doors and gates: All openings on existing elevator cars shall be provided with doors or gates. Car doors and gates of electric or electrically controlled and operated hydraulic passenger elevators shall be provided with approved car door or gate electric contacts conforming to **524 CMR and Modifications.**

2605.8.4 Hydraulic passenger elevators: Hydraulic passenger elevators, except those equipped with electric control and operating devices, shall be provided with self-closing hoistway doors arranged to lock automatically when closed. Car doors or gates on electric or electrically controlled and operated hydraulic elevators shall be equipped with car door or gate electric contacts conforming to the requirements for new elevators.

2605.8.5 Emergency signal or telephone: Existing power passenger and freight elevators shall be provided with emergency signal devices conforming to the requirements of **524 CMR and Modifications.**

2605.9 Existing freight elevators: In addition to other provisions of this section, existing freight elevators shall comply with Sections 2605.9.1 through 2605.9.5.

2605.9.1 Hoistway enclosure: If not now enclosed, enclosures shall be required on existing freight elevators as required for existing passenger elevators in Section 2605.8, except as provided in Section 2605.9.3.

2605.9.2 Hoistway doors: All landing openings in existing electric or electrically controlled and operated hydraulic freight elevator hoistways which are enclosed in fireresistance rated partitions shall be provided with fire doors equipped either with approved hoistway door interlocks, or approved hoistway door electric contacts and mechanical locks conforming to **524 CMR and Modifications**, or with fusible links and automatic self-closing devices.

2605.9.3 Landing gates: Where automatic self-closing landing doors with fusible links are used, or where fireresistance rated hoistway enclosures are not required, the landing openings of electric or electrically controlled and operated hydraulic elevators shall be equipped with landing gates not less than 5½ feet high and provided with either hoistway gate interlocks or hoistway gate electric contacts and mechanical locks conforming to **524 CMR and Modifications.**

2605.9.4 Hydraulic freight elevators: **Not applicable.**

2605.9.5 Gates on cars: All openings on existing electric or electrohydraulic freight elevator cars, except the opening immediately adjacent to the operating device, shall be provided with car gates and car gate electric contacts when the distance between the hoistway side of the landing door adjacent to such opening and the hoistway edge of the landing threshold is more than 4 inches. All such elevators using lever, wheel or cable operating devices shall have car gates and car gate contacts installed at all car openings. All openings on existing continuous-pressure or automatic operation freight elevator cars that can be operated from the landings shall be provided with car gates and car gate electric contacts. Existing sidewalk elevators shall not be subject to the provisions of this section. Car gate electric contacts shall be of an approved type conforming to **524 CMR and Modifications**.

SECTION 2606.0 ALTERATIONS

2606.1 General: **Deleted.**

2606.2 Relocated equipment: The relocation of an existing installation of any device covered by this article shall be deemed to be a new installation and shall conform to the requirements therefor.

SECTION 2607.0 POWER ELEVATOR OPERATION

2607.1 Designated operator: Every power elevator, except automatic and continuous-pressure operation types shall be in the charge of a competent designated operator.

2607.2 Emergency operation of elevators: In all structures where elevators are to be installed, elevator emergency operation shall be provided in accordance with the requirements of ASME A17.1 listed in Appendix A and Sections 2607.1 through 2607.2.3.

2607.2.1 Buildings with elevator service: In all buildings and structures serviced by an elevator, at least one elevator shall be provided with a minimum clear distance between walls, or between wall and door excluding return panels, not less than 68 inches by 54 inches, and a minimum distance from wall to return panel not less than 51 inches. The minimum clear width of the door shall be 32 inches.

2607.2.2 Elevators for fire department use: In all structures where elevator service is required for fire department use (see Section 602.8), at least one elevator shall be provided with a minimum distance between walls, or between wall and door excluding return panels, not less than 80 inches by 54 inches and a minimum distance from wall to return panel not less than 51 inches, with a 42-inch side-slide door to allow for turning a wheelchair or accommodating an ambulance stretcher in its horizontal position.

2607.2.3 Elevator operator: In every structure over 150 feet in height, a competent elevator operator shall be available at all times to assist the fire department in obtaining access to any floor in the building or structure served by elevators except where an automatic or continuous-pressure operation elevator is available.

2607.3 Passenger restriction: Freight elevators shall be subject to the passenger restrictions indicated in Sections 2607.1.1 and 2607.3.2.

2607.3.1 Freight operators: Except as provided in Section 2607.3.2, it shall be unlawful for any person other than the operator or those individuals necessary to handle freight to ride on any elevator other than a passenger elevator. It shall be unlawful for the owner or other responsible person to permit any individual other than above specified to ride on any elevator other than a passenger elevator.

2607.3.2 Other employees: Employees of the owner shall not ride on a freight elevator, unless approved and in conformance with the requirements of **524 CMR and Modifications**.

2607.4 Use by handicapped persons: If interior access in multi-story buildings is provided by elevator(s), they shall conform with the requirements of **521 CMR.**

SECTION 2608.0 HOISTWAY ENCLOSURES AND VENTING

2608.1 Hoistway enclosures: Hoistway enclosures shall be constructed in accordance with Sections 2608.1.1 through 2608.1.3.

2608.1.1 Elevator enclosures: All elevator and other hoistway enclosures other than dumbwaiter shafts shall be constructed to afford at least the fireresistance rating specified in Table 401 with approved opening protectives conforming to Section 2611.0 and Article 9.

2608.1.2 Dumbwaiter enclosures: Shaft enclosures and dumbwaiters having a car area of more than 3 square feet which travel through more than one story and serve more than two adjacent floors shall be of 1-hour fireresistance rated construction with approved ¾-hour opening protectives or the approved labeled equivalent complying with Article 9, except that when the load capacity exceeds 100 psf, the enclosure and opening protectives shall comply with the requirements of Section 2608.1.1 for fireresistance rating.

2608.1.3 Special dumbwaiter enclosures: The enclosure of dumbwaiters not more than 3 square feet in area with a load capacity of not more than 25 pounds, and all dumbwaiters serving not more than two adjacent levels, shall be enclosed with approved noncombustible materials.

2608.2 Number of elevators permitted in hoistway: Where four or more elevators serve all or the same portion of a building, they shall be located in not less than two hoistways, and more than four elevators shall not be located in any one hoistway.

2608.3 Vents required: Hoistways of elevators and dumbwaiters serving more than three stories shall be provided with means for venting smoke and hot gases to the outer air in case of fire, except as listed in Sections 2608.3.1 and 2608.3.2.

2608.3.1 Fire suppression system alternative: In buildings other than Use Groups R-1, R-2 and I-2 and similar buildings with overnight sleeping quarters, hoistways not extending into the top story shall be vented as herein required or shall be provided with an approved automatic fire suppression system connected to the building water supply system or conforming to Section 1004.0.

2608.3.2 Sidewalk elevator hoistways: Sidewalk elevator hoistways are not required to be vented.

2608.4 Location of vents: Vents shall be located in the side of the hoistway enclosure directly below the floor or floors at the top of the hoistway, and shall open either directly to the outer air or through noncombustible ducts to the outer air. Cable slots entering the machine room shall be sleeved beneath the machine room floor and extended to not less than 12 inches below the shaft vent to inhibit the passage of smoke into the machine room.

2608.5 Area of vents: Except as herein provided, the area of the vents shall be not less than 3½ percent of the area of the hoistway nor less than 3 square feet for each elevator car, and not less than 3½ percent nor less than 3½ percent nor less than ½ square foot for each dumbwaiter car whichever is greater. Of the total required vent area, not less than one-third shall be of the permanently open type. Where mechanical ventilation conforming to the Boca National Mechanical Code listed in Appendix A provides equivalent venting, the required vent area shall be reduced, provided the conditions of Sections 2608.5.1 and 2608.5.2 are met.

2608.5.1 Restricted use: The building is not of Use Groups R-1, R-2 or I-2 or a similar building with overnight sleeping quarters.

2608.5.2 Vent location: The required vents in Section 2608.4 are so located that they do not have outside exposure.

2608.6 Closed vents: Closed portions of the required vent area shall consist of windows or duct openings glazed with plain glass not more 1/8 inch thick.

2608.6.1 Windows: Windows used as required vents shall conform to Section 917.0 and they shall be glazed with 1/8 inch plain glass.

2608.7 Plumbing and mechanical systems: Plumbing and mechanical systems, other than floor drains, sumps and sump pumps at the base of the shaft, shall not be located in an elevator shaft.

SECTION 2609.0 ELEVATOR AND DUMBWAITER MACHINERY AND EQUIPMENT

2609.1 General: Elevator and dumbwaiter machinery and equipment shall conform to **524 CMR and Modifications.**

SECTION 2610.0 MACHINE ROOMS AND RELATED CONSTRUCTION FOR PASSENGER AND FREIGHT ELEVATORS AND DUMBWAITERS

2610.1 General: The construction of machine rooms and related construction for passenger and freight elevators and dumbwaiters shall conform to **524 CMR and Modifications.**

2610.2 Required clearances of equipment in elevator machine rooms: Elevator machine rooms shall be constructed of sufficient dimension and equipment be located therein such that the following minimum clearances for maintenance, repair and reset of such equipment shall be established and maintained:

Machines:	**Twenty-four (24) inches, all sides**
Governors:	**Eight (8) inches, all sides**

These minimum clearances shall be established and maintained. Where the type of equipment to be installed requires greater clearances for maintenance, repair or reset, clearances of greater dimension(s) shall be provided as determined by the manufacturers installation instructions and/or the determination of the permit granting authority.

SECTION 2611.0 ELEVATOR OPENING PROTECTIVES

2611.1 General: All hoistway enclosure doors for elevators, dumbwaiters and other hoisting equipment shall be constructed in accordance with the provisions of Article 9 and as herein required.

2611.2 Hoistway doors: Door openings of elevator hoistway enclosures shall be equipped with protective assemblies having a fireresistance rating of not less than 1½ hours or their approved labeled equivalent. However, when the shaft opens into a vestibule enclosed with not less than 2-hour fireresistance rated construction in which all vestibule openings are protected with assemblies having a fireresistance

rating of not less than 1 hour, the required fireresistance rating of the hoistway doors shall be ¾ hour.

2611.3 Hardware: All hardware on opening protectives shall be of an approved type installed as tested, except that interlocks, mechanical elevator door locks and electric contacts and door operating mechanisms of approved types shall be exempt from the fire test requirements.

2611.4 Door operation on dangerous floors: In every structure where elevator emergency operation is provided in accordance with Section 2607.2, each elevator lobby and associated elevator machine rooms shall be provided with a smoke detector installed in accordance with NFiPA 72E listed in Appendix A. A designated level, which shall be the main floor level or other level that best serves the needs of emergency personnel for fire fighting or rescue purposes, shall be approved by the **state elevator inspector** and the fire prevention official. The activation of a smoke detector in any elevator lobby other than the designated level, or in any associated machine room, shall cause all cars in all groups that serve that lobby or are served by that machine room to return nonstop to the designated level. If a smoke detector at the designated level is activated, the cars shall return to an approved alternate level. Manual control to override the smoke detectors shall be provided at the designated level in accordance with **524 CMR and Modifications**. The smoke detector shall operate before the optical density exceeds 0.03 per foot.

SECTION 2612.0 ELEVATOR CAR EMERGENCY SIGNALS AND SIGNS

2612.1 Emergency signals: Elevator cars shall be provided with car emergency signals conforming to the requirements of **524CMR and Modifications listed in Appendix G.**

2612.2 Emergency signs: A pictograph sign, of an approved standardized type, shall be posted over each elevator call station on all floors, indicating that in case of fire, occupants shall not use elevators and that stairways are the approved method of exit.

SECTION 2613.0 MANLIFTS

Manlifts are prohibited.

SECTION 2614.0 INDUSTRIAL LIFTS AND LOADING RAMPS

2614.1 General: Except as exempted by Section 2600.0 or as otherwise provided by statute, the provisions of this section and Section 2615.0 shall control the design, construction, installation, maintenance and operation of all automotive lifts, industrial lifts and loading dock ramps hereafter installed, relocated or altered in all

buildings or structures. The purpose of this code is to provide safety for life and limb. In case of practical difficulty or unnecessary hardship, the **state elevator inspector, or authority having jurisdiction,** shall grant exceptions from the literal requirements or permit the use of other methods, but only when it is evident that safety is hereby secured.

2614.2 General requirements: Industrial lifts and loading ramps shall comply with the requirements of Sections 2614.2.1 through 2614.2.3.

2614.2.1 Markings and labels: All material lifts and loading ramps shall be marked with the name of manufacturer, model number, serial number, and rated capacity. Such markings shall be legibly stamped or etched on a metal plate which shall be permanently secured in a convenient place for inspection. Such marking plates shall not be obscured, obliterated or changed.

2614.2.2 Controls: The controls shall be so located that the operator has a full and unobstructed view of the lift area at all times. All control devices shall be accessible to the operator without exposing him to danger. Alterations or changes shall not be made in the control device, or its manner of use, which will render its normal functioning inoperative.

2614.2.3 Lift control: When the device used for controlling the travel of the lift in either direction is not continuous-pressure or deadman type, an emergency stop button shall be provided and so located as to be readily accessible to the operator at all times.

2614.3 Maintenance: Maintenance of industrial lifts and loading ramps shall be provided in accordance with Sections 2614.3.1 through 2614.3.3.

2614.3.1 Owner responsibility: The owner or the owner's agent shall be responsible for the care, maintenance, and safe operation of all equipment covered by this article after the installation thereof and its acceptance by such owner or agent or its approval. The owner or agent shall not permit the equipment to he used unless it is, to the best of such owner's or agent's knowledge, in safe operating condition.

2614.3.2 Housekeeping: The spaces around or beneath the equipment shall be kept clean. Rubbish or oil shall not be allowed to accumulate therein, nor shall any part of this space be used for storage of materials or equipment. All parts, except those requiring freedom of movement, shall be kept tight at all times. All mechanical working parts shall be kept free of rust, and properly lubricated and adjusted. The owner or the owner's agent, shall be responsible for inspecting the oil level in all hydraulic systems to insure that it is at or above the manufacturer's prescribed minimum level.

2614.3.3 Lighting: The entire operating area shall be illuminated to provide a distributed intensity of not less than 3 foot candles over the area of operating floor and platform.

2614.4 Pressure tanks: All separate tanks for liquid storage under pressure, not an integral part of the cylinder assembly, shall conform to the provisions of ASME Code for Unfired Pressure Vessels listed in Appendix A and shall be marked with a securely attached metal label to indicate the approved operating pressure. For hydropneumatic systems, the storage capacity shall be such that with the lift in fully elevated position there shall remain not less than 3 inches of usable oil in the storage tank. Adequate means shall be provided to determine that the oil level in reservoir, with lift in the lowest position, is at or above the safe minimum operating level as prescribed by the manufacturer.

2614.5 Design and construction: The construction and installation of all power industrial lifts and loading ramps shall comply with the provisions of this section and ANSI A10.5 listed in Appendix A.

2614.5.1 Rated load: The lifting capacity shall be not less than 50 psf for gross platform area.

2614.5.2 Platform construction: The platform and its supports shall be designed for the loads to be transmitted within strength and deflection limitations such that when one-half the capacity load is applied as a static center concentration within 12 inches of the loading edge, the lift platform shall not deflect more than ½ inch at any edge point.

2614.6 Platform and hoist protection: Platform and hoist protection shall be provided in accordance with Sections 2614.6.1 through 2614.6.4.

2614.6.1 Unprotected space not more than 5 feet: When the lift rise is such that the unprotected vertical distance from the landing to the bottom edge of the vertical side of the platform is not more than 5 feet, protection shall be provided as described in Sections 2614.6.1.1 through 2614.6.1.3.

2614.6.1.1 Toe guards: A toe guard plate not less than 8 inches in width shall be provided on all unprotected sides. It shall be made of steel, not less than 0.120-inch nominal thickness, attached flush with the vertical edge of the platform, and slanted inwardly at an angle of approximately 30 degrees from the vertical. Toe guards are not required where skirts are used.

2614.6.1.2 Skirts: For automatic operation, the unprotected sides of the platform shall be provided with metal or wood sheathing or skirts attached to tile platform to protect the exposed vertical openings.

2614.6.1.3 Enclosures: When toe guard or skirt protection is not provided, the unprotected sides shall be provided with solid or mesh enclosures to the full height of the lift rise. Mesh enclosure shall, by test, reject a 2-inch ball.

2614.6.2 Unprotected space more than 5 feet: When the unprotected space exceeds that set forth in Section 2614.6.1, protection shall be provided as described in Sections 2614.6.2.1 and 2614.6.2.2.

2614.6.2.1 Loading or unloading side: Sides used for loading or unloading at the lower level shall be protected with skirts as described in Section 2614.6.1, or by a landing gate with electrical contact, or an automatic landing gate.

2614.6.2.2 Other sides: Sides not used for loading or unloading shall be protected with skirts or enclosures as described in Section 2614.6.1.

2614.6.3 Lift rise more than 5½ feet: When the lift rise exceeds 5½, feet above the lowest level, additional protection shall be provided as described in Sections 2614.6.3.1 and 2614.6.3.2.

2614.6.3.1 Landing gate: The upper landing shall be provided with a landing gate equipped with mechanical lock and electrical contact.

2614.6.3.2 Enclosure: The sides of the platform not used for loading or unloading shall be provided with railings, mesh, or solid enclosures not less than 3½ feet high.

2614.6.4 Surface installations: When the lift is surface mounted, toe clearance space shall be provided on all unprotected sides. Such toe clearance shall provide not less than 3 inches vertical and 4 inches horizontal clearance when the platform is at its lowest position.

2614.7 Platform protection, loading ramps: The sides or edges of loading ramps which rise above the surrounding platform shall be provided with skirts or toe guards protecting the opening under the sides of the lamp.

2614.8 Overload protection: Overload protection shall be provided in accordance with Sections 2614.8.1 and 2614.8.2.

2614.8.1 Electric hydraulic operation: Hydraulic overload protection shall be provided by means of a relief valve that will prevent raising of the elevating device when it is loaded to 125 percent of rated capacity. The relief valve shall be so designed that its operation will not cause the platform to lower.

2614.8.2 Electric operation: Electric overload protection shall be provided by means of a thermal cutout or other suitable device.

SECTION 2615.0 AUTOMOTIVE LIFTS

2615.1 General: All electric, hydraulic and hydropneumatic automotive lifts shall comply with the requirements of Section 2606.0 and **524 CMR and Modifications.**

2615.2 Types: Lifts shall be classified as semi-hydraulic, full hydraulic or mechanical lifts according to their operation as described in Sections 2615.2.1 through 2615.2.3.

2615.2.1 Semi-hydraulic hydropneumatic: A semi-hydraulic lift is an automotive lift of the plunger type which employs compressed air as the primary lifting and load-sustaining agent; such compressed air acts continuously against a column of liquid to provide the lifting and load-sustaining effort.

2615.2.2 Full hydraulic: A full hydraulic lift is an automotive lift of the plunger type that employs a liquid under pressure as the direct lifting and load-sustaining agent. Such a lift is so designed and constructed that the full weight of the load and lifting assembly rests on a continuous column of liquid which extends from the cylinder to the liquid control valve.

2615.2.3 Mechanical lifts: A mechanical lift is an automotive lift so designed that the motive power is transmitted to the lifting frame by mechanical means. There are three principal types: cable and drum; rack and pinion; and screw type.

2615.3 Safeties: All mechanical automotive lifts shall be equipped with approved safeties as specified in Sections 2615.3.1 through 2615.3.3.

2615.3.1 Limit stop: Every mechanical automotive lift shall be equipped with an automatic overtravel device to stop the motor or drive machine before the lifting frame reaches safe limits of travel.

2615.3.2 Holding brake: When the friction of the gear train of the driving mechanism is insufficient to hold the load, the mechanical automotive lift shall be equipped with a brake or other locking device to automatically hold the lift at any level immediately on failure of the lifting power for any cause.

2615.3.3 Stopping brake: When the structural members of the lifting frame are so designed that they interfere with open doors or other projections from the vehicle, the automotive lift shall be provided with a quick-acting automatic brake to stop the ascent of the lift in case of emergency.

2615.4 Controls: Controls shall be provided in accordance with Sections 2615.4.1 and 2615.4.2.

2615.4.1 Automatic release: The direct control device shall be of a type that will automatically return itself to the neutral or off position upon release by the operator.

2615.4.2 Speed control: A speed control device shall be provided to control the descent of the lift at a speed of not more than 20 feet per minute under rated load.

SECTION 2616.0 CONVEYORS

2616.1 Enclosures: All package elevators, boosters or lifts connecting successive floors or levels shall be enclosed in fireresistance rated construction in conformance with the requirements of Sections 2608.0 and 2610.0 and Article 9.

2616.2 Opening protectives: Opening protectives shall be provided in accordance with Sections 2616.2.1 through 2616.2.3.

2616.2.1 Plans and specifications: Whenever conveyor or other material handling devices are designed to pass through floors, ceilings, partitions or walls, the plans and specifications shall give the necessary details of the opening protectives in respect to location, structural strength and fireresistance rating.

2616.2.2 Fire curtains: Openings in partitions and walls through which conveyors pass shall have automatic fire dampers or curtains to prevent the spread of fire when, in the opinion of the **state elevator inspector, or other authority having jurisdiction,** such protection is necessary due to the hazard of operation of the conveyors.

2616.2.3 Fire doors: All opening protectives shall meet the fireresistance rating requirements of Article 9 for the location, type of construction and use of the building or structure.

2616.3 Machinery guards: All conveying devices shall be manufactured, installed, and guarded in accordance with **524 CMR and Modifications.**

2616.4 Chute enclosures: All slides and chutes shall be enclosed with fireresistance rated construction, or protected with approved automatic shutters of noncombustible construction, to insure a full firestop between floors of the building or structure.

2616.5 Conveyor safeties: All power-operated conveyors, belts and other material moving devices shall be equipped with automatic limit switches which will shut off the power in an emergency and automatically stop all operation of the device.

SECTION 2617.0 ESCALATORS

2617.1 General: All escalators and their enclosures shall comply with the provisions of this section and **524 CMR and Modifications.**

2617.2 Construction materials: Escalator construction materials shall comply with the provisions of Sections 2617.2.1 and 2617.2.2.

2617.2.1 Machine room enclosure: The stairwell is not required to be enclosed when protected with an exhaust system or ventilation and water curtains as provided in Section 606.1, or with a power-operated shutter conforming to Section 2617.3; except that the machine room shall be enclosed with 1-hour fireresistance rated construction and shall be properly lighted and ventilated.

2617.2.2 Noncombustible materials: The escalator shall be constructed entirely of noncombustible and fire-retardant materials except electrical equipment, wiring, wheels, handrails and the use of 1/28-inch wood veneers on balustrades backed up with noncombustible materials.

2617.3 Automatic fire shutter: Unenclosed escalators, which are not protected as specified in Section 606.3, shall be equipped with a power-operated automatic shutter at every floor pierced thereby, constructed of noncombustible materials with a fireresistance rating of not less than 1½, hours.

2617.3.1 Construction: The shutter shall close immediately upon the automatic detection of fire or smoke by an approved device and shall completely shut off the well opening. The shutter shall operate at a speed of not more than feet per minute and shall be equipped with a sensitive leading edge to arrest its progress when in contact with any obstacle, and to continue its progress on release therefrom.

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ARTICLE 27

ELECTRICAL WIRING AND EQUIPMENT

(This Article is entirely unique to Massachusetts)

SECTION 2700

Chapter 143, Section 3L of the Massachusetts General Laws Annotated, as amended, provides that all installation, repair and maintenance of wiring and electrical fixtures used for light, heat and power purposes in buildings and structures shall be in conformance with the Massachusetts Electrical Code (527 CMR 12.00) listed in Appendix G and promulgated by the Board of Fire Prevention Regulations of the Commonwealth of Massachusetts, Department of Public Safety.

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ARTICLE 28

PLUMBING AND GAS FITTING

(This Article is entirely unique to Massachusetts)

SECTION 2800.0

Chapter 142, Section 13 of the Massachusetts General Laws Annotated, as amended, provides that all construction, alteration, and repair and inspection of plumbing and gasfitting shall be in conformance with the Massachusetts State Plumbing Code (248CMR 2.00) and the Massachusetts Fuel Gas Code (248CMR 3.00 through 8.00), both listed in Appendix G, and promulgated by the Commonwealth of Massachusetts Board of State Examiners of Plumbers and Gas Fitters. (Also see Article 26 of this code for additional applicable information)

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ARTICLE 29

SIGNS

SECTION 2900.0 GENERAL

2900.1 Scope: The provisions of this article shall govern the construction, alteration, repair and maintenance of all signs together with their appurtenant and auxiliary devices in respect to structural and fire safety.

2900.2 Zoning law: Where more restrictive in respect to location, use, size or height of signs, the limitations of the zoning laws affecting required light and ventilation requirements and use of land shall take precedence over the regulations of this code.

2900.3 Approved rules: In the absence of approved rules governing details of construction, the provisions of the applicable standards listed in Appendix A shall be deemed to conform to the requirements of this code unless otherwise specified in this article.

2900.4 Commonwealth of Massachusetts regulations: Outdoor advertising subject to the Rules and Regulations of the Outdoor Advertising Board, Massachusetts General Laws Annotated, as amended, and as listed in Appendix G and 711 CMR 1.00-3.00, requires the approval of the said Board prior to permit issuance.

SECTION 2901.0 PLANS, SPECIFICATIONS AND PERMITS

2901.1 Owner's consent: Before any permit is granted for the erection of a sign, plans and specifications shall be filed with the building official showing the dimensions, materials and required details of construction, including loads, stresses and anchorage. The applications shall be accompanied by the written consent of the owner or lessee of the premises upon which the sign is to be erected.

2901.2 New signs: A new sign shall not hereafter be erected, constructed, altered or maintained except as herein provided, and until a permit has been issued by the building official and the required bond shall have been filed in accordance with Section 2906.0.

2901.3 Identification: Every sign for which a permit has been issued and hereafter erected, constructed or maintained shall be plainly marked with the name of the person, firm or corporation owning, erecting, maintaining or operating such sign. The method and location of this identification shall appear on the plans and within the specifications filed with the building official.

