CERTIFICATE

By Authority Of
THE UNITED STATES OF AMERICA
Legally Binding Document

By the Authority Vested By Part 5 of the United States Code § 552(a) and Part 1 of the Code of Regulations § 51 the attached document has been duly INCORPORATED BY REFERENCE and shall be considered legally binding upon all citizens and residents of the United States of America. *HEED THIS NOTICE*: Criminal penalties may apply for noncompliance.

Document Name: BOCA: Mechanical Code

CFR Section(s): 24 CFR 200.925c(a)(1)(i)

Standards Body: Building Officials and Code Administrators International

APPROVED

Official Incorporator:
THE EXECUTIVE DIRECTOR
OFFICE OF THE FEDERAL REGISTER
WASHINGTON, D.C.

The BOCA® *National Mechanical Code/* 1993

Model building regulations for the protection of public health, safety and welfare.

EIGHTH EDITION

As recommended and maintained by the voting membership of

BUILDING OFFICIALS & CODE ADMINISTRATORS INTERNATIONAL, INC.

4051 W. Flossmoor Rd.
Country Club Hills, IL 60478-5795

Founded in 1915

708/799-2300
FAX 708/799-4981

REGIONAL OFFICES

3592 Corporate Dr., Ste. 107
Columbus, OH 43231-4987
Telephone 614/890-1064
FAX 614/890-9712

3 Neshaminy Interplex, Ste. 301
Trevose, PA 19053-6939
Telephone 215/638-0554
FAX 215/245-4705

Towne Centre Complex
10830 E. 45th Street, Ste. 200
Tulsa, OK 74146-3809
Telephone 918/664-4434
FAX 918/664-4435

NOTE: The *BOCA National Codes* are designed for adoption by state or local governments by reference only. Jurisdictions adopting them may make necessary additions, deletions and amendments in their adopting document. Incorporation of any part of the *BOCA National Codes* in codes published by states, local governments, regulatory agencies, individuals or organizations is expressly prohibited. When your jurisdiction has adopted one or more of the *BOCA National Codes*, please send a copy of the adopting document to the BOCA Executive offices.

Once this material has been adopted by a rule-making jurisdiction, other than by reference, all parties, including the rule-making jurisdiction, may reproduce the material in whole or in part subject only to a nonexclusive, royalty-bearing license with Building Officials & Code Administrators International, Inc. Any party desiring such a license should contact: Executive Director, BOCA International, 4051 West Flossmoor Road, Country Club Hills, Illinois 60478-5795.

Printed in the United States of America
First printing: March, 1993

PREFACE

The *BOCA National Mechanical Code* was initially prepared and updated on the premise that adequate code requirements are essential to the safe installation and maintenance of all mechanical equipment and systems in order to protect the public health, safety and welfare.

The *BOCA National Mechanical Code* sets forth comprehensive regulations for the safe installation and maintenance of mechanical facilities where great reliance was previously placed on accepted practice and engineering standards. By establishing the end result to be accomplished rather than the method to be followed, the *BOCA National Mechanical Code* allows freedom and flexibility in the development of mechanical systems. The code adopts nationally recognized standards as the criteria for evaluation of minimum safe practice, or for determining the performance of materials or systems of construction. The application of these standards is stated in the text of the code requirements, and the standards are listed and identified in Chapter 21, making it practical and convenient to update any standard as it is revised or reissued by the sponsoring agency.

This eighth edition presents the *BOCA National Mechanical Code* as originally issued with changes through 1992 and with certain editorial changes made to maintain the sequence of the code and to update the references to standards.

This code, as are the other codes published by Building Officials and Code Administrators International, is kept up to date through the review of changes proposed by code enforcement officials, industry and design professionals, and other interested persons and organizations. Proposed changes are discussed in a public hearing, carefully reviewed by committees, and acted upon by code enforcement officials in an open meeting of the organization. A new edition such as this is then prepared every three years, and contains all approved changes since the previous edition.

Changes as described above do not just happen. The *BOCA National Mechanical Code* is dedicated to the thousands of code enforcement officials from throughout the United States and Canada; to the engineers, architects, technicians, builders, contractors, material producers, trade associations and others who voluntarily collaborated in its preparation; and to the members of the code changes committees and their constituent committees, who participated in the important work of keeping the code abreast of new developments in construction technology. These individuals have given unstintingly of their time and their talents to produce and maintain this performance-type code, which has been widely recognized, highly respected, and adopted by countless communities.

Use of the *BOCA National Mechanical Code* or any of the other *BOCA National Codes* within a government jurisdiction is intended to be accomplished only through *adoption by reference* in a proceeding of the jurisdiction's board, council, or other authoritative governing body. At the time of adoption, jurisdictions should insert the appropriate information in those passages of a code requiring specific local information, such as the date of adoption, name of adopting jurisdiction, dollar amount of fines and permit costs, etc. These passages are shown in bracketed small capital letters in the codes, and are also listed in the sample adoption ordinance page of each code for which the local adoption information is required. Additionally, jurisdictions may amend or modify *BOCA National Code* provisions to accomplish desired local requirements, although use of the codes in substantially original and standardized form is encouraged by the BOCA organization. A sample draft of an adopting ordinance for the *BOCA National Mechanical Code* is provided on page *vii*.

This document has been developed under the published procedures of Building Officials and Code Administrators International, Inc. These procedures are designed to obtain the views and comments of those in the construction industry willing to participate. While these procedures assure the highest degree of care, neither BOCA, its members, nor those participating in its activities accepts any liability resulting from compliance or noncompliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text.

BOCA has no power or authority to police or enforce compliance with the contents of this code. It is only the governmental body that enacts the code into law that does so.

NOTE TO BOCA® NATIONAL CODE USERS

The 1993 editions of the *BOCA National Codes* contain, for the benefit and convenience of code users, vertical lines in the outside margins of some pages.

As in previous editions, vertical lines in the margin indicate approved changes to the text of code requirements. Editorial changes are not so marked. For example, lines shown in the margins of the *1993 BOCA National Codes* indicate technical content changes since the 1990 editions. Asterisks in the margin indicate locations from which 1990 code text has been deleted. Unlike the 1990 editions, these asterisks are no longer used to indicate text that has moved to a different location in the code. These features are designed to streamline the review process for jurisdictions wishing to adopt current, up-to-date provisions.

Several additional features are reflected in the 1993 editions of the *BOCA National Codes.*

Definitions of terms have been rearranged in order to locate them within the chapter or section that represents the predominant subject matter associated with each term. Definitions related predominantly to Chapter 1 and those that have broad applicability throughout the code remain in full in Chapter 2. All defined terms are listed alphabetically in Chapter 2 followed by either the text of the definition or a reference to the section number that contains the text of the definition. Selected defined terms are italicized where they appear in the code in the same manner as in previous editions.

Additionally, an indenting feature is used in tandem with the codes' decimal-based section numbering system to indicate the hierarchy of each subsection.

The values stated in the U.S. customary units of measurement are to be regarded as code requirements. The metric equivalents of U.S. customary units may be approximate. Metric equivalents are not indicated for materials identified by nominal sizes. For actual dimensions refer to the appropriate material standard listed in Chapter 21. The nominal sizes included in the *BOCA National Codes* indicate the common designation of materials by that industry.

A GUIDE TO USE OF THE BOCA® NATIONAL MECHANICAL CODE

The format and provisions of the *BOCA National Mechanical Code* are designed to provide units of government with effective minimum requirements for safe mechanical systems.

The following step-by-step approach is recommended for use in determining the code's application to particular building mechanical systems within a governmental jurisdiction.

1. **Mechanical equipment and appliances:** Determine that mechanical equipment and appliances conform to and are installed in compliance with the requirements of Chapters 4, 6, 13, 14, 15 and 18.
2. **Fuel supply:** Determine compliance with gas piping requirements (Chapter 8). Determine compliance with fuel oil piping requirements (Chapter 9).
3. **Combustion air:** Determine that adequate combustion air is provided for all fuel-fired equipment (Chapter 10).
4. **Chimneys and vents:** Determine compliance with chimney and vent requirements (Chapter 12).
5. **Duct and piping:** Determine compliance with air distribution requirements (Chapter 3). Determine compliance with hydronic piping requirements (Chapter 7).
6. **Kitchen exhaust:** Determine compliance with kitchen exhaust requirements (Chapter 5).
7. **Ventilation:** Determine compliance with ventilation air requirements (Chapter 16).
8. **Energy conservation:** Determine compliance with energy conservation requirements (Chapter 19).

ADOPTION INFORMATION

The *BOCA National Codes* are designed and promulgated to be adopted by reference by ordinance. Jurisdictions wishing to adopt the *BOCA National Mechanical Code/1993* as enforceable minimum mechanical safety requirements should insure that certain factual information is included in the adopting ordinance at the time adoption is being considered by the appropriate governmental body. The following sample adoption ordinance addresses several key elements of a code adoption ordinance, including the information required for insertion into the code text.

SAMPLE ORDINANCE FOR ADOPTION OF THE 1993 BOCA NATIONAL MECHANICAL CODE

AN ORDINANCE ESTABLISHING THE MINIMUM REGULATIONS GOVERNING THE DESIGN, INSTALLATION AND CONSTRUCTION OF MECHANICAL SYSTEMS, BY PROVIDING REASONABLE SAFEGUARDS TO PROTECT THE PUBLIC HEALTH AND SAFETY AGAINST THE HAZARDS OF INADEQUATE, DEFECTIVE OR UNSAFE MECHANICAL SYSTEMS AND INSTALLATIONS; KNOWN AS THE MECHANICAL CODE; AND REPEALING OF EXISTING ORDINANCE NUMBER (*Present Ordinance, if any*) OF THE (*Type of Jurisdiction*) OF (*Name of Jurisdiction*), STATE OF (*State Name*).

Be it ordained by the (*Governing Body*) of the (*Name of Jurisdiction*) as follows:

SECTION 1. ADOPTION OF MECHANICAL CODE.

That a certain document, three (3) copies of which are on file in the office of the (*Jurisdiction's Keeper of Records*) of the (*Type of Jurisdiction*) of (*Name of Jurisdiction*), being marked and designated as "The BOCA National Mechanical Code, Eighth Edition, 1993," as published by Building Officials and Code Administrators International, Inc., be and is hereby adopted as the Mechanical Code of the (*Type of Jurisdiction*) of (*Name of Jurisdiction*) in the State of (*State Name*); for the control of buildings and structures as herein provided; and each and all of the regulations, provisions, penalties, conditions and terms of the said *BOCA National Mechanical Code* are hereby referred to, adopted and made a part hereof, as if fully set out in this Ordinance, with the additions, insertions, deletions and changes, if any, prescribed in Section 3 of this Ordinance.

SECTION 2. INCONSISTENT ORDINANCES REPEALED.

That Ordinance Number (*Present Ordinance Number*) of the (*Type of Jurisdiction*) of (*Name of Jurisdiction*) entitled (*Full Title of Present Ordinance*) and all other ordinances or parts of ordinances in conflict herewith are hereby repealed.

SECTION 3. ADDITIONS, INSERTIONS AND CHANGES.

That the following sections are hereby revised as follows:

Section M-101.1 (page 1, second line). Insert: (*Name of Jurisdiction*).

Section M-113.2 (page 4, third line). Insert: (*Fee Schedule*).

Section M-113.3 (page 4, third line). Insert: (*Fee Schedule*).

Section M-116.4 (page 5, seventh, eighth and ninth lines). Insert: (*Offense, Dollar Amount, Number of Days*).

Section M-117.2 (page 5, fifth and sixth lines). Insert: (*Dollar Amounts in Two Locations*).

SECTION 4. SAVING CLAUSE

That nothing in this Ordinance or in the Mechanical Code hereby adopted shall be construed to affect any suit or proceeding impending in any court, or any rights acquired, or liability incurred, or any cause or causes of action acquired or existing, under any act or ordinance hereby repealed as cited in Section 2 of this Ordinance; nor shall any just or legal right or remedy of any character be lost, impaired or affected by this Ordinance.

SECTION 5. DATE OF EFFECT.

That the (*Jurisdiction's Keeper of Records*) shall certify to the adoption of this Ordinance and cause the same to be published as required by law; and this Ordinance shall take full force and effect (*Time Period*) after this date of final passage and approval.

TABLE OF CONTENTS

CHAPTER 1

ADMINISTRATION

SECTION M-101.0 GENERAL

M-101.1 Title: These regulations shall be known as the Mechanical Code of [NAME OF JURISDICTION] hereinafter referred to as "this code."

M-101.2 Scope: The design, installation, maintenance, alteration and inspection of mechanical systems, including heating systems, *ventilating* systems, cooling systems, steam and hot water heating systems, water heaters, process piping, *boilers* and pressure vessels, *appliances* utilizing gas, liquid or solid fuel, chimneys and *vents*, mechanical refrigeration systems, fireplaces, barbecues, incinerators, crematories and air pollution systems as herein defined, shall comply with the requirements of this code.

M-101.3 Intent: This code shall be construed to secure its expressed intent, which is to insure public health, safety and welfare insofar as they are affected by the installation and maintenance of mechanical systems.

SECTION M-102.0 APPLICABILITY

M-102.1 General: The provisions of this code shall apply to all matters affecting or relating to structures, as set forth in Section M-101.0.

M-102.2 Existing mechanical systems: This code shall apply to existing mechanical systems described in this section as if hereafter installed.

1. Mechanical systems serving an occupancy other than the occupancy such systems served at the time this code became applicable.
2. Mechanical systems in a structure moved as specified in Section M-111.0.

M-102.3 Existing utilization continued: Except as otherwise provided for in this chapter, a provision in this code shall not require the removal, alteration or abandonment of, nor prevent the continued utilization of, an existing mechanical system.

M-102.4 Additions or alterations: Any addition or alteration, regardless of cost, made to a mechanical system shall be made in compliance with the applicable regulations of this code. Where additions or alterations subject parts of existing systems to loads exceeding those permitted herein, such parts shall be made to comply with this code.

M-102.5 Referenced standards: The standards referenced in this code and listed in Chapter 21 shall be considered part of the requirements of this code to the prescribed extent of each such reference. Where differences occur between the provisions of this code and the referenced standards, the provisions of this code shall apply.

SECTION M-103.0 REPAIRS AND MAINTENANCE

M-103.1 Repairs: Minor repairs or replacement of any existing system shall be permitted in the same manner and arrangement as in the existing system, provided that such repairs or replacement are not hazardous and are approved.

M-103.2 Maintenance: All mechanical systems, both existing and new, and all parts thereof shall be maintained in a safe condition. All devices and safeguards which are required by this code or which were required by a previous statute or code for the structure, shall be maintained in working order.

M-103.3 Owner responsibility: The owner or the owner's designated agent shall be responsible for the maintenance of mechanical systems.

SECTION M-104.0 VALIDITY

M-104.1 Partial invalidity: In the event any part or provision of this code is held to be illegal or void, this shall not have the effect of making void or illegal any of the other parts or provisions thereof, which are determined to be legal; and it shall be presumed that this code would have been passed without such illegal or invalid parts or provisions.

M-104.2 Segregation of invalid provisions: Any invalid part of this code shall be segregated from the remainder of this code by the court holding such part invalid, and the remainder shall remain effective.

M-104.3 Existing structures: The invalidity of any provision in any section of this code as applied to existing structures shall not be held to affect the validity of such section in its application to structures hereafter erected.

SECTION M-105.0 DEPARTMENT OF MECHANICAL INSPECTION

M-105.1 Code official: The department of mechanical inspection is hereby created and the executive official in charge thereof shall be known as the code official.

M-105.2 Appointment: The code official shall be appointed by the chief appointing authority of the jurisdiction; and the code official shall not be removed from office except for cause and after full opportunity to be heard on specific and relevant charges by and before the appointing authority.

M-105.3 Organization: The code official shall appoint such number of officers, technical assistants, inspectors and other

employees as shall be necessary for the administration of this code and as authorized by the appointing authority.

M-105.4 Deputy: The code official is authorized to designate an employee as deputy who shall exercise all the powers of the code official during the temporary absence or disability of the code official.

M-105.5 Restriction of employees: An official or employee connected with the department of mechanical inspection, except one whose only connection is that of a member of the board of appeals established under the provisions of Section M-121.0, shall not be engaged in, or directly or indirectly connected with the furnishing of labor, materials or *appliances* for the construction, alteration or maintenance of a building, or the preparation of *construction documents* thereof, unless that person is the owner of the building; nor shall such officer or employee engage in any work that conflicts with official duties or with the interests of the department.

M-105.6 Relief from personal responsibility: The code official, officer or employee charged with the enforcement of this code, while acting for the jurisdiction, shall not thereby be rendered liable personally, and is hereby relieved from all personal liability for any damage accruing to persons or property as a result of any act required or permitted in the discharge of official duties. Any suit instituted against an officer or employee because of an act performed by that officer or employee in the lawful discharge of duties and under the provisions of this code shall be defended by the legal representative of the jurisdiction until the final termination of the proceedings. The code official or any subordinate shall not be liable for costs in any action, suit or proceeding that is instituted in pursuance of the provisions of this code; and any officer of the department of mechanical inspection, acting in good faith and without malice, shall be free from liability for acts performed under any of its provisions or by reason of any act or omission in the performance of official duties in connection therewith.

M-105.7 Official records: An official record shall be kept of all business and activities of the department specified in the provisions of this code, and all such records shall be open to public inspection at all appropriate times and according to reasonable rules to maintain the integrity and security of such records.

SECTION M-106.0 DUTIES AND POWERS OF THE CODE OFFICIAL

M-106.1 General: The code official shall enforce all of the provisions of this code and shall act on any question relative to the installation, alteration, repair, maintenance or operation of all mechanical systems, devices and equipment, except as otherwise specifically provided for by statutory requirements or as provided for in Sections M-106.2 through M-106.8.

M-106.2 Applications and permits: The code official shall receive applications and issue permits for the installation and alteration of mechanical systems and equipment, inspect the premises for which such permits have been issued and enforce compliance with the provisions of this code.

M-106.3 Notices and orders: The code official shall issue all necessary notices or orders to ensure compliance with this code.

M-106.4 Inspections: The code official shall make all of the required inspections, or the code official shall accept reports of inspection by approved agencies or individuals. All reports of such inspections shall be in writing and be certified by a responsible officer of such approved agency or by the responsible individual. The code official is authorized to engage such expert opinion as deemed necessary to report upon unusual technical issues that arise, subject to the approval of the appointing authority.

M-106.5 Identification: The code official shall carry proper identification when inspecting structures or premises in the performance of duties under this code.

M-106.6 Rule-making authority: The code official shall have power as necessary in the interest of public health, safety and general welfare, to adopt and promulgate rules and regulations to interpret and implement the provisions of this code to secure the intent thereof and to designate requirements applicable because of local climatic or other conditions. Such rules shall not have the effect of waiving structural or fire performance requirements specifically provided for in this code, or of violating accepted engineering practice involving public safety.

M-106.7 Department records: The code official shall keep official records of applications received, permits and certificates issued, fees collected, reports of inspections, and notices and orders issued. Such records shall be retained in the official records as long as the structure to which such records relate remains in existence unless otherwise provided for by other regulations.

M-106.8 Annual report: At least annually, the code official shall submit to the chief authority of the jurisdiction a written statement of operations in the form and content as shall be prescribed by such authority.

SECTION M-107.0 APPROVAL

M-107.1 Approved materials and equipment: All materials, equipment and devices approved by the code official shall be constructed and installed in accordance with such approval.

M-107.2 Modifications: Where there are practical difficulties involved in carrying out the provisions of this code, the code official shall have the right to vary or modify such provisions upon application of the owner or the owner's representative, provided that the spirit and intent of the law is observed and that the public health, safety and welfare is assured.

M-107.2.1 Records: The application for modification and the final decision of the code official shall be in writing and shall be officially recorded with the application for the permit in the permanent records of the department of mechanical inspection.

M-107.3 Material and equipment reuse: Materials, equipment and devices shall not be reused unless such elements have been reconditioned, tested and placed in good and proper working condition and approved.

M-107.4 Alternative materials and equipment: The provisions of this code are not intended to prevent the installation of any material or to prohibit any method of construction not specifically prescribed by this code, provided that any such

alternative has been approved. An alternative material or method of construction shall be approved where the code official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fireresistance, durability and safety.

M-107.4.1 Research and investigations: Sufficient technical data shall be submitted to substantiate the proposed installation of any material or assembly. If it is determined that the evidence submitted is satisfactory proof of performance for the proposed installation, the code official shall approve such alternative subject to the requirements of this code. The costs of all tests, reports and investigations required under these provisions shall be paid for by the applicant.

SECTION M-108.0 APPLICATION FOR PERMIT

M-108.1 Permits required: Mechanical work shall not be commenced until a permit for such work has been issued by the code official.

M-108.1.1 Permits not required: Permits shall not be required for the following:

1. Any portable heating *appliance*.
2. Any portable *ventilation* equipment.
3. Any portable cooling unit.
4. Any steam, hot water or chilled water piping within any heating or cooling equipment regulated by this code.
5. Replacement of any minor part which does not alter approval of equipment or make such equipment unsafe.
6. Any portable evaporative cooler.
7. Any self-contained refrigeration system containing 10 pounds (4.53 kg) or less of refrigerant, or actuated by motors of 1 horsepower (0.75 kw) or less.

M-108.2 Form: The application for a permit for mechanical work shall be in such written form as the code official prescribes and shall be accompanied by the required fee as prescribed in Section M-113.0 and a description of the proposed mechanical work.

M-108.3 By whom application is made: The application for a permit shall be made by the owner or lessee of a structure, or the agent of either, or by the *registered design professional* employed in connection with the proposed work or the contractor employed to perform the work. If the application is made by a person other than the owner in fee, it shall be accompanied by an affidavit of the owner or the qualified applicant or a signed statement of the qualified applicant witnessed by the code official or his designee to the effect that the proposed work is authorized by the owner in fee and that the applicant is authorized to make such application. The full names and addresses of the owner, lessee, applicant and the responsible officers, if the owner or lessee is a corporate body, shall be stated in the application.

M-108.4 Construction documents: The application for a permit shall be accompanied by not less than two sets of *construction documents*. The code official is permitted to waive the requirements for filing *construction documents* where the work involved is of a minor nature. When the quality of the materials is essential for conformity to this code, specific information shall be given to establish such quality, and this code shall not be cited, or the term "legal" or its equivalent used as a substitute for specific information.

M-108.5 Engineering details: The code official shall require to be filed adequate details of mechanical and electrical work including computations, diagrams and other essential technical data. All *construction documents* shall be signed and sealed by the *registered design professional* of record. *Construction documents* for structures more than two stories in height shall indicate how required structural and fireresistance rating integrity will be maintained, and where penetrations will be made for electrical, mechanical, plumbing and communication conduits, pipes and systems.

M-108.6 Amendments to application: Subject to the limitations of Section M-108.7, amendments to the *construction documents*, application or other records accompanying the same shall be filed at any time before completion of the work for which the permit is sought or issued. Such amendments shall be deemed part of the original application and shall be filed therewith.

M-108.7 Time limitation of application: An application for a permit for any proposed work shall be deemed to have been abandoned six months after the date of filing, unless such application has been diligently prosecuted or a permit shall have been issued; except that the code official shall grant one or more extensions of time for additional periods not exceeding 90 days each if there is reasonable cause.

SECTION M-109.0 PERMITS

M-109.1 Action on application: The code official shall examine or cause to be examined all applications for permits and amendments thereto within a reasonable time after filing. If the application or the *construction documents* do not conform to the requirements of all pertinent laws, the code official shall reject such application in writing, stating the reasons therefor. If the code official is satisfied that the proposed work conforms to the requirements of this code and all laws and ordinances applicable thereto, the code official shall issue a permit therefor as soon as practicable. A mechanical permit shall not be transferable.

M-109.2 Suspension of permit: Any permit issued shall become invalid if the authorized work is not commenced within six months after issuance of the permit, or if the authorized work is suspended or abandoned for a period of six months after the time of commencing the work.

M-109.3 Previous approvals: This code shall not require changes in the *construction documents* or mechanical work for which a lawful permit has been heretofore issued or otherwise lawfully authorized, and the construction of which has been actively prosecuted within 90 days after the effective date of this code and is completed with dispatch.

M-109.4 Signature to permit: The code official's signature shall be attached to every permit; or the code official shall authorize a subordinate to affix such signature thereto.

M-109.5 Approved construction documents: The code official shall stamp or endorse in writing all sets of approved *construction documents* "Approved." One set of approved *construction*

documents shall be retained by the code official and another set shall be kept at the building site, open to inspection by the code official at all reasonable times.

M-109.6 Revocation of permit: The code official shall revoke a permit or approval issued under the provisions of this code in case of any false statement or misrepresentation of fact in the application or on the *construction documents* upon which the permit or approval was based.

M-109.7 Posting of permit: A true copy of the permit shall be kept on the site of operations, open to public inspection during the entire time of prosecution of the work and until the completion of the same.

M-109.8 Notice of start: At least 24-hour notice of start of work under a permit shall be given to the code official.

SECTION M-110.0 DEMOLITION OF STRUCTURES

M-110.1 Service connections: Fuel-fired or electrically supplied heating or cooling *appliances* or equipment shall not be removed from any structure to be demolished until the service supplied to the structure for such equipment has been terminated by the utility company. Notification of the termination shall be given to the code official in writing prior to the authorization for removal of such equipment.

SECTION M-111.0 MOVED STRUCTURES

M-111.1 General: Before any structure that has been moved in the jurisdiction is occupied, all mechanical equipment and devices shall be inspected and tested for safe operation and compliance with the requirements of this code.

SECTION M-112.0 CONDITIONS OF PERMIT

M-112.1 Payment of fees: A permit shall not be issued until the fees prescribed in Section M-113.0 have been paid.

M-112.2 Compliance with code: The permit shall be a license to proceed with the work and shall not be construed as authority to violate, cancel or set aside any of the provisions of this code, except as specifically stipulated by modification or legally granted variation as described in the application.

M-112.3 Compliance with permit: All work shall conform to the approved application and the approved *construction documents* for which the permit has been issued and any approved amendments to the approved application or the approved *construction documents*.

SECTION M-113.0 FEES

M-113.1 General: A permit to begin work for new construction or alteration shall not be issued until the prescribed fees shall have been paid to the department of mechanical inspection or other authorized agency of the jurisdiction, nor shall an amendment to a permit necessitating an additional fee because of the additional work involved be approved until the additional fee has been paid.

M-113.2 Periodic inspections: The fees for all periodic inspections shall be as indicated in the following schedule.

[JURISDICTION TO INSERT APPROPRIATE SCHEDULE.]

M-113.3 Fee schedule: The fees for all mechanical work shall be as indicated in the following schedule.

[JURISDICTION TO INSERT APPROPRIATE SCHEDULE.]

M-113.4 Accounting: The code official shall keep an accurate account of all fees collected; and such collected fees shall be deposited monthly in the jurisdiction treasury, or otherwise disposed of as required by law.

M-113.5 Refunds: In the case of a revocation of a permit or abandonment or discontinuance of a building project, the portion of the work actually completed shall be computed and any excess fee for the incompleted work shall be returned to the permit holder upon written request. All plan examination and permit processing fees and all penalties that have been imposed on the permit holder under the requirements of this code shall first be collected.

SECTION M-114.0 INSPECTIONS

M-114.1 Required: All equipment for which a permit is obtained under this code shall be inspected and approved. Any portion of equipment intended to be concealed by any permanent portion of the structure shall not be concealed until inspected. When installation of any equipment is complete, a final inspection shall be made. Equipment regulated by this code shall not be connected to the fuel or power supply and placed in normal operation until such equipment complies with all applicable requirements of this code, and a final inspection has been completed.

M-114.1.1 Replacement equipment: The requirements of Section M-114.1 shall not be considered to prohibit the operation of any heating equipment installed to replace existing heating equipment serving an occupied portion of a structure in the event a request for inspection of such heating equipment has been filed with the department not more than 48 hours after replacement work is completed, and before any portion of such equipment is concealed by any permanent portion of the structure.

M-114.1.2 Inspection agency: The code official shall accept reports of approved inspection agencies provided such agencies satisfy the requirements as to qualification and reliability.

M-114.1.2.1 Evaluation and follow-up inspection services: Prior to the approval of a closed, prefabricated mechanical system and the issuance of a mechanical permit, the code official shall require the submittal of an evaluation report on each prefabricated mechanical system, indicating the complete details of the mechanical system, including a description of the mechanical system and its components, the basis upon which the mechanical system is being evaluated, test results and similar information, and other data as necessary for the code official to determine conformance to this code.

M-114.1.2.2 Evaluation service: The code official shall designate the evaluation service of an approved agency as the evaluation agency, and review such agency's evaluation report for adequacy and conformance to this code.

M-114.1.2.3 Follow-up inspection: Except where all mechanical systems, service equipment and accessories

have *ready access* provided for complete inspection at the site without disassembly or dismantling, the code official shall conduct the frequency of in-plant inspections necessary to assure conformance to the approved evaluation report or shall designate an independent, approved inspection agency to conduct such inspections. The inspection agency shall furnish the code official with the follow-up inspection manual and a report of inspections upon request, and the mechanical system shall have an identifying *label* permanently affixed to the system indicating that factory inspections have been performed.