2901.4 Alterations: A sign shall not be enlarged or relocated except in conformity to the provisions of this article for new signs. nor until a proper permit has been secured. The changing of movable parts of an approved sign that is designed for such changes, or the repainting or reposting of display matter, shall not be deemed an alteration, provided the conditions of the original approval and the requirements of this article are not violated.

SECTION 2902.0 EXEMPTIONS

2902.1 General: A permit shall not be required for the signs covered by the provisions of this section. Such exceptions, however, shall not be construed to relieve the owner of the sign from responsibility for its erection and maintenance in a safe manner.

2902.2 Wall signs: A sign painted on the surface of a fence or approved building wall, or any nonilluminated wall sign on a building or structure which is not more than 10 square feet in area shall not require a permit.

2902.3 Ground signs: The ground signs listed in Sections 2902.3. 1 through 2902.3.3 shall not require a permit.

2902.3.1 Sale or rent: Signs erected to announce the sale or rent of the property so designated, provided such signs are not more than 25 square feet in area.

2902.3.2 Transit directions: The erection or maintenance of a sign designating the location of a transit line, a railroad station or other public carrier when not more than 3 square feet in area.

2902.3.3 Street signs: Signs erected by a jurisdiction for street direction.

2902.4 Projecting signs: A projecting sign not exceeding 2½ square feet of display surface shall not require a permit.

2902.4.1 Government building signs: Signs erected on a municipal, state or federal building which announce the name, nature of the occupancy and information as to use of, or admission to, the premises.

SECTION 2903.0 UNSAFE AND UNLAWFUL SIGNS

2903.1 Notice of unsafe signs: When any sign becomes insecure, in danger of falling, or otherwise unsafe, or if any sign shall be unlawfully installed, erected or maintained in violation of any of the provisions of this code, the owner thereof or the person or firm maintaining same shall upon written notice of the building official, forthwith in the case of immediate danger and in any case within not more than ten days, make such sign conform to the provisions of this article or shall remove it. If within ten days the order is not complied with, the building official is authorized to remove such sign at the expense of the owner or lessee thereof as provided in Section 121.0.

2903.2 Unlawful signs: The location or positioning of signs listed in the following Sections 2903.2. 1 through 2903.2.4 shall be considered unlawful.

2903.2.1 Egress obstructions: A sign shall not be erected, constructed, or maintained so as to obstruct any fire escape, means of egress, window or door opening used as an element of a means of egress or to prevent free passage from one part of a roof to another part thereof or access thereto as required by the provisions of Article 8 or for the fire-fighting forces having jurisdiction.

2903.2.2 Obstruction to ventilation: A sign shall not be attached in any form, shape or manner which will interfere with any opening required for ventilation by Article 7; except that such signs are permitted to be erected in front of or cover transom windows when not in violation of the provisions of this code.

2903.2.3 Projecting signs: A projecting sign erected at other than right angles to the wall of a building or structure outside of the building line which extends above the roof cornice or parapet wall, or above the roof level when there is not a cornice or parapet wall and which obstructs access to the roof is hereby deemed unlawful. Such signs shall be reconstructed or removed as herein required.

2903.2.4 Alley signs: Signs shall not be permitted to project beyond alley lot lines.

SECTION 2904.0 EXISTING SIGNS

2904.1 Removing or reconstructing signs: A sign heretofore approved and erected shall not be repaired, altered or moved, nor shall any sign or any substantial part thereof which is blown down, destroyed or removed be reerected, reconstructed, rebuilt or relocated unless it is made to comply with all applicable requirements of this article.

2904.2 Repair of unsafe signs: This section shall not be construed to prevent the repair or restoration to a safe condition of any part of an existing sign when damaged by storm or other accidental emergency, as directed by the building official.

2904.3 Relocating signs: Any sign that is moved to another location on the same or other premises shall be considered a new sign, and a permit shall be secured for any work performed in connection therewith when required by this article.

SECTION 2905.0 MAINTENANCE AND INSPECTION

2905.1 Removal: The building official is authorized to order the removal of any sign that is not maintained in accordance with the provisions of this article.

2905.2 Maintenance: All signs for which a permit is required, together with all their supports, braces, guys, and anchors, shall be kept in repair in accordance with the provisions of this article and Article 1. When not galvanized or constructed of approved corrosion-resistive noncombustible materials, signs shall be painted when necessary to prevent corrosion.

2905.3 Housekeeping: It shall be the duty and responsibility of the owner or lessee of every sign to maintain the immediate premises occupied by the sign in a clean, sanitary and healthful condition.

2905.4 Inspection: Every sign shall be subject to the inspection and approval of the building official.

SECTION 2906.0 BONDS AND LIABILITY INSURANCE

2906.1 Filing: A person shall not erect, install, remove, rehang or maintain over public property any sign for which a permit is required under the provisions of this code until an approved bond **or liability insurance** shall have been filed in **accordance with the requirements of the municipality, if any.**

2906.2 Conditions: Such bond or insurance policy shall protect and save the jurisdiction harmless from any and all claims or demands for damages by reason of any negligence of the sign hanger, contractor or agents, or by any reason of defects in the construction, or damages resulting from the collapse, failure or combustion of the sign or parts thereof.

2906.3 Notice of cancellation: The obligation herein specified shall remain in force and effect during the life of every sign and shall not be canceled by the principal or surety until after a 30-day notice to the building official.

SECTION 2907.0 GENERAL REQUIREMENTS FOR ALL SIGNS

2907.1 Construction: All signs shall be designed and constructed in conformance with the provisions for materials, loads and stresses of this code and the requirements of this article.

2907.2 Design loads: Loads listed in Sections 2907.2.1 and 2907.2.2 shall be the minimum for the design of signs.

2907.2.1 Wind: All signs shall be designed and constructed to withstand wind pressure as provided in Section 1112.0.

2907.2.2 Earthquake: Signs adequately designed to withstand wind pressures shall generally be considered capable of withstanding earthquake shocks, except as provided in Section 1113.0 and for combined loading in Section 1114.0.

2907.3 Illumination: A sign shall not be illuminated by other than electrical means and electrical devices and wiring shall be installed in accordance with the requirements of **the Massachusetts State Electrical Code (527 CMR 12.00)** listed in Appendix G. Any open spark or flame shall not be used for display purposes unless specifically approved.

2907.4 Use of combustibles: Sections 2907.4.1 and 2907.4.2 shall apply to combustible material for signs.

2907.4.1 Ornamental features: Wood or approved plastic as provided in Article 20 or other materials of combustible characteristics similar to wood, when used for moldings, cappings, nailing blocks, letters and latticing, shall comply with Section 2908.1, and shall not be used for other ornamental features of signs, unless approved.

2907.4.2 Sign facings: Except as provided for covered malls in Section 601.1.3 where sign facings are of wood or approved combustible plastic, the area of such facing section shall be not more than 120 square feet and the wiring for electric lighting shall be entirely enclosed in the sign cabinet with a clearance of not less than 2 inches from the facing material. The dimensional limitation of 120 square feet shall not apply to sign facing sections made from flameresistant coated fabric ordinarily known as "flexible sign face plastic," which weighs less than 20 ounces per square yard, and which, when tested in accordance with the requirements of NFiPA 701 listed in Appendix A, exhibits an average flame time of 2.5 seconds or less, and an average length of char of 4½ inches or less; or when tested in accordance with the requirements of ASTM D568 listed in Appendix A exhibits an average burn time for ten specimens of 2 seconds or less and burning extent of 15 centimeters or less.

2907.5 Animated devices: Signs which contain moving sections or ornaments shall have fail-safe provisions to prevent the section or ornament from releasing and falling or shifting its center of gravity more than 15 inches. The fail-safe device shall be in addition to the mechanism and its housing which operate the movable section or ornament. The fail-safe device shall be capable of supporting the full dead weight of the section or ornament when the moving mechanism releases.

SECTION 2908.0 GROUND SIGNS

2908.1 Structural frame: The structural frame of ground signs shall not be erected of combustible materials to a height of more than 35 feet above the ground.

2908.2 Maximum size: In all locations, when constructed entirely of noncombustible material, ground signs shall not be erected to a height of greater than 100 feet above the ground. Greater heights are permitted when approved and located so as not to create a hazard or danger to the public.

SECTION 2909.0 ROOF SIGNS

2909.1 Materials: All roof signs shall be constructed entirely of metal or other approved noncombustible materials except as provided in Section 2907.4. Provisions shall be made for electric ground of all metallic parts. Where combustible materials are permitted in letters or other ornamental features, all wiring and tubing shall be kept free and insulated therefrom.

2909.2 Bottom clearance: There shall be a clear space of not less than 6 feet between the lowest part of the sign and the roof level, except for necessary structural supports.

2909.3 Closed signs: A closed roof sign shall not be erected to a height greater than 50 feet above the roof of buildings of Types 1 and 2 construction, nor more than 35 feet above the roof of buildings of Types 3, 4 and 5 construction.

2909.4 Open signs: An open roof sign shall not exceed a height of 100 feet above the roof of buildings of Types 1 and 2 construction; and not more than 60 feet above the roof of buildings of Types 3, 4 and 5 construction.

SECTION 2910.0 WALL SIGNS

2910.1 Materials: Wall signs which have an area exceeding 40 square feet shall be constructed of metal or other approved noncombustible materials, except for nailing rails and as provided in Section 2907.4.

2910.2 Extension: Wall signs shall not be erected to extend above the top of the wall, nor extend beyond the ends of the wall to which they are attached unless meeting all the requirements for roof signs, projecting signs or ground signs.

SECTION 2911.0 PROJECTING SIGNS

2911.1 Materials: Projecting signs shall be constructed entirely of metal or other approved noncombustible materials except as provided in Section 2907.4.

2911.2 Maximum projection: A projecting sign shall not extend beyond a vertical plane 2 feet inside the curb line.

2911.3 Clearances: A clear space of not less than 10 feet shall be provided below all parts of such signs.

2911.4 Additional loads: Projecting sign structures which could be used to support an individual on a ladder or other servicing device whether or not specifically designed for the servicing device shall be capable of supporting the anticipated additional load, but not less than 100 pounds concentrated horizontal load and 300 pounds vertical concentrated load applied at the point of assumed or most eccentric loading. The building component to which the projecting sign is attached shall also be designed to support the additional loads.

SECTION 2912.0 MARQUEE SIGNS

2912.1 Materials: Marquee signs shall be constructed entirely of metal or other approved noncombustible materials except as provided in Section 2907.4.

2912.2 Marquee: Marquee signs shall be attached to approved marquees constructed in accordance with Section 507.10.

2912.3 Dimensions: Marquee signs shall not project beyond the perimeter of the marquee.

SECTION 2913.0 MISCELLANEOUS AND TEMPORARY SIGNS

2913.1 Banner and cloth signs: Temporary signs and banners attached to or suspended from a building, constructed of cloth or other combustible material, shall be constructed in an approved manner and shall be securely attached to their supports. They shall be removed as soon as torn or damaged, and not later than 60 days after erection. Permits for temporary signs suspended from or attached to a canopy or marquee shall be limited to a period of ten days.

2913.2 Maximum size: Temporary signs of combustible construction shall be not more than 10 feet in one dimension nor more than 500 square feet in area.

2913.3 Supports: When more than 100 square feet in area, temporary signs and banners shall be constructed and fastened to supports capable of withstanding the design loads listed in Section 1111.0.

2913.4 Special permits: Temporary signs used for holidays, public demonstrations or promotions of civic welfare or charitable purposes which extend across streets or other public spaces shall be subject to special approval of the authority having jurisdiction.

SECTION 2914.0 ILLUMINATED SIGNS

2914.1 Certificates: All electrically illuminated signs shall be certified as to electric wiring and devices by the agency having jurisdiction, and all wiring and accessory electrical equipment shall conform to the requirements of **the Massachusetts State Electrical Code (CMR 527 12.00)** listed in Appendix G.

2914.2 Additional permits: Electrical permits shall be issued for the erection or maintenance of illuminated signs.

2914.3 Relettering signs: The requirements of this section shall not apply to the relettering of illuminated signs, except where such relettering requires a change of wiring or piping of the sign.

SECTION 2915.0 PORTABLE SIGNS

2915.1 Conformance: Portable signs shall conform to all requirements for ground, roof, projecting, flat and temporary signs when they are used in a similar capacity. The stipulations in this section shall not be construed to require portable signs to have connections to surfaces, tie-downs or foundations when provisions are made by temporary means or configuration of the structure to provide stability for the expected duration of the installation.

2915.2 Electrical: Portable signs which require electrical service shall have a positive connecting device on the sign. Electrical service lines to the sign shall be protected from damage from all anticipated traffic **(see Massachusetts State Electrical Code, 527 CMR 12.00)**, listed in Appendix G.

ARTICLE 30

PRECAUTIONS DURING BUILDING OPERATIONS

SECTION 3000.0 GENERAL

3000.1 Scope: The provisions of this article shall apply to all construction operations in connection with the erection, alteration, repair, removal or demolition of buildings and structures.

3000.2 Other laws: Nothing herein contained shall be construed to nullify any rules, regulations or statutes of state agencies governing the protection of the public or workers from health or other hazards involved in manufacturing, mining and other processes and operations which generate toxic gases, dust or other elements dangerous to the respiratory system, eyesight or health.

3000.2.1 Other regulations: In addition, the following regulations also shall apply when not covered by this code: ***Rules and Regulations in Construction Operations*** **(441 CMR 10.00); and** ***Keeping, Storage, Use, Manufacture, Sale, Handling, Transportation of Explosives*** **(527 CMR 13.00)** listed in Appendix G.

3000.3 Combustible and explosive hazards: The provisions of this code which apply to the storage, use or transportation of explosives, highly flammable and combustible substances, gases and chemicals shall be construed as supplemental to the requirements of the federal laws, the regulations of the Department of Transportation (DOT) and the rules and regulations of the jurisdiction.

SECTION 3001.0 PLANS, SPECIFICATIONS AND SPECIAL PERMITS

3001.1 Temporary construction: Before any construction operation is started, plans and specifications shall be filed with the building official showing the design and construction of all sidewalk sheds, truck runways, trestles, foot bridges, guard fences and other similar devices required in the operation. Approval of the building official shall be secured before the commencement of any work.

3001.2 Special permits: All special licenses and permits for the storage of materials on sidewalks and highways, for the use of water or other public facilities and for the

storage and handling of explosives shall be secured from the administrative authorities having jurisdiction.

3001.3 Temporary encroachments: Subject to approval, sidewalk sheds, underpinning and other temporary protective guards and devices shall project beyond the interior and street lot lines where required to insure the safety of the adjoining property and the public. When necessary, the consent of the adjoining property owner shall be obtained.

SECTION 3002.0 TESTS

3002.1 Loading: It shall be unlawful to load any structure, temporary support, scaffolding, sidewalk bridge or sidewalk shed or any other device or construction equipment during the construction or demolition of any building or structure in excess of its safe working capacity as provided in Article 11 for allowable loads and working stresses.

3002.2 Unsafe equipment: Whenever any doubt arises as to the structural quality or strength of scaffolding plank or other construction equipment, such material shall be replaced, or the building official shall require a strength test to two and one-half times the superimposed live load to which the material or structural member is to be subjected. The member shall sustain the test load without failure.

SECTION 3003.0 INSPECTION

3003.1 Unsafe conditions: When inspection of any construction operation reveals that any unsafe or illegal conditions exist, the building official shall notify the owner and direct the owner to take the necessary remedial measures to remove the hazard or violation.

3003.2 Failure to comply with orders: Unless the owner so notified proceeds to comply with the orders of the building official within 24 hours, the building official shall have full power to correct the unsafe conditions as provided in Sections 121.0 and 123.0. All expenses incurred in the correction of such unsafe conditions shall become a lien on the property.

3003.3 Unsafe construction equipment: When the strength and adequacy of any scaffold or other device or construction equipment is in doubt, or when any complaint is made, the building official shall inspect such equipment and shall prohibit its use until tested as required in Section 3002.2 or until all danger is removed.

SECTION 3004.0 MAINTENANCE

3004.1 General: All construction equipment and safeguards shall be constructed, installed and maintained in a substantial manner and shall be so operated as to insure protection to the workers engaged thereon and to the general public. It shall be unlawful to remove or render inoperative any structural, fire protection or sanitary safeguard or device herein required except when necessary for the actual installation and prosecution of the work.

SECTION 3005.0 EXISTING BUILDINGS

3005.1 Protection: All existing and adjoining public and private property shall be protected from damage incidental to construction operations.

3005.2 Chimney, soil and vent stacks: Whenever a new building or structure is erected to greater or lesser heights than an adjoining building, the construction and extension of new or existing chimneys shall conform to the provisions of the BOCA National Mechanical Code listed in Appendix A, and the construction and extension of soil and vent stacks and the location of window openings shall comply with the provisions of Section 2805.4.

3005.3 Adjoining walls: The owner of the new or altered structure shall preserve all adjoining independent and party walls from damage as provided herein. The owner shall underpin where necessary and support the adjoining building or structure by proper foundations to comply with Section 3007.0.

3005.3.1 Maintenance: In case an existing party wall is intended to be used by the person who causes an excavation to be made, and such party wall is in good condition and sufficient for the use of both the existing and proposed building, such person shall preserve the party wall from injury and support it by proper foundations at his own expense, so that it shall be and remain as safe and useful as it was before the excavation was commenced. During the demolition, the party wall shall be maintained weatherproof and structurally safe by adequate bracing until such time as the permanent structural supports shall have been provided.

3005.3.2 Beam holes: When a structure involving a party wall is being demolished, the owner of the demolished structure shall, at his own expense, bend over all wall anchors at the beam ends of the standing wall and shall brick up wall open beam holes and otherwise maintain the safety and usefulness of the all.

3005.3.3 Party wall exits: A party wall balcony or horizontal exit shall not be destroyed unless and until a substitute means of egress has been provided and approved.

3005.4 Adjoining roofs: When a new building or demolition of an existing building is being conducted at a greater height, the roof, roof outlets and roof structures of adjoining buildings shall be protected against damage with adequate safeguards by the person doing the work.

SECTION 3006.0 PROTECTION OF PUBLIC AND WORKERS

3006.1 General: Whenever a building or structure is erected, altered, repaired, removed or demolished, the operation shall be conducted in a safe manner and suitable protection for the general public and workers employed thereon shall be provided.

3006.2 Fences: Every construction operation located 5 feet or less from the street lot line shall be enclosed with a fence not less than 8 feet high to prevent entry of unauthorized persons. When located more than 5 feet from the street lot line, a fence or other barrier shall be erected when required by the building official. All fences shall be of adequate strength to resist wind pressure as specified in Section 1111.0.

3006.3 Sidewalk bridge: Whenever the ground is excavated under the sidewalk, a sidewalk bridge shall be constructed at least 4 feet wide, or a protected walkway of equal width shall be erected in the street, provided the required permit from such walkway is obtained from the administrative authority.

3006.4 Sidewalk shed: Sidewalk sheds shall be provided in accordance with Sections 3006.4.1 through 3006.4.4.

3006.4.1 Within 10 feet of street lot line: When any building or part thereof which is located within 10 feet of the street lot line is to be erected or raised to exceed 40 feet in height, or whenever a building more than 40 feet in height within 10 feet of the street lot line is to be demolished, a sidewalk shed shall be erected and maintained for the full length of the building on all street fronts for the entire time that work is performed on the exterior of the building.

3006.4.2 Within 20 feet of street lot line: When the building being demolished or erected is located within 20 feet of the street lot line and is more than 40 feet in height, exterior flare fans or catch platforms shall be erected at vertical intervals of not more than two stories.

3006.4.3 Buildings higher than six stories: When the building being demolished or erected is more than six stories or 70 feet in height, unless set back from the street lot line a distance more than one-half its height, a sidewalk shed shall be provided.

3006.4.4 Walkway: An adequately lighted walkway at least 4 feet wide and 8 feet high in the clear shall be maintained under all sidewalk sheds for pedestrians. Where ramps are required, they shall conform to the provisions of this article and Section 815.0.

3006.5 Thrust-out platforms: Thrust-out platforms or other substitute protection in lieu of sidewalk sheds shall not be used unless approved and deemed adequate to insure the public safety. Thrust-out platforms shall not be used for the storage of materials.

3006.6 Watchman: Whenever a building is being demolished, erected or altered, a watchman shall be employed to warn the general public when intermittent hazardous operations are conducted across the sidewalk or walkway.

SECTION 3007.0 DEMOLITION AND EXCAVATION

3007.1 Notice of intent: The person intending to cause a demolition or an excavation shall deliver written notice of such intent to the owner of each potentially affected adjoining lot, building or structure at least one week prior to the commencement of work. The notice shall request license to enter the potentially affected lot, building or structure prior to the commencement of work and at reasonable intervals during its prosecution to inspect and preserve it from any damage which might result from the intended work.

3007.1.2 Temporary support: Until permanent support has been provided, all excavations shall be safeguarded and protected by the person causing the excavations to be made to avoid all danger to life or limb. Where necessary, such excavations shall be retained by temporary retaining walls, sheet-piling and bracing or other approved method to support the adjoining earth. (See 441 CMR 10.00).

3007.2 Protection of adjoining property: If afforded the necessary license to enter the adjoining lot, building or structure, the person causing the demolition or excavation to be made shall at all times and at his own expense preserve and protect it from damage or injury. If the necessary license is not afforded, it shall be the duty of the owner of the adjoining lot, building or structure to make safe his own property, for the prosecution of which he shall be granted the necessary license to enter the premises of the demolition or excavation.

3007.2.1 Removal of debris: All waste materials shall be removed in a manner which prevents injury or damage to persons, adjoining properties and public rights of way.

3007.3 Notice to the building official: If the person causing a demolition or excavation to be made is not afforded license to enter an adjoining structure, he

shall immediately notify in writing both the building official and the owner of the adjoining property that the responsibility of providing support to the adjoining lot, building or structure has become the exclusive responsibility of the owner of the adjoining property.

SECTION 3008.0 REGULATION OF LOTS

3008.1 Grading of lot: When a building or structure has been demolished or removed and building operations have not been projected or approved, the vacant lot shall be filled, graded and maintained in conformity to the established street grades at curb level. The lot shall be maintained free from the accumulation of rubbish and all other unsafe or hazardous conditions which endanger the life or health of the public. Provision shall be made to prevent the accumulation of water or damage to any foundations on the premises or the adjoining property.

3008.2 Utility connections: All service utility connections shall be discontinued and capped in accordance with the approved rules and the requirements of the authority having jurisdiction and Section 105.1.

SECTION 3009.0 RETAINING WALLS AND PARTITION FENCES

3009.1 General: When the adjoining grade is not higher than the legal level, the person causing an excavation to be made shall erect, when necessary, a retaining wall at his own expense and on his own land. Such wall shall be built to a height sufficient to retain the adjoining earth, shall be properly coped as required in Section 1223.0 and shall be provided with a guardrail or fence not less than 42 inches in height.

SECTION 3010.0 STORAGE OF MATERIALS

3010.1 General: All materials and equipment required in construction operations shall be stored and placed so as not to endanger the public, the workers or adjoining property.

3010.2 Design capacity: Materials or equipment stored within the building, or on sidewalks, sheds or scaffolds shall be placed so as not to overload any part of the construction beyond its design capacity, nor interfere with the safe prosecution of the work.

3010.3 Special loading: Unless the construction is designed for special loading, materials stored on sidewalk sheds and scaffolds shall not exceed a one-day supply. All materials shall be piled in an orderly manner and height, to permit removal of individual pieces without endangering the stability of the pile.

3010.4 Pedestrian walkways: Materials or equipment shall not be stored on the street without a permit issued by the administrative official having jurisdiction. When so stored, they shall not unduly interfere with vehicular traffic or the orderly travel of pedestrians on the highway or street. The piles shall be arranged to maintain a safe walkway not less than 4 feet wide, unobstructed for its full length, and adequately lighted at night and at all necessary times for the use of the public.

3010.5 Obstructions: Material and equipment shall not be placed or stored so as to obstruct access to fire hydrants, standpipes, fire or police alarm boxes, utility boxes, catch basins or manholes, nor shall they be located within 20 feet of a street intersection, or so placed as to obstruct normal observations of traffic signals or to hinder the use of public transit loading platforms.

SECTION 3011.0 REMOVAL OF WASTE MATERIAL

3011.1 General: Material shall not be dropped by gravity or thrown outside the exterior walls of a building during demolition or erection. Wood or metal chutes shall be provided for this purpose and any material which in its removal will cause an excessive amount of dust shall be wet down to prevent the creation of a nuisance.

SECTION 3012.0 PROTECTION OF ADJOINING PROPERTY

3012.1 General: Adjoining property shall be completely protected from any damage incidental to the building operation when the owner of the adjoining property permits free access to the building at all reasonable times to provide the necessary safeguards in accordance with Section 3007.0.

SECTION 3013.0 PROTECTION OF FLOOR AND WALL OPENINGS

3013.1 Noncombustible floor construction: The arches, slabs or structural floor fillings of buildings of Types 1 and 2 construction shall be installed as the building progresses.

3013.2 Combustible floor construction: In Types 3, 4 and 5 construction when double flooring is used, the underfloor shall be laid on each story as the building progresses; and when double floors are not used, the floors shall be planked over two stories below the level where work is being performed.

3013.3 Steel structural frames: In steel construction, the entire tier of iron or steel beams upon which the structural work is in progress shall be planked over, with the exception of necessary hoistways and permanent openings. steel work shall not advance more than six floors ahead of the permanent floor construction.

3013.4 Guardrails: All floor and wall openings shall be protected with substantial guardrails and toe boards in accordance with ANSI A12.1 listed in Appendix A.

SECTION 3014.0 SCAFFOLDS

3014.1 Load capacity: Scaffolds and their components shall be capable of supporting without failure at least four times the maximum intended load. All platforms and supporting elements of scaffolds shall be designed and constructed to support uniform minimum live loads in pounds per square foot of the platform area in accordance with the classifications described in Table 3014.

3014.2 Erection: Built-up, swinging and suspended scaffolds shall be erected by competent workers only.

3014.3 Scaffolding: Scaffolding shall be constructed in accordance with Sections 3014.3.1 and 3014.3.2.

3014.3.1 All buildings: All scaffolding exceeding 60 feet or seven stories in height used in construction operations involving the erection, alteration or maintenance of buildings, shall be constructed of noncombustible or fire-retardant materials complying with the provisions of Section 903.0.