M-114.1.2.4 Test and inspection records: All required test and inspection records shall be available to the code official at all times during the fabrication of the mechanical system and the erection of the building; or such records as the code official designates shall be filed.

M-114.2 Final inspection: Upon completion of the mechanical work and before final approval is given, a final inspection shall be made. All violations of the approved *construction documents* and permit shall be noted and the holder of the permit shall be notified of the discrepancies.

M-114.3 Right of entry: The code official shall have the authority to enter at any reasonable time any structure or premises for which a permit has been issued and for which a notice of approval has not been issued in accordance with Section M-118.0.

For all other structures or premises, when the code official has reasonable cause to believe that a code violation exists, the code official is authorized to enter the structure or premises at reasonable times to inspect. Prior to entering into a space not otherwise open to the general public, the code official shall make a reasonable effort to locate the owner or other person having charge or control of the structure or premises, present proper identification and request entry. If requested entry is refused or not obtained, the code official shall pursue recourse as provided by law.

M-114.4 Coordination of inspections: Whenever in the enforcement of this code or another code or ordinance, the responsibility of more than one code official of the jurisdiction is involved, it shall be the duty of the code officials involved to coordinate their inspections and administrative orders as fully as practicable so that the owners and occupants of the structure shall not be subjected to visits by numerous inspectors or multiple or conflicting orders. Whenever an inspector from any agency or department observes an apparent or actual violation of some provision of some law, ordinance or code not within the inspector's authority to enforce, the inspector shall report the findings to the code official having jurisdiction.

SECTION M-115.0 WORKMANSHIP

M-115.1 General: All work shall be conducted, installed and completed in a workmanlike and approved manner so as to secure the results intended by this code.

SECTION M-116.0 VIOLATIONS

M-116.1 Unlawful acts: It shall be unlawful for any person, firm or corporation to erect, construct, alter, repair, remove, demolish or operate mechanical equipment regulated by this code, or cause same to be done, in conflict with or in violation of any of the provisions of this code.

M-116.2 Notice of violation: The code official shall serve a notice of violation or order on the person responsible for the erection, installation, alteration, extension, repair, removal, demolition or operation of mechanical equipment or systems in violation of the provisions of this code, or in violation of a detail statement or the approved *construction documents* thereunder, or in violation of a permit or certificate issued under the provisions of this code. Such order shall direct the discontinuance of the illegal action or condition and the abatement of the violation.

M-116.3 Prosecution of violation: If the notice of violation is not complied with promptly, the code official shall request the legal counsel of the jurisdiction to institute the appropriate proceeding at law or in equity to restrain, correct or abate such violation or to require the removal or termination of the unlawful occupancy of the structure in violation of the provisions of this code or of the order or direction made pursuant thereto.

M-116.4 Violation penalties: Any person who shall violate a provision of this code or shall fail to comply with any of the requirements thereof or who shall erect, construct, alter or repair mechanical equipment or systems in violation of the approved *construction documents* or directive of the code official, or of a permit or certificate issued under the provisions of this code, shall be guilty of an [OFFENSE], punishable by a fine of not more than [AMOUNT], or by imprisonment not exceeding [NUMBER OF DAYS], or both such fine and imprisonment. Each day that a violation continues after notice has been served shall be deemed a separate offense.

M-116.5 Abatement of violation: The imposition of the penalties herein prescribed shall not preclude the legal officer of the jurisdiction from instituting appropriate action to prevent unlawful construction or to restrain, correct or abate a violation, or to prevent illegal occupancy of a building or to stop an illegal act, conduct, business or operation of mechanical equipment or systems on or about any premises.

SECTION M-117.0 STOP WORK ORDER

M-117.1 Notice: Upon notice from the code official that work on any structure is being conducted contrary to the provisions of this code or in an unsafe and dangerous manner, such work shall be immediately stopped. The stop work order shall be in writing and shall be given to the owner of the property involved, or to the owner's agent, or to the person doing the work. The stop work order shall state the conditions under which work will be permitted to resume.

M-117.2 Unlawful continuance: Any person who shall continue any work in or about the structure after having been served with a stop work order, except such work as that person is directed to perform to remove a violation or unsafe condition, shall be liable to a fine of not less than [AMOUNT] or more than [AMOUNT].

SECTION M-118.0 NOTICE OF APPROVAL

M-118.1 Approval: After the prescribed tests and inspections indicate that the work complies in all respects with this code, a notice of approval shall be issued by the code official.

M-118.2 Temporary occupancy: Upon the request of the holder of a permit, the code official shall issue a temporary authorization before the entire work covered by the permit is completed, provided that such portion or portions will be put into service safely prior to full completion of the structure without endangering public health or welfare.

SECTION M-119.0 UNSAFE CONDITIONS

M-119.1 General: All mechanical materials and equipment, regardless of type, which are worn, damaged, defective or constructed so as to constitute a hazard to health, safety or welfare are hereby declared illegal and shall be abated by repair and rehabilitation or removal.

M-119.2 Record: The code official shall cause a report to be filed on an unsafe condition. The report shall state the occupancy of the structure and the nature of the unsafe condition.

M-119.3 Notice: If an unsafe condition is found, the code official shall serve on the owner, agent or person in control of the structure, a written notice that describes the condition deemed unsafe and specifies the required repairs or improvements to be made to abate the unsafe condition, or that requires the unsafe material or equipment to be removed within a stipulated time. Such notice shall require the person thus notified to declare immediately to the code official acceptance or rejection of the terms of the order.

M-119.4 Method of service: Such notice shall be deemed properly served if a copy thereof is (a) delivered to the owner personally; or (b) sent by certified or registered mail addressed to the owner at the last known address with the return receipt requested. If the certified or registered letter is returned showing that the letter was not delivered, a copy thereof shall be posted in a conspicuous place in or about the structure affected by such notice. Service of such notice in the foregoing manner upon the owner's agent or upon the person responsible for the structure shall constitute service of notice upon the owner.

M-119.5 Restoration: The material or equipment determined to be unsafe by the code official is permitted to be restored to a safe condition. To the extent that repairs, alterations or additions are made during the restoration of the structure, such repairs, alterations and additions shall comply with the requirements of Sections M-102.4 and M-103.0.

M-119.6 Disregard of notice: Upon refusal or neglect of the person served with an unsafe notice to comply with the requirements of the order to abate the unsafe condition, the legal counsel of the jurisdiction shall be advised of all the facts in order to pursue recourse provided by law.

SECTION M-120.0 EMERGENCY MEASURES

M-120.1 Imminent danger: When, in the opinion of the code official, there is imminent danger to life, the code official is hereby authorized and empowered to order and require the occupants to vacate the building forthwith. The code official shall cause to be posted at each entrance to such structure a notice reading as follows: "This Structure is Unsafe and its Occupancy has been Prohibited by the Code Official." It shall be unlawful for any person to enter such structure, except for the purpose of making the required repairs or for demolition.

SECTION M-121.0 MEANS OF APPEAL

M-121.1 Application for appeal: Any person shall have the right to appeal a decision of the code official to the board of appeals. An application for appeal shall be based on a claim that the true intent of this code or the rules legally adopted thereunder have been incorrectly interpreted, the provisions of this code do not fully apply, or an equally good or better form of construction is proposed. The application shall be filed on a form obtained from the code official within 20 days after the notice was served.

M-121.2 Membership of board: The board of appeals shall consist of five members appointed by the chief appointing authority as follows: one for five years, one for four years, one for three years, one for two years, and one for one year. Thereafter, each new member shall serve for five years or until a successor has been appointed.

M-121.2.1 Qualifications: The board of appeals shall consist of five individuals, one from each of the following professions or disciplines.

1. *Registered design professional* that is a registered architect; or a builder or superintendent of building construction with at least ten-years experience, five of which shall have been in responsible charge of work.
2. *Registered design professional* with structural engineering or architectural experience.
3. *Registered design professional* with mechanical or plumbing engineering experience; or a mechanical or plumbing contractor with at least ten-years experience, five of which shall have been in responsible charge of work.
4. *Registered design professional* with electrical engineering experience; or an electrical contractor with at least ten-years experience, five of which shall have been in responsible charge of work.
5. *Registered design professional* with fire protection engineering experience; or a fire protection contractor with at least ten-years experience, five of which shall have been in responsible charge of work.

M-121.2.2 Alternate members: The chief appointing authority shall appoint two alternate members who shall be called by the board chairman to hear appeals during the absence or disqualification of a member. Alternate members shall possess the qualifications required for board membership, and shall be appointed for five years or until a successor has been appointed.

M-121.2.3 Chairman: The board shall annually select one of its members to serve as chairman.

M-121.2.4 Disqualification of member: A member shall not hear an appeal in which that member has any personal, professional or financial interest.

M-121.2.5 Secretary: The chief administrative officer shall designate a qualified clerk to serve as secretary to the board.

The secretary shall file a detailed record of all proceedings in the office of the chief administrative officer.

M-121.2.6 Compensation of members: Compensation of members shall be determined by law.

M-121.3 Notice of meeting: The board shall meet upon notice from the chairman, within ten days of the filing of an appeal, or at stated periodic meetings.

M-121.4 Open hearing: All hearings before the board shall be open to the public. The appellant, the appellant's representative, the code official and any person whose interests are affected shall be given an opportunity to be heard.

M-121.4.1 Procedure: The board shall adopt and make available to the public through the secretary, procedures under which a hearing will be conducted. The procedures shall not require compliance with strict rules of evidence but shall mandate that only relevant information be received.

M-121.5 Postponed hearing: When five members are not present to hear an appeal, either the appellant or the appellant's representative shall have the right to request and receive a postponement of the hearing.

M-121.6 Board decision: The board shall modify or reverse the decision of the code official by a concurring vote of three members.

M-121.6.1 Resolution: The decision of the board shall be by resolution. Certified copies shall be furnished to the appellant and to the code official.

M-121.6.2 Administration: The code official shall take immediate action in accordance with the decision of the board.

M-121.7 Court review: Any person, whether or not a previous party of the appeal, shall have the right to apply to the appropriate court for a writ of certiorari to correct errors of law. Application for review shall be made in the manner and time required by law following the filing of the decision in the office of the chief administrative officer.

CHAPTER 2

DEFINITIONS

SECTION M-201.0 GENERAL

M-201.1 Scope: Unless otherwise expressly stated, the following words and terms shall, for the purposes of this code, have the meanings shown in this chapter.

M-201.2 Interchangeability: Words stated in the present tense include the future; words stated in the masculine gender include the feminine and neuter; the singular number includes the plural and the plural the singular.

M-201.3 Terms defined in other codes: Where terms are not defined in this code and are defined in the building or plumbing codes listed in Chapter 21, such terms shall have the meanings ascribed to them as in those codes.

M-201.4 Terms not defined: Where terms are not defined through the methods authorized by this section, such terms shall have ordinarily accepted meanings such as the context implies.

SECTION M-202.0 GENERAL DEFINITIONS

Abrasive materials: See Section M-302.0.

Access (to): That which enables a device, appliance or equipment to be reached by *ready access* or by a means that first requires the removal or movement of a panel, door or similar obstruction (see "*Ready access*").

Administrative authority: The individual official, board, department or agency established and authorized by a state, county, city or other political subdivision created by law to administer and enforce the provisions of the mechanical code.

Air: All air supplied to mechanical equipment for combustion, *ventilation*, cooling, etc. Standard air is air at standard temperature and pressure, namely 70 degrees F. (21 degrees C.) and 29.92 inches of mercury (101.3 kPa).
Excess air: See Section M-1502.0.
Exhaust air: See Section M-302.0.
Makeup air: Outside air required to replace the air being exhausted.
Outdoor air: See Section M-1602.0.
Primary air: See Section M-1502.0.
Recirculated air: See Section M-1602.0.
Return air: See Section M-302.0.
Secondary air: See Section M-1502.0.
Supply air: See Section M-302.0.
Theoretical air: See Section M-1502.0.
Underfire air: See Section M-1502.0.
Ventilation air: See Section M-1602.0.

Air conditioning: See Section M-1902.0.

Air conditioning system: See Section M-1902.0.

Air distribution system: See Section M-1902.0.

Air pollutants: See Section M-1702.0.

Air pollution: See Section M-1702.0.

***Appliance* (mechanical):** See Section M-402.0.
***Appliance*, approved:** See Section M-402.0.
***Appliance*, high heat:** See Section M-1202.0.
***Appliance*, low heat:** See Section M-1202.0.
***Appliance*, medium heat:** See Section M-1202.0.
***Appliance*, unvented:** See Section M-1202.0.
***Appliance*, vented:** See Section M-1202.0.

Approved: Approved by the code official or other authority having jurisdiction.

Auxiliary fuel-firing equipment (incinerator): See Section M-1502.0.

Boiler: See Section M-602.0.

Boiler room: See Section M-402.0.

Building: Any structure occupied or intended for supporting or sheltering any occupancy.

Chimney: See Section M-1202.0.
Factory-built: See Section M-1202.0.
High-heat appliance type: See Section M-1202.0.
Low-heat appliance type: See Section M-1202.0.
Masonry: See Section M-1202.0.
Medium-heat appliance type: See Section M-1202.0.
Metal: See Section M-1202.0.

Chimney connector: See Section M-1202.0.

Chimney liner: See Section M-1202.0.

Code: These regulations, subsequent amendments thereto, or any emergency rule or regulation which the administrative authority having jurisdiction has lawfully adopted.

Code official: The officer or other designated authority charged with the administration and enforcement of this code, or a duly authorized representative.

Coefficient of performance (*COP*), cooling: See Section M-1902.0.

Coefficient of performance (*COP*), heat pump, heating: See Section M-1902.0.

Combustible liquids: See Section M-902.0.
Class II: See Section M-902.0.
Class IIIA: See Section M-902.0.
Class IIIB: See Section M-902.0.

Combustible material: Any material not defined as *noncombustible.*

Combustion: In the context of this code, refers to the rapid oxidation of fuel accompanied by the production of heat or heat and light.

Combustion air: See Section M-1002.0.

Compressor: See Section M-1302.0.

Condensate: The liquid that separates from a gas (including flue gases) because of a reduction in temperature.

Condenser: See Section M-1302.0.

Construction documents: All of the written, graphic and pictorial documents prepared or assembled for describing the design, location and physical characteristics of the elements of the project necessary for obtaining a building permit. The construction drawings shall be drawn to an appropriate scale.

Curtain wall (incinerator): See Section M-1502.0.

Damper: A manually or automatically controlled device to regulate draft or the rate of flow of air or combustion gases.
Barometric: See Section M-1502.0.
Guillotine: See Section M-1502.0.
Sliding: See Section M-1502.0.

Design working pressure: The maximum allowable working pressure, pounds per square inch gauge (psig), for which a specific part of a system is designed.

Downpass: See Section M-1502.0.

Draft: The pressure difference existing between the equipment or any component part and the atmosphere, which causes a continuous flow of air and products of combustion through the gas passages of the *appliance* to the atmosphere.
Induced draft: The pressure difference created by the action of a fan, blower or ejector, which is located between the *appliance* and the chimney or *vent* termination.
Natural draft: The pressure difference created by a *vent* or chimney because of its height, and the temperature difference between the flue gases and the atmosphere.

Draft hood: A device built into a gas *appliance* or made a part of a chimney connector or vent connector from a gas *appliance* which is designed to: permit the ready escape of flue gases in the event of zero draft, a backdraft or stoppage in the *vent* beyond the draft hood; permit the ready relief of the back pressure from a backdraft so that such pressure does not enter the gas *appliance*; and neutralize the possible effects of excess draft (stack action) upon the operation of the *appliance.*

Dry gas: See Section M-802.0.

Duct: See Section M-302.0.

Emission: See Section M-1702.0.

Energy efficiency ratio (*EER*): See Section M-1902.0.

Equipment, existing: Any equipment regulated by this code which was legally installed prior to the effective date of this code, or for which a permit to install has been issued.

Evaporator: See Section M-1302.0.

Exhaust system: See Section M-302.0.

Existing work: Any mechanical system regulated by this code which was legally installed prior to the effective date of this code, or for which a permit to install has been issued.

Fire damper: See Section M-302.0.

Firebrick: An approved refractory brick.

Firebrick, high-heat-duty: Refractory brick clay that meets the standards of this code.

Flammable liquids: See Section M-902.0.
Class IA: See Section M-902.0.
Class IB: See Section M-902.0.
Class IC: See Section M-902.0.
(See "*Combustible liquids*" for Class II or III liquids.)

Flash point: See Section M-902.0.

Flue connection (breeching): See Section M-1502.0.

Flue gases: See Section M-1502.0.

Fuel: A *combustible* substance or material or any combination of such.

Fuel-oil piping system: See Section M-902.0.

Furnace: See Section M-402.0.

Furnace room: See Section M-402.0.

Fusible plug: See Section M-1302.0.

Gas: That state of matter which has neither independent shape nor volume. It expands to fill the entire container in which it is held. Gas is one of the three forms of matter, the other two being solid and liquid.
Liquefied petroleum (LP-gas): See Section M-802.0.
Manufactured: See Section M-802.0.
Natural: See Section M-802.0.

Gas outlet: See Section M-802.0.

Hazardous location: See Section M-402.0.

Heat exchanger: A device that transfers heat from one medium to another.

Heat transfer liquid: See Section M-1803.2.

Heating value: See Section M-802.0.

High-side pressure: See Section M-1302.0.

Incinerator, domestic gas-fired type: See Section M-1502.0.

Label: See Section M-402.0.

Low-side pressure: See Section M-1302.0.

Machinery room: See Section M-1302.0.

Manual gas shutoff valve: See Section M-802.0.

Manufacturer: The company or organization which evidences its responsibility by affixing its name or nationally registered trademark or trade name to the equipment.

Mechanical equipment room: See Section M-302.0.

Mechanical exhaust system: See Section M-1602.0.

Mechanical joint: See Section M-702.0.

Natural ventilation: See Section M-1602.0.

New energy: See Section M-1902.0.

Nonabrasive/abrasive materials: See Section M-302.0.

Noncombustible materials: Materials that, when tested in accordance with ASTM E136 listed in Chapter 21, have at least three of four specimens tested meeting all of the following criteria:

1. The recorded temperature of the surface and interior thermocouples shall not at any time during the test rise more than 54 degrees F. (30 degrees C.) above the furnace temperature at the beginning of the test.
2. There shall not be flaming from the specimen after the first 30 seconds.
3. If the weight loss of the specimen during testing exceeds 50 percent, the recorded temperature of the surface and interior thermocouples shall not at any time during the test rise above the furnace air temperature at the beginning of the test, and there shall not be flaming of the specimen.

Nuisance: See Section M-1702.0.

Occupancy: The purpose for which a building or portion thereof is utilized or occupied.

Outdoor opening: See Section M-302.0.

Particulate: See Section M-1702.0.

Person: A natural person, the heirs, executors, administrators or assigns, and includes a firm, partnership or corporation, its or their successors or assigns.

Plenum: See Section M-303.1.

Premises: A lot, plot or parcel of land, including any structure thereon.

Pressure-imposing element: See Section M-1302.0.

Pressure-limiting device: See Section M-1302.0.

Pressure relief device: See Section M-1302.0.

Pressure relief valve: See Section M-602.0.

Purge: See Section M-802.0.

Quick-opening valve: See Section M-602.0.

Rating input: See Section M-402.0.

Rating output: See Section M-402.0.

Ready access (to): That which enables a device, appliance or equipment to be directly reached, without requiring the removal or movement of any panel, door or similar obstruction (see "*Access*").

Refrigerant: See Section M-1302.0.

Refrigeration system: See Section M-1302.0.
Direct system: See Section M-1302.0.
Indirect system: See Section M-1302.0.

Registered design professional: An architect or engineer, registered or licensed to practice professional architecture or engineering, as defined by the statutory requirements of the professional registration laws of the state in which the project is to be constructed.

Regulator, line gas pressure: See Section M-802.0.

Regulator, LP-gas, first stage: See Section M-802.0.

Regulator, LP-gas, second stage: See Section M-802.0.

Regulator, service pressure: See Section M-802.0.

Reheat: See Section M-1902.0.

Return air system: See Section M-302.0.

Ringelmann: See Section M-1702.0.

Riser, gas: See Section M-802.0.

Safety valve: See Section M-602.0.

Stop valve: See Section M-1302.0.

Structure: That which is built or constructed or a portion thereof.

Supply air system: See Section M-302.0.

Thermal resistance (*R*): A measure of the ability to retard the flow of heat. The *R* value is the reciprocal of thermal conductance; expressed in units of hr. · ft.^{2} · degree F. per Btu.

Thermostat: See Section M-1902.0.

Vent: See Section M-1202.0.

Vent connector: See Section M-1202.0.

Ventilation: See Section M-1602.0.

Water heater: See Section M-602.0.

Zone: See Section M-1902.0.

CHAPTER 3

AIR DISTRIBUTION SYSTEMS

SECTION M-301.0 GENERAL

M-301.1 Scope: This chapter shall govern the construction, installation, alteration, maintenance and repair of air distribution systems.

SECTION M-302.0 DEFINITIONS

M-302.1 General: The following words and terms shall, for the purposes of this chapter and as stated elsewhere in this code, have the meanings shown herein.

Abrasive materials: Moderately abrasive particulate in high concentrations, and highly abrasive particulate in moderate and high concentrations, such as alumina, bauxite, iron silicate, sand and slag.

Duct: A tube or conduit utilized for conveying air. The air passages of self-contained systems are not to be construed as air ducts.

Exhaust air: Air removed from a space and not reused.

Exhaust system: An assembly of connected ducts, plenums, fittings, registers, grilles and hoods through which air is conducted from the space or spaces and exhausted to the outside atmosphere.

Fire damper: A damper arranged to seal off air flow automatically through part of an air duct system, so as to restrict the passage of heat (see Section M-313.0).

Mechanical equipment room: A room or space in which non-fuel-fired equipment is located.

Nonabrasive/abrasive materials: Nonabrasive particulate in high concentrations, moderately abrasive particulate in low and moderate concentrations, and highly abrasive particulate in low concentrations, such as alfalfa, asphalt, plaster, gypsum and salt.

Outdoor opening: A door, window, louver or skylight openable to the outside atmosphere (see Section M-308.0).

Return air: Air removed from a space and recirculated or exhausted.

Return air system: An assembly of connected ducts, plenums, fittings, registers and grilles through which air from the space or spaces to be heated or cooled is conducted back to the supply unit (see also "Supply air system").

Supply air: That air delivered to each or any space in the system or the total air delivered to all spaces in the system, which is provided for *ventilating*, heating, cooling, humidification, dehumidification and other similar purposes.

Supply air system: An assembly of connected ducts, plenums, fittings, registers and grilles through which air, heated or cooled, is conducted from the supply unit to the space or spaces to be heated or cooled (see also "Return air system").

SECTION M-303.0 PLENUMS

M-303.1 General: A plenum is an enclosed portion of the building structure which is designed to allow air movement, and thereby serve as part of an air distribution system. Supply, return, exhaust, relief and *ventilation air* plenums shall be limited to uninhabited crawl spaces, areas above a ceiling or below the floor, attic spaces and *mechanical equipment rooms*. Plenums shall be limited to one fire area. Fuel-fired equipment shall not be installed within a plenum.

M-303.1.1 Construction: In buildings of Type 1 or 2 construction, all plenums shall be *noncombustible* and shall comply with Section M-303.2. In buildings of Type 3, 4 or 5 construction, *noncombustible* plenums in accordance with Section M-303.2, *combustible* plenums in accordance with Section M-303.3, and stud and joist space plenums in accordance with Section M-303.4 shall be permitted.

M-303.1.2 Air movement in egress elements: Exits and exit access corridors shall not serve as supply or return air ducts or plenums.

Exceptions

1. The restriction on the utilization of the space between the corridor ceiling and the floor or roof structure above as a return air plenum shall not apply where the corridor is not required to be of fireresistance rated construction or is separated from the plenum by fireresistance rated construction or is located within a dwelling unit.
2. Within a tenant space that is 1,000 square feet (93 m^2) or less in area in occupancies in Use Group B, this restriction shall not apply to exit access corridors.

M-303.1.3 Flood hazard: For structures located in a flood-hazard zone (A Zone) or a high-hazard zone (V Zone), plenum spaces shall either be placed above the base flood elevation or protected so as to prevent water from entering or accumulating within the plenum space during floods up to the base flood elevation.

M-303.2 Noncombustible plenums: Plenums shall be constructed with *noncombustible material* in accordance with the building code listed in Chapter 21. *Combustible material* shall not be exposed within a plenum except as permitted in Sections M-303.2.1 through M-303.2.6.

M-303.2.1 Pipe: Pipe shall be *noncombustible* except that plastic fire sprinkler piping in wet pipe systems shall be permitted where the piping has a peak optical density not greater than 0.50, an average optical density not greater than 0.15 and a flame spread of not greater than 5 feet (1524 mm) when tested in accordance with UL 1887 listed in Chapter 21. Piping shall bear the *label* of an approved agency.

M-303.2.2 Ceiling and thermal material: Thermal and acoustical materials and pipe insulation shall have a flame spread of 25 or less and a smoke-developed rating of 50 or less when tested in accordance with ASTM E84 listed in Chapter 21.

M-303.2.3 Ducts: Rigid or flexible ducts and connectors shall conform to Sections M-304.0 and M-305.0.

M-303.2.4 Duct coverings: Duct coverings, linings, tape and connectors shall conform to Section M-306.0.

M-303.2.5 Wire: Wire shall be low-voltage or power-limited wire or cable. Wire shall have a peak optical density not greater than 0.50, an average optical density not greater than 0.15 and a flame spread of not greater than 5 feet (1524 mm) when tested in accordance with UL 910 listed in Chapter 21. Wire shall bear the *label* of an approved agency and shall be marked in accordance with NFiPA 70 listed in Chapter 21.

M-303.2.6 Combustible pneumatic tubing: *Combustible* pneumatic tubing shall have a peak optical density not greater than 0.50, an average optical density not greater than 0.15 and a flame spread of not greater than 5.0 feet (1524 mm) when tested in accordance with UL 1820 listed in Chapter 21. Combustible pneumatic tubing shall bear the *label* of an approved agency.

M-303.3 Combustible plenums: The plenum shall be constructed with approved materials. *Combustible material*, pipe or wire exposed within the plenum shall be permitted.

M-303.3.1 Size: *Combustible* plenums shall be draftstopped every 3,000 square feet (279 m^2) in area.

Exception: Plenums shall be limited to one fire area without draftstopping in buildings equipped throughout with an automatic sprinkler system installed in accordance with the building code listed in Chapter 21.

M-303.4 Stud and joist spaces: The space between studs or joists shall not be utilized as a plenum for supply air. The space between studs or joists utilized as a plenum for return air shall not be part of a required fireresistance rated assembly. Air shall not be removed from more than one floor level. All connections shall be firestopped and draftstopped in accordance with the building code listed in Chapter 21.

SECTION M-304.0 DUCT CONSTRUCTION

M-304.1 Metallic ducts: Metallic ducts shall conform to the requirements of UL 181 listed in Chapter 21 for Class 0 or Class 1 rigid air ducts, or shall be constructed with a minimum thickness as specified in Table M-304.1 or the SMACNA *HVAC Duct Construction Standards — Metal and Flexible* listed in Chapter 21. The duct construction shall conform to the requirements of the SMACNA *HVAC Duct Construction Standards—Metal and Flexible* listed in Chapter 21.

M-304.2 Nonmetallic ducts: Nonmetallic ducts shall be constructed with Class 0 or Class 1 duct material in accordance with UL 181 listed in Chapter 21. Fibrous duct construction shall conform to the SMACNA *Fibrous Glass Duct Construction Standards* listed in Chapter 21.

Table M-304.1
DUCT CONSTRUCTION MINIMUM SHEET METAL THICKNESSES

RECTANGULAR DUCTS

Maximum side (inches)[a]	Steel (Minimum thickness, nominal)	Aluminum (Minimum thickness, nominal)
Through 12	0.022 inch (26 Gage, Galv.)	0.020 inch (No. 24 B&S Gage)
13 through 30	0.028 inch (24 Gage, Galv.)	0.025 inch (No. 22 B&S Gage)
31 through 54	0.034 inch (22 Gage, Galv.)	0.032 inch (No. 20 B&S Gage)
55 through 84	0.040 inch (20 Gage, Galv.)	0.040 inch (No. 18 B&S Gage)
Over 84	0.052 inch (18 Gage, Galv.)	0.051 inch (No. 16 B&S Gage)

ROUND DUCTS

Diameter (inches)[a]	Spiral seam duct	Longitudinal seam duct	Fittings
	Steel (Minimum thickness, nominal)	Steel (Minimum thickness, nominal)	Steel (Minimum thickness, nominal)
Through 12	0.019 inch (28 Gage, Galv.)	0.022 inch (26 Gage, Galv.)	0.022 inch (26 Gage, Galv.)
13 through 18	0.022 inch (26 Gage, Galv.)	0.028 inch (24 Gage, Galv.)	0.028 inch (24 Gage, Galv.)
19 through 28	0.028 inch (24 Gage, Galv.)	0.034 inch (22 Gage, Galv.)	0.034 inch (22 Gage, Galv.)
29 through 36	0.034 inch (22 Gage, Galv.)	0.040 inch (20 Gage, Galv.)	0.040 inch (20 Gage, Galv.)
37 through 52	0.040 inch (20 Gage, Galv.)	0.052 inch (18 Gage, Galv.)	0.052 inch (18 Gage, Galv.)