Table 3014
SCAFFOLD LOAD CAPACITY

Classification	Service type ~~(square foot)~~	Load (pounds per s.f.)
Light Duty	Carpenters	25
	Stone setters (no stone on scaffold)	25
	Miscellaneous (no material on scaffold)	25
Medium duty	Bricklayers	50
	Stucco	50
	Lathers and plasterers	50
Heavy duty	Stone masons	75

3014.3.2 Use Group I: All scaffolding used in construction operations involving the repair or partial demolition during occupancy of buildings of Use Groups I-2 and I-3 shall be constructed of noncombustible or fire-retardant materials complying with the provisions of Section 903.0.

SECTION 3015.0 HOISTS

3015.1 Equipment for handling and hoisting material: Equipment for handling and hoisting materials shall be in accordance with **Article 17 of the *Rules and Regulations for the Prevention of Accidents in Construction Operations* (441 CMR 10.00).**

3015.2 Passengers prohibited: Persons shall not be permitted to ride a material hoist. Temporary elevators shall be installed when necessary to transport workers as provided in Article 26.

3015.3 Guarding of cables: All hoisting cables and signal cords shall be guarded whenever they pass through or cross working spaces to prevent injury to persons.

3015.4 Rigger's license: All persons engaged in the erection of derricks and other hoisting apparatus shall secure a license or certificate of fitness for the performance of such work from the authorized administrative official.

SECTION 3016.0 STAIRWAYS AND LADDERS

3016.1 Temporary stairways: When a building has been constructed to a greater height than 50 feet or four stories, or when an existing building exceeding 50 feet in height is altered, at least one temporary lighted stairway shall be provided unless one or more of the permanent stairways are erected as the construction progresses.

3016.2 Ladders: Temporary ladders, when permitted for access to floors before stairways are installed, or which are designed for other working purposes, shall extend at least 42 inches above the floor level which they serve.

SECTION 3017.0 LIGHTING

3017.1 General: All stairways and parts of buildings under demolition, erection or repair shall be adequately lighted while persons are engaged at work, to comply with the provisions of Sections 824.0 and 2701.2.5.

SECTION 3018.0 FIRE HAZARDS

3018.1 General: The provisions of this code and of the fire prevention code listed in Appendix A shall be strictly observed to safeguard against all fire hazards attendant upon construction operations.

3018.2 Temporary heating: Whenever salamanders or other heating devices are used for temporary heating, all regulations as to maximum temperature, distance from combustible materials, spark arrestors, removal of noxious gases, and other requirements prescribed by the building official shall be fully observed. When the

source of temporary heat consists of salamanders or other open-flame devices, temporary canvas enclosures shall comply with Section 904.0

3018.3 Steam boilers: All temporary or permanent high-pressure steam boilers shall be operated, or be in charge of engineers or firemen licensed in accordance with the provisions of Inspection of Boilers, Air Tanks, etc.; Licenses of Hoisting Machinery, Chapter 146 of the Massachusetts General Laws Annotated, as amended, and as listed under Boiler Regulations in Appendix G. When such boilers are located within a building or within ten (10) feet thereof, all such boilers shall be enclosed with approved noncombustible construction.

3018.4 Storage of flammables: Storage of gasoline for hoists, oils, paints and other highly flammable materials shall be permitted only as specified in Article 6 and when stored in approved safety containers. The storage of larger quantities shall not be approved unless stored in separate compartments or enclosures of approved noncombustible construction.

3018.5 Flame cutting and welding: The use of oxyacetylene torches for cutting or welding shall be permitted only in accordance with ANSI Z49.1 listed in Appendix A.

3018.6 Concrete forms: Combustible materials shall not be stored on any floor of a building under construction until all combustible concrete forms are removed from the tier immediately above.

3018.7 Fire extinguishers: Fire extinguishers shall be provided as required by Section 1021.0.

3018.8 Standpipes and fire lines: Where standpipes are provided as a permanent part of the building, they shall be installed and made ready for instant use by the fire department as the structure progresses in accordance with the provisions of Section 1013.0. Free access from the street to such standpipes shall be maintained at all times. Materials shall not be stored within 5 feet of any fire hydrant or in the roadway between such hydrant and the center line of the street.

3018.9 Housekeeping: Rubbish and trash shall not be allowed to accumulate on the site and shall be removed as fast as conditions warrant. Combustible rubbish shall be removed daily, and shall not be disposed of by burning on the premises or in the immediate vicinity. The entire premises and area adjoining and around the operation shall be kept in a safe and sanitary condition and free of accumulation of trash, rubbish, nuts, bolts, small tools and other equipment.

SECTION 3019.0 HEALTH HAZARDS

3019.1 General: Every construction or maintenance operation which results in the diffusion of dust, stone and other small particles, toxic gases or other harmful substances in quantities hazardous to health shall be safeguarded by means of local ventilation or other protective devices to insure the safety of the public as required by the regulations of the administrative official.

3019.2 Removal of dust: Dust, sand blasts or other harmful agents, when employed or occurring in construction operations, shall be disposed of at or near the point of origin to prevent their diffusion over adjoining premises or streets.

3019.3 Protective equipment: Facilities shall be provided in approved closed containers for housing the necessary vision, respiratory and protective equipment required in welding operations, and in accordance with the regulations of the administrative official.

SECTION 3020.0 WELDING SAFETY PRECAUTIONS

3020.1 Welding enclosures: All welding and flame-cutting operations shall be performed in protected areas with full consideration of safety and fire hazards. Such closed spaces shall be properly ventilated while welding or cutting is being done. Suitable protection against the rays of the electric arc shall be maintained by the contractor where arc welding operations might be viewed within harmful range by persons other than the welding operators and inspectors.

3020.2 Flammable materials: Proper precautions shall be taken to avoid all risk of fire or explosion, and flammable or explosive materials shall not be stored in the vicinity of welding or cutting operations.

SECTION 3021.0 SANITATION

3021.1 General: Every building in the course of demolition, erection or repair shall be provided with toilet and drinking water facilities which shall be constructed and installed in accordance with the **Massachusetts State Plumbing Code (248 CMR 2.00)** listed in Appendix G.

SECTION 3022.0 DISPUTES

3022.1 General: The building official, when requested by any person, aggrieved or otherwise, shall serve a written notice on any owner, tenant and their agents who fail to conform to the requirements of this article directing such person to take the necessary remedial action. If the person whose duty it is to protect his own or adjoining property under those provisions fails to proceed to fully comply with such

notice within three days of receipt thereof, or within a reasonable time thereafter as determined by the building official, the building official is authorized to cause the necessary work to be done when the health, safety and general welfare of the public are involved. The cost of such work shall become a lien against the property of the offending owner, and the legal authority of the jurisdiction shall institute appropriate action for its recovery.

ARTICLE 31

ENERGY CONSERVATION

(This Article is entirely unique to Massachusetts)

SECTION 3100.0 GENERAL

3100.1 Scope: This article sets forth requirements for the effective use of energy in structures.

SECTION 3101.0 ADMINISTRATIVE

3101.1 Compliance: Buildings shall be deemed to be in compliance with this article when built to the provisions of the following:

1. component design (Section 3108.0-3114.0); or
2. building design by systems analysis (Section 3115.0); or
3. buildings utilizing nondepletable energy sources (Section 3116.0).

3101.2 Other regulations: This article is not intended to abridge any safety or health provisions required under any other applicable codes or ordinances.

3101.3 Existing buildings: Nothing in this article shall require the removal, alteration, or abandonment, or prevent the continuance of the use and occupancy of, a lawfully existing building, unless provided otherwise specifically by this article.

3101.4 Exempt buildings: The following buildings are exempt from the provisions of this article, with the exception of Section 3113.0 dealing with lighting requirements:

1. Buildings and structures or portions thereof whose peak design rate of energy usage is less than one (1) watt per square foot or three and four tenths (3.4) Btu/h per square foot of floor area for all purposes;
2. Buildings which are neither heated nor cooled;
3. Greenhouses that are free-standing, or attached to a building and separated by a wall having the same thermal value as an exterior wall, and provided with a separate temperature control system;
4. Buildings with less than one hundred (100) square feet of gross floor area.

SECTION 3102.0 EXISTING BUILDINGS

3102.1 Additions to existing buildings: Additions to existing buildings or structures shall be made without making the entire building or structure comply. The new construction shall conform to the provisions of this article as they relate to the addition only.

3102.2 Alterations to existing buildings: See Article 32.

SECTION 3103.0 PLANS AND SPECIFICATIONS

3103.1 Scope: This section applies to all buildings.

3103.2 General: Plans, specifications and necessary computations shall be submitted to indicate conformance with this section and other applicable sections of the code.

3103.3 Details: The data submitted shall show all pertinent information and features to be incorporated into the building, including but not limited to: the exterior envelope component materials; the R values of the respective elements; the U values of the overall assembly; calculations of overall Uo of the walls, roof/ceiling, and floors; the size and type of apparatus and equipment; controls; lighting requirements; and other pertinent data to indicate conformance to this article. Where required by the Board of Building Regulations and Standards or the local enforcement official, such data shall be submitted on forms specified.

3103.4 Calculation procedures: Calculation procedures shall be in accordance with data in the ASHRAE Handbook, 1985 Fundamentals Volume.

SECTION 3104.0 MATERIALS AND EQUIPMENT

3104.1 Identification: Where practicable, all materials and equipment referenced in Section 3103.2 shall be marked in order to show compliance with this article.

3104.2 Maintenance information: Service systems which require preventive maintenance to maintain efficient operation shall be furnished with complete necessary maintenance information. Required routine maintenance actions, as specified by the manufacturer, shall be stated clearly and incorporated on a readily accessible label on the equipment. Such label may be limited to identifying, by title or publication number, the operation and maintenance manual for that particular model and type of product.

SECTION 3105.0 DESIGN CONDITIONS

3105.1 Scope: This section applies to all buildings.

3105.2 General: The criteria of this section establish the minimum requirements for the thermal design of the exterior envelope of buildings and for HVAC systems and equipment.

3105.3 Thermal performance: A building that is designed to be both heated and cooled shall meet the more stringent of the heating or cooling requirements as provided in this article when requirements differ.

3105.4 Design parameters: The design parameters listed in Tables 3105.1 and 3105.2 shall be used for calculations required under this article.

3105.4.1 Indoor design temperature: Indoor design temperature shall be seventy-two (72) degrees F for heating and seventy-eight (78) degrees F for cooling.

3105.4.2 Design humidity: Indoor design relative humidity for heating shall not exceed thirty (30) per cent. For cooling, the actual design relative humidity within the comfort envelope as defined in ASHRAE Standard 55-81 listed in Appendix A shall be selected for minimum total HVAC system energy use in accordance with accepted practice.

3105.5 Ventilation: Ventilation air shall conform to the requirements specified in the mechanical code listed in Appendix A.

Table 3105.1
DESIGN TEMPERATURES
HEATING DEGREE DAYS BASE 65
HDD_{65}

Outside Ambient				
Location	Heating Degrees (°F) Winter	Cooling Degrees (°F) Dry Bulb Summer	Cooling Degrees (°F) Wet Bulb Summer	Heating Degree Days Base 65
Boston	9	88	74	5634
Clinton	2	87	73	6517
Fall River	9	84	73	5774
Framingham	6	86	73	6144
Gloucester	5	86	74	-
Greenfield	-2	85	73	-
Lawrence	0	87	74	6195
Lowell	1	88	74	6056
New Bedford	9	82	73	5395
Pittsfield	-3	84	72	7578
Springfield	0	87	73	5844
Taunton	9	86	74	6184
Worcester	4	84	72	6989

USED WITH ACP TABLES SECTION 3114.4 ONLY.

TABLE 3105.2
HEATING DEGREE DAYS BASE 50
HDD_{50}

Location	Heating Degree Days Base 50
Amherst	3171
Birch Hill Dam	3733
Blue Hill	2926
Boston	2383
Chatham	2377
Chestnut Hill	2658
Clinton	3107
East Wareham	2780
Edgartown	2499
Fitchburg	3156
Framingham	2855
Haverhill	2734
Hyannis	2478
Knightville Dam	3693
Lawrence	2867
Middleton	2676
Nantucket	2347
New Bedford	2107
Plymouth	2619
Rochester	2807
Rockport	2726
Springfield	2706
Stockbridge	3551
Taunton	2800
Tulley Lake	3786
Worcester	3364

SECTION 3106.0 BUILDING INSULATION SPECIFICATIONS

3106.1 Scope: This section applies to all buildings.

3106.2 General: Insulating materials must conform to the Federal Specifications (F.S.), the American Society for Testing Materials (ASTM) Test Standards, or the Code of Federal Regulations (CFR) as listed in Table 3106.

Table 3106
INSULATION MATERIALS STANDARDS

Material	Standard
Mineral Fiber	
blanket/batt	ASTM C665-78
loose-fill	ASTM C-764-73
Mineral Cellular	
perlite	ASTM C549-81
vermiculite	ASTM C516-80
perlite board	ASTM C728-82
cellular glass block	ASTM C552-79
Organic Fiber	
cellulose fiber board	ASTM C208-82
cellulose loose fill	16 CFR Part 1209
Organic Cellular	
polystyrene board	ASTM C578-83
urethane board	ASTM C591-69
flexible unicellular polyurethane or polyisocyanurate with foil face	ASTM C534-70 F.S. HH-1-1972-1
polyurethane or polyisocyanurate with felt face	F.S. HH-1-1972-2

3106.3 Moisture control: The design of buildings for energy conservation shall not create conditions of accelerated deterioration from moisture condensation (additionally, see Article 5 for attic and under-floor space ventilation).

3106.4 Installation

3106.4.1 Recessed light fixtures: Only IC labeled recessed lights allowing direct contact with insulating materials may be used in areas separating conditioned and unconditioned spaces.

3106.4.2 High heat sources: A clearance of three (3) inches from any high heat source, including but not limited to chimneys, flues and vents, shall be maintained for combustible insulating materials.

3106.4.3 Urea formaldehyde foams: Urea formaldehyde foams shall not be used in any building.

3106.4.4 Walls: Batt/blanket insulation with a vapor barrier attached shall be stapled to the sides or faces of wall studs at intervals of eight (8) inches on center vertically.
Where batt/blanket insulation is of a "friction fit" design and a poly vapor barrier is employed, the vapor barrier shall be affixed to the interior face of the wall studs in accordance with the insulation manufacturer's recommendations.

3106.4.5 Cavities: All cavities between rough framing and door and window heads, jambs, and sills shall be filled with insulation and covered with a vapor barrier meeting the criteria of 3107.

3106.4.6.1 Low Rise Residential: Perimeter insulation for slab on grade construction in buildings of Use Group R of three stories or less shall be installed so that the concrete to concrete contact between the foundation wall and the floor slab is broken and the insulation extends downward the thickness of the slab and then extends four (4) feet vertically down from, or four (4) feet horizontally beneath, the floor slab. Perimeter insulation may be installed in alternative locations if installed in a manner to thermally isolate the floor from the exterior.

3106.4.6.2 Perimeter Insulation: Perimeter Insulation for slab on grade construction in buildings of Use Group R of more than three stories or in buildings of other Use Groups shall be installed in a manner consistent with that specified in Section 3106.4.6.1, except that alternate locations and dimensions may be permitted by the provisions of Section 3114.

3106.4.7 Foundation wall insulation:

1. For interior foundation wall insulation, the entire gross wall area extending from the top of the band joist to the floor shall be insulated in accordance with Table 3109.1.

2. For exterior foundation wall insulation, the insulation shall extend from the top of the foundation to a minimum of eight feet below grade or to foundation footing, whichever is less. All exterior basement and foundation wall insulation shall be suitably protected so as to prevent deterioration caused by ultra-violet light or insect damage in accordance with manufacturer's instructions.

3106.5 Fire safety relating to insulation: See Sections 928 and 2002.

3106.6: Labeling

3106.6.1 Batt and blanket and rigid board: Insulation of this type shall be labeled according to type, manufacturer or distributor, R value of the insulation at the labeled thickness, and material specification as listed in Table 3106.

3106.6.2 Blown, poured, or sprayed on types: Insulation of these types shall be labeled according to type, manufacturer, recommended insulation density, thickness and R value, fire safety requirements and material specifications as listed in Table 3106.

SECTION 3107.0 AIR INFILTRATION AND MOISTURE CONTROL

3107.1 This section applies to all buildings.

3107.2 Vapor barriers: A vapor barrier of one point zero (1.0) perm or less shall be installed on the winter warm side of walls, ceilings and floors enclosing a conditioned space.

Exception: Vapor barriers may be eliminated with adequate ventilation as defined in Article 5 (See Section 507.2).

3107.3 Taping: All tears in the vapor barrier shall be taped or sealed.

3107.4 Air leakage for all buildings

1. The requirements of this section shall apply to those locations separating outdoor ambient conditions from interior spaces that are heated or mechanically cooled and are not applicable to the separation of interior conditioned spaces from each other.

2. The following openings in the exterior building envelope shall be caulked, gasketed, weatherstripped, foamed or otherwise sealed to limit infiltration:

    a. Around window and door frames, between the unit and the rough framing;
    b. Between all exterior wall soleplates and the structural floor, using two rows of caulking or alternate approved procedure;
    c. Over all framing joints where floors over conditioned spaces intersect exterior walls, using a water vapor permeable infiltration barrier or alternate approved technique;
    d. Around openings for plumbing, electricity, telephone and gas lines in walls, ceilings and floors;

e. At openings in the ceiling, such as where the ceiling panels meet interior and exterior walls, at exposed beam and masonry fireplaces;
f. At the mudsill, in addition to normal sill sealer in conditioned basements and conditioned crawlspaces; and,
g. At all other openings in the exterior building envelope.

3. Electrical outlet plate gaskets shall be installed on all receptacle, switch, or other electrical boxes in exterior and interior walls.

4. Heating ducts shall be sealed at all joints and corners as specified in 3110.9.

5. Interior openings between conditioned and non-conditioned space shall be sealed using sealant, closed-cell gasket material, permanent tape, or another method that limits infiltration.

3107.5 Air leakage requirements for fenestration and doors

3107.5.1 Windows shall have an air leakage rate of 0.34 cfm per foot of operable sash crack in accordance with the following standards:

ANSI/AANA 101-85, Aluminum Prime Windows,

ASTM D 4099-83, Specifications for Polyvinylchloride (PCV) Prime Windows, or

ANSI/NWMA I.S. 2-80, Wood Window Units (Improved Performance Rating Only).

3107.5.2 Sliding Doors shall meet one of the following standards for air leakage:

ANSI/AANA 101-85, Aluminum Sliding Glass Doors, or

NWMA I.S. 3-83, Wood Sliding Patio Doors.

3107.5.3 Commercial entrance swinging or revolving doors shall limit air leakage to a rate not to exceed 1.2 cfm per square foot of door area, at standard test conditions.

3107.5.4 Residential swinging doors shall limit air leakage to a rate not to exceed 0.5 cfm per square foot of door area, at standard test conditions.

3107.5.5 Spaces that have regular high volume traffic through the building envelopes such as retail store entrances and loading bays, shall be designed accounting for the steady state air transfer between conditioned and unconditioned or exterior space.

SECTION 3108.0 COMPONENT DESIGN

3108.1 Scope: All low rise residential buildings that are heated or mechanically cooled shall be constructed so as to provide the required thermal performance of the various components listed in Sections 3108.0 through 3112.0, and to provide the lighting switching requirements of Section 3113.2.2.1.

All commercial and high rise residential buildings that are mechanically heated and cooled shall be constructed so as to provide the required thermal and lighting system performance of the various components listed in Sections 3108.0, and 3110.0 through 3114.0.

3108.2 Thermal Performance: Information on thermal properties, performance of building envelope sections and components, and heat transfer shall be obtained from laboratory or field test measurements, or when information is not available from these sources, then such information may be obtained from the ASHRAE Handbook, 1985 Fundamentals.

When laboratory or field test measurements are used, they shall be conducted in accordance with ASTM standards:

1. C-177-76, Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Guarded Hot Plate,

2. C-518-76, Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter,

3. C-236-80, Standard Test Method for Steady-State Thermal Performance of Building Assemblies by Means of a Guarded Hot Box, or

4. C-976-82, Thermal Performance of Building Assemblies by Means of a Calibrated Hot Box.

To determine thermal conductance through window assemblies the following ASTM or American Architectural Manufacturers Association (AAMA) standards shall be used.

1. AAMA 1503.1-1980, Test Method of Thermal Transmittance of Windows, Doors and Glazed Wall Sections,

2. ASTM C-236-80, Standard Test Method for Steady-State Thermal Performance of Building Assemblies by Means of Guarded Hot Box, or

3. ASTM C-976-82, Thermal Performance of Building Assemblies by Means of a Calibrated Hot Box.

When using any of the three test procedures above, a fifteen mile per hour wind shall be applied perpendicular to the glazing.

3108.3 Gross wall area: For the purposes of this, Article 31, the gross area of exterior walls consists of all opaque wall areas, including foundation walls, areas between floor spandrels, peripheral edges of floors, window areas including sash, and door areas, where such surfaces enclose a heated or mechanically cooled space including interstitial areas between two (2) such spaces, but excluding vents, grills and pipes.

3108.4 Roof assembly: For the purpose of this article, a roof assembly shall be considered as all components of the roof/ceiling envelope through which heat flows, thereby creating a building transmission heat loss or gain, where such assembly encloses a heated or mechanically cooled space.

3108.4.1 Gross roof area: The gross area of a roof assembly consists of the total interior surface of such assembly, including skylights, exposed to the heated or mechanically cooled space.

3108.4.2 Ceiling plenums: Where air ceiling plenums are employed, the roof/ceiling assembly shall:

1. for thermal transmittance purposes not include the ceiling proper nor the plenum space as part of the assembly; and

2. for gross area purposes be based upon the interior face of the upper plenum surface.

3108.5 Swimming pools: All pool enclosures shall be designed in accordance with the 1982 edition of the ASHRAE Applications Handbook.

Such pool enclosures shall have a maximum overall (roof/gables/sidewalls) U value of 0.25.

SECTION 3109.0 EXTERIOR ENVELOPE REQUIREMENTS FOR LOW RISE RESIDENTIAL BUILDINGS

3109.1 Criteria for low rise residential buildings: The following requirements shall apply to all buildings and structures or portions thereof in use groups R-1, R-2, R-3, and R-4 (hotels, multi-family, and one- and two-family) that are heated or mechanically cooled and not more than three stories high.

1. All buildings in these use groups shall conform to the thermal transmittance values in Table 3109.1 or shall be designed to satisfy the requirements of Section 3109.3 or shall be designed to satisfy the requirements of Section 3115.

2. An overall Uo value of 0.167 for structures heated by oil, gas or heat pumps, or an overall Uo of 0.105 for structures heated by electric resistance may be used for the combination of walls, doors and windows containing heated space in lieu of the separate U values listed for walls, doors and windows. The overall Uo of 0.167 or 0.105 shall be used when the windows exceed fifteen per cent of the gross exterior wall area.

3. For purposes of this section only, framing members shall not be included in the calculations of R and U values.

TABLE 3109.1
MAXIMUM U VALUES AND MINIMUM R VALUES OF WALLS, ROOF/CEILING, AND FLOORS FOR RESIDENTIAL BUILDINGS OF SECTION 3109.1

ELEMENT	DESCRIPTION	U VALUE	TOTAL R VALUE	NOTES
Walls	All wall construction containing heated or mechanically cooled space	0.08	12.5	1
	Electric resistance heating	0.05	20.0	1
Foundation Walls Including Band Joist	Containing heated or mechanically cooled space	0.08	12.5	-
	Containing unheated space	0.08	12.5	4
Roof/Ceiling Assembly	All roof construction containing heated or mechanically cooled space	0.033	30.0	-
Windows	All construction enclosing heated or mechanically cooled space	0.65	1.54	2
	Electric resistance heating	0.40	2.50	6, 7
Doors	All construction enclosing heated or mechanically cooled space	0.40	2.50	-
Floors	Floor sections over areas exposed to outside air or unheated space	0.05	20.0	3
	Slab on grade beneath conditioned space	-	10.0	5

Note 1: These values may be used when the doors and windows do not exceed fifteen (15) percent of the gross exterior wall area. When doors and windows exceed fifteen (15) percent of the gross wall area, see Section 2009.1, item 2.

Note 2: Double glazed primary windows or single glaze primary windows with storm windows will satisfy the required U value of zero point sixty-five (0.65).

Note 3: Insulation may be omitted from floors over unheated areas when foundation walls are provided with a U value of zero point zero eight (0.08).

Note 4: The U value requirement of zero point zero eight for foundation walls may be omitted when floors over unheated spaces are provided with a U value of zero point zero five (0.05).

(Table notes continued on next page)

Note 5: R value for perimeter insulation (see Section 2006.4.6).

Note 6: When doors and windows do not exceed fifteen (15) percent of the gross exterior wall area, this value may be used. When doors and windows do not exceed ten (10) percent of the gross exterior wall area, windows having a U value of 0.65 (R value of 1.54) may be used. When windows and doors exceed fifteen (15) percent of the gross exterior wall area, see Section 3109.1, item 2.

Note 7: Double glazed primary windows with storm windows or most triple glazed primary windows or double glazed low emissivity primary windows will satisfy the required U value of zero point forty (0.40).

3109.2 Calculation of Uo: Separate overall thermal transmittance values shall be calculated for wall assemblies, roof/ceiling assemblies, and floors. Equation 1 is provided as an example of the Uo calculation for walls.

$$\text{Equation 1:} \quad \text{Overall wall } U_o = \frac{U_w A_w + U_g A_g + U_d A_d}{A}$$

Where:

Uo = average or combined transmittance of the gross exterior wall; (Btu/hr-ft^2-^{o}F).

Aw = gross exterior wall area; (ft^2).

Uw = thermal transmittance of the components of the opaque wall; (Btu/hr-ft^2-^{o}F).

Aw = opaque wall area; (ft^2).

Ug = thermal transmittance of the windows; (Btu/hr-ft^2-^{o}F).

Ag = window area; (ft^2).

Ud = thermal transmittance of the door or similar opening; (Btu/hr-ft^2-^{o}F).

Ad = door area; (ft^2).