Note a. 1 inch = 25.4 mm.

M-304.2.1 Gypsum ducts: Gypsum boards that form plenums and vertical air shafts (ducts) shall be limited to dedicated emergency smoke control systems and to return air systems where the air temperatures do not exceed 125 degrees F. (52 degrees C.) and the gypsum board surface temperature is maintained above the air stream dew point temperature. This section shall not be construed to prohibit gypsum return air duct systems as part of an emergency smoke control system. While operating in the emergency smoke control mode, the temperature and humidity limitations of this section shall not apply to such gypsum return air systems. Gypsum return air ducts shall not be incorporated in air-handling systems utilizing evaporative coolers.

M-304.3 Underground plastic pipe duct and fittings: Plastic pipe duct shall conform to cell classification 12454-B of ASTM D1784 listed in Chapter 21 and external loading properties of ASTM D2412 listed in Chapter 21. Plastic pipe duct shall be limited to underground installation with a maximum duct temperature of 150 degrees F. (66 degrees C.).

M-304.4 Ducts formed by parts of the building structure: Ducts or plenums shall be of independent construction or shall be formed by parts of the building structure. Ducts and plenums shall be of sheet metal or other approved materials similar in vapor permeability, structural rigidity, air flow friction coefficient, flexibility and combustibility.

M-304.5 Low-, medium- and high-pressure systems: Ducts shall be rated for the pressure of the air distribution system. A low-pressure system shall be one in which the static pressure in the duct or plenum is 2 inches water gauge (0.5 kPa) or less. A medium-pressure system is one in which the static pressure in the duct or plenum is greater than 2 inches water gauge (0.5 kPa), up to 6 inches water gauge (1.5 kPa). A high-pressure system is one in which the static pressure in the duct or plenum is 6 inches water gauge (1.5 kPa) or greater, up to 10 inches water gauge (2.5 kPa).

M-304.6 Noncommercial kitchen exhaust duct: Ducts for noncommercial kitchen exhaust systems shall be of *noncombustible* construction.

SECTION M-305.0 FLEXIBLE DUCTS AND CONNECTORS

M-305.1 Flexible ducts: Flexible ducts shall conform to the requirements of UL 181 listed in Chapter 21 for Class 0 or Class 1 flexible air ducts, and shall be so identified.

M-305.2 Flexible duct connectors: Flexible connectors shall conform to the requirements of UL 181 listed in Chapter 21 for Class 0 or Class 1 flexible connectors, and shall be so identified.

M-305.2.1 Length limited: Flexible connectors shall be limited in length to 14 feet (4267 mm).

M-305.3 Penetrations prohibited: Flexible ducts and flexible connectors shall not pass through any wall, floor, ceiling or fireresistance rated assembly.

M-305.4 Air temperature: The temperature of air in flexible ducts or flexible connectors shall be less than 250 degrees F. (121 degrees C.). Flexible ducts and connectors shall be installed with a minimum clearance to an *appliance* as specified for the *labeled* equipment.

M-305.5 Low-, medium- and high-pressure systems: Flexible ducts and flexible connectors shall be rated for the pressure of the air distribution system in accordance with Section M-304.5.

SECTION M-306.0 DUCT COVERINGS, LININGS, TAPE AND VIBRATION ISOLATION CONNECTORS

M-306.1 Material requirements: In all occupancies except occupancies in Use Group R-3, duct coverings, duct linings, panels utilized in duct systems, duct tape and vibration isolation connectors shall have a flame spread rating of 25 or less and a smoke-developed rating of 50 or less when tested in accordance with ASTM E84 listed in Chapter 21. Duct coverings and linings shall be rated for the design temperatures of the air distribution system.

M-306.1.1 Hot surface performance: Duct coverings and linings shall not flame, glow, smolder or smoke when tested at their rated temperatures in accordance with ASTM C411 listed in Chapter 21. The temperature of the test shall not be less than 250 degrees F. (121 degrees C.).

M-306.2 Interruption of duct coverings and linings: Duct coverings shall not penetrate fireresistance rated enclosures nor penetrations required to be firestopped. Duct linings shall be interrupted at *fire dampers* and fire doors. Service openings shall not be concealed by duct coverings or linings.

M-306.3 Insulation required: Ducts exposed to nonconditioned spaces shall be insulated to provide a thermal resistance (R), excluding film resistances, of

$$R = \frac{t_i - t_o}{15} \text{ (hr.)(ft.}^2\text{)(degrees F.)/Btu}$$

where $t_i - t_o$ is the design temperature differential between the air in the duct and the surrounding air in degrees Fahrenheit.

Exception: Duct insulation is not required in any of the following cases:

1. Where $t_i - t_o$ is 25 degrees F. (14 degrees C.) or less.
2. Where the heat gain or loss of the ducts, without insulation, will not increase the energy requirements of the building.
3. Exhaust air ducts.
4. Supply or return air ducts installed in basements, cellars or unventilated crawl spaces having insulated walls in occupancies in Use Group R-3.

M-306.3.1 Labeling: Duct insulation shall be *labeled* by the manufacturer. The *label* shall indicate the insulating value, the flame spread rating and the smoke-developed rating.

M-306.3.2 Residential attic temperatures: In occupancies in Use Group R with uninsulated roofs over attics containing ducts, the required duct insulation shall be determined based on the air temperatures shown in Table M-306.3.2.

Table M-306.3.2
RESIDENTIAL ATTIC TEMPERATURES

Roof slope	Degrees F.[a]
Summer conditions	
5 in 12 and up	130
3 in 12 to 5 in 12	140
Less than 3 in 12	150
Winter conditions	
All slopes	10 degrees F. above outdoor design temperature

Note a. Degrees C. = [(degrees F.)- 32]/1.8.

SECTION M-307.0 DUCT INSTALLATION

M-307.1 General: An air distribution system shall be designed and installed to supply the required distribution of air. The installation of an air distribution system shall not affect the fire protection requirements specified in the building code listed in Chapter 21.

M-307.1.1 Cutting or notching: A structural member shall not be cut, notched or pierced in excess of the limitations specified in the building code listed in Chapter 21, unless proven safe by a structural analysis.

M-307.2 Joints: All joints in a duct system shall be made tight.

M-307.3 Supports: Ducts shall be supported with approved hangers at intervals not exceeding 10 feet (3048 mm) or by other approved duct support systems designed in accordance with the building code listed in Chapter 21.

M-307.4 Underground ducts: Ducts shall be rated for underground installation. Metallic ducts not having an approved protective coating shall be completely encased in a minimum of 2 inches (51 mm) of concrete. Metallic ducts having an approved protective coating and nonmetallic ducts shall be installed in accordance with the manufacturer's installation instructions.

M-307.4.1 Flood hazard: All underground ducts located in a flood-hazard zone (A Zone) or a high-hazard zone (V Zone) shall be capable of resisting hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, during the occurrence of flooding to the base flood elevation.

M-307.5 Furnace connections: Ducts connecting to a heat exchanger shall have a clearance to *combustibles* in accordance with the furnace manufacturer's installation instructions.

M-307.6 Registers, grilles and diffusers: Duct registers, grilles and diffusers shall be installed in accordance with the manufacturer's installation instructions. Supply air duct registers, grilles and diffusers shall have a volume adjustment.

M-307.6.1 Nonmetallic registers: Nonmetallic register material shall conform to the requirements of UL 94 listed in Chapter 21, for Class 94 V-0 or 94 V-1 material. Registers shall resist without structural failure a 200-pound (890 N) concentrated load on a 2-inch (51 mm) diameter disc applied to the most critical area of the exposed face. The register shall be tested at a temperature not less than 165 degrees F. (74 degrees C.) and shall be supported in accordance with the manufacturer's instructions.

M-307.7 Visual duct openings: Duct openings in bathrooms, toilet rooms and changing rooms shall prevent visual observation from adjoining rooms.

M-307.8 Capped openings: All duct openings shall be capped during construction.

M-307.9 Condensation: Provisions shall be made to prevent the formation of condensation on the exterior of any duct.

SECTION M-308.0 OUTSIDE AIR EXHAUST AND INTAKE OPENINGS

M-308.1 Location: Outside air exhaust and intake openings shall be located a minimum of 10 feet (3048 mm) from lot lines or buildings on the same lot. Where openings front on a street or public way, the distance shall be measured to the centerline of the street or public way.

Exception: Use Group R-3.

M-308.1.1 Intake openings: Mechanical and gravity outside air intake openings shall be located a minimum of 10 feet (3048 mm) from any hazard or noxious contaminant such as *vents*, chimneys, plumbing vents, streets, alleys, parking lots and loading docks except as otherwise specified in this code. Where a source of contaminant is located within 10 feet (3048 mm) of an intake opening, such opening shall be located a minimum of 2 feet (610 mm) below the contaminant source.

M-308.1.2 Exhaust openings: Outside exhaust openings shall be located so as not to create a nuisance. Exhaust air shall not be directed onto walkways.

M-308.1.2.1 Kitchen exhaust: Commercial kitchen exhaust terminations shall conform to the requirements of Sections M-506.7 through M-506.7.2.

M-308.2 Opening protection: Outside air exhaust and intake openings shall be protected with corrosion-resistant screens, louvers or grilles. Openings shall be protected against all local weather conditions.

SECTION M-309.0 SYSTEMS CONTROL

M-309.1 Controls required: Air distribution systems shall be equipped with smoke detectors *labeled* for installation in air distribution systems, as required by this section.

M-309.2 Where required: Smoke detectors shall be installed where indicated in Sections M-309.2.1 through M-309.2.2.1.

M-309.2.1 Supply air systems: Smoke detectors shall be installed in supply air systems with a design capacity greater than 2,000 cubic feet per minute (cfm) (0.94 m^3/s), downstream of the air filters and ahead of any branch connections.

M-309.2.2 Return air systems: Smoke detectors shall be installed in return air systems with a design capacity greater than 15,000 cfm (7.08 m^3/s), in the return air duct or plenum upstream of any filters, exhaust air connections, outdoor air connections, or decontamination equipment. Systems that exhaust greater than 50 percent of the supply air shall have smoke detectors in both the return and exhaust air ducts or plenums.

Exception: Smoke detectors are not required in the return air system where the space served by the air distribution system is protected by a system of area smoke detectors in accordance with the building code listed in Chapter 21.

M-309.2.2.1 Return risers: Smoke detectors shall be installed at each story, upstream of the connection between a return riser serving two or more stories, and air ducts or plenums in return air systems with a design capacity greater than 15,000 cfm (7.08 m^3/s).

M-309.3 Installation: Smoke detectors required by this section shall be installed in accordance with NFiPA 72E listed in Chapter 21. *Access* shall be provided to smoke detectors for inspection and maintenance.

M-309.4 Controls operation: Upon activation, the smoke detectors shall shut down the air distribution system. Air distribution systems that are part of a smoke control system shall switch to the smoke control mode upon activation of a detector.

M-309.4.1 Supervision: The smoke detectors shall be connected to a fire protective signaling system. The actuation of a smoke detector shall activate a visible and audible supervisory signal at a constantly attended location.

Exceptions

1. The supervisory signal at a constantly attended location is not required where the smoke detector activates the building's alarm-indicating appliances.
2. In occupancies not required to be equipped with a fire protective signaling system, actuation of a smoke detector shall activate a visible and an audible signal in an approved location. Smoke detector trouble conditions shall activate a visible or audible signal in an approved location and shall be identified as air duct detector trouble.

SECTION M-310.0 FILTERS

M-310.1 Approval: Except for occupancies in Use Groups R-2 and R-3, air filters shall bear the *label* of an approved agency. In occupancies in Use Groups R-2 and R-3, air filters shall be designed for the intended installation.

M-310.2 Location: *Access* to filters shall be provided. Filters shall be installed so as to be readily removable.

M-310.3 Air flow over the filter: Ducts shall be constructed to allow an even distribution of air over the entire filter.

SECTION M-311.0 HAZARDOUS EXHAUST SYSTEMS

M-311.1 General: The provisions of this section shall govern the construction of a duct system for hazardous exhaust. Hazardous exhaust systems shall include the removal of flammable vapors, spray-painting residue, corrosive fumes, dust and stock.

M-311.2 Independent system: Hazardous exhaust systems shall be independent of other exhaust systems. Hazardous exhaust systems shall not share common shafts with other duct systems, except where such systems are hazardous exhaust systems originating in the same fire area.

M-311.3 Penetrations: Penetrations of structure elements by a hazardous exhaust system shall conform to Sections M-311.3.1 through M-311.3.4.

M-311.3.1 Floors: Hazardous exhaust systems that penetrate a floor level shall be enclosed in a fireresistance rated shaft in accordance with the building code listed in Chapter 21.

M-311.3.2 Fire separation assemblies: Hazardous exhaust duct systems that penetrate fire separation assemblies shall be enclosed in fireresistance rated construction from the penetration of the first fireresistance rated assembly to the outside exhaust opening, except where an approved automatic fire suppression system protects the interior of the ducts. The fireresistance rating of the enclosure required by this section shall not be less than the fireresistance rating of the highest fireresistance rated fire separation assembly penetrated.

M-311.3.3 Fire walls: Ducts shall not penetrate a fire wall.

M-311.3.4 Fire dampers: *Fire dampers* are not required at penetrations of fireresistance rated assemblies.

M-311.4 Suppression required: Ducts shall be protected with an approved automatic fire suppression system installed in accordance with the building code listed in Chapter 21.

Exception: An approved automatic fire suppression system shall not be required in ducts conveying materials, fumes, mists and vapors which are nonflammable and *noncombustible*.

M-311.5 Equipment in air stream: Fans and mechanical equipment shall not be located within the air stream unless specifically approved for such installation.

M-311.6 Duct construction: Ducts shall be constructed of G90 galvanized sheet steel in accordance with ASTM A525 listed in Chapter 21, with a minimum nominal thickness as specified in Table M-311.6.

Table M-311.6
MINIMUM DUCT THICKNESS

Diameter of duct or maximum side dimension	Minimum nominal thickness		
	Nonabrasive materials	Nonabrasive/abrasive materials	Abrasive materials
0 - 8 inches[a]	0.028 inch (No. 24 Gage)	0.034 inch (No. 22 Gage)	0.040 inch (No. 20 Gage)
9 - 18 inches[a]	0.034 inch (No. 22 Gage)	0.040 inch (No. 20 Gage)	0.052 inch (No. 18 Gage)
19 - 30 inches[a]	0.040 inch (No. 20 Gage)	0.052 inch (No. 18 Gage)	0.064 inch (No. 16 Gage)
Over 30 inches[a]	0.052 inch (No. 18 Gage)	0.064 inch (No. 16 Gage)	0.079 inch (No. 14 Gage)

Note a. 1 inch = 25.4 mm.

M-311.6.1 Alternative materials: Where the products being exhausted are detrimental to the duct material required in Section M-311.6, ducts shall be constructed of alternative materials that are compatible with the exhaust.

M-311.6.2 Duct joints: Ducts shall be made tight with lap joints having a minimum lap of 1 inch (25 mm).

M-311.6.3 Clearance to combustibles: Ducts shall have a clearance to *combustibles* in accordance with Table M-311.6.3. Exhaust gases having temperatures in excess of 600 degrees F. (316 degrees C.) shall be exhausted to a chimney in accordance with Chapter 12.

Table M-311.6.3
CLEARANCE TO COMBUSTIBLES

Type of exhaust or temperature of exhaust (degrees F.)[a]	Clearance to combustibles (inches)[a]
Less than 100	1
100 - 600	12
Flammable vapors	6

Note a. Degrees C. = [(degrees F.)- 32]/1.8; 1 inch = 25.4 mm.

M-311.6.4 Explosion relief: Systems exhausting explosive mixtures shall be protected with an approved explosion relief system. The explosion relief system shall be designed to minimize the structural and mechanical damage resulting from an explosion or deflagration within the exhaust system.

M-311.7 Nonmetallic ducts: Nonmetallic ducts utilized in systems exhausting nonflammable corrosive fumes or vapors shall bear the *label* of an approved agency.

M-311.7.1 Class I ducts: Nonmetallic ducts shall have a flame spread rating of 25 or less. Ducts shall be approved for installation in such an exhaust system.

M-311.8 Supports: Ducts shall be supported at intervals not exceeding 10 feet (3048 mm). Supports shall be constructed of *noncombustible material.*

SECTION M-312.0 CLOTHES DRYER EXHAUST

M-312.1 Installation: Clothes dryers shall be exhausted in accordance with the manufacturer's instructions. Dryer vent systems shall be independent of all other systems and shall convey the products of combustion and moisture to the outside.

M-312.2 Vent size: The minimum diameter of the vent shall be as specified by the manufacturer but not less than the diameter of the *appliance* outlet.

M-312.3 Cleanout: Each vertical riser shall be provided with a means for cleanout.

M-312.4 Vent materials: Dryer vent materials shall be of galvanized steel or aluminum of the thickness specified in Table M-304.1, or of flexible exhaust duct material.

M-312.5 Flexible ducts: Flexible ducts, where installed, shall be installed in accordance with the clothes dryer manufacturer's installation instructions. Flexible ducts that vent clothes dryers shall not penetrate or be located within any firestopping, draftstopping or any wall, floor/ceiling or other assembly required by the building code listed in Chapter 21 to be fireresistance rated, unless such duct is constructed of galvanized steel or aluminum of the thickness specified in Table M-304.1 and the fireresistance rating is maintained in accordance with the building code listed in Chapter 21.

M-312.6 Commercial or multiple installations: Vent systems for commercial or multiple-dryer installations shall conform to the requirements of Sections M-312.6.1 through M-312.6.3.

M-312.6.1 Makeup air: Installations exhausting more than 200 cubic feet per minute (0.09 m^3/s) shall be provided with *makeup air.*

M-312.6.2 Exhaust fan motors: Exhaust fan motors installed in vent systems shall be located outside of the air stream.

M-312.6.3 Interlock: In multiple installations, the fan shall operate continuously or be interlocked to operate when any individual unit is operating.

SECTION M-313.0 FIRE DAMPERS

M-313.1 Approval: *Fire dampers* shall comply with the requirements of UL 555 listed in Chapter 21, and shall bear the *label* of an approved testing agency. *Fire dampers* shall be classified and identified in accordance with UL 555. *Fire dampers* installed in systems that continue to operate when smoke or heat from a fire is detected shall be *labeled* for installation in dynamic systems as required by UL 555.

M-313.2 Where required: *Fire dampers* shall be provided at locations required by the building code listed in Chapter 21 where air distribution systems penetrate assemblies that are required to be fireresistance rated. Where the installation of a *fire damper* will interfere with the operation of a required smoke control system or the operation of an exhaust system conveying hazardous materials in accordance with Section M-311.0, approved alternative protection shall be utilized.

M-313.2.1 Smoke damper: The fire damper shall not be utilized as a smoke damper unless the location lends itself to the dual purpose.

M-313.3 Installation: *Fire dampers* shall be installed in accordance with the manufacturer's installation instructions.

M-313.4 Access: *Access* shall be provided to *fire dampers* for inspection and servicing.

SECTION M-314.0 SMOKE CONTROL SYSTEMS

M-314.1 General: Smoke control systems shall be installed as required by the building code listed in Chapter 21.

SECTION M-315.0 DUST, STOCK AND REFUSE CONVEYOR SYSTEMS

M-315.1 Dust, stock and refuse conveyor systems: Dust, stock and refuse conveyor systems shall comply with the provisions of Section M-311.0 and Sections M-315.1.1 through M-315.1.6.2.

M-315.1.1 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 inside and outside the room.

M-315.1.2 Collectors and separators: Cyclone collectors and separators and associated supports shall be constructed of *noncombustible materials* and shall be located on the exterior of the building or structure. A collector or separator shall not be located nearer than 10 feet (3048 mm) to *combustible* construction or to an unprotected wall or floor opening, unless the collector is provided with a metal vent pipe that extends above the highest part of any roof within a distance of 30 feet (9144 mm).

M-315.1.3 Discharge pipe: Discharge pipe shall conform to the requirements for ducts, including clearances required for high-heat *appliances*, as contained in this code. 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*.

M-315.1.4 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 the system discharges.

M-315.1.5 Spark protection: The outlet of an open air vent shall be protected with an approved metal or other *noncombustible* screen or by other approved means to prevent the entry of sparks.

M-315.1.6 Explosion relief vents: A safety or explosion relief vent shall be provided on all systems that convey *combustible* refuse or stock of an explosive nature, in accordance with the requirements of Section 417.5.1 of the building code listed in Chapter 21.

M-315.1.6.1 Screens: Where a screen is installed in a safety relief vent, the screen shall be so attached as to permit ready release under the explosion pressure.

M-315.1.6.2 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.

CHAPTER 4

MECHANICAL EQUIPMENT

SECTION M-401.0 GENERAL

M-401.1 Scope: This chapter shall govern the approval and installation of all mechanical equipment and *appliances*.

SECTION M-402.0 DEFINITIONS

M-402.1 General: The following words and terms shall, for the purposes of this chapter and as stated elsewhere in this code, have the meanings shown herein.

***Appliance* (mechanical):** A device or apparatus — including any attachments or apparatus designed to be attached — which is manufactured and designed to utilize electricity, natural gas, manufactured gas, mixed gas, liquefied petroleum products, solid fuel, oil or any gas as a fuel for heating, cooling or developing light or power.

***Appliance*, approved:** An *appliance* accepted or acceptable under an applicable nationally recognized standard accepted as suitable for the proposed application under procedures and powers of the administrative authority, or accepted by an approved testing or inspection agency.

Boiler room: A room primarily utilized for the installation of a *boiler*.

Furnace: A completely self-contained heating unit that is designed to supply heated air to spaces remote from or adjacent to the *appliance* location.

Furnace room: A room primarily utilized for the installation of fuel-fired heating equipment other than *boilers* (see also *"Boiler room"*).

Hazardous location: Any location considered to be a fire hazard for flammable vapors, dust, *combustible* fibers or other highly *combustible* substances. The location is not necessarily categorized in the building code listed in Chapter 21 as a high-hazard use group classification.

Label: A plate, tag or other device which is permanently and prominently affixed to a product or material indicating that the product or material has been tested and evaluated by an approved agency (see Section M-404.0).

Rating input: The amount of gas fuel in British thermal units per hour (Btuh) that the *appliance* is capable of burning safely.

Rating output: The amount of heat in British thermal units per hour (Btuh) that an *appliance* will deliver for useful service when operating at rating input.

SECTION M-403.0 EQUIPMENT APPROVAL

M-403.1 Labeling: All mechanical equipment and *appliances* regulated by this code shall bear the *label* of an approved agency unless otherwise approved in accordance with Section M-107.0.

M-403.2 Hazardous location: All mechanical equipment and *appliances* to be utilized in a *hazardous location* shall be approved.

M-403.3 Fuel conversion: Mechanical equipment and *appliances* shall not be converted for the usage of a different fuel, except where approved and converted in accordance with the manufacturer's instructions.

SECTION M-404.0 LABELING

M-404.1 Testing: An approved agency shall test a representative sample of the mechanical equipment or *appliance* being *labeled* to the standard or standards pertinent to that equipment or *appliance*. The approved agency shall maintain a record of all tests performed. The records shall provide sufficient detail to verify compliance with the test standard.

M-404.1.1 Inspection and labeling: The approved agency shall periodically perform an in-plant inspection of the mechanical equipment or *appliance* that is to be *labeled*. The inspection shall confirm that the *labeled* mechanical equipment or *appliance* is representative of the equipment or *appliance* tested.

M-404.2 Agency requirements: An approved agency shall conform to the requirements of Sections M-404.2.1 through M-404.2.3.

M-404.2.1 Approval: The agency to be approved shall be objective and competent. The agency shall also disclose all possible conflicts of interest in order to confirm objectivity of the agency.

M-404.2.2 Equipment: An approved agency shall have adequate equipment to perform all required tests. The equipment shall be calibrated periodically.

M-404.2.3 Personnel: An approved agency shall employ experienced personnel educated in conducting, supervising and evaluating tests.

M-404.3 Label information: The *label* shall be a metal plate, tag or other device permanently and prominently affixed to the mechanical equipment or *appliance*. The information on the *label* shall include, but not be limited to, the manufacturer's or

distributor's identification, the model number, the serial number and the approved agency's identification.

M-404.3.1 Fuel, ratings and clearances: The *label* for fuel-burning *appliances* shall also indicate the type of fuel for which the *appliance* has been tested, the input and output ratings, and the clearance to *combustibles*.

M-404.4 Operating instructions: Operating instructions shall be permanently and prominently affixed to each *appliance* or shall be shipped with the equipment. The instructions shall indicate ignition procedures, operating instructions, owner maintenance and shutdown procedures.

SECTION M-405.0 EQUIPMENT INSTALLATION

M-405.1 General: Mechanical equipment and *appliances* shall be installed in accordance with the manufacturer's installation instructions for the *labeled* equipment. Connections to mechanical equipment and *appliances*, such as fuel supply, electrical, hydronic piping, chimney or *vent*, and ducts, shall conform to the requirements of this code.

M-405.2 Seismic supports: Where earthquake loads are applicable in accordance with Sections 1612.1 and 1612.6 of the building code listed in Chapter 21, mechanical equipment, piping and duct supports shall be designed and installed for seismic forces in accordance with the building code listed in Chapter 21.

M-405.3 Access: *Access* shall be provided to all mechanical equipment, *appliances*, *appliance* controls, gauges, burners, filters, blowers and motors.

M-405.4 Clearance: *Appliances* shall be installed with the minimum clearances to *combustibles* for which the *appliance* has been tested as specified by the manufacturer.

M-405.5 Floor: *Appliances* shall be installed on *combustible* or *noncombustible* flooring in accordance with the manufacturer's installation instructions and the terms of *labeling*. A *noncombustible* floor, where required, shall extend a minimum of 12 inches (305 mm) beyond the sides of the *appliance*. The *noncombustible* floor shall extend a minimum of 36 inches (914 mm) on the burner side or combustion chamber opening side.

M-405.6 Remote location: A walkway having a minimum width of 24 inches (610 mm) shall be provided, leading from the *access* opening to the *appliance* where an *appliance* is installed in a remote location.

SECTION M-406.0 HAZARDOUS LOCATION INSTALLATION

M-406.1 General: Mechanical equipment and *appliances* approved for installation in a *hazardous location* shall be installed in accordance with this section, Section M-405.0 and the manufacturer's installation instructions for the *labeled* equipment.

M-406.2 Height above floor: The combustion chamber of fuel-burning *appliances* shall be installed a minimum of 18 inches (457 mm) above the floor, or higher where required by the manufacturer.

M-406.3 Motor vehicle areas: *Appliances* located in motor vehicle areas shall be installed in accordance with Sections M-406.3.1 through M-406.3.3.

M-406.3.1 Public garages: *Appliances* located in public garages, service stations, repair garages or other areas frequented by motor vehicles, shall be installed a minimum of 8 feet (2438 mm) above the floor. Where motor vehicles exceed 6 feet (1829 mm) in height and are capable of passing under an *appliance*, *appliances* shall be installed a minimum of 2 feet (610 mm) higher above the floor than the highest vehicle.

M-406.3.2 Private garages: *Appliances* located in private garages shall be installed with a minimum clearance of 6 feet (1829 mm) above the floor.

M-406.3.3 Protection alternative: *Appliances* protected from motor vehicle impact shall be installed in accordance with Section M-406.2 and NFiPA 88B listed in Chapter 21.

SECTION M-407.0 OUTDOOR INSTALLATION

M-407.1 Approval: Mechanical equipment and *appliances* located outdoors shall be approved for outdoor installation. Mechanical equipment and *appliances* installed outdoors shall conform to the requirements of Section M-405.0 and this section.

M-407.2 Guards: Guards shall be provided where *appliances*, equipment, fans or other components that require service are located within 10 feet (3048 mm) of a roof edge or open side with a drop greater than 24 inches (610 mm). The top of the guard shall be located 42 inches (1067 mm) above the surface and shall be constructed so as to prevent the passage of a 21-inch-diameter (533 mm) sphere.

M-407.3 Access: *Access* shall be possible under all weather conditions.

SECTION M-408.0 BOILER ROOMS AND FURNACE ROOMS

M-408.1 Construction and protection: *Boiler rooms* and *furnace rooms* shall be enclosed, or shall be protected with an approved automatic fire suppression system, or both, as required by the building code listed in Chapter 21.

SECTION M-409.0 ELECTRIC INSTALLATION

M-409.1 Standard: All wiring and electrical controls shall be installed in accordance with NFiPA 70 listed in Chapter 21.

M-409.2 Convenience outlet: A 125-volt AC grounding-type receptacle outlet shall be available for all *appliances*. The convenience outlet shall be located on the same level within 75 feet (22860 mm) of the *appliance*. The outlet shall not be connected to the load side of the *appliance* disconnect switch.

M-409.3 Lighting: Permanent lighting shall be provided to illuminate the area in which an *appliance* is located. For remote locations, the light switch shall be located near the *access* opening leading to the *appliance*.

Exception: Outdoor installations are not required to be provided with permanent lighting.