NOTE: Where Ug is determined by test, it shall be calculated using the procedure contained in Section 3114.3.2.2 including calculation for framing, sash, edge effects, and all other factors pertinent to the complete window assembly.

3109.3 Alternates: The stated Uo (or U) value of any one assembly, such as roof/ceiling, wall, or floor, may be increased and the Uo (or U) value for other components decreased provided that the overall heat gain or loss for the entire building envelope does not exceed the total resulting from conformance to the stated Uo (or U) values.

SECTION 3110.0 HEATING, VENTILATING AND AIR CONDITIONING (HVAC) SYSTEMS

3110.1 Scope: This section covers the determination of heating and cooling loads, systems performance, and control requirements for all buildings. Criteria are established for insulating HVAC systems and for duct construction.

> **Exception:** Special applications, including but not limited to hospitals, museums, laboratories, rooms containing thermally sensitive equipment such as computers, open refrigerated display cases, may be exempted from the requirements of this section, when calculations and requirements are submitted establishing the unique environmental criteria that exist.

3110.2 Calculation of heating and cooling loads

3110.2.1 Calculation procedures: For the purpose of sizing HVAC systems, heating and cooling design loads shall be determined in accordance with techniques recommended in the 1985 ASHRAE Handbook of Fundamentals or the Air Conditioning Contractors Association's Manual "J". The design parameters specified in Section 3105.0 shall apply for all computations.

3110.3.1 System heating/cooling capacity: The rated output capacity of the heating/cooling system at design conditions shall not be greater than one hundred twenty-five (125) per cent of the design load calculated in accordance with this article. Equipment designed for standby purposes is not included in the capacity limitation requirement. For a single piece of equipment which has both heating and cooling capability, only one function, either the heating or the cooling, need meet the requirements of this section. Capacity for the other function shall be, within available equipment options, the smallest size necessary to meet the load.

> **Exception:** Where the HVAC system for the building uses interconnected equipment designed to sequence with the load and it can be shown that such design will use less energy on an annual basis than one large unit.

3110.3.2 Heat pump supplementary heating capacity: The rated output capacity of a heat pump supplementary heating source shall not be greater than one-hundred twenty-five (125) percent of the design load as calculated in accordance with this article.

3110.4 Simultaneous heating and cooling: Simultaneous heating and cooling by reheating or recooling supply air or by concurrent operation of independent heating and cooling systems serving a common zone shall be restricted as delineated below:

3110.4.1 Recovered energy: Recovered energy, provided the new energy expended in the recovery process is less than the amount recovered, may be used for control of temperature and humidity. (New energy is defined as energy, other than recovered, utilized for the purpose of heating or cooling).

3110.4.2 New energy for humidity control: New energy may be used, when necessary, to prevent relative humidity from rising above fifty-three (53) per cent for comfort control or to prevent condensation on terminal units or outlets.

3110.4.3 New energy for temperature control: New energy may be used for control of temperature if minimized as delineated below:

1. Reheat systems: Systems employing reheat and serving more than one (1) zone, other than those employing variable air volume for temperature control, shall be provided with controls that will automatically reset the cold air supply. The temperature shall be controlled to sequence reheat and cooling.

2. Dual duct and multi zone systems: These systems shall be provided with controls that will automatically reset the cold deck air supply to the highest temperature that will satisfy the zone requiring the coolest air, and the hot deck air supply to the lowest temperature that will satisfy the zone requiring the warmest air.

3. Recooling systems: Systems in which heated air is recooled, directly or indirectly, to maintain space temperature shall be provided with controls that will automatically reset the temperature to which the supply air is heated. The temperature shall be the lowest level that will satisfy the zone requiring the warmest air.

4. Multiple zones: For systems with multiple zones, one (1) or more zones may be chosen to represent a number of zones with similar heating/cooling characteristics. A multiple zone HVAC system that employs reheating or recooling for control of not more than five thousand (5,000) cubic feet per minute (cfm) or twenty (20) percent of the total supply air of the system, whichever is less, shall be exempt from the supply air temperature reset requirement of paragraphs 1 through 3.

5. Concurrent operation: Concurrent operation of independent heating and cooling systems serving common spaces and requiring the use of new

energy for heating or cooling shall be minimized by one (1) or both of the following:

a. by providing sequential temperature control of both heating and cooling capacity in each zone; and/or

b. by limiting the heating energy input through automatic reset control of the temperature of the heating medium to only that necessary to offset heat loss due to transmission and infiltration and, where applicable, to heat the ventilation air supply to the space.

3110.5 Mechanical ventilation: Each mechanical ventilation system (supply and/or exhaust) shall be equipped with motorized or other means of automatic volume shutoff or reduction during periods of non-use or alternate use of the spaces served by the system.

Exceptions:
1. For one- and two-family structures gravity dampers shall be allowed for bath and kitchen exhaust systems.
2. Systems serving areas expected to operate continuously.
3. For Systems which have a design air flow of 300 cfm or less, gravity dampers shall be allowed.
4. Gravity and other non-electrical ventilation systems may be controlled by readily accessible manual damper controls.
5. Where restricted by code, such as combustion air intakes.

3110.6 Fan system design criteria

3110.6.1 General: The following design criteria apply to all HVAC fan systems used for comfort heating, ventilating, and/or air conditioning. For the purposes of this section, the energy demand of a fan system is the sum of the demand of all fans which are required to operate at design conditions to supply air from the heating and/or cooling source to the conditioned space(s) and return it back to the source or exhaust it to the outdoors while bringing in outside air for ventilation.

Exceptions:
1. Systems with total fan system motor horsepower of 10 HP or less.
2. Unitary equipment for which fan energy is included in Section 3111 efficiency ratings.

3110.6.2 Constant volume fan systems: For fan systems which provide a constant air volume whenever the fans are operating, the power required by the motors for the combined fan system at design conditions shall not exceed 0.8 W/cfm.

3110.6.3 Variable air volume (VAV) fan systems

3110.6.3.1 For fan systems which are able to vary system air volume automatically as a function of load, the power required by the motors for the combined fan system at design conditions shall not exceed 1.25 W/cfm.

3110.6.3.2 Individual VAV fans with motors 75 HP and larger shall include controls and devices necessary for the fan motor to demand no more than 50% of design wattage at 50% of design air volume, based on manufacturer's test data.

3110.7 Controls:

3110.7.1 Temperature control: Each HVAC system shall be provided with at least one (1) thermostat for the regulation of temperature. Each thermostat shall be capable of being set as follows:

1. when used to control heating only, 55-75 degrees F;
2. when used to control cooling only, 70-85 degrees F; and
3. when used to control both heating and cooling it shall be capable of being set from 55-85 degrees F, and shall be capable of operating the system heating and cooling in sequence. It shall be adjustable to provide a temperature range of up to ten (10) degrees F between full heating and full cooling, except as allowed in Section 3110.4.3, item 5.

3110.7.2 Humidity control: If an HVAC system is equipped with a means for adding moisture to maintain specific selected relative humidities in spaces or zones, a humidistat shall be provided. This device shall be capable of being set to prevent new energy from being used to produce space relative humidity above thirty (30) per cent relative humidity. When a humidistat is used in an HVAC system for controlling moisture removal to maintain specific selected relative humidities in spaces or zones, it shall be capable of being set to prevent new energy from being used to produce a space relative humidity less than fifty-three (53) percent.

3110.7.3 Zoning for temperature control:

1. One- and two-family dwellings: At least one (1) thermostat for regulation of space temperature shall be provided for each separate HVAC system. In addition, a readily accessible manual or automatic means shall be provided to partially restrict or shut off the heating and/or cooling input to each zone or floor.
2. Multi-family dwellings: For multi-family dwellings, each individual dwelling unit shall be considered separately and shall meet the above requirements. Spaces other than living units shall meet the requirements of item 3 following.
3. In all other types of buildings or occupancies, at least one (1) thermostat for regulation of space temperature shall be provided for:

    a. each separate HVAC system; and
    b. each separate zone as defined in Section 311.0. As a minimum, each floor of a building shall be considered as a separate zone. In a multi-story building in which the perimeter system offsets only the transmission losses of the exterior wall, an entire side of uniform exposure may be zoned separately. A readily accessible manual or automatic means shall be provided to partially restrict or shut off the heating and/or cooling input (for the exposure) to each floor.

3110.7.4 Control setback and shut-off: Lowering thermostat set points to reduce energy consumption of heating systems shall not cause energy to be expended to reach the reduced setting.

3110.7.4.1 Residential occupancy (use groups R-2, R-3, and R-4): The thermostat required in paragraphs 1 and 2 of Section 3110.7.3, or an alternate means such as a switch or a clock, shall provide a readily accessible, manual or automatic means for reducing the energy required for heating and cooling during periods of nonuse or reduced need, such as, but not limited to, unoccupied periods and sleeping hours.

3110.7.4.2 Other buildings and occupancies: Each HVAC system shall be equipped with a readily accessible means of shutting off or reducing the energy used for HVAC during periods of nonuse or alternate uses of the building spaces or zones served by the system.

3110.7.4.3 Swimming pools:

1. Heated swimming pools shall be equipped with controls to limit heating water temperatures to not more than eighty (80) degrees F.

Exceptions:

1. Pools used for therapeutic purposes are exempt from this requirement when approved by the building official.
2. Uncovered (unenclosed) heated pools shall be controlled so that the electric or fossil fuel pool water heating systems are in operative whenever the outdoor air temperature is below sixty (60) degrees F.

3110.8 Duct construction: All air handling ductwork and plenums shall be constructed and erected in accordance with the appropriate Sheet Metal and Air Conditioning Contractors National Association (SMACNA) Standards.

3110.8.1 Ductwork which is intended to operate at static pressures in excess of 3 inches W.C. shall be leak tested and be in conformance with the following sections of the SMACNA Duct Leakage Test Manual, 1985: Test procedures shall be in accordance with those outlined in Section 5, or equivalent; test reports shall be provided in accordance with Section 6, or equivalent; the tested duct leakage class at a test pressure equal to the design duct pressure class rating shall be equal to or less than leakage class 6 as defined in Section 4.1. Leakage testing may be limited to representative sections of the duct system but in no case shall such tested sections include less than 25% of the total installed duct area for the designated pressure class.

3110.8.2 Where supply ductwork and plenums which are intended to operate at static pressures from 1/4 inch to 3 inches W.C. inclusive, are located outside of the conditioned space or in return plenums, joints shall be sealed in accordance with Seal Class C, as defined in the SMACNA manual referenced above. Pressure sensitive tape shall not be used as the primary sealant for such ducts which are intended to operate at static pressures of 1 inch W.C. or greater.

3110.8.3 Dampers: Automatic or manual dampers installed for the purpose of shutting off outside air intakes for ventilation air shall be designed with light tight shut-off characteristics to minimize air leakage.

3110.9 Air handling duct system insulation: All ducts, plenums and enclosures installed in or on buildings shall be thermally insulated as follows:

1. Air Handling System Insulation: All air handling ducts and plenums installed as part of an HVAC air distribution system shall be thermally insulated in accordance with Table 3110.9.

Exception: Duct insulation is not required in any of the following cases:

a. Ducts located within the conditioned space they serve.

b. Supply or return air ducts installed in unventilated crawl spaces with insulated walls, and basements or cellars with insulated walls in one- and two-family dwellings;
c. When the heat gain or loss of the ducts, without insulation, will not increase the energy requirements of the building;
d. Within HVAC equipment;
e. Exhaust air ducts.

TABLE 3110.9[1]
MINIMUM DUCT INSULATION

Duct Location	Cooling [2] Insulation R-Value	Heating [2] Insulation R-Value
Outside of building envelope or in spaces vented to the outside	5.0	6.5
Inside of building envelope: TD [3] <=15	None Required	None Required
Inside of building envelope: 15<TD [3] <=30	3.3	3.3
Inside of building envelope: TD [3] >30	5.0	5.0

Notes to Table 3110.9:

1 Insulation R-values shown are for the insulation only and do not include film resistance. The required minimum thicknesses do not consider condensation. For ducts which are designed to convey both heated and cooled air, duct insulation shall be as required by the most restrictive condition. Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive condition of this Section or Section 3109 (low rise residential) or Section 3114 (high rise residential and commercial).
2 Includes system return ducts.
3 TD is defined as the temperature difference at design conditions (see Section 3105) between the space within which the duct is located and the design air temperature in the duct.

2. Vapor barriers shall be provided, where required, to prevent condensation.

3110.10 Cooling with outdoor air (economizer cycle): Each fan system shall be designed to use up to and including one hundred (100) per cent of the fan system capacity for cooling with outdoor air automatically whenever its use will result in lower usage of new energy. Activation of economizer cycle shall be controlled by sensing outdoor air enthalpy and dry bulb temperature jointly or outdoor air dry bulb temperature alone to accomplish the above.

Exceptions: Cooling with outdoor air is not required under any one (1) or more of the following conditions:

1. Fan system capacity less than five thousand (5,000) cubic feet per minute (cfm) or one hundred thirty-four thousand (134,000) Btu/h of total cooling capacity;
2. The quality of the outdoor air is so poor as to require extensive treatment of the air;
3. The need for humidification or dehumidification requires the use of more energy than is conserved by the outdoor air cooling;
4. The use of outdoor air cooling may affect the operation of other systems so as to increase the overall energy consumption of the building;
5. Internal/external zone heat recovery or other energy recovery is used;
6. When all space cooling is accomplished by a circulating liquid which transfers space heat directly or indirectly to a heat rejection device such as a cooling tower without the use of a refrigeration system.

3110.11 Balancing: The HVAC system design shall provide means for balancing the air and water systems such as but not limited to dampers, temperature and pressure test connections, flow measuring stations or meters, and balancing valves. The HVAC systems shall be field balanced to achieve conditions stated in the plans and specifications.

3110.12 Piping Insulation: All piping installed to serve buildings and within buildings shall be thermally insulated in accordance with Table 3110.12.

Exceptions: Piping insulation is not required in any of the following cases:

1. Piping installed within HVAC equipment;
2. Piping for fluids at temperatures between fifty-five (55) degrees F and one hundred and five (105) degrees F;
3. When the heat loss and/or heat gain of the piping, without insulation, does not increase the heating and/or cooling energy requirements of the building;
4. Piping, installed in unventilated crawl spaces with insulated walls,and basements or cellars with insulated walls in one- and two-family dwellings.

3110.12.1 Other insulation thickness: Insulation thicknesses in Table 3110.12 are based on insulation with thermal conductivities listed in Table 3110.12 for each fluid operating temperature range, rated in accordance with ASTM C 335-79, Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe Insulations, at the average temperature listed in the Table. For insulation which has a conductivity more than 10% in excess of that shown in Table 3110.12 for the applicable fluid operation temperature range and at the average rating temperature shown, minimum thicknesses shall be determined in accordance with equation 3110.12.1:

$$T = PR \times [(1 + t/PR)^{K/k-1} \quad \text{Equation 3110.12.1}$$

Where:

T = new minimum insulation thickness for material with conductivity K, inches.

PR = pipe actual outside radius, inches

t = insulation thickness from Table 3110.12, inches.

K = conductivity of alternate material at the average rating temperature indicated in Table 3110.12 for the applicable fluid temperature range, (Btu-inch/h-^{o}F-ft^{2}).

k = conductivity listed in Table 3110.12 for the applicable fluid temperature range, (Btu-inch/h-^{o}F-ft^{2}).

3110.12.2 Vapor barriers: Vapor barriers shall be provided to prevent condensation where required.

Table 3110.12
MINIMUM PIPE INSULATION[1]
INSULATION THICKNESS IN INCHES FOR PIPE SIZES (Note 2)

PIPING SYSTEM TYPES / HEATING SYSTEMS Steam & Hot Water	FLUID TEMPERATURE RANGE (^{0}F)	RUNOUTS[2] UP TO 2"	1" & LESS	1 1/4" TO 2"	2 1/2" TO 4"	5" TO 6"	8" AND LARGER	INSULATION CONDUCTIVITY (B-in/F-hr-sf) at temp ^{o}F
High Press./Temp.	351-450	1.5	2.5	2.5	3.0	3.5	3.5	0.32 @ 250^o
Med. Press./Temp.	251-350	1.5	2.0	2.5	2.5	3.5	3.5	0.29 @ 200^o
Low Press./Temp.	201-250	1.0	1.5	1.5	2.0	2.0	3.5	0.27 @ 150^o
Low Temp.	141-200	0.5	1.5	1.5	1.5	1.5	1.5	0.25 @ 125^o
Low Temp.	105-140	0.5	1.0	1.0	1.0	1.5	1.5	0.24 @ 100^o
Steam Condensate (for feedwater)	Any	1.0	1.5	1.5	2.0	2.0	2.0	0.27 @ 150^o
COOLING SYSTEMS[3]								
Chilled Water	40-55	0.5	0.5	0.75	1.0	1.0	1.0	0.23 @ 75^o
Refrigerant or Brine	Below 55	1.0	1.0	1.5	1.5	1.5	1.5	0.23 @ 75^o

Notes:

1. For minimum thicknesses of alternative insulation types, see Section 3110.12.1.
2. Runouts to individual terminal units not exceeding 12 ft. in length.
3. The required minimum thicknesses do not consider condensation. Additional insulation and/or vapor barriers may be required to prevent condensation.

SECTION 3111.0 HEATING, VENTILATING AND AIR CONDITIONING EQUIPMENT

3111.1 Scope: This section applies to all buildings.

3111.2 HVAC equipment performance requirements: The requirements of this section apply to equipment and component performance for heating, ventilating, and air conditioning systems. Where equipment efficiency levels are specified, data furnished by the equipment supplier, or certified under a nationally recognized certification program or rating procedure, shall be used to satisfy these requirements.

3111.3 HVAC system combustion heating equipment: All gas and oil fired comfort heating equipment shall have an Annual Fuel Utilization Efficiency (AFUE) not less than the values shown in Table 3111.3. Equipment types not covered in these tables shall show a minimum combustion efficiency of seventy-five (75) per cent at maximum rated output. Combustion efficiency is defined as one hundred (100) percent minus stack losses in per cent of heat input. Stack losses are:

1. loss due to sensible heat in dry flue gas;
2. loss due to incomplete combustion; and
3. loss due to sensible and latent heat in moisture formed by combustion of hydrogen in the flue.

TABLE 3111.3
MINIMUM ANNUAL FUEL UTILIZATION EFFICIENCY
- FOSSIL FUEL HEATING -

EQUIPMENT	MINIMUM AFUE
Gas Boilers < 300,000 Btu/hr	68%
Oil Boilers < 300,000 Btu/hr	77%
Gas Furnaces <225,000 Btu/hr	68%
Oil Furnaces < 225,000 Btu/hr	77%

3111.4 HVAC system heating equipment, heat pumps heating mode: Heat pumps whose energy input is entirely electric shall show a coefficient of performance (COP heating, as defined herein) not less than the values shown in Table 3111.4.

1. These requirements apply to, but are not limited to, unitary heat pumps (air source) in the heating mode, and to packaged terminal heat pumps in the heating mode. Field assembled unitary heat pumps, consisting of one (1) or more components, shall show compliance with this section.

2. Coefficient of performance heating: the ratio of the rate of net heat output to the rate of total on-site energy input, expressed in consistent units and under designated rating conditions. The rate of net heat output shall be defined as the change in the total heat content of the air between entering and leaving the equipment (not including supplementary heat).
3. Supplementary heater: The heat pump shall be installed with a control to prevent supplementary heater operation when the heating load can be met by the heat pump alone. Supplementary heater operation is permitted during transient periods, such as start-ups, following room thermostat set-point advance and during defrost. A two (2) stage thermostat, which controls the supplementary heat on its second stage, shall be accepted as meeting this requirement. The cut-on temperature for the compression heating shall be higher than the cut-on temperature for the supplementary heat, and the cut-off temperature for the compression heating shall be higher than the cut-off temperature for the supplementary heat. Supplementary heat may be derived from any source of electric resistance heating or combustion heating.

TABLE 3111.4
MINIMUM COP FOR HEAT PUMPS, HEATING MODE

CATEGORY	PERFORMANCE	REFERENCE STANDARD(S)
Air Source, single phase: (Cooling capacity less than 65,000 Btu/hr)	Hi-temp (47db/43wb); (Min. COP = 2.7) Low-temp (17db/15wb); (Min. COP = 1.8)	ARI 210-81 ARI 240-81 ARI 210/240-84
Air Source, three phase: (Cooling capacity less than 35,000 Btu/hr)	Hi-temp (47db/43wb); (Min. COP = 2.7) Low-temp (17db/15wb); (Min. COP = 1.8)	
Packaged Terminal Heat Pumps	Min. COP = 2.5	

3111.5 HVAC system equipment, electrically operated cooling mode: HVAC system equipment as listed below whose energy input in the cooling mode is entirely electric shall show a Seasonal Energy Efficiency Ratio (SEER) or Energy Efficiency Ratio (EER) not less than the values shown in Table 3111.5.

3111.5.1 These requirements apply to, but are not limited to, unitary cooling equipment (air-cooled, water-cooled, and evaporatively cooled); the cooling mode of unitary heat pumps; and packaged terminal air conditioners.

TABLE 3111.5
MINIMUM SEER AND EER FOR ELECTRICALLY DRIVEN AIR CONDITIONING EQUIPMENT

TYPE	PERFORMANCE	REFERENCE STANDARD(S)
Air, single phase: (Cooling capacity less than 65,000 Btu/hr)	Min. SEER = 7.8	ARI 210-81 ARI 210/240-84
Air, three phase: (Cooling capacity less than 65,000 Btu/hr)	Min. EER (Hi-temp) = 6.2	
Air: (Cooling capacity greater than 65,000 Btu/hr but less than 135,000 Btu/hr)	Min. EER (Hi-temp) = 8.2	
Packaged Terminal Heat Pump	Min. EER = 7.8	
Packaged Terminal Air Conditioner	Min. EER = 7.8	

3111.6 Applied HVAC system components, electrically operated cooling mode: HVAC system components, as listed in Table 3111.6, whose energy input is entirely electric shall show a coefficient of performance (COP) cooling, as defined herein, not less than the values shown in Table 3111.6.

3111.6.1 Coefficient of performance: Coefficient of Performance (COP) cooling is the ratio of the rate of net heat removal to the rate of total energy input, expressed in consistent units and under designated rating conditions.

The rate of net heat removal is defined as the difference in total heat content of the water or refrigerant entering and leaving the component.

Total on-site energy input shall be determined by combining the energy inputs to all elements and accessories of the component, including but not limited to compressors, internal circulating pumps, purge, and the HVAC system component control circuit.

TABLE 3111.6
MINIMUM EER AND COP FOR ELECTRICALLY DRIVEN AIR CONDITIONING SYSTEM COMPONENTS

Component	Condensing Means	Coolant	EER	COP	Reference Standard
Self-Contained Chillers	Centrifugal	Air	8.2	2.4	ARI 550-83
Self-Contained Chillers	Centrifugal < 250 Tons	Water	16.4	4.8	ARI 550-83
Self-Contained Chillers	Centrifugal > 250 Tons	Water	17.1	5.0	ARI 550-83
Self-Contained Chillers	Rotary	Air	8.2	2.4	ARI 550-83
Self-Contained Chillers	Rotary	Water	14.0	4.1	ARI 550-83
Self-Contained Chillers - with Condenser	Positive Displacement	Air	8.9	2.6	ARI 590-81
Self-Contained Chillers - with Condenser	Positive Displacement	Water	12.6	3.7	ARI 590-81
Self-Contained Chillers - without Condenser	Positive Displacement	Air	10.1	3.0	ARI 590-81
Condenser Units 135,000 Btu/hr or Less		Air	9.5	2.8	ARI 365-85
Condenser Units 135,000 Btu/hr or Less		Water (Evap)	12.7	3.7	ARI 365-85

3111.7 HVAC system equipment, heat operated, cooling mode: Heat operated cooling equipment shall show a coefficient of performance (COP) cooling not less than the values shown in Table 3111.7. These requirements apply to, but are not limited to, absorption equipment, engine driven equipment, and turbine drive equipment.

When the refrigeration components are supplied by different manufacturers, it shall be the responsibility of the system designer to determine compliance with these requirements, using data provided by the suppliers of the elements.

TABLE 3111.7
MINIMUM COP FOR HEAT OPERATED
AIR CONDITIONING SYSTEM EQUIPMENT

HEAT SOURCE	MINIMUM COP
Direct fired (gas/oil)	0.48
Indirect fired (steam/hot water)	0.68

SECTION 3112.0 ELECTRICAL POWER DISTRIBUTION

3112.1 Scope: Electrical distribution systems shall be designed for the efficient distribution of electrical energy from the service entrance to the points of use.

3112.1.1 Exempt buildings: Buildings in use groups R-3 and R-4 (one-and two-family dwellings) shall be exempt from the requirements of this section.

3112.2 Power factor: Utilization equipment greater than one thousand (1,000) watts and lighting equipment greater than fifteen (15) watts with an inductive reactance load component shall have a power factor of not less than eighty-five (85) per cent under rated load conditions. Power factor of less than eighty-five (85) per cent shall be corrected to at least ninety (90) per cent under rated load conditions. Power factor corrective devices, installed to comply with this code, shall be switched with the utilization equipment, except where this results in an unsafe condition or interferes with the intended operation of the equipment.

3112.3 Service voltage: Where a choice of service voltage is available, a computation shall be made to determine which service voltage would produce the least energy loss, and that voltage shall be selected.

3112.4 Electric energy determination: In all multi-family dwellings, each dwelling unit shall be separately metered.

Exceptions:
1. Publicly financed housing for the elderly with fuel fired heating systems, with centrally operated air conditioning systems, or without air conditioning systems are exempt from this requirement.
2. Publicly financed housing for the elderly with electric resistance or storage heating systems are exempt from this requirement provided there is informational metering of the individual dwelling units.

SECTION 3113.0 LIGHTING SYSTEMS

3113.1 Scope: This section establishes the maximum power limits and control requirements for interior and exterior illumination systems.

3113.1.1 The rooms, spaces and areas covered by this section include:

1. Interior spaces of buildings.
2. Building exterior areas such as: entrances, exits, loading docks, etc.
3. Roads, grounds and other exterior areas including open-air covered areas where lighting is required and is energized through the building electrical service.