SECTION M-410.0 ENERGY-SAVING DEVICES

M-410.1 General: Energy-saving devices shall bear the *label* of an approved agency. The devices shall be installed in accordance with the approval and the manufacturer's installation instructions.

CHAPTER 5

KITCHEN EXHAUST EQUIPMENT

SECTION M-501.0 GENERAL

M-501.1 Scope: This chapter shall govern the construction, installation, alteration and repair of all kitchen exhaust equipment.

SECTION M-502.0 WHERE REQUIRED

M-502.1 Commercial cooking appliances: A commercial exhaust hood shall be provided for each commercial cooking *appliance.*

Exceptions

1. An *appliance* located within a dwelling unit and not utilized for commercial purposes.
2. Completely enclosed ovens.
3. Steam tables.
4. Auxiliary cooking equipment that does not produce grease-laden vapors, including toasters, coffee makers and egg cookers.

M-502.2 Domestic cooking appliances: Domestic cooking *appliances* utilized for commercial purposes shall be provided with a commercial exhaust hood. Domestic cooking *appliances* utilized for noncommercial purposes shall be provided with *ventilation* in accordance with Chapter 16.

Exception: Completely enclosed ovens.

SECTION M-503.0 FACTORY-BUILT COMMERCIAL HOODS AND DUCTS

M-503.1 Approval of hoods: Factory-built commercial exhaust hoods tested in accordance with UL 710 listed in Chapter 21, and bearing the *label* of an approved agency, shall be installed in accordance with the manufacturer's instructions for the *labeled* equipment. The exhaust hood shall be designed for the type of cooking *appliance* provided, and shall conform to Section M-504.1.

M-503.2 Other type hoods: Factory-built commercial exhaust hoods that are not tested in accordance with UL 710 listed in Chapter 21 shall conform to all of the requirements in this chapter for commercial exhaust hoods.

M-503.3 Approval of ducts: Ducts bearing the *label* of an approved agency shall be installed in accordance with the manufacturer's instructions for the *labeled* duct. Ducts shall be designed for the type of cooking *appliance* and the hoods served.

SECTION M-504.0 COMMERCIAL HOOD DESIGN

M-504.1 Vapor confinement: The commercial hood system shall be designed to confine cooking vapors and residues within the hood.

M-504.2 Hood construction: The hood and other parts of the primary collection system shall be constructed of steel or stainless steel. The minimum nominal thickness of steel shall be 0.048 inch (No. 18 Manufacturers Standard Gage). The minimum nominal thickness of stainless steel shall be 0.037 inch (No. 20 U.S. Standard Gage).

M-504.2.1 Joints: All external joints and seams shall be welded liquid tight.

M-504.2.2 Interior surfaces: The interior surfaces of the hood shall not have any areas that accumulate grease.

Exception: Grease collection systems under filters and troughs on the perimeter of canopy hoods.

M-504.3 Canopy hoods: Canopy hoods shall be designed to cover completely the cooking equipment. The edge of the hood shall extend a minimum horizontal distance of 6 inches (152 mm) beyond the edge of the cooking surface on all open sides.

M-504.4 Noncanopy-type hoods: Hoods of the noncanopy type shall be located a maximum of 3 feet (914 mm) above the cooking surface. The edge of the hood shall be set back a maximum of 1 foot (305 mm) from the edge of the cooking surface.

M-504.5 Hood exhaust: The hood exhaust shall create a draft from the cooking surface into the hood.

M-504.5.1 Quantity of exhaust: Canopy hoods attached to the wall shall exhaust a minimum of 100 cubic feet per minute (cfm) per square foot ($0.50\ m^3/s \cdot m^2$) of the hood area. Canopy hoods exposed on all sides shall exhaust a minimum of 150 cfm per square foot ($0.75\ m^3/s \cdot m^2$) of hood area. Hoods of the noncanopy type shall exhaust a minimum of 300 cfm per lineal foot ($0.46\ m^3/s \cdot m$) of cooking surface. The minimum quantity of exhaust shall only be reduced where tests indicate conformance to Section M-504.1.

M-504.5.2 Makeup air: *Makeup air* shall be supplied during the operation of the kitchen exhaust system. The amount of *makeup air* shall be approximately equal to the amount of exhaust air. The *makeup air* shall not reduce the effectiveness of the exhaust system.

The temperature differential between *makeup air* and air in

the conditioned space shall not exceed 10 degrees F. (5.5 degrees C.).

Exceptions

1. *Makeup air* that is part of the air conditioning system.
2. *Makeup air* that does not decrease the comfort conditions of the occupied space.

SECTION M-505.0 GREASE REMOVAL

M-505.1 General: The air exhausted in every commercial exhaust hood shall pass through grease filters or a grease removal device.

M-505.2 Removal device: Grease removal devices shall bear the *label* of an approved agency, and shall be installed in accordance with the manufacturer's instructions for the *labeled* equipment.

M-505.3 Filters: Grease filters shall bear the *label* of an approved agency. *Access* shall be provided to all grease filters.

M-505.3.1 Angle of filter: Grease filters shall be installed at a minimum angle of 45 degrees (0.79 rad) to the horizontal. The filters shall be arranged so as to capture and drain grease to a point of collection.

M-505.3.2 Height above cooking surfaces: Grease filters shall be installed a minimum height above the cooking surface as specified in Table M-505.3.2.

Exception: With cooking devices without exposed flame and where flue gases bypass filters, filters shall be installed at an effective height of not less than 6 inches (152 mm) above cooking surfaces.

Table M-505.3.2
HEIGHT OF GREASE FILTERS

Type of cooking equipment	Height above cooking surface[a]
Without exposed flame	2½ feet
Exposed flame	3½ feet
Charcoal burning	4 feet

Note a. 1 foot = 304.8 mm.

M-505.3.3 Size: Grease filters shall have a minimum area of 1 square inch (645 mm^2) for every 2 cubic feet per minute (.0009 m^3/s) of air exhausted.

Exception: Filters and grease extractors which are of such size, type and arrangement as to permit the required quantity of air to pass through such units at rates not exceeding those for which the filter or unit was designed and approved shall be acceptable.

SECTION M-506.0 COMMERCIAL DUCT SYSTEMS

M-506.1 Duct design: The duct system shall be an independent system designed for the removal of kitchen exhaust without any obstructions that are capable of collecting grease or residue. A point of collection shall be provided at the base of each vertical rise.

M-506.2 Duct construction: The ducts shall be constructed of steel or stainless steel. The minimum nominal thickness of steel shall be 0.060 inch (No. 16 Manufacturers Standard Gage). The minimum nominal thickness of stainless steel shall be 0.050 inch (No. 18 U.S. Standard Gage).

M-506.2.1 Joints: All external joints and seams shall be welded liquid tight. Duct connections to the hood shall be welded liquid tight.

Exception: Joints that bear the *label* of an approved agency and which connect the hood to the duct are not required to be welded liquid tight.

M-506.3 Air velocity: The air velocity in the duct shall be a minimum of 1,500 feet per minute (7620 mm/s) and a maximum of 2,200 feet per minute (11176 mm/s).

M-506.4 Enclosed in shaft: Ducts that penetrate a floor, wall or fireresistance rated assembly shall be enclosed in a fireresistance rated shaft in accordance with the building code listed in Chapter 21. A minimum clearance of 6 inches (152 mm) shall be maintained between the shaft and the duct. *Access* openings shall be provided at cleanout points.

M-506.5 Horizontal cleanouts: Cleanouts shall be located on horizontal sections of ducts spaced not more than 20 feet (6096 mm) apart. The cleanouts shall be located on the side of the duct having a minimum opening dimension of 12 inches (305 mm) or on the width of the duct where less than 12 inches (305 mm).

M-506.6 Fan motor: The motor to an exhaust fan shall be located outside the exhaust air stream.

M-506.7 Duct termination: Ducts shall exhaust to the outdoors. The location of the system termination shall conform to the requirements of Section M-308.0 and shall be a minimum of 10 feet (3048 mm) above the adjoining finished ground level. The discharge shall direct exhaust away from the building.

M-506.7.1 Termination above the roof: Ducts that terminate above the roof shall have the discharge located a minimum of 40 inches (1016 mm) above the roof surface.

M-506.7.2 Termination through an exterior wall: The exterior wall in which a duct terminates shall be *noncombustible* in accordance with the building code listed in Chapter 21. Other exterior openings shall not be located within 3 feet (914 mm) of the duct termination.

M-506.8 Cutting or notching: A structural member shall not be cut, notched or pierced in excess of the limitations specified in the building code listed in Chapter 21, unless proven safe by a structural analysis.

SECTION M-507.0 CLEARANCE IN COMMERCIAL SYSTEMS

M-507.1 General: Commercial exhaust system hoods and ducts shall have a minimum clearance of 18 inches (457 mm) to *combustible materials*. For the purposes of this section, "combustible materials" shall be as defined in the building code listed in Chapter 21. Exposed surfaces within 18 inches (457 mm) of the cooking surface or hood opening shall be finished with smooth, readily cleanable, nonabsorbent material.

SECTION M-508.0 SUPPRESSION FOR COMMERCIAL SYSTEMS

M-508.1 Fire suppression system required: All cooking surfaces, kitchen exhaust systems, grease removal devices and hoods shall be protected with an approved automatic fire sup-

pression system in accordance with the building code listed in Chapter 21. The automatic fire suppression system shall bear the *label* of an approved agency, and shall be installed in accordance with the manufacturer's installation instructions.

M-508.2 System actuation: All fire suppression systems shall have automatic actuation. All fire suppression systems except automatic sprinkler systems shall have manual actuation. The manual actuation shall require a maximum force of 40 pounds (178 N) and a maximum movement of 14 inches (356 mm) to actuate the fire suppression system.

M-508.2.1 Location of manual actuation: A manual actuation station shall be located at or near a means of egress from the cooking area, a minimum of 10 feet (3048 mm) from the kitchen exhaust system. The actuation device shall be located a minimum of 4½ feet (1372 mm) and a maximum of 5 feet (1524 mm) above the floor.

M-508.3 System interconnection: The actuation of the fire suppression system shall automatically shut down the fuel or electrical supply to the cooking equipment. The fuel and electrical supply reset shall be manual.

M-508.4 Nozzles: *Access* shall be provided to all nozzles in the fire suppression system.

M-508.5 System test and inspection: The fire suppression system shall be tested in accordance with the fire prevention code listed in Chapter 21.

SECTION M-509.0 TEST AND CLEANING SCHEDULE

M-509.1 Cleaning schedule: A cleaning schedule shall be submitted for every commercial kitchen exhaust system. The schedule shall indicate methods of cleaning and the time interval between cleanings.

M-509.2 Test: The code official shall require a full-scale test of the commercial kitchen exhaust system to determine conformance to this chapter. The test shall simulate the most severe cooking conditions for the particular installation.

CHAPTER 6

BOILERS AND WATER HEATERS

SECTION M-601.0 GENERAL

M-601.1 Scope: This chapter shall govern the installation, alteration and repair of water heaters and *boilers*.

SECTION M-602.0 DEFINITIONS

M-602.1 General: The following words and terms shall, for the purposes of this chapter and as stated elsewhere in this code, have the meanings shown herein.

Boiler: A closed heating *appliance* intended to supply hot water or steam for space heating, processing or power purposes. Low-pressure boilers operate at pressures less than or equal to 15 pounds per square inch (103 kPa) for steam and 160 pounds per square inch (1103 kPa) for water. High-pressure boilers operate at pressures exceeding those pressures.

Pressure relief valve: A pressure-actuated valve held closed by a spring or other means and designed to relieve pressure automatically in excess of the device's setting.

Quick-opening valve: A valve that opens completely by fast action, either manually or automatically controlled. A valve requiring one-quarter round turn or less is considered to be quick opening.

Safety valve: A valve that relieves pressure in a steam *boiler* by opening fully at the rated discharge pressure. The valve is of the spring-pop type.

Water heater: Any heating *appliance* or equipment which heats potable water and supplies such water to the potable hot water distribution system.

SECTION M-603.0 WATER HEATERS

M-603.1 General: All water heaters shall be capable of being removed without first removing a permanent portion of the building structure. The potable water connections and relief valves for all water heaters shall conform to the requirements of the plumbing code listed in Chapter 21.

SECTION M-604.0 BOILER CONNECTIONS

M-604.1 Valves: Every *boiler* or battery of modular units shall have a shutoff valve in the supply and return piping. For multiple *boiler* or battery of modular unit installations, each *boiler* or battery of modular units shall have individual shutoff valves in the supply and return piping.

Exception: Shutoff valves are not required in a system having a single low-pressure steam *boiler*.

M-604.2 Potable water supply: The water supply to all *boilers* shall be connected in accordance with the plumbing code listed in Chapter 21.

SECTION M-605.0 SAFETY AND PRESSURE RELIEF VALVES

M-605.1 Safety valve for steam boilers: All steam *boilers* shall be protected with a safety valve.

M-605.2 Pressure relief for hot water boilers: All hot water *boilers* shall be protected with a pressure relief valve.

M-605.3 Approval of safety and relief valves: All safety and relief valves shall bear the *label* of an approved agency. Safety and relief valves shall have a minimum rated capacity for the equipment served. Pressure relief valves shall be set at a maximum of the nameplate pressure rating of the *boiler*.

M-605.4 Installation: Safety or relief valves shall be installed directly into the safety or relief valve opening on the *boiler*. Valves shall not be located on either side of a safety or relief valve connection. The relief valve shall discharge by gravity.

M-605.5 Safety and relief valve discharge: Safety and relief valve discharge pipes shall be of rigid pipe that is approved for the temperature of the system. The discharge pipe shall be the same diameter as the safety or relief valve outlet.

Safety and relief valves shall not discharge so as to be a hazard, a potential cause of damage or otherwise a nuisance. High-pressure steam safety valves shall be vented to outside the structure. Where a low-pressure safety valve or a relief valve discharges to the drainage system, the installation shall conform to the plumbing code listed in Chapter 21.

SECTION M-606.0 STEAM BOILER EQUALIZING PIPE

M-606.1 Equalizing pipe required: An equalizing pipe shall be installed between the supply header and the return header of each steam *boiler*. Valves shall not be installed between the supply header and the return header so as to isolate the equalizing pipe.

M-606.2 Installation: The size of the equalizing pipe shall conform to Table M-606.2. A return shall be permitted to connect to the equalizing pipe.

Table M-606.2
EQUALIZING PIPE SIZE

Minimum safety valve capacity (pounds per hour)	Equalizing pipe size (inches)
250 or less	1½
251 to 2,000	2½
Greater than 2,000	4

SECTION M-607.0 BOILER LOW-WATER CUTOFF

M-607.1 General: All steam *boilers* shall be protected with a low-water cutoff control. All hot water heating *boilers* with a heat input greater than 400,000 British thermal units per hour shall be protected with a low-water cutoff control. Such controls shall be installed externally or as an integral part of the *boiler*.

M-607.2 Operation: The low-water cutoff shall automatically stop the combustion operation of the equipment when the water level drops below the lowest safe water level as established by the manufacturer.

SECTION M-608.0 STEAM BLOWOFF VALVE

M-608.1 General: Every steam *boiler* shall be equipped with a quick-opening blowoff valve. The valve shall be installed in the opening provided on the *boiler*. The minimum size of the valve shall be the size specified by the *boiler* manufacturer or the size of the *boiler* blowoff-valve opening.

M-608.2 Discharge: Blowoff valves shall discharge to a safe place of disposal. Where discharging to the drainage system, the installation shall conform to the plumbing code listed in Chapter 21.

SECTION M-609.0 HOT WATER BOILER EXPANSION TANK

M-609.1 Where required: An expansion tank shall be installed in every hot water system. For multiple *boiler* installations, a minimum of one expansion tank is required. Expansion tanks shall be of the closed or open type. Tanks shall be rated for the pressure of the hot water system.

M-609.2 Closed-type expansion tanks: Closed-type expansion tanks shall be installed in accordance with the manufacturer's installation instructions. The size of the tank shall be based on the capacity of the hot water heating system. The minimum size of the tank shall be determined in accordance with the following equation:

$$V_t = \frac{(0.00041T - 0.0466)\,V_s}{\left(\frac{P_a}{P_f}\right) - \left(\frac{P_a}{P_o}\right)}$$

where:

V_t = Minimum volume of tanks (gallons).
V_s = Volume of system, not including expansion tanks (gallons).
T = Average operating temperature (degrees Fahrenheit).
P_a = Atmospheric pressure (pounds per square inch).
P_f = Fill pressure (pounds per square inch).
P_o = Maximum operating pressure (pounds per square inch).

M-609.3 Open-type expansion tanks: Open-type expansion tanks shall be located a minimum of 4 feet (1219 mm) above the highest heating element. The tank shall be adequately sized for the hot water system. An overflow with a minimum diameter of 1 inch shall be installed at the top of the tank. The overflow shall discharge to the drainage system in accordance with the plumbing code listed in Chapter 21.

SECTION M-610.0 GAUGES

M-610.1 Hot water boiler gauges: Every hot water *boiler* shall have a pressure gauge and a temperature gauge, or a combination pressure and temperature gauge. The gauges shall indicate the temperature and pressure within the normal range of the system's operation.

M-610.2 Steam boiler gauges: Every steam *boiler* shall have a water-gauge glass and a pressure gauge. The pressure gauge shall indicate the pressure within the normal range of the system's operation.

M-610.2.1 Water-gauge glass: The gauge glass shall be installed so that the midpoint is at the normal *boiler* water level.

CHAPTER 7

HYDRONIC PIPING

SECTION M-701.0 GENERAL

M-701.1 Scope: The provisions of this chapter shall govern the construction, installation, alteration and repair of all hydronic piping systems. Potable cold and hot water distribution systems shall be installed in accordance with the plumbing code listed in Chapter 21.

M-701.2 Pipe sizing: All piping for hydronic systems shall be sized for the demand of the system.

SECTION M-702.0 DEFINITIONS

M-702.1 General: The following words and terms shall, for the purposes of this chapter and as stated elsewhere in this code, have the meanings shown herein.

Mechanical joint: A connection between pipes, fittings or pipes and fittings, which is neither screwed, caulked, threaded, soldered, solvent cemented, brazed, nor welded. A joint in which compression is applied along the centerline of the pieces being joined. Some joints are part of a coupling, fitting or adapter.

SECTION M-703.0 MATERIAL

M-703.1 Piping: Piping material shall conform to the standards cited in this section.

M-703.2 Reuse of materials: Pipe, fittings, valves or other materials shall not be reused unless such materials are free from foreign materials and have been determined to be adequate for the service intended.

M-703.3 Material rating: All materials shall be rated for the operating temperature and pressure of the hydronic system. All materials shall be suitable for the type of fluid in the hydronic system.

M-703.4 Piping material standards: Hydronic pipe shall conform to one of the standards listed in Table M-703.4. The exterior of the pipe shall be protected from corrosion and degradation.

M-703.5 Pipe fittings: Hydronic pipe fittings shall be approved for installation with the piping materials to be installed, and shall conform to the respective pipe standards or to one of the standards listed in Table M-703.5.

M-703.6 Valves: All valves shall be of the approved type and compatible with the type of piping material in the system.

M-703.7 Flexible connectors, expansion and vibration compensators: Flexible connectors, expansion and vibration control devices and fittings shall be of an approved type.

Table M-703.4
HYDRONIC PIPE

Material	Standard (see Chapter 21)
Acrylonitrile butadiene styrene (ABS) plastic pipe	ASTM D1527; ASTM D2282
Brass pipe	ASTM B43
Brass tubing	ASTM B135
Copper or copper-alloy pipe	ASTM B42; ASTM B302
Copper or copper-alloy tubing (Type K, L or M)	ASTM B75; ASTM B88; ASTM B251
Chlorinated polyvinyl chloride (CPVC) plastic pipe	ASTM D2846; ASTM F441; ASTM F442
Cross-linked polyethylene (PEX) tubing	ASTM F876; ASTM F877
Lead pipe	FS WW-P-325B
Polybutylene (PB) plastic pipe and tubing	ASTM D3309
Polyvinyl chloride (PVC) plastic pipe	ASTM D1785; ASTM D2241
Steel pipe	ASTM A53; ASTM A106
Steel tubing	ASTM A254

Table M-703.5
HYDRONIC PIPE FITTINGS

Material	Standard (see Chapter 21)
Bronze	ASME B16.24
Copper	ASME B16.15; ASME B16.18; ASME B16.22; ASME B16.23; ASME B16.26; ASME B16.29
Gray iron	ASTM A126
Malleable iron	ASME B16.3
Plastic	ASTM D2466; ASTM D2467; ASTM D2468; ASTM F438; ASTM F439; ASTM F877
Steel	ASME B16.5; ASME B16.9; ASME B16.11; ASME B16.28; ASTM A420

SECTION M-704.0 JOINTS AND CONNECTIONS

M-704.1 Approval: All joints and connections shall be of an approved type. Joints and connections shall be tight for the pressure of the hydronic system.

M-704.1.1 Joints between different piping materials: Joints between different piping materials shall be made with approved adapter fittings. Joints between different metallic piping materials shall be made with approved dielectric fittings or brass converter fittings.

M-704.2 Preparation of pipe ends: All pipe shall be cut square, reamed and chamfered, and shall be free from all burrs and

obstructions. Pipe ends shall have full-bore openings and shall not be undercut.

M-704.3 Joint preparation and installation: Where required by Sections M-704.4 through M-704.15, the preparation and installation of brazed, *mechanical*, soldered, solvent-cemented, threaded and welded joints shall comply with Sections M-704.3.1 through M-704.3.6.

M-704.3.1 Brazed joints: All joint surfaces shall be cleaned. An approved flux shall be applied where required. The joint shall be brazed with a filler metal conforming to AWS A5.8 listed in Chapter 21.

M-704.3.2 Mechanical joints: *Mechanical joints* shall be installed in accordance with the manufacturer's instructions.

M-704.3.3 Soldered joints: All joint surfaces shall be cleaned. An approved flux shall be applied. The joint shall be soldered with a solder conforming to ASTM B32 listed in Chapter 21.

M-704.3.4 Solvent-cemented joints: Joint surfaces shall be clean and free from moisture. An approved primer shall be applied to CPVC and to PVC pipe-joint surfaces. Joints shall be made while the cement is wet. Solvent cement conforming to the following standards listed in Chapter 21 shall be applied to all joint surfaces:

1. ASTM D2235 for ABS joints.
2. ASTM F493 for CPVC joints.
3. ASTM D2564 for PVC joints.

CPVC joints shall be made in accordance with ASTM D2846 listed in Chapter 21.

M-704.3.5 Threaded joints: Threads shall conform to ASME B1.20.1 listed in Chapter 21. Schedule 80 or heavier plastic pipe shall be threaded with dies specifically designed for plastic pipe. Thread lubricant, pipe-joint compound or tape shall be applied on the male threads only and shall be approved for application on the piping material.

M-704.3.6 Welded joints: All joint surfaces shall be cleaned by approved procedure. The joint shall be welded with an approved filler metal.

M-704.4 ABS plastic pipe: Joints between ABS plastic pipe or fittings shall be solvent-cemented or threaded joints conforming to Section M-704.3.

M-704.5 Brass pipe: Joints between brass pipe or fittings shall be brazed, *mechanical*, threaded or welded joints conforming to Section M-704.3.

M-704.6 Brass tubing: Joints between brass tubing or fittings shall be brazed, *mechanical* or soldered joints conforming to Section M-704.3.

M-704.7 Copper or copper-alloy pipe: Joints between copper or copper-alloy pipe or fittings shall be brazed, *mechanical,* soldered, threaded or welded joints conforming to Section M-704.3.

M-704.8 Copper or copper-alloy tubing: Joints between copper or copper-alloy tubing or fittings shall be brazed, *mechanical* or soldered joints conforming to Section M-704.3 or flared joints conforming to Section M-704.8.1.

M-704.8.1 Flared joints: Flared joints shall be made by a tool designed for that operation.

M-704.9 CPVC plastic pipe: Joints between CPVC plastic pipe or fittings shall be solvent-cemented or threaded joints conforming to Section M-704.3.

M-704.10 Lead pipe: Joints between lead pipe or fittings shall be burned or wiped joints conforming to Sections M-704.10.1 and M-704.10.2.

M-704.10.1 Burned: Burned joints shall be uniformly fused together into one continuous piece. The thickness of the joint shall be at least as thick as the lead being joined. The filler metal shall be of the same material as the pipe.

M-704.10.2 Wiped: Joints shall be full wiped, having an exposed surface on each side of the joint not less than ¾ inch (19 mm). The joint shall be at least ⅜ inch (10 mm) thick at the thickest point.

M-704.11 Polybutylene plastic pipe and tubing: Joints between polybutylene plastic pipe and tubing or fittings shall be mechanical joints conforming to Section M-704.3.2 or heat-fusion joints conforming to Section M-704.11.1.

M-704.11.1 Heat-fusion joints: Joints shall be of the socket-fusion or butt-fusion type. Joint surfaces shall be clean and free from moisture. All joint surfaces shall be heated to melt temperatures and joined. The joint shall be undisturbed until cool. Joints shall be made in accordance with ASTM D3309 listed in Chapter 21.

M-704.12 Cross-linked polyethylene (PEX) plastic tubing: Joints between cross-linked polyethylene plastic tubing and fittings shall conform to Sections M-704.12.1 and M-704.12.2. *Mechanical joints* shall conform to Section M-704.3.2.

M-704.12.1 Compression-type fittings: Where compression-type fittings include inserts and ferrules or O-rings, the fittings shall be installed without omitting such inserts and ferrules or O-rings.

M-704.12.2 Plastic-to-metal connections: Soldering on the metal portion of the system shall not be performed closer than 18 inches (457 mm) to any plastic-to-metal adapter in the same water line.

M-704.13 PVC plastic pipe: Joints between PVC plastic pipe and fittings shall be solvent-cemented or threaded joints conforming to Section M-704.3.

M-704.14 Steel pipe: Joints between steel pipe or fittings shall be *mechanical joints* that are made with an approved elastomeric seal, or shall be threaded or welded joints conforming to Section M-704.3.

M-704.15 Steel tubing: Joints between steel tubing or fittings shall be *mechanical* or welded joints conforming to Section M-704.3.

SECTION M-705.0 EXPANSION AND CONTRACTION

M-705.1 General: Piping shall be installed so as to prevent strains and stresses which will exceed the limitations of the pipe. Provisions shall be made to protect the piping from damage resulting from expansion, contraction and structural settlement.

Piping shall be installed so as not to create structural stresses or strains within building components.

M-705.1.1 Flood hazard: All piping located in a flood-hazard zone (A Zone) or a high-hazard zone (V Zone) shall be capable of resisting hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, during the occurrence of flooding to the base flood elevation.

SECTION M-706.0 PIPE SUPPORT

M-706.1 Hanger material: Hangers and supports shall be of material of sufficient strength to support the piping. Hangers and strapping material shall be compatible with the piping to avoid galvanic action.

M-706.2 Interval of spacing: Piping shall be supported at distances not exceeding the spacing specified in Table M-706.2, or piping shall be supported in accordance with MSS SP-69 listed in Chapter 21.

Table M-706.2
HANGER SPACING

Piping material	Maximum horizontal spacing (feet)[a]	Maximum vertical spacing (feet)[a]
ABS pipe	4	4
Brass pipe	10	10
Brass tubing, 1¼-inch diameter and smaller	6	10
Brass tubing, 1½-inch diameter and larger	10	10
Copper or copper-alloy pipe	12	10
Copper or copper-alloy tubing, 1¼-inch diameter and smaller	6	10
Copper or copper-alloy tubing, 1½-inch diameter and larger	10	10
CPVC pipe	4	4
Lead pipe	Continuous	4
PB pipe or tubing	2⅔ (32 inches)	4
PVC pipe	4	4
Steel pipe	12	15
Steel tubing	8	10

Note a. 1 foot = 304.8 mm.

SECTION M-707.0 PIPING INSTALLATION

M-707.1 General: All piping, valves, fittings and connections shall be installed in accordance with the conditions of approval.

M-707.1.1 Bull-heading tees prohibited: Fluid in a system shall not enter a tee fitting through the side opening.

M-707.1.2 Cutting or notching: A structural member shall not be cut, notched or pierced in excess of the limitations specified in the building code listed in Chapter 21, unless proven safe by a structural analysis.

M-707.2 System drain down: Hydronic piping systems shall be designed and installed to permit the system to be drained. Where the system drains to the plumbing drainage system, the installation shall conform to the requirements of the plumbing code listed in Chapter 21.

M-707.3 Protection of potable water: The potable water system shall be protected from backflow in accordance with the plumbing code listed in Chapter 21.

M-707.4 Pipe penetrations: Openings for pipe penetrations in walls, floors or ceilings shall be larger than the penetrating pipe. Openings through concrete or masonry building elements shall be sleeved. The annular space of all pipe penetrations shall be fire-stopped in accordance with the building code listed in Chapter 21.

M-707.5 Clearance to combustibles: Any pipe in a hydronic piping system in which the exterior temperature exceeds 250 degrees F. (121 degrees C.) shall have a minimum clearance of 1 inch (25 mm) to *combustible materials*.

M-707.6 Contact with building material: A hydronic piping system shall not be in direct contact with any building material that causes the piping material to degrade or corrode, or which interferes with the operation of the system.