3113.1.2 Exempt buildings and spaces: The following buildings and spaces are exempt from the provisions of this section:
1. Lighting for dwellings units contained in use groups R-2, R-3 and R-4, except for the switching requirements in 3113.2.2.1.
2. Outdoor activities such as manufacturing, storage, commercial green houses and processing facilities.
3. Lighting power for theatrical productions, television broadcasting, audio-visual presentations and those portions of entertainment facilities where lighting is an essential technical element for the function performed.
4. Specialized luminaires for medical and dental purposes.
5. Outdoor athletic facilities.
6. Display lighting required for art exhibits or displays in galleries, museums and monuments.
7. Exterior lighting for public monuments and recognized landmarks such as buildings individually listed on the National Register of Historic Places.
8. Special lighting needs for research.
9. Lighting to be used solely for indoor plant growth during the hours of 10:00 p.m. to 6:00 a.m.

10. Emergency lighting that is automatically "off" during normal operation.
11. High risk security areas identified by local ordinances or regulations or by security or safety personnel as requiring additional lighting.
12. Classrooms specifically designed for the hard of seeing, hard of hearing (lip-reading), and for senior citizens.
13. Lighting for signs.
14. Store-front display windows in retail facilities.
15. Spaces regularly used for religious services or worship.

3113.2 Minimum requirements: This sub-section establishes the minimum requirements which must be met for all spaces covered by Section 3113.0.

3113.2.1 Building Lighting Power Limit (BLPL): A Building Lighting Power Limit (BLPL) is the upper limit of the power to be available to provide the lighting needs of a building.

The Building Lighting Power Limit (BLPL) is the sum of the building Exterior Lighting Power Allowance (ELPA), the Roads and Grounds Lighting Power Allowance (RLPA), and the building Interior Lighting Power Limit (ILPL).

1. The building Exterior Lighting Power Allowance (ELPA) is calculated in Section 3113.2.1.4.
2. The Roads and Grounds Lighting Power Allowance (RLPA) is calculated in Section 3113.2.1.5.
3. The building Interior Lighting Power Limit (ILPL) may be calculated either by the prescriptive criteria in Section 3113.4 or by the system performance criteria in Section 3113.5.

The prescriptive criteria (3113.4) provide a simple calculation procedure with limited flexibility. The system performance criteria (3113.5) provide a more complex and lengthy calculation procedure with greater flexibility usually suitable for complex lighting systems in larger buildings.

When using the system performance criteria (3113.5) a computer-based procedure, approved by the State Board of Building Regulations and Standards, may be used to calculate the ILPL compliance value.

3113.2.1.1 Compliance: A building design shall be considered in compliance with this section if:

1. The exterior lighting power to be installed is no greater than the Exterior Lighting Power Allowance (ELPA).

2. The roads and ground lighting power to be installed is not greater than the Roads and Grounds Lighting Power Allowance (RLPA).
3. The interior lighting power to be installed is not greater than the Interior Lighting Power Limit (ILPL). Tradeoffs between ILPL and ELPA or RLPA shall not be allowed (also see Section 3113.2.1.2 below).

3113.2.1.2 Compliance for multiple buildings of a facility: The lighting power limits for each building in a facility shall be calculated separately. Tradeoffs among buildings shall be restricted as described below:

1. Tradeoffs of Interior Lighting Power Limits among other buildings of the same facility shall not be allowed.
2. Tradeoffs between Interior Lighting Power Limits and Exterior Lighting Power Allowances or Roads and Grounds Power Allowances shall not be allowed.
3. Tradeoffs of Exterior Lighting Power Allowances among buildings of the same facility are allowed.

3113.2.1.3 Forms for compliance: Forms approved by the Board of Building Regulations and Standards, when such Forms exist, shall be completed to show compliance with this section, as follows:

1. To summarize the total Exterior Lighting Power Allowance (ELPA).
2. To summarize the maximum Road and Grounds Lighting Power Allowance (RLPA).
3. To summarize the maximum Building or Facility Lighting Power Limit (BLPL, FLPL). The BLPL or FLPL shall be the sum of the ILPL and the ELPA of the building (or of all buildings) and the RLPA of the road and grounds.
4. If the prescriptive criteria of Section 3113.4 are used to determine the Interior Lighting Power Limit (ILPL), then an approved form shall be used to summarize the maximum Interior Lighting Power Limit.
5. If the system performance criteria of Section 3113.5 are used to determined the interior lighting power limit (ILPL), then an approved form (or an equivalent computer generated printout) shall be used to summarize the Interior Lighting Power Limit.

3113.2.1.4 Exterior Lighting Power Allowance (ELPA): Lighting power for building exteriors shall not exceed the values given in Table 3113.2.1.4 in accordance with the activities to be performed.

TABLE 3113.2.1.4
MAXIMUM LIGHTING POWER ALLOWANCES (CONNECTED LOAD)
FOR BUILDING EXTERIORS

LOCATION	ALLOWANCE [1]
Exit (with or without a canopy)	20 W/lin. ft. of door opening
Entrance (without a canopy)	30 W/lin. ft. of door opening
Entrance (with a canopy) High traffic (retail, hotel, airport, theater, etc.)	10 W/ft^2 of canopied area
Light traffic (hospital, office, school, etc.)	4 W/ft^2 of canopied area
Loading area	0.030 W/ft^2
Loading door	20 W/lin. ft. of door opening

NOTE: Total illumination allowance for the building is 10 W/Lin. Ft. exterior (including the above allowances) of building perimeter.

3113.2.1.5 Roads and Grounds Power Allowance (RLPA): Lighting power for roads and grounds shall not exceed the values in Table 3113.2.1.5.

TABLE 3113.2.1.5
MAXIMUM LIGHTING POWER ALLOWANCES (CONNECTED LOAD)
FOR ROADS AND GROUNDS

LOCATION	ALLOWANCE
Storage and work areas	0.20 W/ft^2
Other activity areas for casual use such as picnic grounds, gardens, parks, and other landscaped areas	0.10 W/ft^2
Private driveways/walkways	0.10 W/ft^2
Public driveways/walkways	0.15 W/ft^2
Private parking lots	0.12 W/ft^2
Public parking lots	0.18 W/ft^2

3113.2.2 Interior and exterior lighting controls: All lighting systems except those required for emergency or exit lightings shall be provided with manual, automatic or programmable controls.

3113.2.2.1 Minimum number of lighting controls:

1. Each area enclosed by ceiling height partitions shall have independent control of the lighting within that area.

2. The maximum area to be controlled by a single switch shall be seven hundred and fifty (750) square feet. The total number of switches shall be not less than one switch for each sixteen hundred (1600) watts (@ 277 volts) of connected load, or one switch for each twelve hundred and fifty (1250) watts (@ 120 volts) of connected load.

Exception: Lighting control requirements for spaces which must be used as a whole may be controlled by a lesser number of controls, but not less than one control point for each 1500 W of connected lighting power, or a total of three (3) control points, whichever is greater. Examples of such spaces include public lobbies of office buildings, hotels and hospitals: retail and department stores; warehouses; and store rooms and service corridors under centralized supervision. Lighting in such spaces shall be controlled in accordance with the work activities.

3. Hotel and motel guest rooms excluding bathrooms shall have one or more master switches at the door that turn off all permanently wired lighting fixtures and switched receptacles. For multiple room hotel suites, switches at the entry of each room, in lieu of the switch at the main door, will be acceptable to meet these requirements.

4. Bathrooms in hotels and motels shall have a switchable, permanently installed night light with a maximum wattage of five (5) watts.

5. Switches controlling the same load from more than one location shall not be credited as increasing the number of controls to meet the requirements of this Section.

6. All task lighting shall be separately controlled. There shall be at least one switch per task area. Switches for task lighting may be incorporated as part of the lighting fixture.

Exceptions:
1. Lighting controls for spaces which must be used as a whole, such as public lobbies of office buildings, hotels, and hospitals; and warehouses, storerooms and service corridors under centralized supervision may be centralized in remote locations.

2. Manual and automatic control devices may reduce the number of controls required as listed in Table 3113.2.2.

TABLE 3113.2.2
REDUCTION ALLOWANCE FOR SELECTED CONTROLS

TYPE OF CONTROL	EQUIVALENT NUMBER OF CONTROL POINTS
Occupancy sensors	2
Timer - Programmable from the space being controlled	2
Three level, including off, step control or pre-set dimming	2
Four level, including off, step control or pre-set dimming	3
Automatic or continuous dimming	3

3113.2.2.2 Accessibility of switches: All switching devices used to control lighting within an area shall be readily accessible to personnel occupying that area.

Exceptions:
1. Lighting controls for spaces which must be used a whole, such as public lobbies of office buildings, hotels, and hospitals; retail and department stores and warehouses, storerooms and service corridors under centralized supervision may be centralized in remote locations.
2. Automatic controls
3. Programmable controls
4. Controls requiring trained operators.
5. Controls for safety hazards and security.

3113.2.2.3 Exterior lighting controls: In all exterior areas, lighting fixtures shall be automatically switched for non-operation when natural light is available except where security considerations would dictate otherwise.

3113.2.3 Ballasts

3113.2.3.1 Fluorescent lamp ballasts: Fluorescent lamp ballasts which have all the following characteristics shall meet or exceed the minimum ballast efficiency factor as shown in Table 3113.2.3.
1. Operate at nominal input voltages of 120 or 277 volts;
2. Have a power factor equal to or greater than 0.60 for a single F40T12 lamp;

3. Used to operate either F40T12 or F96T12 lamps as specified in Table 3113.2.3;
4. Designed for use at temperatures above $0^{o}F$;
5. Not specifically designed for use with dimming controls.

TABLE 3113.2.3
MINIMUM BALLAST EFFICIENCY FACTOR

BALLAST TYPE	BALLAST EFFICIENCY FACTOR
One - 4 foot lamp	1.805
Two - 4 foot lamps (120 V)	1.06
Two - 4 foot lamps (277 V)	1.05
Two - 8 foot slimline lamps	0.57
Two - 8 foot high output rapid start lamps	0.39

Note: The Ballast efficiency factor shall be calculated in accordance with Equation 3113.2.3.1:

$$BEF = \frac{BF}{\text{Power Input}} \qquad \text{Equation 3113.2.3.1}$$

where:

BEF = Ballast efficiency factor
BF = Ballast factor, expressed as a percent (also known as Relative Light Output)
Power Input = Total wattage of combined lamps and ballasts

Tests for ballast factor and power input shall be in accordance with ANSI Standard C82.2 1984 Method of Measurement for Fluorescent Lamps Ballasts using Standard Lamps.

3113.2.3.2 One-lamp or three-lamp fluorescent luminaires recess-mounted within ten (10) feet center-to-center of each other or pendant-mounted or surface-mounted within one (1) foot of each other, and within the same room, shall be tandem wired to eliminate unnecessary use of single-lamp ballast.

3113.2.3.3 Ballasts shall have a power factor greater than 90%.

Exception:
1. Ballasts for circline and compact fluorescent lamps and low wattage high intensity discharge lamps of less than 100 watts.
2. Dimming ballasts.

3113.3 Interior lighting power adjustment factors

3113.3.1 Adjusted Lighting Power (ALP): When determining interior lighting compliance in Section 3113.4 or 3113.5, the Connected Lighting Power (CLP) for lights controlled by normal switching must not exceed the Interior Lighting Power Limit (ILPL). However, when the switching controls are automatic (i.e. daylight sensors, occupancy sensors, or lumen maintenance controls) the connected lighting power may exceed the ILPL provided that the Adjusted Lighting Power (ALP), calculated using equation 3113.3.1 does not exceed the ILPL.

$$ALP = CLP \times PAF \qquad \text{Equation 3113.3.1}$$

Where:

ALP = Adjusted Lighting Power, watts

CLP = Connected Lighting Power for the luminaires controlled by the automatic control device, watts

PAF = Power Adjustment Factor

3113.3.2 Power Adjustment Factor (PAF): The Power Adjustment Factor is limited to the specific area controlled by the automatic control device. The Power Adjustment Factor shall be as shown in Table 3113.3.2.

3113.3.3 Daylighting credits: Where daylighting credit is utilized, based on the procedures in Sections 3113.2.2.1 or 3113.3.2, automatic controls such as photoelectric switches or automatic dimmers shall be provided in the daylighted spaces.

TABLE 3113.3.2
POWER ADJUSTMENT FACTOR (PAF)

AUTOMATIC CONTROL DEVICE	PAF
1. Occupancy sensors	0.70
2. Daylighting sensors a) Continuous dimming b) Multiple step control c) On-off control	 0.70 0.80 0.90
3. Lumen maintenance control	0.90
4. Combination of 1. and 2. above	0.60
5. Combination of 1. and 3. above	0.65
6. Combination of 1., 2 and 3. above	0.55
7. Programmable timing control	0.85

Notes:

1. PAF credits shall not be applied to the dimming controls of incandescent lamps or luminaires.
2. Only one adjustment factor may be used for each building space or luminaire, and 50% or more of the luminaire shall be within the applicable space to qualify for the power adjustment factor. Controls shall be installed in series with the lights and in series with all manual switching devices in order to qualify for an adjustment factor.
3. Daylighting controls shall be able to reduce electrical power consumption for lighting, continuously or in two or more steps, to 50% or less of maximum power consumption; shall control all luminaires more than 50% within a daylighted space, and shall not control any luminaire more than 50% outside a daylighted space.
4. Programmable timing controls used for credit in conjunction with Table 3113.3.2 shall be capable of:
   a. programming different schedules for week days and weekends.
   b. temporary override by occupants with automatic return to the original schedules. Override controls shall be readily accessible.
   c. providing independent control of each lighting load which is required to be separately controlled.

3113.4 Prescriptive criteria: These prescriptive lighting requirements shall be used with Section 3113.2 and 3113.3. Section 3113.5 may be used instead of this section.

3113.4.1 Interior Lighting Power Limit (ILPL) calculation: Installed adjusted lighting power, including supplemental or task lighting provided by fixtures permanently wired in place but not by movable fixtures shall comply with the power limits established in this section. To establish a lighting power allowance, the following procedure shall be used:

1. Determine the space use categories and Unit Lighting Power Allowances (ULPA) for the various parts of the building from Table 2013.4.1. If a space use intended for the building is not listed in Table 2013.4.1, then the closest related building or space type listed in the Table shall be used.
2. Multiply the Unit Lighting Power Allowance (ULPA) for each space use category by the gross floor area included in that space use category.
3. Add the total number of watts for each area to arrive at the Interior Lighting Power Limit (ILPL) for the building.
4. In all cases of alterations or additions to existing buildings, the unit lighting power allowance for the new or altered area shall be calculated by combining the square footage of each category represented in such alterations or additions with the total square footage of the respective categories of the building within which such alterations or additions are planned.

3113.4.2 Compliance: A building shall be considered in compliance with this section if the interior Adjusted Lighting Power (ALP) to be installed, as determined in 3113.3.1, does not exceed the Interior Lighting Power Limit (ILPL) for the building, as determined in 3113.4.1.

TABLE 3113.4.1
UNIT LIGHTING POWER ALLOWANCE (ULPA), W/ft^2

BUILDING SIZE RANGE, Ft^2					
BUILDING SPACE/TYPE	Less than 6,000	6,001 to 15,000	15,001 to 30,000	30,001 to 50,000	50,001 or more
Food Service					
Fast Food/Cafeteria	1.5	1.4	1.3	1.3	1.3
Leisure Dining/Bar	2.2	1.9	1.7	1.5	1.4
Offices	1.9	1.8	1.7	1.6	1.5
Retail [1]					
Type B & C [2]	3.3	2.8	2.5	2.3	2.1
Type D & E [3]	3.0	2.5	2.2	2.0	1.8
Mall Concourse at multi-store shopping centers	1.4	1.4	1.3	1.3	1.2
Garages and Basements	0.3	0.3	0.2	0.2	0.2
Schools					
Pre-High School	1.8	1.8	1.7	1.6	1.5
High School/Technical University	2.0	2.0	2.0	1.9	1.8
Warehouse/Storage	0.8	0.6	0.5	0.5	0.4
Factory and Workshop [4]	1.2	1.1	1.0	1.0	1.0

Notes:

1 Includes general merchandising and display lighting.
2 Type B & C Retail: Fine Merchandising and Mass Merchandising.
3 Type D & E Retail: General Merchandising and Food and Miscellaneous Merchandising.
4 General lighting.

3113.5 System performance criteria: These system performance lighting requirements shall be used with the minimum requirements specified in Sections 3113.2 and 3113.3. The prescriptive criteria listed in Section 3113.4 may be used instead of this Section (Note that if Section 3113.5, "System Performance Criteria", is employed, a supplemental computer program, available through the State House Bookstore is available to assist in such analysis).

NOTE: A COMPUTER SOFTWARE PROGRAM, *LGTSTD* (LIGHTING STANDARD) IS AVAILABLE TO PERFORM SECTION 3113.5 EVALUATION. THIS PROGRAM PERFORMS PASS/FAIL ANALYSIS.

THE *LGTSTD* SOFTWARE PROGRAM, ALONG WITH THE *ENVSTD* SOFTWARE PROGRAM (SEE SECTION 3114.5) ARE COMBINED ON A SINGLE 5 1/4" FLOPPY DISC AND THIS DISC, PLUS A USER'S MANUAL FOR BOTH PROGRAMS, ARE AVAILABLE THROUGH THE STATE BOOKSTORE (617) 727-2834.

3113.5.1 Unit power density procedure: Installed Adjusted Lighting Power (ALP), including supplemental or task related lighting provided by movable fixtures shall comply with the power allowances established in this section.

3113.5.1.1 The Lighting Power Budget (LPB) of each interior space shall be determined in accordance with equation 3113.5.1.

$$LPB = A \times Pb \times AF \qquad \text{Equation 3113.5.1}$$

where:

LPB	=	Lighting power budget of the space, watts
A	=	Area of the space, ft^2
Pb	=	Base UPD, w/ft^2 (Table 3113.5.1)
AF	=	Area factor of the space (Figure 3113.5.1)

1. The Room Area (A) shall be calculated from the inside dimensions of the room.
2. The Base UPD (Pb) shall be selected from Table 3113.5.1. For applications to areas or activities other than those given, select values for similar areas or activities.
3. The Area Factor (AF) shall be determined from Figure 3113.5.1 based on the room area and ceiling height. Rooms of identical ceiling height and activities may be listed as a group. The AF of a group of rooms shall be determined from the average area of these rooms.

3113.5.1.2 Special Spaces and Activities

1. Multi-Function Rooms. For rooms serving multi-functions, such as hotel banquet/meeting rooms and office conference/presentation rooms, a supplementary lighting system with independent controls may be installed. The installed power for the supplementary system shall not be greater than 50% of the base LPB calculated in accordance with Section 3113.5.1.1.
2. Simultaneous Activities. In rooms containing multiple simultaneous activities such as a large general office having separate accounting and drafting areas within the same room, the LPB for the rooms shall be the weighted average of the activities in proportion to the areas being served.

3113.5.2 The Interior Lighting Power Limit (ILPL) shall include a $0.31W/ft^2$ allowance for unlisted space areas. The ILPL shall be calculated in accordance with equation 3113.5.2.

Equation 3113.5.2:

ILPL = LPB (Listed Spaces) + $0.20W/ft^2$ x (Unlisted Space)

where:

ILPL = Interior Lighting Power Limit

Unlisted space = (LBA - Area of listed spaces), ft^2

LBA = Lighting Building Area, ft^2

LPB = Lighting Power Budget

3113.5.3 Compliance: A building shall be considered in compliance with this section if the interior Adjusted Lighting Power (ALP) to be installed in the building, as determined in 3113.3.1, does not exceed the Interior Lighting Power Limit (ILPL) for the building, as determined in 3113.5.2.

TABLE 3113.5.1
BASE UNIT POWER DENSITY (UPD FOR AREA/ACTIVITY-W/FT^2)

AREA/ACTIVITY	UPD	NOTE
COMMON ACTIVITY AREAS		
Auditorium	1.6	(a)
Corridor	0.9	(b)
Classroom/Lecture hall	2.0	
Elec/Mech equipment room		
General	0.7	(b)
Control rooms	1.5	(b)
Food Service		
Fast food/Cafeteria	1.3	
Leisure dining	2.5	
Bar/Lounge	2.5	(c)
Kitchen	1.4	(c)
Recreation/lounge	0.7	
Stair		
Active traffic	0.6	
Emergency exit	0.4	
Toilet & Washroom	0.8	
Garage		
Auto & Pedestrian		
Circulation	0.3	
Parking area	0.2	
Laboratory	2.3	
OFFICE CATEGORY 1 Enclosed offices, all open plan offices without partitions or with partitions lower than 4.5 ft. below the ceiling		d
Reading, typing and filing	1.6	e
Drafting	2.5	e
Accounting	2.0	e
OFFICE CATEGORY 2 Open plan offices 900 square feet or larger with partitions 3.5 to 4.5 feet below the ceiling. (Offices less than 900 square feet shall use Category 1)		(d)

TABLE 3113.5.1 (continued)
BASE UNIT POWER DENSITY (UPD FOR AREA/ACTIVITY-W/FT^2)

AREA/ACTIVITY	UPD	NOTE
Reading, typing and filing Drafting Accounting	1.9 2.9 2.4	b b b
OFFICE CATEGORY 3 Open plan offices 900 square feet or larger with partitions higher than 3.5 feet below the ceiling.(Offices less than 900 square feet shall use Category 1)		d
Reading, typing and filing Drafting Accounting	2.1 3.4 2.7	(b) (b) (b)
COMMON ACTIVITY AREAS		
Library Audio visual Stack area Card file and cataloging Reading area	 1.1 1.5 1.6 1.9	
Lobby (General) Reception and waiting Elevator lobbies Atrium (multi-story) First 3 floors Each additional floor	 1.0 0.8 0.7 0.2	
Locker room and shower	0.8	
Conference/meeting room Computer/office equipment Filing, inactive Mail room	1.8 2.1 1.0 1.8	(a)
Shop (Non-industrial) Machiner Electrical/electronic Painting Carpentry Welding	 2.5 2.5 1.6 2.3 1.2	

TABLE 3113.5.1 (continued)
BASE UNIT POWER DENSITY (UPD FOR AREA/ACTIVITY-W/FT^2)

AREA/ACTIVITY	UPD	NOTE
Storage and Warehouse		
Inactive storage	0.3	
Active storage, bulky	0.3	
Active storage, fine	1.0	
Material handling	1.0	
Unlisted space	0.2	
SPECIFIC BUILDINGS		
Airport, Bus and Rail Station		
Baggage area	0.8	
Concourse/Main thruway	0.9	
Ticket counter	2.5	
Waiting and Lounge area	1.2	
Bank		
Customer area	1.0	
Banking activity area	2.8	
Barber and Beauty parlor	2.0	
Church, Synagogue, Chapel		
Worship/Congregational	2.3	
Preaching and Sermon/Choir	2.7	
Dormitory		
Bedroom	1.0	
Bedroom with study	1.2	
Study hall	1.8	
Fire and Police Department		
Fire engine room	0.7	
Jail cell	0.8	

TABLE 3113.5.1 (continued)
BASE UNIT POWER DENSITY (UPD FOR AREA/ACTIVITY-W/FT^2)

AREA/ACTIVITY	UPD	NOTE
Hospital/Nursing Home		
Corridor	1.3	(b)
Dental suite/Exam./Treat	1.6	
Emergency	2.3	
Laboratory	1.9	
Loundg/Waiting room	0.9	
Medical supplies	2.4	
Nursery	2.0	
Nurse station	2.1	
Occu./Physical therapy	1.6	
Patient room	1.4	
Pharmacy	1.7	
Radiology	2.1	
Surgical and O.B. Suites		
Genral area	2.1	
Operating room	7.0	
Recovery	3.0	
Hotel/Conference Center		
Banquet room /Multi-purpose	2.4	(a)
Bathroom/Powder room	1.2	
Guest room	1.4	
Public area	1.1	
Exhibition hall	2.6	
Conference/Meeting	1.8	(a)
Lobby	1.9	
Reception desk	2.4	
Laundry		
Washing	0.9	
Ironing and Sorting	1.3	
Museum and Gallery		
General exhibition	1.9	
Inspect/Restoration	3.9	
Storage (Artifacts)		
Inactive	0.6	
Active	0.7	

TABLE 3113.5.1 (continued)
BASE UNIT POWER DENSITY (UPD FOR AREA/ACTIVITY-W/FT^2)

AREA/ACTIVITY	UPD	NOTE
Post Office		
Lobby	1.1	
Sorting	2.1	
Service Station/Auto Repair	1.0	
Theater		
Performance arts	1.5	
Motion picture	1.0	
Lobby	1.5	
Retail Establishments (Merchandising and Circulation Area) Applicable to all lighting, including accent and display lighting, installed in merchandisiing and circulation area		
Type A	4.0	(f)
Type B	3.2	(f)
Type C	3.0	(f)
Type D	2.8	(f)
Type #	2.6	(f)
Mall concourse	1.4	
Retail support areas		
Tailoring	2.1	
Dressing/Fitting rooms	1.4	
INDOOR ATHLETIC AREAS		
Seating Area, All Sports	0.4	(g)
Badminton		
Club	0.5	
Tournament	0.8	
Basketball/Volleyball		
Intramural	0.8	
College	1.3	
Professional	1.9	
Bowling		
Approach area	0.5	
Lanes	1.1	

TABLE 3113.5.1 (continued)
BASE UNIT POWER DENSITY (UPD FOR AREA/ACTIVITY-W/FT^2)

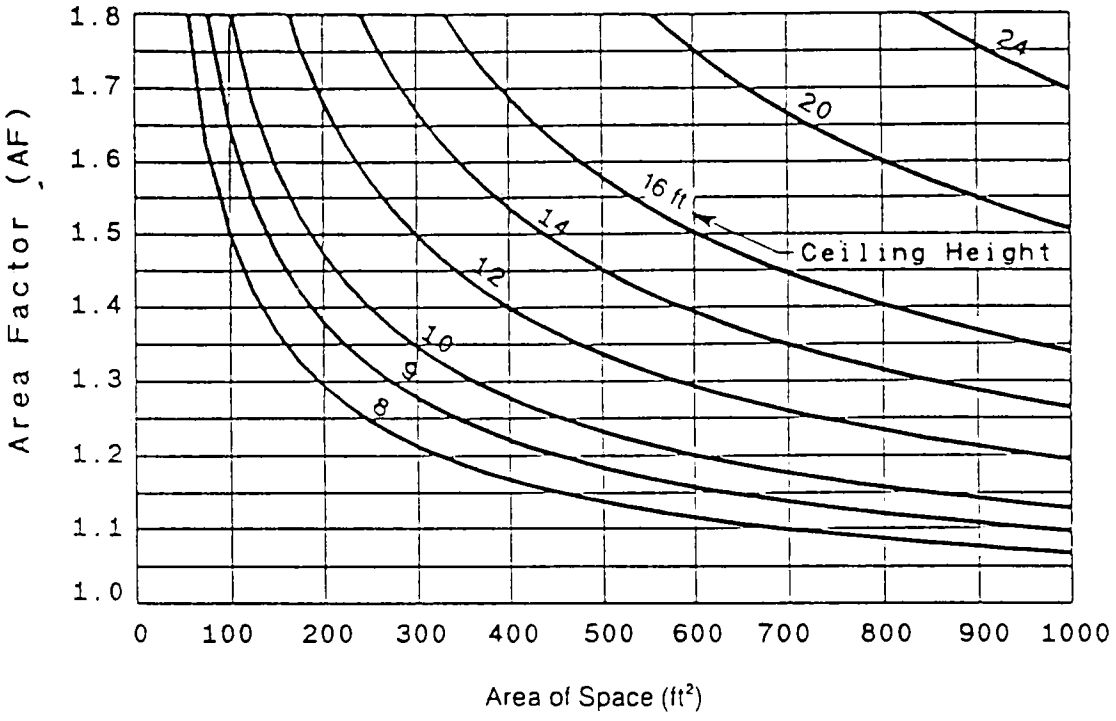
AREA/ACTIVITY	UPD	NOTE
Boxing or Wrestling (platform)		
Amateur	2.4	
Professional	4.8	
Gymnasium		
General exercising and Recreation only	1.0	
Handball/Racquetball/Squash		
Club	1.3	
Tournment	2.6	
Hockey, ice		
Amateur	1.3	
College or Professional	2.7	
Skating Rink		
Recreational	0.6	
Exhibition/Professional	2.7	
Swimming		
Recreational	0.9	
Exhibition	1.5	
Tennis		
Recreational (Class III)	1.3	
Club/College (Class II)	1.9	
Professional (Class I)	2.7	
Tennis, Table		
Club	1.0	
Tournment	1.6	

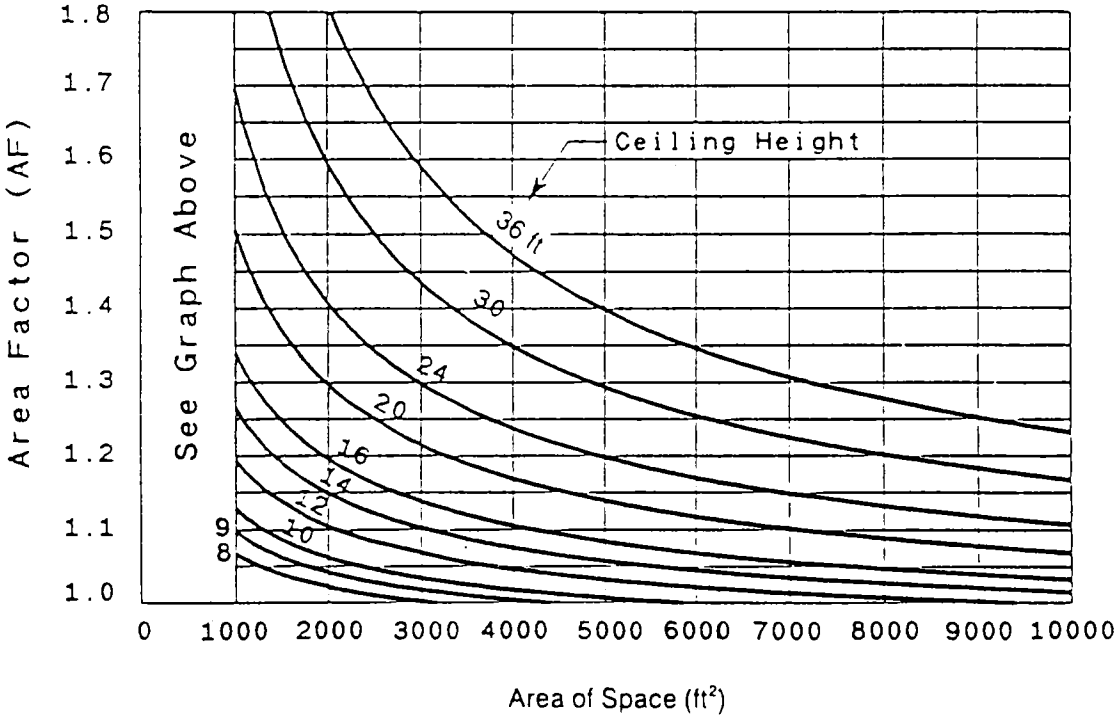
Notes:

(a) A 1.5 adjustment factor is applicable for multi-functional spaces.
(b) Area Factor of 1.0 shall be used for these spaces.
(c) Base UPD includes lighting power required for clean-up purpose.
(d) Not less than 90% of all work stations shall be individually enclosed with partitions of at least the height described.
(e) Area Factor shall not exceed 1.55.
(f) See Article 2 for definitions of Retail Facilities.
(g) Area Factor of 1.0 shall be used for all indoor athletic spaces.

FIGURE 3113.5.1
AREA FACTOR ADJUSTMENTS

THESE TWO FIGURES GO HERE (EXTRACTED FROM ASHRAE STANDARD 90.1 AND THE SAME AS THE FIGURES FOUND IN FOURTH EDITION)





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SECTION 3114.0 BUILDING ENVELOPE REQUIREMENTS FOR COMMERCIAL AND HIGH RISE RESIDENTIAL BUILDINGS

3114.1 Scope: This section applies to commercial buildings and to high rise residential buildings over three (3) stories.

3114.2 Compliance: The envelope design of a building being evaluated is on compliance with the requirements of this section provided that:

1. The minimum requirements and calculation procedures of Section 3114.3 are met; and,
2. Compliance with either the prescriptive criteria (3114.4) or the system performance criteria (3114.5) is met.

3114.2.1 The prescriptive criteria (3114.4) provide a simple calculation procedure with limited flexibility. The system performance criteria (3114.5) provide a more complex and lengthy calculation procedure with greater flexibility usually suitable for complex envelope assemblies in larger buildings.

When using the system performance criteria (3114.5) a computer-based procedure, approved by the State Board of Building Regulations and Standards, may be used to calculate the exterior envelope compliance values.

3114.3 Minimum Requirements

3114.3.1 Overall thermal transmittance (Uo): The overall thermal transmittance of building envelope assemblies shall be calculated in accordance with Equation 3114.3.1:

$$Uo = (UiAi + ... + UnAn)/Ao \qquad \text{Equation 3114.3.1}$$

where:

Uo = the average thermal transmittance of the gross area of an envelope assembly, e.g., the exterior wall assembly, including fenestration and doors; roof and/or ceiling assembly; or floor assembly, (Btu/h-ft^2-^{o}F).

Ao = the gross area of the envelope assembly, (ft^2).

Ui = the thermal transmittance of each individual element of the envelope assembly, e.g., the opaque portion of the wall or the fenestration - see section 3114.3.2, (Btu/h-ft^2-^{o}F).

Ut = 1/Rt, the total resistance of the envelope assembly, (Btu/h-ft^2-^{o}F).

Ai = the area of each individual element of the envelope assembly, (ft^2).

3114.3.2 Thermal transmittance (Ui) of an individual element of an envelope assembly: The thermal transmittance of each envelope assembly shall be determined accounting for all series and parallel heat flow paths through the elements of the assembly. Compression of insulation shall be accounted for in determining the thermal resistance.

3114.3.2.1 The thermal transmittance of opaque elements of assemblies shall be determined using a series path procedure with correction for the presence of parallel paths within an element of the envelope assembly (such as parallel paths through wall cavities with insulation and studs). The procedure to be used in meeting the requirements of this section is given in Appendix E.

3114.3.2.2 The thermal transmittance of fenestration assemblies shall be corrected to account for the presence of sash, frames, edge effects and spacers in multiple glazed units. If thermal transmittances of sash and frames are known, then Equation 3114.3.1 shall be used for calculation, otherwise Equation 3114.3.2 shall be used:

Equation 3114.3.2

$$Uof = \frac{(Ug,1 \cdot Ff,1 \cdot A1 + Ug,2 \cdot Ff,2 \cdot A2 + \ldots + Ug,n \cdot Ff,n \cdot An)}{A_{of}}$$

Where:

Uof = the overall thermal transmittance of the fenestration assemblies, including sash and frames, (Btu/h-ft^2-^{o}F).

Ug = the thermal transmittance of the central area of the fenestration excluding edge effects, spacers in multiple-glazed units, and the sash and frame, (Btu/h-ft^2-^{o}F).

Ff = framing adjustment factor for sash, frames, etc.

Aof = the area all fenestration including glazed portions, sash, frames, etc., (ft^2).

Values for Ug shall be the larger of the winter or summer values obtained from Figure 14, Chapter 27 of the ASHRAE Handbook, 1985 Fundamentals Volume. Values for Ff shall be obtained from Table 13, Part C, in Chapter 27, of the ASHRAE Handbook, 1985 Fundamentals Volume. Values for Ug and Ff may also be obtained from manufacturer's test data for specific product assemblies. Where a

range of framing adjustment factors is provided, the average of the range shall be used.

3114.3.3 Shading coefficients: The Shading Coefficient (SC) for fenestration shall be obtained from Chapter 27 of the ASHRAE Handbook, 1985 Fundamentals Volume or from manufacturers' test data. For the prescriptive or systems performance envelope compliance calculations in Sections 3114.4 and 3114.5 a factor, SCx, is used. SCx is the Shading Coefficient of the fenestration, including internal and external shading devices, but excluding the effect of external shading projections which is calculated separately. The shading coefficient used for louvered shade screens shall be determined using a profile angle of 30°, as found in Table 41, Chapter 27 of the ASHRAE Handbook, 1985 Fundamentals Volume.

3114.3.4 Shell buildings: If determination of building envelope compliance occurs prior to the determination of lighting power density, equipment power density, or fenestration shading device characteristics, then the following conditions shall be assumed when determining building envelope compliance by either the prescriptive method of Section 3114.4 or the systems performance method of Section 3114.5.

1. Lighting Power Density and Equipment Power Density: For Section 3114.4 the total power density shall be assumed to be those listed in Table 3114.3.4. For section 3114.5, the values in Table 3114.4.3.4 shall be apportioned as 2/3 lighting and 1/3 for other equipment. Note that these are not recommended design values, but are for compliance purposes only.

2. Fenestration shading devices: Only those shading devices that are part of the design when it is being evaluated for compliance shall be considered when determining compliance.

3. Electric lighting controls for perimeter daylighting utilization: Only those controls that are part of the design when it is being evaluated for compliance shall be considered when determining compliance.

TABLE 3114.3.4
ASSUMED COMBINED LIGHTING AND EQUIPMENT POWER DENSITIES FOR SHELL BUILDINGS

LIGHTING CONTROL TYPE	FOR $3000 < HDD_{65} > 6000$	FOR $HDD_{65} > 6000$
With automatic lighting controls provided for the perimeter area to be daylighted	1.75 W/ft^2	1.50 W/ft^2
All other lighting controls	2.25 W/ft^2	1.50 W/ft^2

3114.4 Prescriptive criteria

3114.4.1 Purpose: This section provides precalculated prescriptive requirements for selected exterior envelope configurations of new buildings. There are four different sets of precalculated design parameters, including a base case and buildings designed with perimeter daylighting, with high performance glazing with perimeter daylighting or with increased wall thermal mass. Any one set of parameters will achieve compliance.

The Alternate Component Packages (ACP) provide design criteria for the following:

1. "Base Case Buildings" - buildings with envelopes designed without perimeter daylighting.

2. "Perimeter Daylighting Buildings" - buildings which are allotted additional fenestration area due to the incorporation of automatic electric lighting controls for daylight utilization in the perimeter zones.

Note: This daylighting credit is for thermal benefits of daylighting controls on the electric lighting system. This is in addition to the credit provided in Section 3113 for the reduction in lighting energy.

3114.4.2 Compliance: The basic requirements and procedures of Section 3114.3 shall be used with this section. The systems performance criteria in Section 3114.5 may be used instead of this section.

The envelope design of the building being evaluated is in compliance with the prescriptive criteria of this section provided that:

1. The minimum requirements and calculation procedures of Section 3114. are met.
2. All U values are less than or equal to those chosen from the ACP Table selected.

3. All R values are greater than or equal to those listed in the ACP Table for walls below grade and for slab-on-grade floors.
4. The percentage of fenestration relative to the gross external wall area is less than or equal to the value chosen from the ACP Table.

Exception: Portions of external envelopes enclosing atria are not covered by the envelope criteria of this section if the atria are unconditioned and are thermally isolated from conditioned spaces.

3114.4.3 Procedure for using the alternate component package (ACP): The prescriptive envelope criteria are contained in Tables 3114.4.1 through 3114.4.3.

The following steps shall be used to determine compliance with these prescriptive envelope criteria:

3114.4.3.1 Determine appropriate ACP Table: Based upon the heating degree days (base 50), choose the appropriate ACP Table from one of the three ACP Tables found on the following pages.

ONLY USED TO ESTABLISH THE ALLOWABLE FENESTRATION AREA.

SEE TABLE 3105.2 p 31-5

TABLE 3114.4.1
ALTERNATE COMPONENT PACKAGES FOR HDD$_{(base\ 50)}$ 1751 - 2600

INTERNAL LOAD RANGE	PROJECTION FACTOR (PF)	Uof SHADING COEFF RANGE	BASE CASE 0.68 to 0.46	BASE CASE 0.45 to 0.39	BASE CASE 0.38 to 0.0	PERIMETER DAYLIGHTING 0.68 to 0.46	PERIMETER DAYLIGHTING 0.45 to 0.39	PERIMETER DAYLIGHTING 0.38 to 0.0
0.00 - 1.50	0.000 - 0.249	1.000 - 0.71	21	24	24	22	26	27
		0.709 - 0.60	25	28	30	26	31	32
		0.599 - 0.50	28	33	34	29	35	37
		0.499 - 0.38	31	38	40	32	40	43
		0.379 - 0.25	35	46	50	36	48	53
		0.249 - 0.0	41	58	65	42	59	68
	0.250 - 0.499	1.000 - 0.71	26	30	32	27	33	34
		0.709 - 0.60	30	36	38	31	38	41
		0.599 - 0.50	33	41	44	34	43	47
		0.499 - 0.38	36	46	50	36	48	53
		0.379 - 0.25	40	54	60	40	56	63
	0.500	1.000 - 0.71	31	37	40	32	40	43
		0.709 - 0.60	34	44	47	35	46	51
		0.599 - 0.50	37	49	53	38	51	57
		0.499 - 0.38	40	54	60	40	56	63
1.51 - 3.00	0.00 - 0.249	1.000 - 0.71	17	18	18	21	24	25
		0.709 - 0.60	20	22	22	25	29	31
		0.599 - 0.50	22	25	26	27	33	36
		0.499 - 0.38	25	30	31	30	38	42
		0.379 - 0.25	30	37	39	35	45	51
		0.249 - 0.00	37	49	54	41	57	67
	0.250 - 0.499	1.000 - 0.71	21	23	24	26	31	33
		0.709 - 0.60	24	28	29	29	36	40
		0.599 - 0.50	27	32	34	32	41	45
		0.499 - 0.38	30	37	40	35	46	52
		0.379 - 0.25	35	45	49	39	53	62
	0.500	1.000 - 0.71	25	29	30	30	37	41
		0.709 - 0.60	29	35	37	34	43	49
		0.599 - 0.50	32	39	42	36	48	55
		0.499 - 0.38	35	45	48	39	53	62

THERMAL MASS ADJUSTMENT FOR OPAQUE WALLS

OPAQUE WALL Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.096	HC ≥ 5	21	0.10	0.13
	HC ≥ 10	21	0.11	0.15
	HC ≥ 15	21	0.12	0.16
	HC ≥ 5	68	0.10	0.12
	HC ≥ 10	68	0.11	0.14
	HC ≥ 15	68	0.12	0.14

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.096	HC ≥ 5	17	0.10	0.14
	HC ≥ 10	17	0.12	0.17
	HC ≥ 15	17	0.13	0.18
	HC ≥ 5	67	0.10	0.12
	HC ≥ 10	67	0.11	0.14
	HC ≥ 15	67	0.12	0.15

3.01 - 3.50	0.000 - 0.249	1.000 - 0.71		15	16	16		20	23	25
		0.709 - 0.60		17	19	20		24	28	30
		0.599 - 0.50		20	22	23		26	32	35
		0.499 - 0.38		23	26	27		29	36	41
		0.379 - 0.25		27	33	35		34	44	50
		0.249 - 0.00		34	44	48		39	55	65
	0.250 - 0.499	1.000 - 0.71		18	20	21		25	29	32
		0.709 - 0.60		22	25	25		28	35	39
		0.599 - 0.50		24	28	30		31	39	44
		0.499 - 0.38		27	33	35		34	44	51
		0.379 - 0.25		32	40	43		38	51	61
	0.500	1.000 - 0.71		22	25	26		29	36	40
		0 709 - 0.60		26	30	32		32	41	48
		0.599 - 0.50		29	35	37		35	46	54
		0.499 - 0.38		32	40	43		37	51	60

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.096	HC ≥ 5	15	0.10	0.14
	HC ≥ 10	15	0.12	0.17
	HC ≥ 15	15	0.14	0.19
	HC ≥ 5	65	0.10	0.12
	HC ≥ 10	65	0.11	0.14
	HC ≥ 15	65	0.12	0.15

VT ≥ SC

Daylight Sensing Controls

LOCATION	MINIMUM R-VALUE
Wall Below Grade:	8
Unheated Slab on Grade: Horizontal	24" 36" 48" 15 13 10
Vertical	7 5 4

LOCATION	MINIMUM Uo
Roof:	0.060
Wall Adjacent to Unconditioned Space:	0.16
Floor Over Unconditioned Space:	0.060

USED TO ESTABLISH U AND R VALUES FOR THE BUILDING.

TABLE 3114.4.2
ALTERNATE COMPONENT PACKAGES FOR
$HDD_{(base\ 50)}$ 2601 - 3200

INTERNAL LOAD RANGE	PROJECTION FACTOR (PF)	Uof SHADING COEFF RANGE	BASE CASE 0.68 to 0.46	BASE CASE 0.45 to 0.39	BASE CASE 0.38 to 0.0	PERIMETER DAYLIGHTING 0.68 to 0.46	PERIMETER DAYLIGHTING 0.45 to 0.39	PERIMETER DAYLIGHTING 0.38 to 0.0
0.00 - 1.50	0.000 - 0.249	1.000 - 0.71	21	25	26	22	26	27
		0.709 - 0.60	24	29	31	25	31	33
		0.599 - 0.50	26	33	35	27	34	37
		0.499 - 0.38	29	37	40	29	38	42
		0.379 - 0.25	32	43	48	32	44	50
		0.249 - 0.0	35	52	60	35	52	60
	0.250 - 0.499	1.000 - 0.71	25	31	33	26	32	35
		0.709 - 0.60	28	36	39	28	37	41
		0.599 - 0.50	30	40	44	30	41	46
		0.499 - 0.38	32	44	49	32	45	51
		0.379 - 0.25	35	50	57	34	50	58
	0.500	1.000 - 0.71	29	37	40	29	39	43
		0.709 - 0.60	31	42	47	31	43	49
		0.599 - 0.50	33	46	52	33	47	53
		0.499 - 0.38	35	50	57	34	50	58
1.51 - 3.00	0.00 - 0.249	1.000 - 0.71	17	19	20	21	24	26
		0.709 - 0.60	20	23	24	24	29	31
		0.599 - 0.50	22	26	28	26	32	36
		0.499 - 0.38	25	30	32	28	36	41
		0.379 - 0.25	28	37	40	31	42	49
		0.249 - 0.00	33	46	52	35	51	60
	0.250 - 0.499	1.000 - 0.71	21	24	25	25	31	33
		0.709 - 0.60	24	29	31	27	35	39
		0.599 - 0.50	26	33	35	29	39	44
		0.499 - 0.38	29	37	40	31	43	49
		0.379 - 0.25	32	43	48	34	48	56
	0.500	1.000 - 0.71	25	30	32	28	36	41
		0.709 - 0.60	27	35	38	30	41	47
		0.599 - 0.50	30	39	42	32	45	52
		0.499 - 0.38	32	43	48	34	48	57

THERMAL MASS ADJUSTMENT FOR OPAQUE WALLS

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.085	HC ≥ 5	21	0.096	0.11
	HC ≥ 10	21	0.098	0.12
	HC ≥ 15	21	0.10	0.13
	HC ≥ 5	60	0.089	0.10
	HC ≥ 10	60	0.095	0.11
	HC ≥ 15	60	0.099	0.11

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.085	HC ≥ 5	17	0.092	0.12
	HC ≥ 10	17	0.10	0.13
	HC ≥ 15	17	0.11	0.14
	HC ≥ 5	60	0.091	0.10
	HC ≥ 10	60	0.098	0.12
	HC ≥ 15	60	0.10	0.12

3.01 - 3.50	0.000 - 0.249	1.000 - 0.71		15	17	17		20	24	26	
		0.709 - 0.60		18	20	21		23	28	31	
		0.599 - 0.50		20	23	25		25	32	35	
		0.499 - 0.38		23	27	29		27	35	40	
		0.379 - 0.25		26	33	36		30	41	48	
		0.249 - 0.00		31	42	47		34	50	59	
	0.250 - 0.499	1.000 - 0.71		19	22	22		24	30	33	
		0.709 - 0.60		22	26	27		26	34	39	
		0.599 - 0.50		24	29	31		28	38	43	
		0.499 - 0.38		26	33	36		30	42	48	
		0.379 - 0.25		30	39	43		33	47	56	
	0.500	1.000 - 0.71		22	27	28		27	35	40	
		0.709 - 0.60		25	31	33		29	40	46	
		0.599 - 0.50		27	35	38		31	43	51	
		0.499 - 0.38		30	39	43		33	47	56	

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.085	HC ≥ 5	15	0.092	0.12
	HC ≥ 10	15	0.10	0.14
	HC ≥ 15	15	0.11	0.15
	HC ≥ 5	59	0.090	0.10
	HC ≥ 10	59	0.097	0.12
	HC ≥ 15	59	0.10	0.12

VT ≥ SC

Daylight Sensing Controls

LOCATION	MINIMUM R-VALUE		
Wall Below Grade:	9		
Unheated Slab on Grade:	24"	36"	48"
Horizontal	16	13	10
Vertical	7	6	4

LOCATION	MINIMUM Uo
Roof:	0.056
Wall Adjacent to Unconditioned Space:	0.14
Floor Over Unconditioned Space:	0.051

TABLE 3114.4.3
ALTERNATE COMPONENT PACKAGES FOR
$HDD_{(base\ 50)}$ 3201 - 4000

INTERNAL LOAD RANGE	PROJECTION FACTOR (PF)	Uof SHADING COEFF RANGE	BASE CASE 0.68 to 0.46	BASE CASE 0.45 to 0.39	BASE CASE 0.38 to 0.0	PERIMETER DAYLIGHTING 0.68 to 0.46	PERIMETER DAYLIGHTING 0.45 to 0.39	PERIMETER DAYLIGHTING 0.38 to 0.0
0.00 - 1.50	0.000 - 0.249	1.000 - 0.71	20	25	26	20	26	27
		0.709 - 0.60	22	29	31	22	29	32
		0.599 - 0.50	24	32	35	23	33	36
		0.499 - 0.38	25	35	39	25	35	39
		0.379 - 0.25	27	39	45	26	38	44
		0.249 - 0.0	28	44	52	28	43	51
	0.250 - 0.499	1.000 - 0.71	23	31	33	23	31	34
		0.709 - 0.60	25	34	38	25	34	39
		0.599 - 0.50	26	37	42	25	37	42
		0.499 - 0.38	27	40	46	26	39	45
		0.379 - 0.25	28	43	51	27	42	49
	0.500	1.000 - 0.71	26	36	40	25	36	41
		0.709 - 0.60	27	39	44	26	39	45
		0.599 - 0.50	28	41	48	27	41	47
		0.499 - 0.38	28	43	51	28	42	50
1.51 - 3.00	0.00 - 0.249	1.000 - 0.71	17	20	21	20	24	26
		0.709 - 0.60	19	24	25	22	28	31
		0.599 - 0.50	21	27	29	23	31	34
		0.499 - 0.38	23	30	33	25	34	38
		0.379 - 0.25	26	35	39	26	38	44
		0.249 - 0.00	29	42	48	29	43	51
	0.250 - 0.499	1.000 - 0.71	20	25	27	22	29	33
		0.709 - 0.60	23	29	31	24	33	37
		0.599 - 0.50	24	32	35	25	36	41
		0.499 - 0.38	26	35	39	27	38	44
		0.379 - 0.25	28	40	45	28	42	49
	0.500	1.000 - 0.71	23	30	32	25	34	39
		0.709 - 0.60	25	34	37	26	37	43
		0.599 - 0.50	27	37	41	27	39	46
		0.499 - 0.38	28	40	45	28	42	49

THERMAL MASS ADJUSTMENT FOR OPAQUE WALLS

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.077	HC ≥ 5	20	0.080	0.099
	HC ≥ 10	20	0.087	0.11
	HC ≥ 15	20	0.092	0.11
	HC ≥ 5	52	0.080	0.095
	HC ≥ 10	52	0.085	0.10
	HC ≥ 15	52	0.089	0.10

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.077	HC ≥ 5	17	0.081	0.10
	HC ≥ 10	17	0.089	0.12
	HC ≥ 15	17	0.096	0.12
	HC ≥ 5	51	0.080	0.096
	HC ≥ 10	51	0.085	0.10
	HC ≥ 15	51	0.089	0.11

3.01 - 3.50	0.000 - 0.249	1.000 - 0.71		16	18	19		19	24	26	
		0.709 - 0.60		18	21	22		21	27	30	
		0.599 - 0.50		20	24	26		23	30	34	
		0.499 - 0.38		22	27	30		24	33	38	
		0.379 - 0.25		24	32	36		26	37	43	
		0.249 - 0.00		28	39	45		29	43	51	
	0.250 - 0.499	1.000 - 0.71		19	23	24		22	29	32	
		0.709 - 0.60		21	26	28		24	32	37	
		0.599 - 0.50		23	29	32		25	35	41	
		0.499 - 0.38		24	33	36		26	38	44	
		0.379 - 0.25		27	37	42		28	41	49	
	0.500	1.000 - 0.71		22	27	29		24	33	39	
		0.709 - 0.60		24	31	34		26	37	43	
		0.599 - 0.50		25	34	38		27	39	46	
		0.499 - 0.38		27	37	42		28	41	49	

Uow (HC<5)	HC RANGE	PCT FEN	INT INS	EXT INS
0.077	HC ≥ 5	16	0.081	0.10
	HC ≥ 10	16	0.090	0.12
	HC ≥ 15	16	0.098	0.13
	HC ≥ 5	51	0.080	0.097
	HC ≥ 10	51	0.086	0.10
	HC ≥ 15	51	0.090	0.11

VT ≥ SC

Daylight Sensing Controls

LOCATION	MINIMUM R-VALUE
Wall Below Grade:	10
Unheated Slab on Grade:	24" 36" 48"
Horizontal	17 14 11
Vertical	8 6 4

LOCATION	MINIMUM Uo
Roof:	0.052
Wall Adjacent to Unconditioned Space:	0.13
Floor Over Unconditioned Space:	0.045

3114.4.3.2 Determine the Maximum Allowable Percent Fenestration: Using the appropriate ACP Table as determined in 3114.4.3.1, determine the maximum allowable percent fenestration. The maximum allowable percent fenestration is the total area of fenestration assemblies divided by the total gross external wall area, considering all elevations of the building. Determining the maximum allowable percent fenestration requires the following five steps:

STEP 1. Based on the Internal Load Density (ILD) for the design building, select one of the three Internal Load Ranges as the point of entry to the tables. Note: for ILD's greater than 3.5 Watts per ft^2, use the 3.5 Watts per ft^2 range. Determine the Internal Load Density (ILD) of the design building, based on the sum of the Internal Lighting Power Allowance (ILPA), the Equipment Power Density (EPD) and the Occupant Load Adjustment (OLA), as shown in Equation 3114.4.3.2.1.

$$ILD = ILPA + EPD + OLA \qquad \text{Equation 3114.4.3.2.1}$$

Where:

The Internal Lighting Power Allowance (ILPA) shall be either:

1. The building average Internal Lighting Power Allowance (ILPA) of the design building in W/ft^2 as determined from Section 3113.4 (for dwelling units within high rise residential buildings the limit is 0.0 W/ft^2); or

2. The average of the Lighting Power Budgets (LPB) for all activity areas within 15 feet of each exterior wall based on the prodecures specified by the Systems Performance Criteria of Section 3113.5.