M-707.7 Water hammer: The flow velocity of the hydronic piping system shall be controlled to reduce the possibility of water hammer. Where a quick-closing valve creates water hammer, an approved water-hammer arrestor shall be installed. The arrestor shall be located within a range as specified by the manufacturer of the quick-closing valve.

M-707.8 Steam piping pitch: All steam piping shall be installed to drain to the *boiler* or the steam trap. Steam systems shall not have any drip pockets that reduce the capacity of the steam piping.

M-707.9 Condensation: Provisions shall be made to prevent the formation of condensation on the exterior of all piping.

SECTION M-708.0 PIPE INSULATION

M-708.1 General: Pipe in hydronic piping systems shall be insulated to provide a thermal resistance (R), excluding film resistances, as specified in Table M-708.1. For insulation that has a conductivity value outside the range shown in Table M-708.1 for the applicable fluid operating temperature range at the mean rating temperature shown, the minimum thicknesses shall be:

$$T = PR\,[(1 + t/PR)^{K/k} - 1]$$

where:

T = Minimum insulation thickness for material with conductivity (K), in inches.
PR = Actual outside radius of the pipe, in inches.
t = Insulation thickness from Table M-708.1, in inches.
K = Conductivity of alternative material at the mean rating temperature indicated in Table M-708.1 for the applicable fluid temperature range, in Btu · in./(hour · ft.^{2} · °F).
k = The lower value of the conductivity range listed in Table M-708.1 for the applicable fluid temperature range, Btu · in./(hour · ft.^{2} · °F).

Exception: Pipe insulation is not required in any of the following cases:

1. Piping installed within heating, *ventilating* and air conditioning equipment.
2. Piping at temperatures between 55 degrees F. (13 degrees C.) and 105 degrees F. (41 degrees C.).
3. Where the heat loss or heat gain of the piping, without insulation, does not increase the energy requirements of the structure.

4. Piping installed in basements or cellars in occupancies in Use Group R-3.

M-708.2 Insulation characteristics: Pipe insulation installed in concealed spaces in buildings of Type 1 or 2 construction shall have a maximum flame spread rating of 25 when tested in accordance with ASTM E84 listed in Chapter 21. Pipe insulation installed in concealed spaces in buildings of Type 3, 4 or 5 construction shall have a maximum flame spread rating of 75 when tested in accordance with ASTM E84 listed in Chapter 21.

M-708.2.1 Exposed insulation: Insulation exposed within a building shall conform to the requirements for interior finish in accordance with the building code listed in Chapter 21.

SECTION M-709.0 VALVES

M-709.1 Where required: Shutoff valves shall be installed in hydronic piping systems in the locations indicated in Sections M-709.1.1 through M-709.1.6.

M-709.1.1 Heat exchangers: Shutoff valves shall be installed on the supply and return side of every heat exchanger.

M-709.1.2 Central systems: Shutoff valves shall be installed on the building supply and return of a central utility system.

M-709.1.3 Pressure vessels: Shutoff valves shall be installed on the connection to any pressure vessel.

M-709.1.4 Pressure-reducing valves: Shutoff valves shall be installed on both sides of a pressure-reducing valve.

M-709.1.5 Equipment: Shutoff valves shall be installed on connections to mechanical equipment. This requirement does not apply to components of a hydronic system such as pumps, air separators, metering devices and similar equipment.

M-709.1.6 Expansion tanks: Shutoff valves shall be installed on connections to nondiaphragm-type expansion tanks.

M-709.2 Reduced pressure: A pressure relief valve shall be installed on the low-pressure side of a hydronic piping system that has been reduced in pressure. The relief valve shall be set at the maximum pressure of the system design. The valve shall be installed in accordance with Section M-605.0.

SECTION M-710.0 TRANSFER FLUID

M-710.1 Flash point: The *flash point* of transfer fluid in a hydronic piping system shall be a minimum of 50 degrees F. (10 degrees C.) above the maximum system operating temperature.

M-710.2 Makeup water: The transfer fluid shall be compatible with the makeup water supplied to the system.

SECTION M-711.0 TESTS

M-711.1 General: All hydronic piping systems shall be tested to the maximum system pressure.

Table M-708.1
MINIMUM PIPE INSULATION

Type of system	Fluid design operating temperature range (degrees F.)[c]	Insulation conductivity		Nominal pipe diameter (inches)					
		Conductivity range [Btu · in./(hr. · ft.^{2} · °F.)]	Mean rating temperature (degrees F.)[c]	Runouts[a] up to 2	1 and less	1¼ to 2	2½ to 4	5 and 6	8 and up
Heating (steam, steam condensate and hot water)	Above 350	0.32-0.34	250	1.5	2.5	2.5	3.0	3.5	3.5
	251-350	0.29-0.31	200	1.5	2.0	2.5	2.5	3.5	3.5
	201-250	0.27-0.30	150	1.0	1.5	1.5	2.0	2.0	3.5
	141-200	0.25-0.29	125	0.5	1.5	1.5	1.5	1.5	1.5
	105-140	0.24-0.28	100	0.5	1.0	1.0	1.0	1.5	1.5
Cooling (chilled water, brine and refrigerant)[b]	40-55	0.23-0.27	75	0.5	0.5	0.75	1.0	1.0	1.0
	Below 40	0.23-0.27	75	1.0	1.0	1.5	1.5	1.5	1.5

Note a. Runouts to individual terminal units not exceeding 12 feet in length.
Note b. The required minimum thicknesses do not consider water vapor transmission and condensation. Where necessary to control condensation, additional insulation, vapor retarders, or both, shall be required.
Note c. Degrees C. = [(degrees F.) -32]/1.8.

CHAPTER 8

GAS PIPING SYSTEMS

SECTION M-801.0 GENERAL

M-801.1 Scope: This chapter shall govern the installation, repair and maintenance of fuel-gas piping systems. Coverage of piping systems extends from the point of delivery to the connections with each utilization device and includes the design, materials, components, fabrication, assembly, installation, testing, inspection, operation and maintenance of such piping systems.

M-801.1.1 Point of delivery: Except for undiluted liquefied petroleum gas systems, the point of delivery is the outlet of the service meter assembly, or the outlet of the service regulator or service shutoff valve where a meter is not provided. For undiluted liquefied petroleum gas systems, the point of delivery is the outlet of the first stage pressure regulator.

M-801.2 Liquefied petroleum gas storage: The storage system for liquefied petroleum gas shall be designed and installed in accordance with NFiPA 58 listed in Chapter 21.

M-801.3 Modifications to existing systems: In modifying or adding to existing piping systems, sizes shall be maintained in accordance with this chapter.

M-801.4 Interconnections: Where two or more meters are installed on the same premises but supply separate consumers, the piping systems shall not be interconnected on the outlet side of the meters.

M-801.5 Interconnections for standby fuels: Where a supplemental gas supply for standby utilization is connected downstream from a meter, an approved device to prevent backflow shall be installed.

SECTION M-802.0 DEFINITIONS

M-802.1 General: The following words and terms shall, for the purposes of this chapter and as stated elsewhere in this code, have the meanings shown herein.

Dry gas: A gas having a moisture and hydrocarbon dew point below any normal temperature to which the gas piping is exposed.

Gas outlet: A connection in a gas piping system to which gas equipment is intended to be attached.

Heating value: The heat released by combustion of a unit quantity of waste or fuel, measured in British thermal units (Btu).

Liquefied petroleum gas (LP-gas): A gas containing certain specific hydrocarbons which are gaseous under normal atmospheric conditions, but are capable of being liquefied under moderate pressure at normal temperatures.

Manual gas shutoff valve: A manually operated valve in the gas line for the purpose of completely turning on or shutting off the gas supply downstream of the valve.

Manufactured gas: A gas obtained by destructive distillation of coal, or by the thermal decomposition of oil, or by the reaction of steam passing through a bed of heated coal or coke or catalyst beds. Examples are coal gases, coke oven gases, producer gas, blast furnace gas, blue (water) gas, and carbureted water gas. British thermal unit (Btu) content varies widely.

Natural gas: A naturally occurring mixture of hydrocarbon and nonhydrocarbon gases found in porous geologic formations beneath the earth's surface, often in association with petroleum. The principal constituent is methane.

Purge: To clear of air, water or other foreign substances.

Regulator, line gas pressure: A device placed in a gas line between the service pressure regulator and the gas equipment for controlling, maintaining or reducing the pressure in that portion of the piping system downstream of the device.

Regulator, LP-gas, first stage: On undiluted LP-gas systems, the first pressure regulator reduces the storage container pressure.

Regulator, LP-gas, second stage: A line gas pressure regulator for service on undiluted LP-gas systems, reducing an intermediate high pressure to utilization pressure.

Regulator, service pressure: A device installed by the serving gas supplier to reduce and limit the service line gas pressure to delivery pressure.

Riser, gas: A fuel gas supply pipe that extends vertically one full story or more.

SECTION M-803.0 PIPING MATERIAL

M-803.1 General: Piping material shall conform to the standards cited in this section for the installation, alteration or repair of fuel-gas piping systems.

M-803.2 Piping standards: Fuel gas pipe shall conform to one of the standards listed in Table M-803.2.

Table M-803.2
FUEL GAS PIPE

Material	Standard (see Chapter 21)
Aluminum-alloy pipe and tubing	ASTM B210; ASTM B241
Brass pipe	ASTM B43
Copper or copper-alloy pipe	ASTM B42; ASTM B302
Copper or copper-alloy tubing (Type K or L)	ASTM B75; ASTM B88; ASTM B280
Ductile iron pipe	ANSI A21.52
Plastic pipe and tubing	ASTM D2513; ASTM D2517
Stainless steel pipe and tubing	ASTM A240
Steel pipe	ASTM A53; ASTM A106
Steel tubing	ASTM A539; ASTM A254

M-803.3 Metallic pipe and tubing: Metallic pipe and tubing shall be utilized for systems which supply fuel gas that is not corrosive to the pipe or tubing material.

M-803.4 Aluminum-alloy pipe or tubing: Aluminum-alloy pipe or tubing shall not be installed underground or outside of the structure. The pipe or tubing shall not be subject to moisture or come in contact with masonry, plaster or insulation.

M-803.5 Plastic pipe and tubing: Plastic pipe and tubing shall not be installed above ground or inside of the structure.

M-803.6 Ductile iron pipe: Ductile iron pipe shall not be installed above ground or inside of the structure.

M-803.7 Corrosion protection: Metallic pipe or tubing exposed to corrosive action, such as soil conditions or moisture, shall be protected in an approved manner.

M-803.8 Fittings: Fittings shall be approved for gas piping systems. The fittings shall be compatible with or shall be of the same material as the pipe or tubing. Bushings shall not be utilized.

M-803.8.1 Flanges: Flange fittings shall conform to ASME B16.1 or ASME B16.5 listed in Chapter 21. Gasket material for flanged fittings shall be approved for the quality of the fuel gas.

M-803.9 Bending of piping: Pipe shall be approved for bending. Pipe bends shall be made with approved equipment. The bend shall not exceed the structural limitations of the pipe.

M-803.10 Flexible connectors: Flexible connectors shall bear the *label* of an approved agency. The connectors shall be a maximum of 6 feet (1829 mm) in length.

M-803.11 Interior gas piping systems utilizing corrugated stainless steel tubing (conduit): Interior gas piping systems constructed of corrugated stainless steel tubing (conduit) shall be tested and *labeled* by an approved testing agency for such installation and shall be installed in accordance with the manufacturer's instructions.

M-803.12 Identification: Fuel gas piping shall be identified as fuel gas piping. Identification shall be in the form of a tag, stencil or other permanent marking, spaced at intervals of not more than 25 feet (7620 mm) in concealed locations, not more than 50 feet (5240 mm) in exposed locations, and not less than once in any room or space.

SECTION M-804.0 JOINTS AND CONNECTIONS

M-804.1 Approval: All joints and connections shall be of an approved type for gas piping systems. Joints and connections shall be gas tight for the pressure required by test.

M-804.1.1 Joints between different piping materials: Joints between different piping materials shall be made with approved adapter fittings. Joints between different metallic piping materials at the point of delivery, and at other locations where necessary, shall be made with approved dielectric fittings to isolate electrically above-ground piping from underground piping or to isolate electrically different metallic piping materials joined underground.

M-804.2 Preparation of pipe ends: All pipe shall be cut square, reamed and chamfered and be free from all burrs and obstructions. Pipe ends shall have full-bore openings and shall not be undercut.

M-804.3 Joint preparation and installation: Where required by Sections M-804.4 through M-804.11, the preparation and installation of brazed, flared, *mechanical,* threaded and welded joints shall comply with Sections M-804.3.1 through M-804.3.5.

M-804.3.1 Brazed joints: All joint surfaces shall be cleaned. An approved flux shall be applied where required. The joint shall be brazed with a filler metal conforming to AWS A5.8 listed in Chapter 21.

M-804.3.2 Flared joints: Flared joints shall be made by a tool designed for that operation.

M-804.3.3 Mechanical joints: *Mechanical joints* shall be installed in accordance with the manufacturer's instructions.

M-804.3.4 Threaded joints: Threads shall conform to ASME B1.20.1 listed in Chapter 21. Pipe-joint compound or tape shall be applied on the male threads only.

M-804.3.5 Welded joints: All joint surfaces shall be cleaned by approved procedure. The joint shall be welded with an approved filler metal.

M-804.4 Aluminum-alloy pipe and tubing: Joints between aluminum-alloy pipe and tubing or fittings shall be flared or *mechanical joints* conforming to Section M-804.3.

M-804.5 Brass pipe: Joints between brass pipe or fittings shall be brazed, *mechanical,* threaded or welded joints conforming to Section M-804.3.

M-804.6 Copper or copper-alloy pipe: Joints between copper or copper-alloy pipe or fittings shall be brazed, *mechanical,* threaded or welded joints conforming to Section M-804.3.

M-804.7 Copper or copper-alloy tubing: Joints between copper or copper-alloy tubing or fittings shall be brazed, flared or *mechanical joints* conforming to Section M-804.3.

M-804.8 Ductile iron pipe: Joints between ductile iron pipe and fittings shall be flanged. Joints shall be installed in accordance with the manufacturer's instructions.

M-804.9 Plastic pipe and tubing: Joints between plastic pipe and tubing or fittings shall be in accordance with Sections M-804.9.1 through M-804.9.3.

M-804.9.1 Heat-fusion joints: Only polyolefin (PE and PB) piping shall be heat fused. Joint surfaces shall be clean and free from moisture. All joint surfaces shall be heated to melt temperature and joined. The joint shall be undisturbed until cool in accordance with the manufacturer's instructions.

M-804.9.2 Mechanical compression joints: *Mechanical compression joints* shall be made with an elastomeric seal. Joints shall be installed in accordance with the manufacturer's instructions.

M-804.9.3 Solvent cementing: Joint surfaces shall be clean and free from moisture. An approved primer shall be applied to PVC pipe, tubing or fittings. An approved solvent cement shall be applied to all joint surfaces. The joint shall be made while the cement is wet. Joints shall be made in accordance with the manufacturer's instructions. Polyolefin plastic pipe, tubing or fittings (PE and PB) shall not be solvent cemented.

M-804.10 Steel pipe: Joints between steel pipe or fittings shall be threaded or welded joints conforming to Section M-804.3 or *mechanical joints* conforming to Section M-804.10.1.

M-804.10.1 Mechanical joints: Joints shall be made with an approved elastomeric seal. *Mechanical joints* shall be installed in accordance with the manufacturer's instructions. *Mechanical joints* shall be installed outside, underground, unless otherwise approved.

M-804.11 Steel tubing: Joints between steel tubing or fittings shall be *mechanical* or welded joints conforming to Section M-804.3.

SECTION M-805.0 SIZING OF GAS PIPING SYSTEMS

M-805.1 General: All pipe utilized for the installation, extension and alteration of any gas piping system shall be sized to supply the full number of outlets for the intended purpose. The gas piping system shall be sized in accordance with this section.

M-805.2 Appliance gas volume: The hourly gas volume for each gas-burning *appliance* shall be determined based on the input rating of the *appliance*. The hourly gas volume (demand quantity) shall equal the input rating of the *appliance* divided by the average heating value of the fuel gas.

M-805.3 Sizing criteria: The fuel gas piping shall be sized for the maximum length of pipe, measured from the point of delivery to the most remote outlet. Piping shall be sized for the total gas demand for each section of pipe.

M-805.3.1 Diversity factor for multiple-family dwelling units: The common gas supply line to multiple-family dwelling units is permitted to be sized for a percentage of the total gas demand. The total gas demand for each common section of pipe shall be sized in accordance with the multiplier indicated in Table M-805.3.1.

Where individual heating equipment is installed in each dwelling unit, the gas demand for such equipment shall be multiplied by 0.9 and added to the demand value of the common piping.

Table M-805.3.1
DEMAND VALUES FOR DETERMINING GAS PIPING SIZE IN MULTIPLE-FAMILY DWELLING UNITS

Number of units	Multiplier of total connected load based on similar appliances being installed in each unit	
	Ranges only	Ranges and water heaters
2	.85	.77
4	.65	.59
6	.54	.49
8	.46	.44
10	.42	.40
15	.36	.34
20	.31	.30
30	.25	.24
40	.23	.22
50	.21	.20
60	.19	.19
70	.18	.18
80	.17	.16
90	.16	.15
100	.15	.14
125	.14	.14
150	.13	.13
175	.13	.12
200	.12	.11

M-805.4 Pipe sizing: The size of gas piping shall be determined by computing the maximum demand quantity in accordance with the following equation:

High Pressure (1.5 psig and above):

$$Q = 181.6 \sqrt{\frac{D^5 \cdot (P_1^2 - P_2^2) \cdot Y}{Cr \cdot fba \cdot L}}$$

$$= 2237\, D^{2.623} \left[\frac{(P_1^2 - P_2^2) \cdot Y}{Cr \cdot L} \right]^{0.541}$$

Low pressure (less than 1.5 psig):

$$Q = 187.3 \sqrt{\frac{D^5 \cdot \Delta H}{Cr \cdot fba \cdot L}}$$

$$= 2313\, D^{2.623} \left[\frac{\Delta H}{Cr \cdot L} \right]^{0.541}$$

where:

Q = Rate, cubic feet per hour at 60 degrees F. and 30-inch mercury column.
D = Inside diameter of pipe (inches).
P_1 = Upstream pressure (psia).
P_2 = Downstream pressure (psia).
Y = Superexpansibility factor.
= 1/supercompressibility factor.
Cr = Factor for viscosity, density and temperature.

$$= 0.00354\, ST \left(\frac{Z}{S} \right)^{.152}$$

S = Specific gravity of gas at 60 degrees F. and 30-inch mercury column.
T = Absolute temperature (degrees Rankine).
= t (degrees Fahrenheit) + 460.
t = Temperature (degrees Fahrenheit).

Z = Viscosity of gas, centipoise (0.012 for natural gas, 0.008 for propane).
= 1488 μ.
μ = Viscosity (pounds per second feet).
fba = Base friction factor for air at 60 degrees F. ($CF = 1$).
L = Length of pipe (feet).
ΔH = Pressure drop, inch water column (27.7 inch water column = 1 psi).

CF = Factor $CF = \left(\frac{fb}{fba}\right)$; and

fb = Base friction factor for any fluid at a given temperature (degrees F.).

M-805.4.1 Sizing by tables: Gas piping systems are permitted to be sized for the maximum capacity of pipe in accordance with Tables M-805.4.1(1) through M-805.4.1(16).

M-805.4.1.1 Basis for table selection: The table selected for sizing the system shall be based on the fuel-gas system pressure, the pressure drop, and the specific gravity.

M-805.4.1.2 Table application: The length utilized to compute the gas pipe size for a section of pipe shall equal the maximum length of pipe for the entire system. The tables take into consideration the normal installation of valves and fittings.

M-805.4.1.3 Specific gravity other than 0.60: Where the specific gravity of the gas is other than 0.60, the values in Tables M-805.4.1(1) through M-805.4.1(14) shall be multiplied by the applicable value from Table M-805.4.1.3.

M-805.5 Maximum design pressure: The maximum design operating pressure of a system inside the structure shall not exceed 5 psig (34 kPa) unless otherwise approved.

Exceptions

1. Industrial processing or heating structures.
2. Research structures.
3. Structures that exclusively contain *boilers* or mechanical equipment.
4. Where the piping system is welded steel pipe.
5. Where the piping is a temporary installation for structures under construction.

Table M-805.4.1.3
MULTIPLIERS FOR SPECIFIC GRAVITY OF THE GAS OTHER THAN 0.60

Specific gravity	Multiplier	Specific gravity	Multiplier
.35	1.31	1.00	.78
.40	1.23	1.10	.74
.45	1.16	1.20	.71
.50	1.10	1.30	.68
.55	1.04	1.40	.66
.60	1.00	1.50	.63
.65	.96	1.60	.61
.70	.93	1.70	.59
.75	.90	1.80	.58
.80	.87	1.90	.56
.85	.84	2.00	.55
.90	.82	2.10	.54

M-805.5.1 Liquefied petroleum gas systems: The maximum design operating pressure for undiluted LP-gas systems shall be 20 psig (138 kPa).

Exception: The minimum design operating pressure shall not apply to structures, or separate areas of structures, constructed in accordance with Chapter 7 of NFiPA 58 listed in Chapter 21, and which exclusively contain industrial processes, research and experimental laboratories, or equipment or processing having similar hazards.

SECTION M-806.0 GAS FLOW CONTROLS

M-806.1 Gas pressure regulators: A gas pressure regulator or gas equipment pressure regulator shall be installed where the gas *appliance* is designed to operate at a lower pressure than the fuel gas system. *Access* shall be provided to pressure regulators. Pressure regulators shall be protected from physical damage. Regulators installed on the exterior of the building shall be approved for outdoor installation.

M-806.1.1 Second stage LP-gas regulators: Second stage regulators for undiluted liquefied petroleum gas piping systems shall conform to UL 144 listed in Chapter 21.

Table M-805.4.1(1)
MAXIMUM CAPACITY OF PIPE FOR GAS PRESSURE OF 0.5 PSIG OR LESS WITH PRESSURE DROP OF 0.5 INCH WATER COLUMN AND 0.60 SPECIFIC GRAVITY

Pipe size of Schedule 40 standard pipe (inches)	Internal diameter (inches)	Pipe capacity (cubic feet of gas per hour)													
		Length of pipe (feet)													
		10	20	30	40	50	60	70	80	90	100	125	150	175	200
¼	.364	43	29	24	20	18	16	15	14	13	12	11	10	9	8
⅜	.493	95	65	52	45	40	36	33	31	29	27	24	22	20	19
½	.622	175	120	97	82	73	66	61	57	53	50	44	40	37	35
¾	.824	360	250	200	170	151	138	125	118	110	103	93	84	77	72
1	1.049	680	465	375	320	285	260	240	220	205	195	175	160	145	135
1¼	1.380	1,400	950	770	660	580	530	490	460	430	400	360	325	300	280
1½	1.610	2,100	1,460	1,180	990	900	810	750	690	650	620	550	500	460	430
2	2.067	3,950	2,750	2,200	1,900	1,680	1,520	1,400	1,300	1,220	1,150	1,020	950	850	800
2½	2.469	6,300	4,350	3,520	3,000	2,650	2,400	2,250	2,050	1,950	1,850	1,650	1,500	1,370	1,280
3	3.068	11,000	7,700	6,250	5,300	4,750	4,300	3,900	3,700	3,450	3,250	2,950	2,650	2,450	2,280
4	4.026	23,000	15,800	12,800	10,900	9,700	8,800	8,100	7,500	7,200	6,700	6,000	5,500	5,000	4,600

Table M-805.4.1(2)
MAXIMUM CAPACITY OF PIPE FOR GAS PRESSURE OF 0.5 PSIG OR LESS WITH PRESSURE DROP OF 0.3 INCH WATER COLUMN AND 0.60 SPECIFIC GRAVITY

Pipe size of Schedule 40 standard pipe (inches)	Internal diameter (inches)	Pipe capacity (cubic feet of gas per hour)													
		Length of pipe (feet)													
		10	20	30	40	50	60	70	80	90	100	125	150	175	200
1/4	.364	32	22	18	15	14	12	11	11	10	9	8	8	7	6
3/8	.493	72	49	40	34	30	27	25	23	22	21	18	17	15	14
1/2	.622	132	92	73	63	56	50	46	43	40	38	34	31	28	26
3/4	.824	278	190	152	130	115	105	96	90	84	79	72	64	59	55
1	1.049	520	350	285	245	215	195	180	170	160	150	130	120	110	100
1 1/4	1.380	1,050	730	590	500	440	400	370	350	320	305	275	250	225	210
1 1/2	1.610	1,600	1,100	890	760	670	610	560	530	490	460	410	380	350	320
2	2.067	3,050	2,100	1,650	1,450	1,270	1,150	1,050	990	930	870	780	710	650	610
2 1/2	2.469	4,800	3,300	2,700	2,300	2,000	1,850	1,700	1,600	1,500	1,400	1,250	1,130	1,050	980
3	3.068	8,500	5,900	4,700	4,100	3,600	3,250	3,000	2,800	2,600	2,500	2,200	2,000	1,850	1,700
4	4.026	17,500	12,000	9,700	8,300	7,400	6,800	6,200	5,800	5,400	5,100	4,500	4,100	3,800	3,500

Table M-805.4.1(3)
MAXIMUM CAPACITY OF SEMI-RIGID TUBING FOR GAS PRESSURE OF 0.5 PSIG OR LESS WITH PRESSURE DROP OF 0.3 INCH WATER COLUMN AND 0.60 SPECIFIC GRAVITY

Outside diameter (inch)	Tubing capacity (cubic feet of gas per hour)													
	Length of tubing (feet)													
	10	20	30	40	50	60	70	80	90	100	125	150	175	200
3/8	20	14	11	10	9	8	7	7	6	6	5	5	4	4
1/2	42	29	23	20	18	16	15	14	13	12	11	10	9	8
5/8	86	59	47	40	36	33	30	28	26	25	22	20	18	17
3/4	150	103	83	71	63	57	52	49	46	43	38	35	32	30
7/8	212	146	117	100	89	81	74	69	65	61	54	49	45	42

Table M-805.4.1(4)
MAXIMUM CAPACITY OF SEMI-RIGID TUBING FOR GAS PRESSURE OF 0.5 PSIG OR LESS WITH PRESSURE DROP OF 0.5 INCH WATER COLUMN AND 0.60 SPECIFIC GRAVITY

Outside diameter (inch)	Tubing capacity (cubic feet of gas per hour)													
	Length of tubing (feet)													
	10	20	30	40	50	60	70	80	90	100	125	150	175	200
3/8	27	18	15	13	11	10	9	9	8	8	7	6	6	5
1/2	56	38	31	26	23	21	19	18	17	16	14	13	12	11
5/8	113	78	62	53	47	43	39	37	34	33	29	26	24	22
3/4	197	136	109	93	83	75	69	64	60	57	50	46	42	39
7/8	280	193	155	132	117	106	98	91	85	81	71	65	60	55

Table M-805.4.1(5)
PIPE SIZING TABLE FOR PRESSURES UNDER 1 POUND APPROXIMATE CAPACITY OF PIPES WITH PRESSURE DROP OF 0.3 INCH WATER COLUMN AND 0.60 SPECIFIC GRAVITY

Pipe size of Schedule 40 standard pipe (inches)	Internal diameter (inches)	Pipe capacity (cubic feet of gas per hour)										
		Total equivalent length of pipe (feet)										
		50	100	150	200	250	300	400	500	1,000	1,500	2,000
1.00	1.049	215	148	119	102	90	82	70	62	43	34	29
1.25	1.380	442	304	244	209	185	168	143	127	87	70	60
1.50	1.610	662	455	366	313	277	251	215	191	131	105	90
2.00	2.067	1,275	877	704	602	534	484	414	367	252	203	173
2.50	2.469	2,033	1,397	1,122	960	851	771	660	585	402	323	276
3.00	3.068	3,594	2,470	1,983	1,698	1,505	1,363	1,167	1,034	711	571	488
3.50	3.548	5,262	3,616	2,904	2,485	2,203	1,996	1,708	1,514	1,041	836	715
4.00	4.026	7,330	5,038	4,046	3,462	3,069	2,780	2,380	2,109	1,450	1,164	995
5.00	5.047	13,261	9,114	7,319	6,264	5,552	5,030	4,305	3,816	2,623	2,106	1,802
6.00	6.065	21,472	14,758	11,851	10,143	8,990	8,145	6,971	6,178	4,246	3,410	2,919
8.00	7.981	44,118	30,322	24,350	20,840	18,470	16,735	14,323	12,694	8,725	7,006	5,997
10.00	10.020	80,130	55,073	44,225	37,851	33,547	30,396	26,015	23,056	15,847	12,725	10,891
12.00	11.938	126,855	87,187	70,014	59,923	53,109	48,120	41,185	36,501	25,087	20,146	17,242

Table M-805.4.1(6)
PIPE SIZING TABLE FOR PRESSURES UNDER 1 POUND APPROXIMATE CAPACITY OF PIPES WITH PRESSURE DROP OF 0.5 INCH WATER COLUMN AND 0.60 SPECIFIC GRAVITY