The Equipment Power Density (EPD) shall be either:

1. The building average receptacle power density selected from Table 3114.4.4 is W/ft^2; or

2. The actual average receptacle power density for all activity areas within 15 feet of each exterior wall in W/ft^2, considering diversity. For determining compliance in Tables 3114.4.1 through 3114.4.3, the actual average receptable power densities calculated by this method that exceed 1.0 W/ft^2 shall be limited to 1.0 W/ft^2.

TABLE 3114.4.4
AVERAGE RECEPTACLE POWER DENSITIES

BUILDING TYPE	WATTS/FT^2
1. Assembly	0.25
2. Office	0.75
3. Retail	0.25
4. Warehouse	0.1
5. School	0.5
6. Hotel/Motel	0.25
7. Restaurant	0.1
8. Health	1.0
9. Multi-family	0.75

The Occupant Load Adjustment (OLA) shall be either:

1. 0.0 W/ft^2: this recognizes the assumed occupant sensible load of 0.6 W/ft^2 that is built into the ACP tables; or

2. A positive or negative difference between the actual occupant load and 0.6 W/ft^2 if the design building has a larger or smaller occupant load.

STEP 2. Select external shading projection factor (PF). If no external shading projections are used in the proposed design, select the **row/column** designated Proj. Factor = 0.0 If external shading projections are used, determine the average projection factor on window area weighted basis. Then select the appropriate column in the ACP Table using Equation 3114.4.3.2.2.

$$PF = Pd / H \qquad \text{Equation 3114.4.3.2.2}$$

Where:

PF = External shading projection factor

Pd = External shading projection depth, inches or feet

H = Sum of height of the fenestration and the distance from the top of the fenestration to the bottom of external shading projection in units consistent with Pd.

STEP 3. Select the Shading Coefficient of the fenestration (SCx) including internal, integral and external shading devices, but excluding the effect of external shading projections (PF). Note: This includes curtains, shades, or blinds. Reference ASHRAE Handbook, 1985 Fundamentals, Chapter 27.

STEP 4. Select one of the daylighting options, either:

1. Base Case, no daylighting

2. Perimeter Daylighting (automatic daylight controls for lighting system must be used).

STEP 5. Select appropriate fenestration type. For most options, this is determined by the thermal transmittance value (Uof) of the fenestration assemble. For the high performance fenestration options (the far right column of each case), the visible transmittance (VT) of the fenestration should not be less than the shading coefficient of the glazed portion of the fenestration assemble, not considering any shading devices. The ranges correspond to double glazing, triple glazing, and high performance glazing.

3114.4.3.3 Determine the Maximum Uow for the Opaque Wall Assembly: In the appropriate ACP Table the Maximum Uow for the opaque wall assembly is determined using the applicable following steps (Note that if the wall has a heat capacity of 5 BTU/ft^2-^{o}F or greater, the "thermal mass adjustment" calculations discussed in item 2 below, allow for the development of a relaxed value for Uow):

1. For a lightweight wall assembly; i.e., a wall with a heat capacity (HC) less than 5 BTU/ft^2-^{o}F, use the value indicated under the ACP Table column labelled Uow (HC<5). This Uow is constant over all internal load ranges.

or

2. To use the mass wall adjustment (only for walls with heat capacities of 5 BTU/ft^2-^{o}F or greater), the following two additional steps are necessary:

    1. Select the same internal load range as that used in determining the maximum allowable percent fenestration.

    2. Select the mass wall heat capacity (HC) and insulation position. If the wall insulation is positioned internal to or integral with the wall mass, use the column headed Interior/Integral Insulation. If the wall insulation is positioned external to the wall mass, use the

column headed Exterior Insulation. For HC less that 5 BTU/ft2. °F, this adjustment table cannot be used.

3. Select or interpolate for the appropriate maximum Uow for the opaque wall based on the maximum allowable percent fenestration determined in Section 3114.4.3.1 or the actual building percent fenestration whichever value is lower. The Uow shall be determined by straight line interpolation for fenestration percentages between the smallest and largest values listed. If the design building percentage fenestration is less than the smallest value listed, select the Uow for the smallest percentage fenestration listed. If the design building percentage fenestration is greater than the largest value listed, select the Uow for the largest percentage fenestration listed.

3114.4.3.4 Determine Other Envelope Criteria: In each ACP table, the criteria for roof, wall adjacent to unconditioned space, wall below grade, floor over unconditioned space, and slab-on-grade floors shall be met. For heated slabs-on-grade, the R-value shall be the R-value for slab-on-grade plus R-2.0.

3114.5 Systems performance criteria

3114.5.1 Purpose: This section provides a systems approach to envelope compliance.

3114.5.2 Compliance: The basic requirements and procedures of Section 3114.3 shall be used with this section. The prescriptive envelope criteria in Section 3114.4 may be used instead of this section.

Note that portions of external envelopes enclosing atria are not covered by the envelope criteria of this section if the atria are unconditioned and are thermally isolated from conditioned spaces.

NOTE 1: A COMPUTER SOFTWARE PROGRAM, *ENVSTD* (ENVELOPE STANDARD) IS REQUIRED TO PERFORM SECTION 3114.5 EVALUATION (Certain data is only available in the libraries of the computer software program and are not found within the printed Building Code).
THE *ENVSTD* SOFTWARE PROGRAM, ALONG WITH THE *LTGSTD* SOFTWARE PROGRAM (SEE SECTION 3113.5) ARE COMBINED ON A SINGLE 5 1/4 " FLOPPY DISC AND THIS DISC, PLUS A USER'S MANUAL FOR BOTH PROGRAMS, ARE AVAILABLE THROUGH THE STATE BOOKSTORE (617) 727-2834.

NOTE 2: THE INFORMATION PROVIDED IN SECTIONS 3114.5.3 THROUGH 3114.5.8.6 IS ONLY PRESENTED TO PROVIDE THE READER WITH AN OVERVIEW OF ANALYSIS TECHNIQUES EMPLOYED BY THE *ENVSTD* PROGRAM, AND SHOULD NOT BE UTILIZED TO PERFORM ANALYSIS BY HAND - THE *ENVSTD* PROGRAM MUST BE USED FOR ANALYSIS UNDER SECTION 3114.5 (THIS PROGRAM PERFORMS PASS/FAIL ANALYSIS).

3114.5.3 Roof thermal transmittance requirements: Any building that is heated and/or mechanically cooled shall have an overall thermal transmittance value (Uor) for the gross area of the roof assembly less than or equal to the value determined by Equation 3114.5.3. The provisions of Section 3114.3 shall be followed in determining acceptable combinations of materials that will meet the required Uor values of Equation 3114.5.3.

Equation 3114.5.3

$$Uor = 1/(5.3 + 1.8 \times 0^{-3} \times HDD65 + 1.3 \times 10^{-3} \times CDD65 + 2.6 \times 10^{-4} \times CDH80)$$

3114.5.3.1 Skylights for which daylight credit is taken may be excluded from the calculation of the overall thermal transmittance value (Uor) of the roof assembly, if all of the following conditions are met:

1. The opaque roof thermal transmittance Uor value does not exceed the values determined by Equation 3114.5.3.

2. The overall thermal transmittance of the skylight assembly, including framing, shall be less than or equal to 0.7 Btu/h-ft^2-^{o}F.

3. Skylight areas, including framing, as a percentage of the roof area do not exceed the values specified in Tables 3114.5.3.1a and 3114.5.3.1b, where Visible Transmittance (VT) is the transmittance of a particular glazing material over the visible portion of the solar spectrum. (Skylight areas shall only be interpolated between visible transmittance values of 0.75 and 0.50).

4. The skylight area for which daylight credit can be taken is the area un der each skylight whose dimension in each direction (centered on the skylight) is equal to the skylight dimension in that direction plus the floor to ceiling height.

5. Skylight areas that have already taken daylight credit (perimeter window areas or other skylight areas) cannot again take daylight credit.

6. All electric lighting fixtures within skylight areas shall be controlled by automatic daylighting controls.

7. Skylight curbs shall have thermal transmittance U values less than or equal to 0.21 Btu/hr-ft^2-^{o}F.

8. The infiltration coefficient of the skylights shall be less than or equal to 0.05 cfm/ft^2.

TABLE 3114.5.3.1a
MAXIMUM PERCENT SKYLIGHT AREA (VT = 0.75)

LIGHT LEVEL IN fc	RANGE OF LIGHTING POWER DENSITY, W/ft^2			
	< 1.0	1.1 - 1.5	1.6 - 2.0	> 2.0
30	2.3	3.4	4.5	5.6
50	2.5	4.0	5.5	7.0
70	2.8	4.6	6.4	8.2

TABLE 3114.5.3.1b
MAXIMUM PERCENT SKYLIGHT AREA (VT = 0.50)

LIGHT LEVEL IN fc	RANGE OF LIGHTING POWER DENSITY, W/ft^2			
	< 1.0	1.1 - 1.5	1.6 - 2.0	> 2.0
30	3.6	5.1	6.6	8.1
50	3.9	6.0	8.1	10.2
70	4.2	6.9	9.6	12.3

3114.5.3.2 Skylight areas in Tables 3114.5.3.1a and 3114.5.3.1b may be increased by 50 percent if a shading device is used that blocks over 50 percent of the solar gain during the peak cooling design condition.

3114.5.3.3 Areas for vertical glazing in clerestories and roof monitors shall be included in the wall fenestration calculation.

3114.5.4 Floor thermal transmittance criteria: Any building that is heated or mechanically cooled shall have floors that meet the following thermal requirements:

1. Floors of conditioned spaces over unconditioned spaces shall have a thermal transmittance (Uof) less than or equal to that specified in Equation 3114.5.4:

$$Uof = 1/(0.840 + 0.00302 \times HDD65) \quad \text{Equation 3114.5.4}$$

2. Slab-on-grade floors shall have insulation around the perimeter of the floor with the thermal resistance (R) of the insulation as specified in Figure 3114.5.4. The insulation specified in Figure 3114.5.4 shall extend either in a vertical plane downward from the top of the slab for the minimum distance shown or downward to the bottom of the slab then in a horizontal plane beneath the slab for the minimum distance shown. The horizontal length, or the vertical depth, of the insulation required varies from 24 inches to 48 inches depending upon the R-value selected. For heated slabs, an R of 2 shall be added to the thermal resistance required in Figure 3114.5.4.

Vertical insulation shall not be required to extend below the foundation footing.

3114.5.5 Thermal transmittance requirements for walls below grade: For walls below grade, the thermal resistance calculated in accordance with Chapter 25 of the ASHRAE Handbook, 1985 Fundamentals Volume shall be greater than or equal to that specified in Equation 3114.5.5:

$$R = 7.5 \times 10^{-4} HDD65 + 4.5 \quad \text{Equation 3114.5.5}$$

3114.5.6 Thermal transmittance requirement for opaque walls enclosing conditioned spaces exposed to interior unconditioned spaces: All opaque portions of walls enclosing conditioned spaces exposed to interior unconditioned spaces shall have an overall thermal transmittance (Uow) not greater than the value specified in Equation 3114.5.6:

$$Uow = 0.0528 + 510.9/HDD65 \quad \text{Equation 3114.5.6}$$

3114.5.7 External wall criteria for heating and cooling: The external wall heating criteria (WCh) and cooling criteria (WCc) shall be determined for a building envelope design per the cited required software program discussed in Section 3114.5.2 (For additional overview, refer to ASHRAE STANDARD 90.1, *ENERGY EFFICIENT DESIGN OF NEW BUILDINGS EXCEPT NEW LOW-RISE RESIDENTIAL BUILDINGS*).

The external wall heating and cooling criteria are determined for each exterior wall orientation of a building using the internal load range as determined in 3114.5.8.4 - 3114.5.8.6.

3114.5.8 Wall heating and cooling compliance values: The wall heating compliance value Hi and the wall cooling compliance value Ci shall be calculated per the cited required software program discussed in Section 3114.5.2 (For additional overview, refer to ASHRAE STANDARD 90.1, *ENERGY EFFICIENT DESIGN OF NEW BUILDINGS EXCEPT NEW LOW-RISE RESIDENTIAL BUILDINGS*).

3114.5.8.1 Applying the criteria: The wall criteria shall be applied as follows:

1. For all buildings that are heated and mechanically cooled, the sum of the calculated wall heating (Hi) and cooling (Ci) compliance values for all orientations of the proposed design as determined in Section 3114.5.7 shall not exceed the sum of the corresponding wall heating (WCh) and wall cooling (WCc) wall criteria for all orientations combined.

2. For buildings that are only heated, the sum of the calculated wall heat ing compliance values (Hi) for all orientations of the proposed design, as determined in Section 3114.5.7, shall not exceed the sum of the corresponding wall heating criteria, (WCh) criteria for all orientations combined.

3114.5.8.2 Constraints on thermal transmittance values: In applying the wall criteria as described in Section 3114.5.8.1 two constraints are imposed on thermal transmittance values for opaque wall assemblies and fenestration assemblies comprising the Uo term as follows:

1. Opaque wall assemblies: The opaque portion of walls with heat capacity (HC) less that 7 Btu/ft^2-^{o}F shall have an overall thermal transmittance (Uow) not greater than the value specified in equation 3114.5.6.

2. Fenestration Assemblies: The overall thermal transmittance (Uof) of fenestration assemblies shall be less than or equal to 0.81 Btu/ft^2-h-^{o}F if the fenestration area exceeds 10% of the total wall. Thermal transmittance for the fenestration shall be determined using the calculation procedures in Section 3114.3.2 and shall include the effects of sash, frames, edge effects and spacers for multiple-glazed units.

3114.5.8.3 Constraint on daylighting credit: For a given orientation, daylight credit may be used in the *ENVSTD* program only for that portion of the fenestration area that is less than or equal to 65 percent of the gross wall area of the orientation.

3114.5.8.4 Lighting power density: The lighting power density used in calculating the compliance value shall be either:

1. Building average unit Interior Lighting Power Limit in W/ft2 as specified by the prescriptive criteria in Section 3113.4. (For dwelling units in high rise residential buildings, if Table 3114.4.1 is used, the limit is 0.0 W/ft^2).

2. Designed building average lighting Unit Power Density for those activity areas within 15 feet of each exterior wall based on the procedures set forth by the system performance criteria in Section 3113.5.

3114.5.8.5 Equipment power density: The equipment power density used in determining compliance shall be either:

1. The "Average Receptable Power Densities" from Table 3114.4.1 or

2. The actual average Equipment Unit Power Density, considering diversity in the activity areas within 15 feet of each exterior wall, not to exceed 1 W/ft^2.

3114.5.8.6 Loads from occupants: Sensible load from occupants is assumed to be 0.6 W/ft^2. Thus, the sensible load that shall be used is either 0.0 W/ft^2 or the difference between 0.6 W/ft^2 and the actual sensible load.

SECTION 3115.0 BUILDING DESIGN BY SYSTEMS ANALYSIS

3115.1 Scope: This section establishes design criteria in terms of total energy use by a building including all of its systems.

3115.2 Compliance: Compliance with this section is optional and will require an analysis of the annual energy consumption. Sections 3107.0 through 3112.0 establish criteria for different energy consuming and enclosure elements of a low rise residential building. Sections 3107.0, 3108.0 and 3110.0 through 3114.0 establish criteria for different energy consuming and enclosure elements of commercial and high rise residential buildings. These criteria if followed, will eliminate the requirement for an annual energy analysis while meeting the intent of this article.

A low rise residential building designed in accordance with this section will be deemed as complying with this article if the annual energy consumption is not greater than if the building were designed with enclosure elements and energy consuming systems in compliance with Sections 3107.0 through 3112.0.

A commercial or high rise residential designed in accordance with this section will be deemed as complying with this article if the annual energy comsumption is not greater than if the building were designed with enclosure elements and energy consuming systems in compliance with Section 3107.0, Section 3108.0 and Sections 3110.0 through 3114.0.

3115.3 Standard design: The standard design, conforming to the criteria of Section 3108.0, and the proposed alternative design, shall be designed on a common basis as specified herein. The comparison shall be expressed as Btu input per square foot of gross floor area per year.

Identical energy sources must serve the same purpose in both the standard and the proposed alternative design. If the proposed alternative design results in an increase in consumption of one (1) energy source and a decrease in another energy source, each energy source shall be converted to equivalent Btu units for purposes of comparing the total energy used.

3115.4 Analysis procedure: The analysis of the annual energy usage of the standard and the proposed alternative building and system design shall meet the following criteria:

1. The building heating/cooling load calculation procedure used for annual energy consumption analysis shall be of sufficient detail to permit the evaluation of the effect of the factors specified in Section 3115.4.1.

2. The calculation procedure used to simulate the operation of the building and its service systems through a full year operating period shall be of sufficient detail to permit the evaluation of the effect of system design, climatic factors, operational characteristics, and mechanical equipment on annual energy usage. Manufacturer's data or comparable field test data shall be used when available in the simulation of all systems and equipment. The calculation procedure shall be based upon eighty-seven hundred and sixty (8760) hours of operation of the building and its service systems and shall utilize techniques recommended in the ASHRAE Handbook, 1985 Fundamentals Volume.

3115.4.1 Calculation procedure: The calculation procedure shall cover the following items:

1. Environmental requirements as indicated in Section 3105.0.

2. Climatic data: coincident hourly data for temperatures, solar radiation, wind and humidity of typical days in the year representing seasonal variation.

3. Building data: orientation, size, shape, transfer characteristics of mass, air, moisture and heat.

4. Operational characteristics: temperature, humidity, ventilation, illumination, control sequence for occupied and unoccupied hours.

5. Mechanical equipment: design capacity, part load profile.

6. Internal heat generation from lighting, equipment, number of people during occupied and unoccupied periods.

7. Electrical equipment: lighting, power consumption.

3115.4.2 Documentation: Proposed alternative designs, submitted as requests for exception to the standard design criteria, shall be accompanied by an energy analysis comparison report prepared by a professional registered engineer or registered architect. The report shall provide sufficient technical detail on the two (2) buildings and systems designs, and on the data used in and resulting from the comparative analysis, to verify that both the analysis and the designs meet the criteria of this article. The documentation shall demonstrate that the analysis used is consistent with ASHRAE calculation procedures and accepted engineering practice.

> **Exception:** Proposed alternative designs for buildings having an area of five thousand (5,000) square feet or less and having the indoor temperature controlled from a single point are exempted from the full year energy analysis as described above. A comparison of energy consumption between the alternative design and the standard design shall be provided in a report prepared by a registered professional engineer or architect. Such analysis shall follow the bin or degree day methods or other simplified analysis procedures consistent with accepted engineering practice.

SECTION 3116.0 BUILDINGS UTILIZING SOLAR, GEOTHERMAL, WIND, OR OTHER NONDEPLETABLE ENERGY SOURCES AS ALTERNATIVE DESIGNS

3116.1 General: When a proposed alternative building, submitted in accordance with Section 3115.0, utilizes solar, geothermal, wind, or other nondepletable energy, that portion supplied to the building shall be excluded from the total energy chargeable to the proposed alternative design.

3116.2 Passive solar energy: The solar energy passing through windows shall be considered if there is a net Btu/year saving over fossil fuel or electric energy systems.

3116.2.1 Nocturnal cooling: This provision shall also apply to nocturnal cooling processes in lieu of energy consuming processes.

3116.2.2 Other criteria: All other criteria covered in Section 3115.0 shall apply to the proposed alternative designs utilizing nondepletable sources of energy.

3116.3 Documentation: Proposed alternative designs, submitted as requests for exception to the standard design criteria shall be accompanied by an energy analysis, as specified in Section 3115.0. The report shall provide sufficient technical detail on the alternative building and system designs and on the data employed in and resulting from the comparative analysis to verify that both the analysis and the designs meet the criteria of this article. The documentation shall demonstrate that the analysis used is consistent with ASHRAE calculation procedures.

> **Exception:** Proposed alternative designs that derive over fifty (50) per cent of their annual thermal requirements (heating, cooling, service water heating) or over thirty (30) per cent of their annual total energy requirements from nondepletable sources shall be exempted from the necessity of comparing the proposed design to a standard design. Documentation, verifying the percentage of annual energy use derived from such nondepletable sources shall be required as provided in Section 3116.3 and shall be prepared by a registered professional engineer or architect.

3116.3.1 Performance data: The energy derived from nondepletable sources and the reduction in conventional energy requirements derived shall be separately identified from the overall building energy use. Supporting documentation, on the basis of the performance estimates for the aforementioned nondepletable energy sources or nocturnal cooling means, must be submitted.

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ARTICLE 32

REPAIR, ALTERATION, ADDITION, AND CHANGE OF USE OF EXISTING BUILDINGS

(This Article is entirely unique to Massachusetts)

SECTION 3200.0 SCOPE

3200.1 General: The provisions of this article are intended to maintain or increase public safety, health, and general welfare in existing buildings by permitting repair, alteration, addition, and/or change of use without requiring full compliance with the code for new construction except where otherwise specified in this article.

3200.2 Compliance: Repairs, alterations, additions, and changes of use shall conform to the requirements of this article. Where compliance with the provisions of this code for new construction, required by this article, is impractical because of structural or construction difficulties or regulatory conflicts, compliance alternatives as described in Section 3206.0 may be accepted by the building official.

Note: Specialized codes, rules, regulations, and laws pertaining to repair, alteration, addition, or change of use of existing buildings promulgated by various authorized agencies may impact upon the provisions of this article. Specialized state codes, rules, regulations, and laws include, but are not limited to those listed in Appendix G.

3200.3 Applicability: The provisions of this article apply to repair, alteration and/or addition to existing buildings which qualify to use this article (see Section 3200.3.1), based on the proposed continuation of or change in use group, as follows:

1. Continuation of the same use group, or a change in use group to a use group of an equal or lesser hazard index number (as listed in Table 3204) shall comply with Section 3203.0.
2. Change in use group to a use group of one (1) or greater hazard index number (as listed in Table 3204) shall comply with Section 3204.0.
3. Change in use group to a use group of two (2) or greater hazard index numbers (as listed in Table 3204) shall comply with the requirements of Section 3205.0 and the code for new construction.

4. Part change in use: If a portion of the building is changed to a new use group, and that portion is separated from the remainder of the building with vertical and horizontal fire separation assemblies complying with the fire grading required in Table 902, or with approved compliance alternatives, then the portion changed shall be made to conform to the provisions of this article. If a portion of the building is changed to a new use group, and that portion is not separated from the remainder of the building with vertical and horizontal fire separation assemblies complying with the fire grading required in Table 902, or with approved compliance alternatives, then the provisions of this article applying to each use shall apply to the entire building. If there are conflicting provisions, then those requirements which secure the greater public safety shall apply.

5. Additions: Additions to existing buildings shall comply with all code requirements for new construction. The combined height and area of the existing building and new addition shall not exceed that allowed by Table 501 and Sections 501.0 and 506.0. Where a fire wall complying with Section 907.0 is provided, the addition may be considered as a separate building.

   Exception: No addition shall impose loads which would cause the existing building to be subject to stresses exceeding those permitted by the code for new construction.

6. Ordinary repairs: Ordinary repairs conforming to Section 102.0 may be performed without a building permit.

7. Institutional use groups: When there is no change in occupancy within the institutional use group (I), the provisions of Section 3203.0 shall apply. Any change to an institutional use group (I) or any change in occupancy within an institutional use group shall comply with the requirements of the code for new construction.

8. Places of assembly: Nothing contained herein shall prohibit the alteration of a building heretofore occupied as a place of assembly for such continued use, provided that the seats, aisles, passage ways, balconies, stages, appurtenant rooms, and all special permanent equipment comply with the provisions of Sections 417.0 and 418.0. All buildings changed to an assembly use group (A) or changed within the assembly use groups shall comply with the

requirements of Section 417.0 and 418.0 and the applicable provisions of this article.

9. Historic buildings: Buildings which qualify as historic under Section 436.0 need only meet the provisions set forth in that section. The provisions of this article shall apply to historic buildings only when specifically cited in Section 436.0.

3200.3.1 Buildings which qualify: The provisions of this article shall apply to existing buildings which have been legally occupied and/or used for a period of at least five (5) years. No building for which there exists an outstanding notice of violation or other order of the building official shall qualify to use this article unless such proposed work includes correction of all outstanding violations and compliance with all outstanding orders of the building official. Structures which fail to qualify for use of the provisions of this article shall comply fully with the code for new construction.

3200.4 Hazardous exitways: The following exitway conditions shall be deemed to be hazardous when so cited by the building official. The owner of any building where such conditions are cited shall be required to correct such condition immediately:

1. Less than two (2) acceptable exitways serving every story.

   Exceptions: One- or two-family dwellings and buildings subject to Sections 417.0, 418.0, or 809.3

2. Any required door, aisle, passageway, stairway, or other required means of egress which is not of sufficient width to comply with Section 808.0 or is not so arranged as to provide safe and adequate means of egress.

SECTION 3201.0 DEFINITIONS

3201.1 General: Definitions shall be construed as being the same as defined in Article 2, except as follows:

Building system: Any mechanical, structural, egress, electrical, plumbing, building enclosure and/or fire protection system, or fire resistive construction system, or portion thereof.

Existing building or structure: Any completed building or structure.

Hazard index: The rating of a use group for relative hazard as listed in Table 3204.

SECTION 3202.0 IMPLEMENTATION

3202.1 Investigation and evaluation: For any proposed work covered by this article, the building owner shall cause the existing building to be investigated and evaluated in accordance with the provisions of this Article (see Appendix F).

3202.2 Submittal: The results of the investigation and evaluation, along with any proposed compliance alternatives, shall be submitted to the building official.

3202.3 Determination of compliance: The building official shall determine whether the existing building, with the proposed work incorporated, complies with the provisions of this article.

3202.4 Permit application: In addition to the requirements specified in Article 1, the application for a building permit shall include items of non or partial compliance with the requirements of this article, and compliance alternatives, if any are proposed, for approval by the building official. The building official shall respond to the acceptability of any proposed compliance alternatives within thirty (30) days of the filing of the building permit application.

3202.5 Documentation of compliance alternatives: Whenever action is taken on any building permit application to repair, make alterations or additions or change the use or occupancy of an existing building, and when said application proposes the use of compliance alternatives, the building official shall ensure that one (1) copy of the proposed compliance alternatives, including applicable plans, test data, or other data for evaluation, be submitted to the Commission, along with a copy of the building permit application and the building official's decision regarding the proposed compliance alternatives.

SECTION 3203.0 REQUIREMENTS FOR CONTINUATION OF THE SAME USE GROUP OR CHANGE TO A USE GROUP OF EQUAL OR LESSER HAZARD INDEX

3203.1 General: The requirements of this section shall apply to all repairs and alterations to existing buildings having a continuation of the same use group or to existing buildings changed in use group to an equal or lesser hazard index number (Table 3204).

3203.2 Requirements exceeding those required for new construction: Existing buildings which, in part or as a whole, exceed the requirements of this code may, in the course of compliance with this article, reduce or remove, in part or completely, features not required by this code for new construction.

3203.3 New systems: Any new building system or portion thereof shall conform to this code for new construction to the fullest extent practical. However, individual components of an existing building system may be repaired or replaced without requiring that system to comply fully with the code for new construction.

3203.4 Alterations and repairs: Alterations or repairs to existing buildings, except for child day care centers as provided for in Section 633.0, which maintain or improve the performance of the building may be made with the same or like materials. Full compliance to the provisions of Section 3203.0 is not required unless there is a change in use.

3203.5 Floor loads: All floors shall be specifically investigated to determine the adequacy of the existing floor system to support the proposed specific floor loads, which shall not be less than those provided in Article 7 for the proposed use group. However, the loads specified in Article 7 may be reduced by a registered professional engineer based on the specific occupancy loads to be encountered, provided such reduction is approved by the building official.

3203.6 Structural loads: Any portion of the existing building which will not safely support the loads of the proposed use group as specified in Article 11 or Section 3203.5 shall be replaced or strengthened to provide such support.

3203.7 Number of exits: Any existing building shall provide at least two (2) means of egress serving every story which are acceptable to the building official.

> **Exception:** One- and two-family dwellings and buildings as modified in Sections 417.0,418.0 (places of assembly), or 809.3 (two-story business buildings).

3203.8 Capacity of exits: All required means of egress shall comply with Section 808.0. Existing means of egress may be used to contribute to the total egress capacity requirement based on the unit egress widths of Section 808.0.

3203.9 Exit signs and lights: Exit signs and lighting shall be provided in accordance with Section 823.0.

3203.10 Means of egress lighting: Means of egress lighting shall be provided in accordance with Section 824.0.

3203.11 Fire alarm systems: Fire alarm systems shall be provided in accordance with Sections 1016.0 and 1017.0.

3203.12 Enclosure of stairways: Open stairways are prohibited except in one- and two-family dwellings or unless otherwise permitted by Article 8. There shall be

no minimum fireresistance rating required for an existing enclosure of a stairway. Partitions or other new construction which is added in order to fully and solidly enclose a stairway shall provide a minimum fireresistance rating of one (1) hour. All doors in the enclosure shall be self-closing and tight-fitting with approved hardware. All doors in those portions of the stairway which are fireresistance rated shall comply to the applicable portions of Article 9.

3203.13 Places of assembly: Nothing herein contained shall prohibit the alteration of a building heretofore occupied as a place of public assembly for such continued use provided the seats, aisles, passageways, balconies, stages, appurtenant rooms, and all special permanent equipment comply with the requirements of Sections 417.0 and 418.0. All buildings changed to an assembly use group (A) or changed within the assembly use groups shall comply with the requirements of Sections 417.0 and 418.0 and the applicable provisions of this article.

3203.14 Fire hazard to adjacent buildings: Any proposed change to the occupancy of an existing building shall not increase the fire hazard to adjacent buildings. If the fire hazard to adjacent buildings is substantially increased, then the requirements of Table 214 for exterior walls shall apply.

3203.15 Increase in the number of dwelling units: In buildings classified in residential use groups (R), the number of dwelling units may be increased up to fifteen (15) per cent without full compliance to the provisions of Section 3203.9 through 3203.11 inclusive. If an increase of greater than fifteen (15) per cent in the number of dwelling units is involved, the building shall comply with the requirements of Section 3203.0. For the purposes of this section only, the base number of dwelling units, which shall be used to calculate percentages of all increases in numbers of dwelling units, shall be that number of dwelling units legally occupied on June 1, 1979.

> **Exception:** Buildings classified in residential use groups (R) containing less than seven (7) dwelling units may be altered to add one (1) dwelling unit without requiring full compliance with the provisions of Section 3203.0.

3203.16 Institutional uses: When there is no change in use or occupancy within the institutional use group (I), the provisions of Section 3203.0 shall apply.

> Any change to an institutional use group (I) or any change within an institutional use group shall comply with the requirements of the code for new construction.

SECTION 3204.0 REQUIREMENTS FOR CHANGE IN USE GROUP TO ONE HAZARD INDEX GREATER

3204.1 General: When the existing use group is changed to a new use group of one (1) hazard index higher (as provided in Table 3204), the existing building shall conform to the requirements of the code for new construction, except as further provided in this section.

3204.2 Mixed use: Compliance is required with Section 213.0 and Table 902 except that floors and walls providing horizontal and vertical separation in buildings of Types 3 and 4 construction shall have a fire-resistance rating of not less than one (1) hour and shall be equipped with a fire suppression system.

3204.3 Restrictions within fire limits: No further compliance is required with Section 302.0. However, if the fire hazard to adjacent buildings is substantially increased due to an increased fire loading, then the requirements of Section 302.0 shall apply.

3204.4 Area and height limitations: No further compliance is required with Sections 501.2 and 501.3 (e.g., a change in use is allowed in an existing building even if it exceeds the area and height limits of Table 501).

3204.5 Accessibility for physically handicapped: No further compliance is required with Section 512.

3204.6 Exitway stairs: Compliance is required with Section 616.0, except that existing exitway stairways may be used as part of the required egress for the new use, provided that the width is of sufficient capacity for the occupancy load, they are structurally sound, and that the enclosures in buildings of Types 3 and 4 construction shall have a fireresistance rating of not less than one (1) hour. Stairway enclosures in buildings of Type 1 and 2 construction shall have a fire resistance rating of not less than two (2) hours. Where stair exitway doors are doors to an apartment or office they need not swing onto the landing. Such doors shall be self-closing and tight-fitting with approved hardware.

3204.7 Earthquake resistance and liquefaction: No further compliance to Sections 1113.0 and 1201.0 is required. Structural alterations may be made to existing buildings, but the resistance to lateral forces shall not be less than before such alterations were made, unless the building as altered meets the requirements of this code for earthquake loads.

3204.8 Mortar: No further compliance is required with Section 815.0.

3204.9 Fire and party walls: No further compliance is required with Section 907.0. The height above the roof of existing fire, party and exterior walls need not comply with this section.

Table 3204
HAZARD INDEX
Scale: 1-8 (1 is lowest, 8 is highest hazard)

USE GROUP	DESCRIPTION	INDEX NO.**
A-1-A	Theater with stage	6
A-1-B	Theater without stage	5
A-2	Night Club	7
A-3	Restaurant Lecture halls, recreations centers, museums, libraries. similar assembly buildings	5 4
A-4	Churches and schools	4
B	Business	2
F	Factory and industrial	3
H	High hazard	8
I-1 3	Institutional restrained	5
I-2	Institutional incapacitated	4
M	Mercantile	3
R-1	Hotels, motels	2
R-2	Multi-family	2
R-3	One and two family	2
S-1	Storage, moderate hazard	3
S-2	Storage, low hazard	1

Notes to Table 3204:
* See Section 203.0 through 212.0 and Appendix F.
** Hazard Index Modifier for selected construction types.

When a building is classified in Construction Type 1A, 1B, 2A, or 2B, subtract one (1) from the Hazard Index number shown in Table 3204 **for the applicable proposed new use group only.** When a building is classified in construction Type 3C or 4B, add one (1) to the Hazard Index number shown in Table 3204 **for the applicable proposed new use group only.**

SECTION 3205.0 REQUIREMENT FOR CHANGE IN USE GROUP TO TWO OR MORE HAZARD INDICES GREATER

3205.1 General: When the existing use group is changed to a new use group of two (2) or more hazard indices higher (as provided in Table 3204), the existing building shall conform to the requirements of the code for new construction.

SECTION 3206.0 COMPLIANCE ALTERNATIVES

3206.1 General: Where compliance with the provisions of the code for new construction, required by this article, is impractical because of structural or construction difficulties or regulatory conflicts, compliance alternatives may be accepted by the building official.

Some compliance alternatives which have been used are provided in Appendix F. The building official may accept these compliance alternatives or others proposed.

3206.2 Documentation: In accordance with Section 3202.5, the building official shall ensure that the Commission is provided with information regarding compliance alternatives accepted or rejected by him.

SECTION 3207.0 ENERGY PROVISIONS FOR EXISTING BUILDINGS

3207.1 General: This section establishes the energy provisions for existing buildings governed by Section 3203.0. Existing buildings governed by Sections 3204.0, 3205.0, or by the code for new construction shall comply with the requirements of Article 20 for new construction.

3207.2 Compliance alternatives: Alterations to any of the building elements of an existing building must comply with Table 3207 on either a component basis; or an equivalent energy usage analysis basis; or a system analysis basis.

3207.2.1 Component basis: Alterations to any of the building elements (walls, windows, doors, roofs or mechanical systems) shall comply with Table 3207 and the applicable subsections of Article 20 for the altered elements only.

3207.2.2 Equivalent energy usage analysis: Alterations to any of the building envelope elements (walls, windows, doors, or roof) may be adjusted so that the energy losses of any element may be increased or decreased as long as the total does not exceed that which would have been calculated for the individual components.

3207.2.3 Systems analysis: Refer to Section 3113.0 of this code for design criteria for systems analysis.

3207.3 Exempt buildings: Refer to Section 3001.4 for thermally exempt buildings and Section 3015.0 for lighting exemptions.

3207.4 Compliance exceptions

3207.4.1 Fenestration: When alterations to a wall assembly include only altering the fenestration component, the areas of fenestration may be decreased or replaced with an opaque wall element made to comply with the thermal transmittance value of the existing wall.

3207.4.2 Ordinary repairs: Ordinary repairs need not comply with the energy provisions.

3207.4.3 Roofs: Compliance of the roof/ceiling assembly is not required unless the existing roofing material is stripped off the roof deck. However, if a structural analysis by a registered professional engineer shows that the roof will not support the additional live loads imposed by compliance of the roof/ceiling assembly, or, if such analysis shows that addition of the required amount of insulation will cause ponding of water, then compliance of the roof/ceiling assembly is not required.

TABLE 3207
COMPONENT VALUES FOR ALTERED ELEMENTS

WALLS	All wall construction containing heated or mechanically cooled space	0.08	6,8
Foundation Walls Including Band	Containing heated or mechanically cooled space Containing unheated space	0.08 0.17	4
Roof/Ceiling Assy	Wood plank and beam construction containing heated or mechanically cooled space	0.08	1
Roof/Ceiling Assy	Construction other than wood plank and beam containing heated or mechanically cooled space	0.05	
Doors, Skylights and Windows	All construction enclosing heated or mechanically cooled space	0.65 0.65	2, 7 5 6
Floors	Floor sections over area exposed to outside air or unheated areas Unheated slab on grade Heated slab on grade	0.08 5.50 (R) 7.75 (R)	3
Mechanical Equipment	Heating, cooling, sizing and efficiency	Sect. ~~20~~10.0, ~~20~~11.0	9
Equipment Controls	Humidistats, thermostats & zoning	Sect. ~~20~~10.0	9
Duct and Pipe Insulation and Construction	Located in or on buildings	Sect. ~~20~~10.9 ~~20~~10.12	
Electrical Equip. & Power Dist.	-	Sect. ~~2010.0~~ ~~2011.0, 2012.0~~	
Lighting	Lighting	Sect. ~~20~~13.0	

Notes to Table 3207:

Note 1. Wood plank and beam assemblies are constructions in which the finished interior surface is the underside of the roof deck.

Note 2. Double glazing or storm windows will satisfy the required U Value of 0.65.

Note 3. Insulation may be omitted from floors over unheated areas when foundation walls are provided with a U value of 0.17.

Note 4. The U value requirement of 0.17 for foundation walls may be omitted when floors over unheated spaces are provided with a U value of 0.08.

Note 5. Allowable air infiltration values for windows - .50 cfm/lin. ft. of operable sash crack; residential doors - (sliding) .50 cfm/sf., (entrance) 1.25 cfm/sf.; commercial doors 11 cfm/lin.ft.

Note 6. The first floor exterior envelope of business and mercantile use groups shall have an overall thermal transmittance value not greater than .65 in lieu of individual component values for walls and fenestration.

Note 7. When the glass area is increased, the glass and wall components which are altered shall comply with the component values in Table 3207. The extent of wall made to comply shall be equivalent to the decreased opaque wall area.

Note 8. When any alterations to the exterior wall component exposes the wall cavity or, when a finished system is added to a wall having no cavity, the wall must comply with the values in Table 3207.

Note 9. When mechanical system compliance is required on an existing system, only the portions of the system altered and any other portions which can reasonably be incorporated need comply.

SECTION 3208.0 OTHER CODE SECTIONS PERTAINING TO REPAIR, ALTERATION, OR CHANGE OF USE OF EXISTING BUILDINGS

3208.1 General: The following is a list of some additional code sections which may pertain to repair, alteration, or change of use of existing buildings:

101.0	Applicability
102.0	Ordinary Repairs
103.0	Installation of Service Equipment
104.0	Maintenance
105.0	Change in Existing Use
106.0	Alterations and Repairs
108.5.1	Duties and Powers of the Building Official and State Inspector - Inspection and Certification - Specified Use Groups
111.1	Preliminary Inspection
116.0	Demolition of Structures
117.0	Moved Structures
119.2	Certificate of Use and Occupancy - Buildings or Structures Hereafter Altered
120.0	Posting Structures
121.0	Violations
123.0	Unsafe Structures
124.0	Emergency Measures
506.0	Street Encroachments
627.0	Fire Prevention Code

629.0	Existing Buildings
609.0	Public Garages
617.0	Places of Public Assembly other than Theaters
624.0	Group Residence
607.0	Open Parking Structures
637.0	Day Care Centers
638.0	Summer Camps for Children - New and Existing Occupancies
639.0	Historic Buildings
637.0	Detoxification Facilities
702.0	Existing Buildings (Light, Ventilation and Sound Transmission Control)
800.1	Means of Egress - Scope
800.2	Modification of Exitway Requirements
805.0	Maintenance of Exitways
821.0	Fire Escapes
1105.0	Structural and Foundation Loads and Stresses - Existing Buildings
1113.0	Earthquake Loads - Minor Alterations
2102.0	Flood Resistant Construction
1306.0	Heretofore Approved Materials
926.0	Exterior Trim Restrictions - Existing Combustible Construction
2301.0	Roof Covering - Existing Roof
1000.3	Fire Protection Systems - Maintenance
1000.8	Fire Protection Systems - Periodic Inspections and Tests
1001.1	Fire Protection Systems - Plans and Specifications - Required
1001.2	Fire Protection Systems - Plans and Specifications - Approved by other Agencies
1012.7	Standpipes for Buildings Under Demolition
	Article 13 Precautions During Building Operations
2903.0	Unsafe and Unlawful Signs - Notices
2904.0	Existing Signs
2905.0	Signs - Maintenance and Inspection
3101.3	Energy Conservation - Existing Buildings
3101.4	Energy Conservation - Exempt Buildings
3100.2.4	Building Code Provisions for One- and Two-Family Dwellings - Alterations to Existing Buildings

Mechanical Code:

	Chimneys, Flues, and Vent Pipes - Existing Buildings
	Mechanical Equipment and Systems - Existing Buildings

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ARTICLE 33

MANUFACTURED BUILDINGS, BUILDING COMPONENTS AND MOBILE HOMES

(This Article is entirely unique to Massachusetts)

SECTION 3300.0 GENERAL

3300.1 Installation in the State: The provisions of this article shall govern the materials, design, manufacture, handling, storage, transportation, assembly, construction and/or installation of manufactured buildings and building components intended for installation in the Commonwealth of Massachusetts. Manufactured buildings or building components shall not be installed in any jurisdiction of this State unless such manufactured buildings or building components have been approved and certified, in accordance with the applicable codes as provided in this article, applicable provisions of the code, and the Rules and Regulations for Manufactured Buildings, Building Components and Mobile Homes of the Board of Building Regulations and Standards(BBRS) and hereinafter referred to in this article as the "rules and regulations."

Exception: All manufactured buildings and building components manufactured prior to January 1, 1975, with the approval of the building official and which met all the requirements of state laws , rules and regulations, or local by-laws or ordinances in force at that time shall be deemed approved in accordance with the provisions of Section 114.4 of this code; provided that such manufactured buildings or building components are used for the purpose and within the limitations for which they were approved and provided such uses are not detrimental to the health and safety of the occupants and the public.

3300.2 Manufactured in the State: The provisions of this article shall also govern manufactured buildings and building components manufactured in the State for shipment to any other State or government jurisdiction where such manufactured buildings and building components and the label thereon are accepted.

3300.3 Mobile homes: The article shall also govern the installation within the State of all mobile homes. The evaluation and approval of all mobile homes for installation

Exception: All mobile homes manufactured between January 1, 1975 and July 17, 1976 and sold, delivered to or installed on building sites in any jurisdiction of this State shall comply with the provisions of ANSI A119.1 (1974 edition) as amended by the Board of Building Regulations and Standards with this article and the rules and regulations pursuant thereto.

SECTION 3301.0 APPROVAL

3301.1 General: The Commonwealth of Massachusetts, Department of Public Safety, Division of Inspection (hereinafter referred to as the "Division of Inspection" in this article) shall evaluate manufactured buildings and building components and recommend approval to the BBRS of those which it determines to be in compliance with applicable sections of this article, other applicable sections of this code, and the rules and regulations.

However, all approvals of plumbing, electrical or gas systems shall be made by the appropriate state agencies having jurisdiction, as specified in the rules and regulations.

3301.2 Approved tests: The Division of Inspection may utilize the results of approved tests to determine whether a manufactured building or building component meets the requirements of this article and the rules and regulations, if that determination cannot be made from evaluation of plans, specifications and documentation alone.

3301.3 Approval of compliance assurance programs: The Division of Inspection shall evaluate manufacturers' compliance assurance programs and make recommendations for approval to the BBRS of those which it determines to be in compliance with this article and the rules and regulations.

3301.4 Authorization to vary: A manufactured building, building component or a compliance assurance program which has approval shall not be varied in any way without prior authorization by the Division of Inspection in accordance with the rules and regulations.

SECTION 3302.0 CERTIFICATION

3302.1 Labeling: Any manufactured building or building component which has approval, in accordance with section 3301.0, shall have an approved device or seal affixed as certification of such approval.

SECTION 3303.0 RECIPROCITY

3303.1 General: If the BBRS finds that the standards for manufacture and inspection of manufactured buildings or building components prescribed by the statutes or rules and regulations of another state or other governmental agency meet the objectives of this article and the rules and regulations, and such standards are enforced satisfactorily by such other state or governmental agency or by its agents, the BBRS shall grant approval and the Division of Inspection shall accept all manufactured buildings or building components which have been approved by such other state or governmental agency and shall insure that the product is properly labeled.

3303.1.1 Condition of reciprocity: The standards of another state shall not be deemed to be satisfactorily enforced unless such other state provides for notification to the Division of Inspection of suspensions or revocations of approvals issued by that other state, in a manner satisfactory to the BBRS.

3303.2 Suspension of reciprocal approval: The Division of Inspection shall suspend or cause to be suspended reciprocal approval for the following reasons:

1. if it determines that the standards for the manufacture and inspection of such manufactured buildings or building components of another state or other governmental agency do not meet the objectives of this article and the rules and regulations or that the standards are not being enforced to the satisfaction of the Division of Inspection; and
2. if another state or governmental agency, or its agent, suspends or revokes its approval, the approval granted under this section shall be suspended or revoked accordingly.

SECTION 3304.0 ASSURANCE INSPECTION

3304.1 General: Any person or firm manufacturing buildings or building components desiring certification shall agree in writing that the Division of Inspection has the right to conduct unannounced inspections at any reasonable time.

3304.2 Responsibilities of Division of Inspection: The Division of Inspection shall carry out the following responsibilities:

1. Periodically make, or cause to be made, inspections of the entire process of manufacture of buildings or building components in order to verify the reliability of the compliance assurance program and of the approved inspection agency.
2. In addition to other on-site inspection provided for in this section, the Division of Inspection shall inspect, or cause to be inspected, certified

manufactured buildings or building components which it determines to have been sufficiently damaged after certification to warrant such action with regard to such buildings or building components as is authorized hereof, or as is otherwise necessary to eliminate dangerous conditions.

Note: An inspection entailing disassembly, damage to or destruction of certified manufactured buildings or building components shall not be conducted except to implement the provisions of this article.

SECTION 3305.0 RESPONSIBILITY OF THE LOCAL ENFORCEMENT AGENCIES

3305.1 Issuance of building permits: Upon application and in conformity with the provisions of this code, the building official shall issue building permits for installation of certified manufactured buildings or building components or mobile homes.

3305.2 Inspection: The local enforcement agency shall make the following inspections

1. The site preparation work, including foundations, installation of any certified manufactured buildings or building components or approved homes; and for all utility service connections, including plumbing, electrical, gas, water and sewer; for compliance with the applicable codes.
2. Inspect all certified manufactured buildings or building components or approved mobile homes upon, or promptly after, installation at the building sites to determine whether all applicable instructions or conditions have been followed. This may include tests for tightness of plumbing and mechanical systems, for malfunctions in the electrical system, and a visual inspection for obvious violations of the rules and regulations. Destructive disassembly of certified buildings or building components or approved mobile homes shall not be performed in order to conduct such inspections. Nondestructive disassembly may be performed only in accordance with the rules and regulations.

3305.3 Issuance of certificates of occupancy: The building official shall issue a certificate of occupancy for all certified manufactured buildings or approved mobile homes that have been installed and inspected and that meet the requirements of this code.

SECTION 3306.0 SUSPENSION OR REVOCATION OF CERTIFICATION

3306.1 General: The Board shall suspend or revoke the approval of any manufactured building or building component which does not comply with the provisions of this code or with the rules and regulations.

3306.2 Labels of certification: The Division of Inspection shall remove or cause to be removed the label of certification from any such manufactured building or building component not in compliance until such time as it is brought into compliance with this article and the rules and regulations.

3306.3 Notice of suspension or revocation: Notice shall be submitted in writing to the affected parties stating the reason for the suspension or revocation.

3306.4 Appeals Procedure: All appeals from suspension or revocation shall be heard by the State Building Code Appeals BBRS as specified in the pertinent provisions of Section 126.0 of this code.

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ARTICLE 34

ONE AND TWO FAMILY DWELLINGS

(This Article is entirely unique to Massachusetts)

It is the intent of the BBRS to adopt the CABO One and Two Family Dwelling Code with appropriate changes to correspond to Massachusetts General Laws and other Massachusetts requirements. The review of the CABO code is in process, and should be completed by year-end.

In the meantime, Article 21 of the Fourth Edition of the Massachusetts State Building Code remains in full force and effect. A separate publication which contains Article 21 (now renumbered to Article 34) and Article 1, Administration and Enforcement, is available from the State House Bookstore.

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