Pipe size of Schedule 40 standard pipe (inches)	Internal diameter (inches)	Pipe capacity (cubic feet of gas per hour)										
		Total equivalent length of pipe (feet)										
		50	100	150	200	250	300	400	500	1,000	1,500	2,000
1.00	1.049	284	195	157	134	119	108	92	82	56	45	39
1.25	1.380	583	400	322	275	244	221	189	168	115	93	79
1.50	1.610	873	600	482	412	366	331	283	251	173	139	119
2.00	2.067	1,681	1,156	928	794	704	638	546	484	333	267	229
2.50	2.469	2,680	1,842	1,479	1,266	1,122	1,017	870	771	530	426	364
3.00	3.068	4,738	3,256	2,615	2,238	1,983	1,797	1,538	1,363	937	752	644
3.50	3.548	6,937	4,767	3,828	3,277	2,904	2,631	2,252	1,996	1,372	1,102	943
4.00	4.026	9,663	6,641	5,333	4,565	4,046	3,666	3,137	2,780	1,911	1,535	1,313
5.00	5.047	17,482	12,015	9,649	8,258	7,319	6,632	5,676	5,030	3,457	2,776	2,376
6.00	6.065	28,308	19,456	15,624	13,372	11,851	10,738	9,190	8,145	5,598	4,496	3,848
8.00	7.981	58,161	39,974	32,100	27,474	24,350	22,062	18,883	16,735	11,502	9,237	7,905
10.00	10.020	105,636	72,603	58,303	49,900	44,225	40,071	34,296	30,396	20,891	16,776	14,358
12.00	11.938	167,236	114,940	92,301	78,998	70,014	63,438	54,295	48,120	33,073	26,559	22,731

Table M-805.4.1(7)
PIPE SIZING TABLE FOR PRESSURES UNDER 1 POUND PRESSURE CAPACITY OF PIPES FOR AN INITIAL PRESSURE OF 1.0 PSIG WITH A 10-PERCENT PRESSURE DROP AND A GAS OF 0.60 SPECIFIC GRAVITY

Pipe size of Schedule 40 standard pipe (inches)	Internal diameter (inches)	Pipe capacity (cubic feet of gas per hour)										
		Total equivalent length of pipe (feet)										
		50	100	150	200	250	300	400	500	1,000	1,500	2,000
1.00	1.049	717	493	396	338	300	272	233	206	142	114	97
1.25	1.380	1,471	1,011	812	695	616	558	478	423	291	234	200
1.50	1.610	2,204	1,515	1,217	1,041	923	836	716	634	436	350	300
2.00	2.067	4,245	2,918	2,343	2,005	1,777	1,610	1,378	1,222	840	674	577
2.50	2.469	6,766	4,651	3,735	3,196	2,833	2,567	2,197	1,947	1,338	1,075	920
3.00	3.068	11,962	8,221	6,602	5,650	5,008	4,538	3,884	3,442	2,366	1,900	1,626
3.50	3.548	17,514	12,037	9,666	8,273	7,332	6,644	5,686	5,039	3,464	2,781	2,381
4.00	4.026	24,398	16,769	13,466	11,525	10,214	9,255	7,921	7,020	4,825	3,875	3,316
5.00	5.047	44,140	30,337	24,362	20,851	18,479	16,744	14,330	12,701	8,729	7,010	6,000
6.00	6.065	71,473	49,123	39,447	33,762	29,923	27,112	23,204	20,566	14,135	11,351	9,715
8.00	7.981	146,849	100,929	81,049	69,368	61,479	55,705	47,676	42,254	29,041	23,321	19,960
10.00	10.020	266,718	183,314	147,207	125,990	111,663	101,175	86,592	76,745	52,747	42,357	36,252
12.00	11.938	422,248	290,209	233,048	199,459	176,777	160,172	137,087	121,498	83,505	67,057	57,392

Table M-805.4.1(8)
PIPE SIZING TABLE FOR 2 POUNDS PRESSURE CAPACITY OF PIPES FOR AN INITIAL PRESSURE OF 2.0 PSIG WITH A 10-PERCENT PRESSURE DROP AND A GAS OF 0.60 SPECIFIC GRAVITY

Pipe size of Schedule 40 standard pipe (inches)	Internal diameter (inches)	Pipe capacity (cubic feet of gas per hour)										
		Total equivalent length of pipe (feet)										
		50	100	150	200	250	300	400	500	1,000	1,500	2,000
1.00	1.049	1,112	764	614	525	466	422	361	320	220	177	151
1.25	1.380	2,283	1,569	1,260	1,079	956	866	741	657	452	363	310
1.50	1.610	3,421	2,351	1,888	1,616	1,432	1,298	1,111	984	677	543	465
2.00	2.067	6,589	4,528	3,636	3,112	2,758	2,499	2,139	1,896	1,303	1,046	896
2.50	2.469	10,501	7,217	5,796	4,961	4,396	3,983	3,409	3,022	2,077	1,668	1,427
3.00	3.068	18,564	12,759	10,246	8,769	7,772	7,042	6,027	5,342	3,671	2,948	2,523
3.50	3.548	27,181	18,681	15,002	12,840	11,379	10,311	8,825	7,821	5,375	4,317	3,694
4.00	4.026	37,865	26,025	20,899	17,887	15,853	14,364	12,293	10,895	7,488	6,013	5,147
5.00	5.047	68,504	47,082	37,809	32,359	28,680	25,986	22,240	19,711	13,547	10,879	9,311
6.00	6.065	110,924	76,237	61,221	52,397	46,439	42,077	36,012	31,917	21,936	17,616	15,077
8.00	7.981	227,906	156,638	125,786	107,657	95,414	86,452	73,992	65,578	45,071	36,194	30,977
10.00	10.020	413,937	284,497	228,461	195,533	173,297	157,020	134,389	119,106	81,861	65,737	56,263
12.00	11.938	655,315	450,394	361,682	309,553	274,351	248,582	212,754	188,560	129,596	104,070	89,071

Table M-805.4.1(9)
PIPE SIZING TABLE FOR 2 POUNDS PRESSURE CAPACITY OF PIPES OR TUBING FROM POINT OF DELIVERY TO 2 PSIG REGULATOR, BASED ON A PRESSURE DROP OF 1.5 PSI AND A GAS OF 0.65 SPECIFIC GRAVITY[a]

Tubing diameter inside (OD) (inches)	Pipe capacity (cubic feet of gas per hour)																	
	Length of tubing (feet)																	
	5	10	15	20	30	40	50	60	70	80	90	100	125	150	175	200	250	300
¼ (⅜)	540	360	285	240	192	163	143	130	118	110	102	96	85	76	69	64	58	51
⅜ (½)	1,260	850	670	570	450	380	335	300	275	255	240	225	198	178	164	146	140	120
½ (⅝)	2,400	1,630	1,280	1,080	860	730	645	580	530	490	460	430	380	340	315	290	255	230
⅝ (¾)	4,150	2,780	2,150	1,860	1,480	1,250	1,100	1,000	910	850	790	740	650	585	540	500	440	395
¾ (⅞)	6,500	4,350	3,450	2,950	2,300	2,000	1,750	1,560	1,430	1,330	1,230	1,160	1,025	920	845	780	690	620
1 (1⅛)	10,500	7,600	6,200	5,400	4,400	3,800	3,350	3,050	2,800	2,650	2,500	2,350	2,100	1,900	1,800	1,700	1,500	1,350
1¼ (1⅜)	21,000	15,000	12,000	10,500	8,600	7,500	6,700	6,100	5,600	5,200	4,900	4,700	4,150	3,800	3,550	3,300	2,950	2,700
1½ (1⅝)	31,000	22,000	18,000	15,000	13,000	11,000	9,800	9,000	8,200	7,700	7,200	6,800	6,100	5,600	5,200	4,900	4,300	4,000
2 (2⅛)	58,000	41,000	34,000	29,000	24,000	20,000	18,000	17,000	15,000	14,000	13,500	12,500	11,300	10,400	9,700	9,000	8,100	7,400
2½ (2⅝)	90,000	64,000	52,000	45,000	36,000	32,000	28,000	26,000	24,000	22,000	21,000	20,000	18,000	16,000	15,500	14,000	12,500	11,500
3 (3⅛)	150M	110M	90,000	79,000	63,000	55,000	49,000	45,000	41,000	38,000	36,000	34,500	31,000	28,000	26,000	24,000	22,000	19,000
4 (4⅛)	310M	220M	180M	150M	125M	110M	97,000	90,000	82,000	77,000	72,000	70,000	62,000	56,000	53,000	49,000	44,000	40,000

Note a. Use this table when metering or reduced pressure is 2 psig. Minimum inlet pressure to pounds-to-inches regulator will be ½ pound or 14 inches.

Table M-805.4.1(10)
PIPE SIZING TABLE FOR 2 POUNDS PRESSURE CAPACITY OF PIPES OR TUBING FROM 2 PSIG REGULATOR TO APPLIANCE, BASED ON A PRESSURE DROP OF 1 INCH WATER COLUMN AND A GAS OF 0.65 SPECIFIC GRAVITY[a]

Tubing diameter inside (OD) (inches)	Pipe capacity (cubic feet of gas per hour)																	
	Length of tubing (feet)																	
	5	10	15	20	30	40	50	60	70	80	90	100	125	150	175	200	250	300
¼ (⅜)	62	42	33	28	22	19	16	15	14	13	12	11	10	9	8	7	6	6
⅜ (½)	145	96	76	66	52	44	39	35	32	30	28	26	23	21	19	18	16	14
½ (⅝)	280	187	148	126	100	84	74	67	61	57	53	50	44	39	36	34	30	26
⅝ (¾)	475	320	252	215	170	145	129	115	105	97	91	86	76	68	62	58	51	45
¾ (⅞)	750	500	395	335	265	225	200	180	165	153	142	134	118	106	97	90	79	71
1 (1⅛)	1,080	760	620	520	440	380	345	315	290	270	255	240	215	195	180	170	150	140
1¼ (1⅜)	2,200	1,550	1,300	1,100	900	795	700	640	600	560	520	500	450	410	380	355	315	285
1½ (1⅝)	3,450	2,450	2,000	1,700	1,400	1,200	1,100	1,000	920	860	810	770	690	620	580	540	490	445
2 (2⅛)	7,000	4,950	4,000	3,450	2,850	2,500	2,200	2,000	1,850	1,750	1,650	1,580	1,400	1,290	1,190	1,100	980	900
2½ (2⅝)	11,200	8,000	6,500	5,600	4,600	4,000	3,550	3,250	3,000	2,800	2,650	2,500	2,250	2,050	1,900	1,780	1,600	1,460
3 (3⅛)	20,000	14,200	11,500	10,000	8,300	7,200	6,350	5,800	5,400	5,050	4,750	4,500	4,000	3,650	3,400	3,200	2,850	2,600
4 (4⅛)	42,000	29,500	24,000	21,000	17,000	14,500	13,000	12,000	11,000	10,400	9,700	9,300	8,400	7,600	7,000	6,600	5,900	5,400

Note a. Use this table when metering or reducing pressure is 6 inches water column.

Table M-805.4.1(11)
PIPE SIZING TABLE FOR 5 POUNDS PRESSURE CAPACITY OF PIPES FOR AN INITIAL PRESSURE OF 5.0 PSIG WITH A 10-PERCENT PRESSURE DROP AND A GAS OF 0.60 SPECIFIC GRAVITY

Pipe size of Schedule 40 standard pipe (inches)	Internal diameter (inches)	Pipe capacity (cubic feet of gas per hour)										
		Total equivalent length of pipe (feet)										
		50	100	150	200	250	300	400	500	1,000	1,500	2,000
1.00	1.049	1,989	1,367	1,098	940	833	755	646	572	393	316	270
1.25	1.380	4,084	2,807	2,254	1,929	1,710	1,549	1,326	1,175	808	649	555
1.50	1.610	6,120	4,206	3,378	2,891	2,562	2,321	1,987	1,761	1,210	972	832
2.00	2.067	11,786	8,101	6,505	5,567	4,934	4,471	3,827	3,391	2,331	1,872	1,602
2.50	2.469	18,785	12,911	10,368	8,874	7,865	7,126	6,099	5,405	3,715	2,983	2,553
3.00	3.068	33,209	22,824	18,329	15,687	13,903	12,597	10,782	9,556	6,568	5,274	4,514
3.50	3.548	48,623	33,418	26,836	22,968	20,356	18,444	15,786	13,991	9,616	7,722	6,609
4.00	4.026	67,736	46,555	37,385	31,997	28,358	25,694	21,991	19,490	13,396	10,757	9,207
5.00	5.047	122,544	84,224	67,635	57,887	51,304	46,485	39,785	35,261	24,235	19,461	16,656
6.00	6.065	198,427	136,378	109,516	93,732	83,073	75,270	64,421	57,095	39,241	31,512	26,970
8.00	7.981	407,692	280,204	225,014	192,583	170,683	154,651	132,361	117,309	80,626	64,745	55,414
10.00	10.020	740,477	508,926	408,686	349,782	310,005	280,887	240,403	213,065	146,438	117,595	100,646
12.00	11.938	1,172,269	805,694	647,001	553,749	490,777	444,680	380,588	337,309	231,830	186,168	159,336

Table M-805.4.1(12)
PIPE SIZING TABLE FOR 10 POUNDS PRESSURE CAPACITY OF PIPES FOR AN INITIAL PRESSURE OF 10.0 PSIG WITH A 10-PERCENT PRESSURE DROP AND A GAS OF 0.60 SPECIFIC GRAVITY

Pipe size of Schedule 40 standard pipe (inches)	Internal diameter (inches)	Pipe capacity (cubic feet of gas per hour)										
		Total equivalent length of pipe (feet)										
		50	100	150	200	250	300	400	500	1,000	1,500	2,000
1.00	1.049	3,259	2,240	1,798	1,539	1,364	1,236	1,058	938	644	517	443
1.25	1.380	6,690	4,598	3,692	3,160	2,801	2,538	2,172	1,925	1,323	1,062	909
1.50	1.610	10,024	6,889	5,532	4,735	4,197	3,802	3,254	2,884	1,982	1,592	1,362
2.00	2.067	19,305	13,268	10,655	9,119	8,082	7,323	6,268	5,555	3,818	3,066	2,624
2.50	2.469	30,769	21,148	16,982	14,535	12,882	11,672	9,990	8,854	6,085	4,886	4,182
3.00	3.068	54,395	37,385	30,022	25,695	22,773	20,634	17,660	15,652	10,757	8,638	7,393
3.50	3.548	79,642	54,737	43,956	37,621	33,343	30,211	25,857	22,916	15,750	12,648	10,825
4.00	4.026	110,948	76,254	61,235	52,409	46,449	42,086	36,020	31,924	21,941	17,620	15,080
5.00	5.047	200,720	137,954	110,782	94,815	84,033	76,140	65,166	57,755	39,695	1,875	27,282
6.00	6.065	325,013	223,379	179,382	153,527	136,068	123,288	105,518	93,519	64,275	51,615	44,176
8.00	7.981	667,777	458,959	368,561	315,440	279,569	253,310	216,800	192,146	132,061	106,050	90,765
10.00	10.020	1,212,861	833,593	669,404	572,924	507,772	460,078	393,767	348,988	239,858	192,614	164,853
12.00	11.938	1,920,112	1,319,682	1,059,751	907,010	803,866	728,361	623,383	552,493	379,725	304,933	260,980

Table M-805.4.1(13)
PIPE SIZING TABLE FOR 20 POUNDS PRESSURE CAPACITY OF PIPES FOR AN INITIAL PRESSURE OF 20.0 PSIG WITH A 10-PERCENT PRESSURE DROP AND A GAS OF 0.60 SPECIFIC GRAVITY

Pipe size of Schedule 40 standard pipe (inches)	Internal diameter (inches)	Pipe capacity (cubic feet of gas per hour)										
		Total equivalent length of pipe (feet)										
		50	100	150	200	250	300	400	500	1,000	1,500	2,000
1.00	1.049	5,674	3,900	3,132	2,680	2,375	2,152	1,842	1,633	1,122	901	771
1.25	1.380	11,649	8,006	6,429	5,503	4,877	4,419	3,782	3,352	2,304	1,850	1,583
1.50	1.610	17,454	11,996	9,633	8,245	7,307	6,621	5,667	5,022	3,452	2,772	2,372
2.00	2.067	33,615	23,103	18,553	15,879	14,073	12,751	10,913	9,672	6,648	5,338	4,569
2.50	2.469	53,577	36,823	29,570	25,308	22,430	20,323	17,394	15,416	10,595	8,509	7,282
3.00	3.068	94,714	65,097	52,275	44,741	39,653	35,928	30,750	27,253	18,731	15,042	12,874
3.50	3.548	138,676	95,311	76,538	65,507	58,058	52,604	45,023	39,903	27,425	22,023	18,849
4.00	4.026	193,187	132,777	106,624	91,257	80,879	73,282	62,720	55,538	38,205	30,680	26,258
5.00	5.047	349,503	240,211	192,898	165,096	146,322	132,578	113,470	100,566	69,118	55,505	47,505
6.00	6.065	565,926	388,958	312,347	267,329	236,928	214,674	183,733	162,840	111,919	89,875	76,921
8.00	7.981	1,162,762	799,160	641,754	549,258	486,797	441,074	377,502	334,573	229,950	184,658	158,048
10.00	10.020	2,111,887	1,451,488	1,165,596	997,600	884,154	801,108	685,645	607,674	417,651	335,388	287,049
12.00	11.938	3,343,383	2,297,888	1,845,285	1,579,326	1,399,727	1,268,254	1,085,462	962,025	661,194	530,962	454,435

Table M-805.4.1(14)
PIPE SIZING TABLE FOR 50 POUNDS PRESSURE CAPACITY OF PIPES FOR AN INITIAL PRESSURE OF 50.0 PSIG WITH A 10-PERCENT PRESSURE DROP AND A GAS OF 0.60 SPECIFIC GRAVITY

Pipe size of Schedule 40 standard pipe (inches)	Internal diameter (inches)	Pipe capacity (cubic feet of gas per hour)										
		Total equivalent length of pipe (feet)										
		50	100	150	200	250	300	400	500	1,000	1,500	2,000
1.00	1.049	12,993	8,930	7,171	6,138	5,440	4,929	4,218	3,739	2,570	2,063	1,766
1.25	1.380	26,676	18,335	14,723	12,601	11,168	10,119	8,661	7,676	5,276	4,236	3,626
1.50	1.610	39,970	27,471	22,060	18,881	16,733	15,162	12,976	11,501	7,904	6,348	5,433
2.00	2.067	76,977	52,906	42,485	36,362	32,227	29,200	24,991	22,149	15,223	12,225	10,463
2.50	2.469	122,690	84,324	67,715	57,955	51,365	46,540	39,832	35,303	24,263	19,484	16,676
3.00	3.068	216,893	149,070	119,708	102,455	90,804	82,275	70,417	62,409	42,893	34,445	29,480
3.50	3.548	317,564	218,260	175,271	150,009	132,950	120,463	103,100	91,376	62,802	50,432	43,164
4.00	4.026	442,393	304,054	244,166	208,975	185,211	167,814	143,627	127,294	87,489	70,256	60,130
5.00	5.047	800,352	550,077	441,732	378,065	335,072	303,600	259,842	230,293	158,279	127,104	108,784
6.00	6.065	1,295,955	890,703	715,266	612,175	542,559	491,598	420,744	372,898	256,291	205,810	176,147
8.00	7.981	2,662,693	1,830,054	1,469,598	1,257,785	1,114,752	1,010,046	864,469	766,163	526,579	422,862	361,915
10.00	10.020	4,836,161	3,323,866	2,669,182	2,284,474	2,024,687	1,834,514	1,570,106	1,391,556	956,409	768,030	657,334
12.00	11.938	7,656,252	5,262,099	4,225,651	3,616,611	3,205,335	2,904,266	2,485,676	2,203,009	1,514,115	1,215,888	1,040,843

Table M-805.4.1(15)
MAXIMUM CAPACITY OF PIPE FOR UNDILUTED LIQUEFIED PETROLEUM GASES AT 11 INCHES WATER COLUMN INLET PRESSURE BASED ON A PRESSURE DROP OF 0.5 INCH WATER COLUMN

Nominal iron pipe size (inches)	Pipe capacity (thousands of Btu per hour)											
	Length of pipe (feet)											
	10	20	30	40	50	60	70	80	90	100	125	150
½	275	189	152	129	114	103	96	89	83	78	69	63
¾	567	393	315	267	237	217	196	185	173	162	146	132
1	1,071	732	590	504	448	409	378	346	322	307	275	252
1¼	2,205	1,496	1,212	1,039	913	834	771	724	677	630	567	511
1½	3,307	2,299	1,858	1,559	1,417	1,275	1,181	1,086	1,023	976	866	787
2	6,221	4,331	3,465	2,992	2,646	2,394	2,205	2,047	1,921	1,811	1,606	1,496

Table M-805.4.1(16)
MAXIMUM CAPACITY OF SEMI-RIGID TUBING FOR UNDILUTED LIQUEFIED PETROLEUM GASES AT 11 INCHES WATER COLUMN INLET PRESSURE BASED ON A PRESSURE DROP OF 0.5 INCH WATER COLUMN

Outside diameter (inch)	Tubing capacity (thousands of Btu per hour)									
	Length of tubing (feet)									
	10	20	30	40	50	60	70	80	90	100
⅜	39	26	21	19	—	—	—	—	—	—
½	92	62	50	41	37	35	31	29	27	26
⅝	199	131	107	90	79	72	67	62	59	55
¾	329	216	181	145	131	121	112	104	95	90
⅞	501	346	277	233	198	187	164	155	146	138

M-806.2 Venting of regulators: Gas pressure regulators that require a vent shall have an independent vent to the outside of the building. The vent shall be designed to prevent the entry of water or foreign objects.

Exception: A vent to the outside of the building is not required for second stage regulators equipped with and *labeled* for utilization with approved vent-limiting devices.

SECTION M-807.0 UNDERGROUND GAS PIPING

M-807.1 Clearance: Underground gas piping shall be installed to allow proper maintenance and to protect against contact or damage resulting from proximity to other structures. Underground plastic piping shall be installed with sufficient clearance from any source of heat.

M-807.2 Minimum depth: Underground piping systems shall be installed a minimum depth of 18 inches (457 mm) below grade except as provided for in Section M-807.2.1.

M-807.2.1 Individual outside appliances: Individual gas lines to outside lights, grills or other *appliances* shall be installed a minimum of 8 inches (203 mm) below grade provided that such installation is approved and is installed in locations not susceptible to physical damage.

M-807.2.2 Protection of footings: Trenching installed parallel to footings shall not extend below the line of a 45-degree (0.79 rad) angle downward from the loadbearing plane of the footing, and shall conform to the requirements of the building code listed in Chapter 21.

M-807.3 Protection against corrosion: Gas piping in contact with material that will corrode the piping shall be protected in an approved manner. Where dissimilar metals are joined underground, dielectric fittings or couplings shall be installed.

M-807.4 Connection of plastic piping: Connections between metallic and plastic piping shall only be made outside, underground, with approved fittings. Where plastic pipe is connected to rigidly held fittings, a protective sleeve complying with the manufacturer's instructions shall be installed.

M-807.5 Piping through foundation walls: Where installed below grade through the outer foundation or basement wall of a structure, underground piping shall be encased in an approved sleeve. The annular space between the gas piping and the sleeve shall be sealed at the foundation or basement wall to prevent entry of gas or water.

M-807.6 Flood hazard: All underground piping located in a flood-hazard zone (A Zone) or a high-hazard zone (V Zone) shall be capable of resisting hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, during the occurrence of flooding to the base flood elevation.

M-807.7 Tracer for plastic piping: An insulated copper tracer wire or other approved conductor shall be installed adjacent to underground nonmetallic gas piping. *Access* shall be provided to the tracer wire or the tracer wire shall terminate above ground at each end of the nonmetallic gas piping. The tracer wire size shall not be less than 18 AWG and the insulation type shall be suitable for direct burial.

Exception: A tracer wire is not required for individual gas lines to outside lights and grills installed in accordance with Section M-807.2.1.

SECTION M-808.0 OUTSIDE ABOVE-GROUND PIPING

M-808.1 General: Piping installed outside above ground shall be securely supported and protected from physical damage. Pipe shall not be laid on the ground surface where subject to mechanical injury.

M-808.2 Flood hazard: All outside above-ground piping located in a flood-hazard zone (A Zone) or a high-hazard zone (V Zone) shall be anchored and reinforced so that the piping is capable of resisting hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, and loads resulting from water-borne debris during the occurrence of flooding to the base flood elevation.

SECTION M-809.0 INSIDE BUILDING GAS PIPING

M-809.1 Stresses and strains: Gas piping shall be installed so as to prevent strains and stresses which exceed the structural strength of the pipe. Provisions shall be made to protect the piping from damage resulting from expansion, contraction and structural settlement.

Piping shall be installed so as not to create structural stresses or strains within building components.

M-809.2 Piping for other than dry gas: Piping for other than dry gas shall be sloped not less than ¼ inch in 15 feet (1:720). Horizontal lines shall slope upward to the risers and upward from the risers to the meter, the service regulator or the equipment. Drips shall be provided at such points to act as storage for condensate. *Access* shall be provided to drips. A drip shall not be located where the condensate will freeze.

M-809.2.1 Branch connections: All branch connections shall be made on the top or side of horizontal lines.

M-809.3 Prohibited locations: Gas piping shall not be run in or through supply air ducts, clothes chutes, chimneys, *vents*, dumbwaiters or elevator shafts.

M-809.3.1 Air plenums: Valves shall not be located in any air plenum.

M-809.4 Piping in concealed locations: Portions of a gas piping system installed in concealed locations shall not have unions, tubing fittings or running threads.

M-809.5 Protection against physical damage: In concealed locations, where gas piping other than black or galvanized steel is installed through holes or notches in wood studs, joists, rafters or similar members less than 1¼ inches (32 mm) from the nearest edge of the member, the pipe shall be protected by shield plates. Shield plates shall be a minimum of 1/16-inch-thick (2 mm) steel, shall cover the area of the pipe where the member is notched or bored, and shall extend a minimum of 4 inches (102 mm) above sole plates, below top plates and to each side of a stud, joist or rafter.

M-809.6 Concrete slabs: Gas piping embedded in concrete slabs shall be surrounded with a minimum of 1½ inches (38 mm) of concrete. The pipe shall not be in contact with any metal. The slab concrete shall not contain quickset additives or cinder aggregate.

M-809.7 Cutting or notching: A structural member shall not be cut, notched or pierced in excess of the limitations specified in the building code listed in Chapter 21, unless proven safe by a structural analysis.

SECTION M-810.0 HANGERS AND SUPPORTS

M-810.1 Hanger material: Hangers and supports shall be of material of sufficient strength to support the piping. Hangers and strapping material shall be of similar material as the piping to avoid galvanic action.

M-810.2 Interval of support: Gas piping shall be supported at intervals not exceeding the spacing specified in Table M-810.2.

Table M-810.2
HANGER SPACING

Material	Maximum spacing (feet)[a]
Rigid pipe, ¾-inch diameter and under	10
Rigid pipe, 1-inch diameter and over	12
Tubing, 1¼-inch diameter and under	6
Tubing, 1½-inch diameter and over	10

Note a. 1 foot = 304.8 mm.

SECTION M-811.0 SHUTOFF VALVES

M-811.1 Valve approval: Shutoff valves shall be of an approved type. Shutoff valves shall be constructed with materials compatible with the gas piping.

M-811.2 Exterior shutoff: An exterior shutoff valve shall be provided for each structure.

M-811.3 Meter valve: Every meter shall be equipped with a shutoff valve located on the supply side of the meter.

M-811.4 Appliance connection: Every gas outlet shall have an individual shutoff valve. The shutoff valve shall be adjacent to the *appliance*. *Access* shall be provided to the shutoff valve.

SECTION M-812.0 OUTLETS AND CONNECTIONS

M-812.1 Gas connections: Gas *appliances* and equipment shall be connected by rigid pipe, tubing or flexible connectors. A union shall be installed between the *appliance* and the *appliance* shutoff valve.

M-812.2 Capped outlets: Gas outlets that do not connect to *appliances* shall be capped gas tight.

SECTION M-813.0 GAS-DISPENSING SYSTEMS

M-813.1 Dispenser protection: The gas dispenser shall have an emergency switch to shut off the power to the dispenser. An approved backflow device that prevents the reverse flow of gas shall be installed on the gas supply pipe or in the gas dispenser.

M-813.2 Ventilation: Gas-dispensing systems installed inside the structure shall be *ventilated* by mechanical means in accordance with Section M-1604.0.

M-813.3 Compressed natural gas vehicular fuel systems: Compressed natural gas (CNG) fuel-dispensing systems for CNG vehicles shall be designed and installed in accordance with NFiPA 52 listed in Chapter 21.

SECTION M-814.0 SUPPLEMENTAL AND STANDBY GAS SUPPLY

M-814.1 Special supplementary gas: Where air, oxygen or other special supplementary gas is introduced into the gas piping

system, an approved backflow preventer shall be installed. The backflow preventer shall be on the gas line to the equipment supplied by the special gas and located between the source of the special gas and the gas meter.

M-814.2 Standby gas: Where LP-gas or other standby gas is interconnected with regular gas piping systems, an approved three-way, two-port valve or other approved safeguard shall be installed to prevent backflow into either supply system.

SECTION M-815.0 TESTING

M-815.1 General: The gas piping shall be tested and inspected in accordance with NFiPA 54 listed in Chapter 21.

*

SECTION M-816.0 PURGING GAS PIPING

M-816.1 General: Gas piping systems shall be purged in accordance with NFiPA 54 listed in Chapter 21.

CHAPTER 9

FLAMMABLE AND COMBUSTIBLE LIQUID STORAGE AND PIPING SYSTEMS

SECTION M-901.0 GENERAL

M-901.1 Scope: This chapter shall govern the design, installation, construction and repair of *flammable* and *combustible liquid* storage and piping systems, including fuel oil piping, except where such work is governed by the fire prevention code listed in Chapter 21.

M-901.2 Storage systems: All *flammable* and *combustible liquid* storage systems shall be installed in accordance with the requirements of this code and NFiPA 30 or NFiPA 31 listed in Chapter 21.

M-901.2.1 Maximum outside fuel oil storage above ground: Where a *combustible liquid* storage system connects to a fuel-oil piping system, the maximum amount stored outside above ground without additional protection shall be 660 gallons (2.5 m^3). Where the amount stored outside above ground exceeds 660 gallons (2.5 m^3), the installation shall conform to NFiPA 31 listed in Chapter 21.

M-901.2.2 Maximum inside fuel oil storage: Where a *combustible liquid* storage system connects to a fuel-oil piping system, the maximum amount stored inside any building shall be 660 gallons (2.5 m^3). Where the amount stored inside a building exceeds 660 gallons (2.5 m^3), the storage area shall be classified as Use Group H and shall conform to the requirements for Use Group H in the building code listed in Chapter 21.

SECTION M-902.0 DEFINITIONS

M-902.1 General: The following words and terms shall, for the purposes of this chapter and as stated elsewhere in this code, have the meanings shown herein.

Combustible liquids: Any liquids having a *flash point* at or above 100 degrees F. (38 degrees C.) shall be known as Class II or III liquids. Combustible liquids shall be divided into the following classifications:
Class II: Liquids having *flash points* at or above 100 degrees F. (38 degrees C.) and below 140 degrees F. (60 degrees C.).
Class IIIA: Liquids having *flash points* at or above 140 degrees F. (60 degrees C.) and below 200 degrees F. (93 degrees C.).
Class IIIB: Liquids having *flash points* at or above 200 degrees F. (93 degrees C.).

Flammable liquids: Any liquid that has a *flash point* below 100 degrees F. (38 degrees C.), and has a vapor pressure not exceeding 40 psia (276 kPa) at 100 degrees F. (38 degrees C.). Flammable liquids shall be known as Class I liquids and shall be divided into the following classifications:
Class IA: Liquids having a *flash point* below 73 degrees F. (23 degrees C.) and having a boiling point below 100 degrees F. (38 degrees C.).
Class IB: Liquids having a *flash point* below 73 degrees F. (23 degrees C.) and having a boiling point at or above 100 degrees F. (38 degrees C.).
Class IC: Liquids having a *flash point* at or above 73 degrees F. (23 degrees C.) and below 100 degrees F. (38 degrees C.).

Flash point: The minimum temperature in degrees Fahrenheit at which a *flammable liquid* will give off sufficient vapors to form an ignitable mixture with air near the surface or in the container, but will not sustain combustion. The flash point of a liquid shall be determined by appropriate test procedure and apparatus as specified in ASTM D56 and ASTM D93 listed in Chapter 21.

Fuel-oil piping system: A closed piping system that connects a *combustible liquid* from a source of supply to a fuel-oil-burning *appliance*.

SECTION M-903.0 MATERIAL

M-903.1 General: Storage tanks and piping materials shall conform to the standards cited in this section.

M-903.2 Rated for system: All materials shall be rated for the operating temperatures and pressures of the system, and shall be compatible with the type of liquid.

M-903.3 Storage tanks: All shop-fabricated *flammable* and *combustible liquid* storage tanks shall bear the *label* of an approved agency. Bolted and field-welded tanks shall comply with this code and with the structural and inspection requirements of the building code listed in Chapter 21. The tanks shall conform to one of the appropriate standards listed in Table M-903.3.

M-903.4 Pipe standards: *Flammable* and *combustible liquid* pipe shall conform to one of the standards listed in Table M-903.4.

M-903.5 Nonmetallic pipe: All nonmetallic pipe shall bear the *label* of an approved agency as being acceptable for the intended application for *flammable* and *combustible liquids*. Nonmetallic pipe shall only be installed outside, underground.

Table M-903.3
FLAMMABLE AND COMBUSTIBLE LIQUID STORAGE TANKS

Material	Standard (see Chapter 21)
Glass-fiber reinforced plastic	UL 1316
Glass-fiber reinforced polyester	ASTM D4021
Steel	API 12B; API 12D; API 12F; API 650; UL 58; UL 80; UL 142; UL 443; STI Standard for Dual Wall Underground Steel Storage Tanks

Table M-903.4
FLAMMABLE AND COMBUSTIBLE LIQUID PIPE

Material	Standard (see Chapter 21)
Brass pipe	ASTM B43
Brass tubing	ASTM B135
Copper or copper-alloy pipe	ASTM B42; ASTM B302
Copper or copper-alloy tubing (Type K, L or M)	ASTM B75; ASTM B88; ASTM B280
Labeled pipe	(see Section M-903.5)
Nonmetallic pipe	ASTM D2996
Steel pipe	ASTM A53; ASTM A106
Steel tubing	ASTM A254; ASTM A539

M-903.6 Fittings and valves: Fittings and valves shall be approved for the piping systems, and shall be compatible with or shall be of the same material as the pipe or tubing.

M-903.7 Bending of pipe: Pipe shall be approved for bending. Pipe bends shall be made with approved equipment. The bend shall not exceed the structural limitations of the pipe.

M-903.8 Pumps: Pumps that are not part of an *appliance* shall be of a positive-displacement type. The pump shall automatically shut off the supply when not in operation. All pumps shall bear the *label* of an approved agency.

M-903.9 Flexible connectors and hoses: Flexible connectors and hoses shall bear the *label* of an approved agency.

SECTION M-904.0 JOINTS AND CONNECTIONS

M-904.1 Approval: All joints and connections shall be of an approved type for *flammable* and *combustible liquid* piping systems. Joints and connections shall be tight for the pressure required by test.

M-904.1.1 Joints between different piping materials: Joints between different piping materials shall be made with approved adapter fittings. Joints between different metallic piping materials shall be made with approved dielectric fittings or brass converter fittings.

M-904.2 Preparation of pipe ends: All pipe shall be cut square, reamed and chamfered and be free from all burrs and obstructions. Pipe ends shall have full-bore openings and shall not be undercut.

M-904.3 Joint preparation and installation: Where required by Sections M-904.4 through M-904.10, the preparation and installation of brazed, *mechanical*, threaded and welded joints shall comply with Sections M-904.3.1 through M-904.3.4.

M-904.3.1 Brazed joints: All joint surfaces shall be cleaned. An approved flux shall be applied where required. The joints shall be brazed with a filler metal conforming to AWS A5.8 listed in Chapter 21.

M-904.3.2 Mechanical joints: *Mechanical joints* shall be installed in accordance with the manufacturer's instructions.

M-904.3.3 Threaded joints: Threads shall conform to ASME B1.20.1 listed in Chapter 21. Pipe-joint compound or tape shall be applied on the male threads only.

M-904.3.4 Welded joints: All joint surfaces shall be cleaned by approved procedure. The joint shall be welded with an approved filler metal.

M-904.4 Brass pipe: Joints between brass pipe or fittings shall be brazed, *mechanical*, threaded or welded joints complying with Section M-904.3.

M-904.5 Brass tubing: Joints between brass tubing or fittings shall be brazed or *mechanical* joints complying with Section M-904.3.

M-904.6 Copper or copper-alloy pipe: Joints between copper or copper-alloy pipe or fittings shall be brazed, *mechanical*, threaded or welded joints complying with Section M-904.3.

M-904.7 Copper or copper-alloy tubing: Joints between copper or copper-alloy tubing or fittings shall be brazed or *mechanical joints* complying with Section M-904.3 or flared joints complying with Section M-904.7.1.

M-904.7.1 Flared joints: Flared joints shall be made by a tool designed for that operation.

M-904.8 Nonmetallic pipe: Joints between nonmetallic pipe or fittings shall be installed in accordance with the manufacturer's instructions for the *labeled* pipe and fittings.

M-904.9 Steel pipe: Joints between steel pipe or fittings shall be threaded or welded joints complying with Section M-904.3 or *mechanical joints* complying with Section M-904.9.1.

M-904.9.1 Mechanical joints: Joints shall be made with an approved elastomeric seal. *Mechanical joints* shall be installed in accordance with the manufacturer's instructions. *Mechanical joints* shall be installed outside, underground, unless otherwise approved.

M-904.10 Steel tubing: Joints between steel tubing or fittings shall be *mechanical* or welded joints complying with Section M-904.3.

SECTION M-905.0 CORROSION PROTECTION AND LEAK DETECTION

M-905.1 Corrosion protection: All underground storage tanks, hold-down straps and piping systems shall be protected against corrosion. The means of protection shall conform to STI P3, UL 1746 or ULC CAN/ULC-S603.1 listed in Chapter 21, or shall be specifically designed by a *registered design professional* and approved.

Exception: Corrosion protection is not required for nonmetallic tanks and nonmetallic piping systems.

M-905.2 Steel pipe coating: Steel pipe or tubing installed underground shall be coated with an approved coating such as bituminous, epoxy or polyethylene.

M-905.3 Tank isolation: Metallic piping connections to a steel underground storage tank shall be by approved dielectric fittings. Metallic hold-down straps shall be electrically isolated from steel tanks.

M-905.4 Leak detection: All underground storage tanks and piping systems shall be monitored in an approved manner for leaks of *flammable* or *combustible liquid.*

Exception: Monitoring is not required for underground storage tanks that have a capacity of 1,000 gallons (3.8 m^3) or less and that serve fuel-oil-burning equipment.

SECTION M-906.0 HANGERS AND SUPPORTS

M-906.1 Expansion and contraction: Piping shall be installed so as to prevent strains and stresses which will exceed the limitations of the pipe. Provisions shall be made to protect the piping from damage resulting from expansion, contraction and structural settlement. Piping shall be installed so as not to create structural stresses or strains within building components.

M-906.2 Hanger material: Hangers and supports shall be of material of sufficient strength to support the piping. Hangers and strapping material shall be of similar materials as the piping to avoid galvanic action.

M-906.3 Interval of spacing: Piping shall be supported at distances not exceeding the spacing specified in Table M-906.3.

Table M-906.3
HANGER SPACING

Piping material	Maximum horizontal spacing (feet)[a]	Maximum vertical spacing (feet)[a]
Brass pipe	10	10
Brass tubing, 1¼-inch diameter and smaller	6	10
Brass tubing, 1½-inch diameter and larger	10	10
Copper or copper-alloy pipe	12	10
Copper or copper-alloy tubing, 1¼-inch diameter and smaller	6	10
Copper or copper-alloy tubing, 1½-inch diameter and larger	10	10
Steel pipe	12	15
Steel tubing	8	10

Note a. 1 foot = 304.8 mm.

SECTION M-907.0 UNDERGROUND PIPING

M-907.1 Material protection: The piping material shall be installed to protect against contact or damage from structures.

M-907.2 Trenching and bedding: Trenches shall be excavated to a depth below the elevation of the pipe such that the bottom of the trench does not form the bed for the pipe. The trench shall be backfilled to the elevation of the pipe with noncorrosive inert material such as sand or gravel placed in a maximum of 6-inch (152 mm) layers compacted after placement. Where rock is encountered, the rock shall be removed to a point a minimum of 3 inches (76 mm) below the elevation of the pipe. The trench shall be backfilled with noncorrosive inert material such as sand or gravel to a minimum of 6 inches (152 mm) above the pipe. The backfill shall be compacted to retain pipe alignment.

M-907.3 Depth: The minimum depth of pipe installed underground shall be 18 inches (457 mm).

M-907.3.1 Protection of footings: Trenching installed parallel to footings shall not extend below the line of a 45-degree (0.79 rad) angle downward from the loadbearing plane of the footing, and shall conform to the requirements of the building code listed in Chapter 21.

M-907.4 Flexible joints: A flexible (swing) joint shall be installed at every change in direction from the vertical to the horizontal or from the horizontal to the vertical in an underground piping system. A flexible joint shall be a joint that makes a single change in direction with either an approved flexible connector or two fittings with a nipple between the fittings. The fittings shall not be street fittings, nor shall the nipple be a close nipple.

SECTION M-908.0 UNDERGROUND STORAGE TANK INSTALLATION

M-908.1 Tank handling: Storage tanks shall not be lifted and lowered by any means other than the lifting lugs installed by the tank manufacturer. Tanks shall not be dropped, dragged or handled with sharp objects.

M-908.2 Location: Storage tanks installed underground or below a building shall not have any loads from the building foundation system transmitted to the tank. *Flammable liquid* storage tanks shall be located a minimum of 1 foot (305 mm) from any wall and 3 feet (914 mm) from a lot line. *Combustible liquid* storage tanks shall be located a minimum of 1 foot (305 mm) from any wall or lot line.

M-908.3 Excavation: The excavation for the tank shall be sized to permit the minimum backfill around the tank required by Section M-908.5 and 1 foot (305 mm) of bedding underneath the tank. The maximum depth of the excavation shall be twice the tank diameter or 23 feet (7010 mm), whichever is less, unless the installation is designed for a greater depth and approved by the tank manufacturer.

M-908.4 High ground water and flood hazard: Tanks and piping installed in areas of high ground water, flood-hazard zones (A Zones) or high-hazard zones (V Zones) shall be anchored and reinforced to resist hydrostatic and hydrodynamic loads and stresses. The anchoring and reinforcing shall resist the effects of buoyancy with the tank either empty or full when the ground water table is at the high point and during the occurrence of flooding to the base flood elevation.

M-908.4.1 Hold-down straps: Hold-down straps or cables shall be acceptable to the tank manufacturer and installed in accordance with the tank manufacturer's instructions.

M-908.4.2 Hold-down pads: Hold-down pads shall be separated from the tank by a minimum of 6 inches (152 mm) of backfill for steel tanks and 12 inches (305 mm) of backfill for nonmetallic tanks.

M-908.5 Installation and backfill: Tanks shall be installed on a minimum of 12 inches (305 mm) of backfill, forming a bed of the excavation. Backfill material shall be placed around the tank in such a manner as to prevent the movement of the tank. The minimum amount of backfill around the tank shall be 12 inches

(305 mm) for a steel tank and 24 inches (610 mm) for a nonmetallic tank.

M-908.5.1 Backfill material: Backfill shall be noncorrosive inert material such as pea gravel, crushed rock, sand or gravel. The pea gravel shall have a minimum size of ½ inch (13 mm) and a maximum size of ¾ inch (19 mm). Washed crushed rock or gravel shall have a minimum size of ⅛ inch (3 mm) and a maximum size of ½ inch (13 mm). Backfill for nonmetallic tanks shall not be sand unless approved by the tank manufacturer.

M-908.6 Cover in traffic areas or under a building: Tanks installed in areas subject to vehicular traffic or under a building shall have a minimum cover of 18 inches (457 mm) of backfill material and 6 inches (152 mm) of reinforced concrete, or 30 inches (762 mm) of backfill material and 6 inches (152 mm) of asphaltic concrete. The cover shall extend a minimum of 1 foot (305 mm) beyond the vertically projected outline of the tank.

M-908.7 Cover in nontraffic areas: Tanks installed in areas not subject to vehicular traffic shall have a minimum cover of 12 inches (305 mm) of backfill material and 12 inches (305 mm) of earth, or 12 inches (305 mm) of backfill material and 4 inches (102 mm) of reinforced concrete.

SECTION M-909.0 FUEL OIL SYSTEM INSTALLATION

M-909.1 Size: The fuel oil system shall be sized for the maximum capacity of fuel oil required. The minimum size of a supply line shall be ⅜-inch inside diameter nominal. The minimum size of a return line shall be ¼-inch inside diameter nominal.

M-909.2 Protection of pipe and equipment: All fuel oil pipe and equipment shall be protected from physical damage.

M-909.2.1 Flood hazard: All fuel oil pipe located in a flood-hazard zone (A Zone) or a high-hazard zone (V Zone) shall be capable of resisting hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, during the occurrence of flooding to the base flood elevation.

M-909.3 Supply piping: Supply piping shall connect to the top of the fuel oil tank. Fuel oil shall be supplied by a transfer pump or automatic pump or by other approved means.

Exception: This section shall not apply to inside or aboveground fuel oil tanks.

M-909.4 Return piping: Return piping shall connect to the top of the fuel oil tank. Valves shall not be installed on return piping.

M-909.5 System pressure: The system shall be designed for the maximum pressure required by the fuel-oil-burning equipment.

SECTION M-910.0 FUEL-DISPENSING SYSTEMS

M-910.1 Installation: All fuel-dispensing systems shall be installed in accordance with the requirements of this section and NFiPA 30 or NFiPA 30A listed in Chapter 21.

M-910.2 Dispenser protection: Each fuel dispenser shall be protected against motor vehicle impact. Where physical barriers are installed, such barriers shall rise a minimum of 30 inches (762 mm) above the driving surface.

M-910.3 Fuel dispensing outside the building: Fuel dispensing outside the building shall be located a minimum of 10 feet (3048 mm) from the lot line and 5 feet (1524 mm) from any building opening. Where a dispenser fronts on a street or public way, the separation distance shall be measured to the centerline of the street or public way.

M-910.4 Fuel dispensing inside the building: Fuel-dispensing areas located inside the building shall be *ventilated* by mechanical means in accordance with Section M-1604.0. The fuel-dispensing area shall be equipped with an approved automatic fire suppression system installed in accordance with the building code listed in Chapter 21.

M-910.5 Warning signs: Warning signs shall be visibly posted in every fuel-dispensing area open to the public. The signs shall indicate the following information:

1. It is illegal and dangerous to fill unapproved containers with fuel.
2. Smoking is prohibited.
3. Engine shall be shut off during refueling.

M-910.6 Self-service instructions: Operating instructions shall be visibly posted on every dispenser at a self-service fuel-dispensing area.

SECTION M-911.0 FUEL OIL VALVES

M-911.1 Building shutoff: A shutoff valve shall be installed on the fuel oil supply line at the entrance to the building. Inside or above-ground tanks are permitted to have valves installed at the tank. The valve shall be capable of stopping the flow of fuel oil to the building or to the equipment served where the valve is installed at a tank inside the building.

M-911.2 Appliance shutoff: A shutoff valve shall be installed at the connection to each *appliance* where more than one fuel-oil-burning *appliance* is installed.

M-911.3 Pump relief valve: A relief valve shall be installed on the pump discharge line where a valve is located downstream of the pump and the pump is capable of exceeding the pressure limitations of the fuel oil system.

M-911.4 Fuel oil heater relief valve: A relief valve shall be installed on the discharge line of fuel-oil-heating equipment.

M-911.5 Relief valve operation: The relief valve shall discharge fuel oil when the pressure exceeds the limitations of the system. The discharge line shall connect to the fuel oil tank.

SECTION M-912.0 TESTS

M-912.1 Piping: All *flammable* and *combustible liquid* piping systems shall be tested after installation and prior to being placed in service with air or with any of the following gases: helium, argon, nitrogen or carbon dioxide. The system shall be tested to a minimum of one and one-half times the system operating pressure, but not less than 5 psi (34 kPa). The system shall maintain the test pressure without the addition of air or other test gas for a minimum of 10 minutes.

M-912.2 Tanks: All *flammable* and *combustible liquid* storage tanks shall be tested after installation and prior to the introduction of product with air or with any of the following gases: helium, argon, nitrogen or carbon dioxide. The tanks shall be

CHAPTER 10

COMBUSTION AIR

SECTION M-1001.0 GENERAL

M-1001.1 Scope: The provisions of this chapter shall govern the requirements for combustion air for all fuel-burning *appliances* or equipment.

M-1001.2 Combustion air required: All fuel-burning *appliances* shall be provided with adequate combustion air. Combustion air shall be inside or outdoor air, or shall be provided by a direct outdoor connection or a special engineered system.

M-1001.3 Circulation of air: Every room containing fuel-burning equipment shall be designed for the free circulation of air. Adequate provisions shall be made for any openings or devices which cause the depletion of combustion air.

SECTION M-1002.0 DEFINITIONS

M-1002.1 General: The following words and terms shall, for the purposes of this chapter and as stated elsewhere in this code, have the meanings shown herein.

Combustion air: The amount of air required for safe and proper combustion.

SECTION M-1003.0 INSIDE AIR

M-1003.1 Amount of air: Inside air shall be available for each fuel-burning *appliance* at a rate of 40 cubic feet of room air volume per 1,000 British thermal units per hour (Btuh) (3.86 m^3/kW) input rating. In buildings of tight construction where the air exchange rate is less than 0.5 air changes per hour, additional air shall be provided in accordance with Section M-1004.0 or M-1006.0.

M-1003.2 Openings: Where the room in which the *appliance* is located does not meet the criterion specified in Section M-1003.1, openings to adjacent spaces shall be provided so that the combined volume of all spaces meets the criterion. Two openings shall be provided, one near the top of the room and one near the bottom.

M-1003.2.1 Size of opening: Each opening shall have an unobstructed area equal to a minimum of 1 square inch per 1,000 Btuh (2201 mm^2/kW) input rating of all *appliances* installed in the space, but not less than 100 square inches (64516 mm^2).

SECTION M-1004.0 OUTDOOR AIR

M-1004.1 Connections to outdoors: Where the space in which fuel-burning *appliances* are located does not meet the criterion for indoor air as specified in Section M-1003.1, the room shall have two openings to the outdoors. One opening shall be located near the top of the room and one near the bottom. Openings are permitted to connect to spaces directly communicating with the outdoors, such as *ventilated* crawl spaces or attic spaces.

M-1004.2 Size of horizontal openings: Each opening through a horizontal duct shall have an unobstructed area equal to a minimum of 1 square inch per 2,000 British thermal units per hour (Btuh) (1100 mm^2/kW) total input rating. Each direct opening through a wall shall have an unobstructed area equal to a minimum of 1 square inch per 4,000 Btuh (550 mm^2/kW) total input rating.

M-1004.3 Size of vertical openings: Each opening through a floor, ceiling or vertical duct shall have an unobstructed area equal to a minimum of 1 square inch per 4,000 Btuh (550 mm^2/kW) total input rating.

M-1004.4 Operation of openings: Combustion air openings shall be open when the fuel-burning *appliance* is operating. Dampers are permitted to be electrically connected to the firing cycle of the *appliance*.

SECTION M-1005.0 DIRECT CONNECTION

M-1005.1 General: Fuel-burning *appliances* that have been tested for direct combustion air connection to the outdoors shall be installed in accordance with the manufacturer's installation instructions.

SECTION M-1006.0 MECHANICAL VENTILATION

M-1006.1 General: Combustion air is permitted to be provided by the mechanical *ventilation* system. The supply air rate shall be increased over the required *ventilation air* by a rate equal to a minimum of 1 cubic foot per minute per 3,000 British thermal units per hour (0.00047 m^3/s per 0.8793 kW) total input rating. Each *appliance* shall be electrically connected to the *ventilation* system to prevent fuel burning when the *ventilation* system is not in operation.

SECTION M-1007.0 OPENING OBSTRUCTIONS

M-1007.1 General: The unobstructed area of each opening shall be considered for determining combustion air. The opening determined by the manufacturer shall be considered unobstructed.

M-1007.2 Louvered openings: The unobstructed area of metal-louvered openings shall be considered 75 percent of the total area. The unobstructed area of wood-louvered openings shall be considered 25 percent of the total area.

CHAPTER 11

CLEARANCE REDUCTION

SECTION M-1101.0 GENERAL

M-1101.1 Scope: This chapter shall govern the reduction in required clearances to *combustibles* of chimneys, *vents*, kitchen exhaust equipment, *appliances* and mechanical equipment.

SECTION M-1102.0 REDUCED CLEARANCES

M-1102.1 Labeled reduction: The required clearances to *combustibles* are permitted to be reduced by methods that have been tested and bear the *label* of an approved agency.

M-1102.2 Reduction table: The required clearances to *combustibles* are permitted to be reduced where protected in accordance with one of the methods specified in Table M-1102.2. The reduced clearance distances in the table shall be measured from the device to the face of the protection.

Table M-1102.2
REDUCED CLEARANCE TO COMBUSTIBLES

Reduced clearance protection assembly (spacers shall be noncombustible)	Minimum air space between the device and the reduced clearance protection assembly (inches)[a]			
	Required clearance to combustibles without protection (inches)[a]			
	36	18	9	6
1/8-inch unpainted aluminum plate, spaced 1 inch off the wall	3	3	3	3
1/8-inch painted aluminum plate, spaced 1 inch off the wall	28	9	3	3
Unpainted galvanized sheet metal, minimum nominal thickness of 0.019 inch (No. 28 Gage), mounted on 1/2-inch inorganic insulating board attached directly to the wall	3	3	3	3
Unpainted galvanized sheet metal, minimum nominal thickness of 0.019 inch (No. 28 Gage), spaced 1 inch off the wall	3	3	3	3
Painted galvanized sheet metal, minimum nominal thickness of 0.019 inch (No. 28 Gage), spaced 1 inch off the wall	24	6	3	3
Two layers of painted galvanized sheet metal, minimum nominal thickness of 0.019 inch (No. 28 Gage), having a 1-inch air space between layers, spaced 1 inch off the wall	3	3	3	3
1/4-inch inorganic insulating board having painted galvanized sheet metal, minimum nominal thickness of 0.019 inch (No. 28 Gage), attached on both sides spaced 1 inch off the wall	3	3	3	3
1/4-inch inorganic insulating board, spaced 1 inch off the wall	30	9	3	3
Two layers of painted galvanized sheet metal, minimum nominal thickness of 0.028 inch (No. 24 Gage), having 1 inch of fiberglass insulation between layers, spaced 1 inch off the wall	3	3	3	3
3 1/2-inch brick wall, spaced 1 inch off the wall	18	5	3	0

Note a. 1 inch = 25.4 mm.

CHAPTER 12

CHIMNEYS AND VENTS

SECTION M-1201.0 GENERAL

M-1201.1 Scope: This chapter shall govern the installation, maintenance, repair and approval of all chimneys, *vents* and connectors.

M-1201.2 Location: Chimney or *vent* termination openings shall be located a minimum of 10 feet (3048 mm) from the lot line unless otherwise approved.

M-1201.3 Size of chimney or vent: The size of the chimney or *vent*, in other than multiple connections and engineered systems, shall have a minimum area equal to the area of the *appliance* connection.

M-1201.4 Abandoned inlet openings: Abandoned inlet openings in chimneys and *vents* shall be closed by an approved method.

M-1201.5 Cutting or notching: A structural member shall not be cut, notched or pierced in excess of the limitations specified in the building code listed in Chapter 21, unless proven safe by a structural analysis.

SECTION M-1202.0 DEFINITIONS

M-1202.1 General: The following words and terms shall, for the purposes of this chapter and as stated elsewhere in this code, have the meanings shown herein.

***Appliance* (mechanical):**

***Appliance*, high heat:** Any appliance operating at higher temperatures than a medium-heat appliance.

***Appliance*, low heat:** Any appliance in which the products of combustion at the point of entrance to the flue under normal operating conditions have a temperature of 1,000 degrees F. (538 degrees C.) or less.

***Appliance*, medium heat:** Any appliance in which the products of combustion at the point of entrance to the flue under normal operating conditions have a temperature not greater than 2,000 degrees F. (1093 degrees C.).

***Appliance*, unvented:** An appliance designed or installed in such a manner that the products of combustion are not conveyed by a *vent* or chimney directly to the outside atmosphere.

***Appliance*, vented:** An appliance designed and installed in such a manner that all of the products of combustion are conveyed directly from the appliance to the outside atmosphere through an approved chimney or *vent* system.

Chimney: A primarily vertical enclosure containing one or more passageways.

Factory-built: A chimney that is factory made and *labeled* by an approved testing or inspection agency for the venting of gas *appliances*, gas incinerators and solid or liquid fuel-burning *appliances*.

High-heat appliance type: An approved chimney for removing the products of combustion from fuel-burning, high-heat *appliances* producing combustion gases in excess of 2,000 degrees F. (1093 degrees C.) measured at the *appliance* fuel outlet.

Low-heat appliance type: An approved chimney for removing the products of combustion from fuel-burning, low-heat *appliances* producing combustion gases not in excess of 1,000 degrees F. (538 degrees C.) under normal operating conditions, but capable of producing combustion gases of 1,400 degrees F. (760 degrees C.) during intermittent forced firing for periods up to 1 hour. All temperatures shall be measured at the *appliance* flue outlet.

Masonry: A field-constructed chimney of solid masonry units, stones or reinforced concrete.

Medium-heat appliance type: An approved chimney for removing the products of combustion from fuel-burning, medium-heat *appliances* producing combustion gases not exceeding 2,000 degrees F. (1093 degrees C.) measured at the *appliance* flue outlet.

Metal: A field-constructed chimney made of metal.

Chimney connector: A pipe that connects a fuel-burning *appliance* to a chimney.

Chimney liner: The lining material of approved fire clay or other approved material.

Vent: A conduit or passageway for conveying products of combustion from fuel-fired *appliances*, or their *vent connectors*, to the outside atmosphere.

Vent connector: The pipe that connects an approved fuel-fired *appliance* to a chimney or *vent*.

SECTION M-1203.0 WHERE REQUIRED

M-1203.1 General: Every fuel-burning *appliance* shall discharge the products of combustion to a *vent*, factory-built chimney, masonry chimney or metal chimney, except for *appliances* conforming to Section M-1203.2. The chimney or *vent* shall be designed for the type of *appliance* being *vented*.

M-1203.1.1 Special vent systems: *Appliances* that have been tested for utilization with a special *vent* system shall be vented in accordance with the manufacturer's installation instructions.

M-1203.2 Unvented appliances: A chimney or *vent* shall not be required for *appliances* that are tested for unvented operation. Unvented *appliances* shall be operated and installed in accordance with the manufacturer's installation instructions.

SECTION M-1204.0 VENT SYSTEM

M-1204.1 Approval: All *vent* systems shall bear the *label* of an approved agency. Type B and BW *vents* shall be tested in accordance with UL 441 listed in Chapter 21. Type L *vents* shall be tested in accordance with UL 641 listed in Chapter 21.

M-1204.2 Connection and size: *Appliances* shall be approved for connection to a *vent* system.

M-1204.3 Installation: *Vent* systems shall be installed and terminated in accordance with the manufacturer's installation instructions.

M-1204.3.1 Starting height: The *vent* system shall originate at a point that is convenient for the *appliance* installation.

M-1204.3.2 Protection of the vent system: *Vent* systems shall be protected from physical damage, except for the floor where the connecting *appliance* is located. Floor and ceiling penetrations shall be firestopped in accordance with the building code listed in Chapter 21.

SECTION M-1205.0 FACTORY-BUILT CHIMNEYS

M-1205.1 Approval: All factory-built chimneys shall bear the *label* of an approved agency. Factory-built chimneys for residential-type and building-heating *appliances* shall be tested in accordance with UL 103 listed in Chapter 21. Factory-built chimneys for medium-heat *appliances* shall be tested in accordance with UL 959 listed in Chapter 21.

M-1205.2 Installation: Factory-built chimneys shall be installed in accordance with the manufacturer's installation instructions.

M-1205.2.1 Starting height: The chimney shall originate at a point that is convenient for the *appliance* installation.

M-1205.2.2 Protection of the chimney: Factory-built chimneys shall be protected from physical damage, except for the floor where the connecting *appliance* is located. Floor and ceiling penetrations shall be firestopped in accordance with the building code listed in Chapter 21.

M-1205.2.3 Termination: Factory-built chimneys shall terminate outdoors above the roof of the building. Chimney outlets shall be located a minimum of 3 feet (914 mm) above the highest point that the chimney penetrates the roof. Chimney outlets shall be a minimum of 2 feet (610 mm) higher than any portion of the building within 10 feet (3048 mm).

M-1205.3 Connection: Factory-built chimneys for installation with closed combustion, wood-burning residential and low-heat *appliances* shall comply with the "Type HT" requirements of UL 103 listed in Chapter 21. Chimneys for factory-built fireplaces shall conform to UL 127 listed in Chapter 21. Factory-built chimneys for open combustion chamber free-standing fireplace stoves conforming only to UL 737 in Chapter 21 shall utilize residential-type and building-heating *appliance* chimneys that conform to UL 103 listed in Chapter 21.

SECTION M-1206.0 MASONRY CHIMNEYS, GENERAL REQUIREMENTS

M-1206.1 Foundations: Masonry chimneys shall be supported on approved *noncombustible* foundations. The supports shall be independent of the building construction and the load shall be transferred to the ground.

M-1206.2 Structural design: Chimneys shall not support any structural load other than the weight of the chimney unless such chimneys are designed to act as supporting members. Chimneys shall be anchored laterally at the ceiling lines and at each floor line that is more than 6 feet (1829 mm) above grade.

M-1206.3 Corbeling: Masonry chimneys shall not be corbeled from a wall more than 6 inches (152 mm). A masonry chimney shall not be corbeled from a wall that is less than 12 inches (305 mm) in thickness, unless the chimney projects equally on each side of the wall. In the second story of a two-story building, corbeling of masonry chimneys on the exterior of the enclosing walls shall not exceed the exterior wall thickness. The maximum horizontal projection of each course of brick shall not exceed one-half of the height of the masonry unit and one-third of the thickness or depth of the masonry unit.

M-1206.4 Change in size or shape: Masonry chimneys shall not change in size or shape within 6 inches (152 mm) above or below any *combustible* floor, ceiling or roof component penetrated by the chimney.

M-1206.5 Offsets: Where a masonry chimney is constructed with a fire-clay flue liner surrounded by one wythe of masonry, the maximum offset shall be such that the centerline of the flue above the offset does not extend beyond the center of the chimney wall below the offset. Where the chimney offset is supported by masonry below the offset in an approved manner, the maximum offset limitations shall not apply. Each individual corbeled masonry course of the offset shall not exceed the projection limitations specified in Section M-1206.3.

M-1206.6 Cleanouts: All masonry chimneys, except chimneys serving fireplaces, shall be provided with an approved cleanout having a tight-fitting cover. Such cleanouts shall be installed at least 12 inches (305 mm) below the lowest chimney inlet opening.

M-1206.7 Firestopping: All spaces between chimneys and floors and ceilings through which chimneys pass shall be firestopped with *noncombustible material.* The firestopping of spaces between chimneys and wood joists, beams or headers shall be to a depth of 1 inch (25 mm), and shall only be placed on strips of metal or metal lath laid across the spaces between *combustible material* and the chimney.

SECTION M-1207.0 MASONRY CHIMNEYS FOR LOW-HEAT APPLIANCES

M-1207.1 Construction: Masonry chimneys for low-heat *appliances* shall be constructed of solid masonry units or reinforced concrete with walls not less than 4 inches (102 mm) thick or rubble stone masonry not less than 12 inches (305 mm) thick.

Masonry shall be constructed with full bed and head mortar joints.

M-1207.2 Lining: Masonry chimneys for low-heat *appliances* shall be lined with fire-clay lining complying with ASTM C315 listed in Chapter 21 or an approved equivalent, not less than 5/8 inch (16 mm) thick, or with a liner of other approved material that will resist corrosion, softening or cracking from flue gases at temperatures up to 1,800 degrees F. (982 degrees C.).

M-1207.2.1 Fire-clay flue liner: The fire-clay flue liner shall be installed ahead of the construction of the chimney as the chimney is carried up and carefully bedded one on the other in an approved medium-duty refractory mortar, with close-fitting joints left smooth on the inside.

M-1207.2.2 Space between liner and chimney: Liners shall be separate from the chimney wall, and the space between the liner and masonry shall not be filled. Only enough mortar shall be placed to make the joint and hold the liners in position.

M-1207.2.3 Extension of lining: Flue liners shall start from a point a minimum of 8 inches (203 mm) below the lowest *vent* connector entrance. The lining shall extend vertically for the entire height of the chimney.

M-1207.2.4 Two adjoining flues: Where two adjoining flues in the same chimney are separated only by flue liners, the joints of the adjacent flue liners shall be staggered a minimum of 7 inches (178 mm).

M-1207.2.5 More than two flues: Where more than two flues are located in the same chimney, masonry wythes (partitions) a minimum of 4 inches (102 mm) wide and bonded into the masonry walls of the chimney shall be built at such points between adjacent flue linings so that there are not more than two flues in any group of adjoining flues without such wythe separation.

M-1207.3 Termination height: Masonry chimneys shall terminate outdoors above the roof of the building. Chimney outlets shall be located a minimum of 3 feet (914 mm) above the highest point that the chimney penetrates the roof. Chimney outlets shall be a minimum of 2 feet (610 mm) higher than any portion of the building within 10 feet (3048 mm).

M-1207.4 Clearances: Any portion of a masonry chimney located within the exterior wall of the building shall have a minimum airspace clearance of 2 inches (51 mm) to *combustible materials*. Chimneys located entirely outside the exterior walls of the building, including chimneys that pass through the soffit or cornice, shall have a minimum airspace clearance of 1 inch (25 mm). The airspace shall not be filled, except to provide firestopping in accordance with Section M-1207.5.

Exception: Masonry chimneys equipped with a chimney lining system tested and *labeled* for installations in contact with *combustibles* in accordance with UL 1777 listed in Chapter 21, and installed in accordance with the manufacturer's instructions, are permitted to have *combustible material* in contact with the masonry chimney exterior surfaces. *Noncombustible* firestopping shall be provided in accordance with Section M-1207.5.

M-1207.5 Firestopping: Floor and ceiling penetrations shall be firestopped in accordance with Section M-1206.7 and the building code listed in Chapter 21.

SECTION M-1208.0 MASONRY CHIMNEYS FOR MEDIUM-HEAT APPLIANCES

M-1208.1 Construction: Masonry chimneys for medium-heat *appliances* shall be constructed of solid masonry units or of reinforced concrete with walls a minimum of 8 inches (203 mm) thick, or with stone masonry a minimum of 12 inches (305 mm) thick.

M-1208.2 Lining: Masonry for medium-heat *appliance* chimneys shall be lined with an approved medium-duty refractory brick, a minimum of 4½ inches (114 mm) thick laid on the 4½-inch (114 mm) bed in an approved medium-duty refractory mortar. The lining shall start 2 feet (610 mm) or more below the lowest chimney connector entrance and shall extend to a minimum height of 25 feet (7620 mm) above the highest chimney connector entrance. Chimneys terminating 25 feet (7620 mm) or less above a chimney connector entrance shall be lined to the top.

M-1208.2.1 Multiple passageway: Masonry chimneys containing more than one passageway shall have the liners separated by a minimum 4-inch-thick (102 mm) solid masonry wall.

M-1208.3 Termination height: Masonry chimneys for medium-heat *appliances* shall extend a minimum of 10 feet (3048 mm) higher than any portion of any building within 25 feet (7620 mm).

M-1208.4 Clearance: A minimum clearance of 4 inches (102 mm) shall be provided between the exterior surfaces of a masonry chimney for medium-heat *appliances* and *combustible material.*

SECTION M-1209.0 MASONRY CHIMNEYS FOR HIGH-HEAT APPLIANCES

M-1209.1 Construction: Masonry chimneys for high-heat *appliances* shall be constructed with double walls of solid masonry units or reinforced concrete, each wall to be a minimum of 8 inches (203 mm) thick with a minimum airspace of 2 inches (51 mm) between the walls.

M-1209.2 Lining: The inside of the interior wall shall be lined with an approved high-duty refractory brick, a minimum of 4½ inches (102 mm) thick laid on the 4½-inch (102 mm) bed in an approved high-duty refractory mortar. The lining shall start at the base of the chimney and extend continuously to the top.

M-1209.3 Termination height: Masonry chimneys for high-heat *appliances* shall extend a minimum of 20 feet (6096 mm) higher than any portion of any building within 50 feet (15240 mm).

M-1209.4 Clearance: Masonry chimneys for high-heat *appliances* shall have approved clearance from buildings and structures to prevent overheating *combustible material*, to permit inspection and maintenance operations on the chimney, and to prevent danger of burns to persons.

SECTION M-1210.0 METAL CHIMNEYS, GENERAL REQUIREMENTS

M-1210.1 Support: Metal chimneys shall be supported on approved *noncombustible* foundations. The supports shall be independent of the building construction and the load shall be transferred to the ground.

M-1210.2 Cleanouts: Cleanout openings shall be provided at the base of every metal chimney.

M-1210.3 Construction: Metal chimneys shall be riveted or welded. Chimneys shall be structurally supported and anchored to the building. Metal chimneys shall have a minimum thickness as specified in Table M-1210.3.

Table M-1210.3
METAL CHIMNEY MINIMUM THICKNESS

Area of chimney (square inches)[a]	Minimum nominal thickness (inches)
0 - 154	0.060 (No. 16 Manufacturers Standard Gage)
155 - 200	0.075 (No. 14 Manufacturers Standard Gage)
201 - 254	0.105 (No. 12 Manufacturers Standard Gage)
Greater than 254	0.135 (No. 10 Manufacturers Standard Gage)

Note a. 1 square inch = 645.16 mm^2.

SECTION M-1211.0 METAL CHIMNEYS FOR LOW-HEAT APPLIANCES

M-1211.1 Termination height: Metal chimneys for low-heat *appliances* shall terminate outdoors above the roof of the building. Chimney outlets shall be located a minimum of 3 feet (914 mm) above the highest point that the chimney penetrates the roof. Chimney outlets shall be a minimum of 2 feet (610 mm) higher than any portion of the building within 10 feet (3048 mm).

M-1211.2 Exterior clearances: Exterior metal chimneys shall be installed in accordance with Sections M-1211.2.1 through M-1211.2.3.

M-1211.2.1 Clearance to combustibles: Exterior metal chimneys that serve low-heat *appliances* shall have a minimum clearance of 6 inches (152 mm) to *combustible materials.*

M-1211.2.2 Clearance from other than combustible walls: Exterior metal chimneys over 18 inches (457 mm) in diameter shall have a minimum clearance of 4 inches (102 mm), and those 18 inches (457 mm) or less in diameter shall have a minimum clearance of 2 inches (51 mm) from a building wall of *noncombustible* construction.

M-1211.2.3 Clearance from window, door or walkway: An exterior metal chimney shall be a minimum of 24 inches (610 mm) from any door or window or from any walkway, unless insulated or shielded in an approved manner to prevent burns to persons coming into contact with the chimney.

M-1211.3 Interior clearances: Interior metal chimneys shall be installed as required in Sections M-1211.3.1 through M-1211.3.5.

M-1211.3.1 Enclosure: A metal chimney shall be enclosed in a fireresistance rated shaft in accordance with the shaft requirements of the building code listed in Chapter 21.

M-1211.3.2 Access: The enclosure shall provide a minimum clear space of 12 inches (305 mm) on all sides of the chimney for inspection and repair.

M-1211.3.3 Openings: The enclosing walls shall be without openings, except doorways equipped with approved self-closing fire doors at various floor levels for inspection purposes.

M-1211.3.4 Clearance: Metal chimneys that serve low-heat *appliances* located in the same story as the connecting *appliances* shall have a minimum clearance of 18 inches (457 mm) to *combustible materials.* Such interior metal chimneys over 18 inches (457 mm) in diameter shall have a minimum clearance of 4 inches (102 mm), and such chimneys 18 inches (457 mm) or less in diameter shall have a minimum clearance of 2 inches (51 mm) from a building wall of *noncombustible* construction.

M-1211.3.5 Roof penetration: Metal chimneys passing through a roof constructed of *combustible material* shall be guarded by a ventilating thimble of approved corrosion-resistant metal, extending a minimum of 9 inches (229 mm) below and 9 inches (229 mm) above the roof construction, and of a size to provide a minimum 6-inch (152 mm) clearance on all sides of the chimney, or the *combustible material* in the roof construction shall be cut away so as to provide a minimum 18-inch (457 mm) clearance on all sides of the chimney with the opening closed up with *noncombustible material.*

SECTION M-1212.0 METAL CHIMNEYS FOR MEDIUM-HEAT APPLIANCES

M-1212.1 Lining: Metal chimneys for medium-heat *appliances* shall be lined with an approved medium-duty refractory brick, laid in an approved medium-duty fire-clay mortar. The minimum lining thickness shall be 2½ inches (635 mm) for chimneys wherein the greatest cross-sectional dimension is 18 inches (457 mm) or less, and the minimum lining thickness shall be 4½ inches (114 mm) laid on the 4½-inch (114 mm) bed for chimneys wherein the greatest cross-sectional dimension is more than 18 inches (457 mm). The lining shall start 2 feet (610 mm) or more below the lowest chimney connector entrance and shall extend to a minimum height of 25 feet (7620 mm) above the highest chimney connector entrance. Chimneys terminating 25 feet (7629 mm) or less above the highest chimney connector entrance shall be lined to the top.

M-1212.2 Termination height: Metal chimneys for medium-heat *appliances* shall extend a minimum of 10 feet (3048 mm) higher than any portion of any building within 25 feet (7620 mm).

M-1212.3 Exterior clearances: Exterior metal chimneys shall be installed in accordance with Sections M-1212.3.1 through M-1212.3.3.

M-1212.3.1 Clearance to combustibles: Exterior metal chimneys that serve medium-heat *appliances* shall have a minimum clearance of 24 inches (610 mm) to *combustible materials.*

M-1212.3.2 Clearance from other than combustible construction: Exterior metal chimneys over 18 inches (457 mm) in diameter shall have a minimum clearance of 4 inches (102

mm), and such chimneys 18 inches (457 mm) or less in diameter shall have a minimum clearance of 2 inches (51 mm) from *noncombustible* construction.

M-1212.3.3 Clearance from window, door or walkway: All portions of an exterior metal chimney shall be a minimum of 24 inches (610 mm) from any door or window or from any walkway, unless insulated or shielded to prevent burns to persons coming into contact with the chimney.

M-1212.4 Interior clearances: Interior metal chimneys shall be installed in accordance with Sections M-1212.4.1 through M-1212.4.4.

M-1212.4.1 Enclosures: A metal chimney shall be enclosed in a fireresistance rated shaft in accordance with the shaft requirements of the building code listed in Chapter 21.

M-1212.4.2 Access: The enclosing walls shall provide a minimum clear space of 12 inches (305 mm) on all sides of the chimney for inspection and repair.

M-1212.4.3 Roof penetration: Metal chimneys serving a medium-heat *appliance* passing through a roof constructed of *combustible material* shall be guarded by a ventilating thimble of approved corrosion-resistant metal, extending a minimum of 9 inches (229 mm) below and 9 inches (229 mm) above the roof construction and shall be of a size to provide a minimum clearance of 18 inches (457 mm) on all sides of the chimney.

M-1212.4.4 Clearance: Metal chimneys that serve medium-heat *appliances* located in the same story as the connecting *appliances* shall have a minimum clearance of 36 inches (914 mm) to *combustible materials*. Such interior metal chimneys over 18 inches (457 mm) in diameter shall have a minimum clearance of 4 inches (102 mm), and such chimneys 18 inches (457 mm) or less in diameter shall have a minimum clearance of 2 inches (51 mm) from a building wall of *noncombustible* construction.

SECTION M-1213.0 METAL CHIMNEYS FOR HIGH-HEAT APPLIANCES

M-1213.1 Lining: Metal chimneys for high-heat *appliances* shall be lined with an approved high-duty refractory brick, a minimum of 4½ inches (114 mm) in thickness laid on a 4½-inch (114 mm) bed in an approved high-duty refractory mortar. The lining shall start 2 feet (610 mm) or more below the lowest chimney connector entrance and shall extend to a minimum height of 25 feet (7620 mm) above the highest chimney connector entrance. Chimneys terminating 25 feet (7620 mm) or less above the highest chimney connector entrance shall be lined to the top.

M-1213.2 Termination height: Metal chimneys for high-heat *appliances* shall extend a minimum of 20 feet (6096 mm) higher than any portion of any building within 50 feet (1520 mm).

M-1213.3 Clearance: Metal chimneys for high-heat *appliances* shall have approved clearance from structures to prevent overheating *combustible material*, to permit inspection and maintenance operations on the chimney, and to prevent danger of burns to persons.

SECTION M-1214.0 MULTIPLE CONNECTIONS

M-1214.1 General: Multiple *appliance* connections to a single chimney passageway or *vent* system shall conform to the requirements of this section.

M-1214.2 Multiple solid fuel prohibited: A solid fuel-burning *appliance* or fireplace shall not connect to a chimney passageway venting another *appliance*.

M-1214.3 Inlets to be offset: Connections to a chimney or *vent* shall be offset so that portions of an inlet are not opposite another inlet.

M-1214.4 Size of chimney or vent: The chimney or *vent* shall be sized to vent all connected *appliances*. *Appliances* connecting on different floor levels shall be sized by approved *vent* tables.

M-1214.4.1 Alternative area method: The minimum area of the chimney or *vent* shall be equal to the area of the largest *appliance* connection plus 50 percent of the area of each additional *appliance* connection.

SECTION M-1215.0 EXHAUSTERS

M-1215.1 General: This section shall govern the requirements for power exhausters, which are separately field-installed systems designed to *vent appliance* combustion products, and *vent* systems utilizing induced draft fans or power combustion means for venting, which are integral components of *appliances*.

M-1215.2 Connections to exhauster: All *appliance* connections to a chimney or *vent* equipped with a power exhauster shall be made on the inlet side of the exhauster. All joints on the positive pressure side of the exhauster shall be sealed to prevent flue gas leakage.

M-1215.3 Automatic shutoff: Power exhausters shall be electrically connected to each *appliance* to prevent operation of the *appliance* when the power exhauster is not in operation.

M-1215.4 Termination: The termination of chimneys or *vents* equipped with power exhausters shall be located a minimum of 10 feet (3048 mm) from the lot line or from adjacent buildings. The exhaust shall be directed away from the building.

M-1215.4.1 Horizontal vents: Horizontal *vents* shall terminate in accordance with the following requirements:

1. Where located adjacent to walkways, the termination of mechanical draft systems shall not be less than 7 feet (2134 mm) above the level of the walkway.
2. *Vents* shall terminate at least 3 feet (914 mm) above any forced air inlet located within 10 feet (3048 mm).
3. The *vent* system shall terminate at least 4 feet (1219 mm) below, 4 feet (1219 mm) horizontally from or 1 foot (305 mm) above any door, window or gravity air inlet into the building.
4. The *vent* termination point shall not be located closer than 3 feet (914 mm) to an interior corner formed by two walls perpendicular to each other.
5. The *vent* termination shall not be mounted directly above or within 3 feet (914 mm) horizontally from an oil tank vent or gas meter.
6. The bottom of the *vent* termination shall be located at least 12 inches (305 mm) above finished grade.

M-1215.4.2 Vertical vents: Vertical *vents* shall terminate in accordance with the following requirements:

1. Where located adjacent to walkways, the termination of mechanical draft systems shall not be less than 7 feet (2134 mm) above the level of the walkway.
2. *Vents* shall terminate at least 3 feet (914 mm) above any forced air inlet located within 10 feet (3048 mm).
3. Where the *vent* termination is located below an adjacent roof structure, the termination point shall be located at least 3 feet (3048 mm) from such structure.
4. The *vent* shall terminate at least 4 feet (1219 mm) below, 4 feet (1219 mm) horizontally from, or 1 foot (305 mm) above any door, window or gravity air inlet for the building.
5. A *vent* cap shall be installed to prevent rain from entering the *vent* system.
6. The *vent* termination shall be located at least 3 feet (914 mm) horizontally from any portion of the roof structure.

SECTION M-1216.0 CONNECTORS

M-1216.1 Vent connector construction: *Vent* connectors shall be constructed of metal. The minimum nominal thickness of the connector shall be 0.019 inch (No. 28 Gage) for galvanized steel, 0.022 inch (No. 26 B & S Gage) for copper, and 0.020 inch (No. 24 B & S Gage) for aluminum.

M-1216.2 Chimney connector construction: Chimney connectors shall be constructed of metal. The minimum thickness of the connector shall conform to Table M-1216.2(1) for low-heat *appliances* and to Table M-1216.2(2) for medium- and high-heat *appliances*.

Connectors for low-heat *appliances* shall be of steel pipe having resistance to corrosion and heat not less than that specified in Table M-1216.2(1). Connectors for medium-heat *appliances* and high-heat *appliances* shall be of steel not less than the thickness specified in Table M-1216.2(2).

Table M-1216.2(1)
MINIMUM CHIMNEY CONNECTOR THICKNESS FOR LOW-HEAT APPLIANCES

Diameter of connector (inches)[a]	Minimum nominal thickness (galvanized) (inches)
0 - 5	0.022 (No. 26 Gage)
6 - 9	0.028 (No. 24 Gage)
10 - 16	0.034 (No. 22 Gage)
Greater than 16	0.064 (No. 16 Gage)

Note a. 1 inch = 25.4 mm.

M-1216.3 Installation: Connectors shall be installed in accordance with Sections M-1216.3.1 through M-1216.3.7.

M-1216.3.1 Supports and joints: Connectors shall be supported in an approved manner, and joints shall be fastened with sheet metal screws, rivets or other approved means.

M-1216.3.2 Size: The connection shall be the same size as the *appliance* flue outlet.

M-1216.3.3 Length: The maximum horizontal length of a connector shall be 75 percent of the height of the chimney or *vent*, except that the maximum horizontal length of insulated connectors shall be 100 percent of the height of the chimney or *vent*.

M-1216.3.4 Connection: The connector shall extend to the inner face of the chimney or *vent* liner, but not beyond. A connector entering a masonry chimney shall be cemented to masonry in an approved manner. Where thimbles are installed to facilitate removal of the connector from the masonry chimney, the thimble shall be permanently cemented in place with high-temperature cement.

M-1216.3.4.1 Chimney connector pass-through: Chimney connectors for domestic-type *appliances* shall not pass through walls or partitions constructed of *combustible material* to reach a masonry chimney unless:

1. The connector is *labeled* for wall pass-through and is installed in accordance with the manufacturer's instructions; or
2. The connector is put through a device *labeled* for wall pass-through; or
3. The connector has a diameter not larger than 10 inches and is installed in accordance with one of the methods in Table M-1216.3.4.1 and Figure M-1216.3.4.1. Concealed metal parts of the pass-through system in contact with flue gases shall be of stainless steel or equivalent material that resists corrosion, softening or cracking up to 1,800 degrees F. (980 degrees C.).

M-1216.3.5 Pitch: Connectors shall rise vertically to the chimney or *vent* with a minimum pitch equal to ¼ inch per foot (21 mm/m).

M-1216.3.6 Location: Connectors shall be located entirely within the room in which the connecting *appliance* is located except as permitted in Section M-1216.3.4.1.

Table M-1216.2(2)
MINIMUM CHIMNEY CONNECTOR THICKNESS FOR MEDIUM- AND HIGH-HEAT APPLIANCES

Area (square inches)[a]	Equivalent round diameter (inches)[a]	Minimum nominal thickness (inches)
0 - 154	0 - 14	0.060 (No. 16 Manufacturers Standard Gage)
155 - 201	15 - 16	0.075 (No. 14 Manufacturers Standard Gage)
202 - 254	17 - 18	0.105 (No. 12 Manufacturers Standard Gage)
Greater than 254	Greater than 18	0.135 (No. 10 Manufacturers Standard Gage)

Note a. 1 inch = 25.4 mm; 1 square inch = 645.16 mm^2.

Table M-1216.3.4.1
CHIMNEY CONNECTOR SYSTEMS AND CLEARANCES TO COMBUSTIBLE WALL MATERIALS FOR DOMESTIC HEATING APPLIANCES[a, b, c, d]

System A (12-inch clearance)	A 3½-inch-thick brick wall shall be framed into the combustible wall. A ⅝-inch-thick fire-clay liner (ASTM C315 or equivalent)[e] shall be firmly cemented in the center of the brick wall maintaining a 12-inch clearance to combustibles. The clay liner shall run from the outer surface of the bricks to the inner surface of the chimney liner but shall not protrude into the chimney liner.
System B (9-inch clearance)	A labeled solid-insulated factory-built chimney section (1-inch insulation) the same inside diameter as the connector shall be utilized. Sheet metal supports cut to maintain a 9-inch clearance to combustibles shall be fastened to the wall surface and to the chimney section. Fasteners shall not penetrate the chimney flue liner. The chimney length shall be flush with the masonry chimney liner and sealed to the masonry with water-insoluble refractory cement. Chimney manufacturer's parts shall be utilized to fasten securely the chimney connector to the chimney section.
System C (6-inch clearance)	A sheet metal (minimum 24 gage) ventilated thimble having two 1-inch air channels shall be installed with a sheet steel chimney connector (minimum 24 gage). Sheet steel supports (minimum 24 gage) shall be cut to maintain a 6-inch clearance between the thimble and combustibles. One side of the support shall be fastened to the wall on all sides. Glass-fiber insulation shall fill the 6-inch space between the thimble and the supports.
System D (2-inch clearance)	A labeled solid-insulated factory-built chimney section (1-inch insulation) with a diameter 2 inches larger than the chimney connector shall be installed with a sheet steel chimney connector (minimum 24 gage). Sheet metal supports shall be positioned to maintain a 2-inch clearance to combustibles and to hold the chimney connector to ensure that a 1-inch airspace surrounds the chimney connector through the chimney section. The steel support shall be fastened to the wall on all sides and the chimney section shall be fastened to the supports. Fasteners shall not penetrate the liner of the chimney section.

Note a. Insulation material that is part of the wall pass-through system shall be noncombustible and shall have a thermal conductivity of 1.0 Btu · in./ft.^{2} · degrees F. or less.
Note b. All clearances and thicknesses are minimums.
Note c. Materials utilized to seal penetrations for the connector shall be noncombustible.
Note d. Connectors for all systems except System B shall extend through the wall pass-through system to the inner face of the flue liner.
Note e. ASTM C315 listed in Chapter 21.

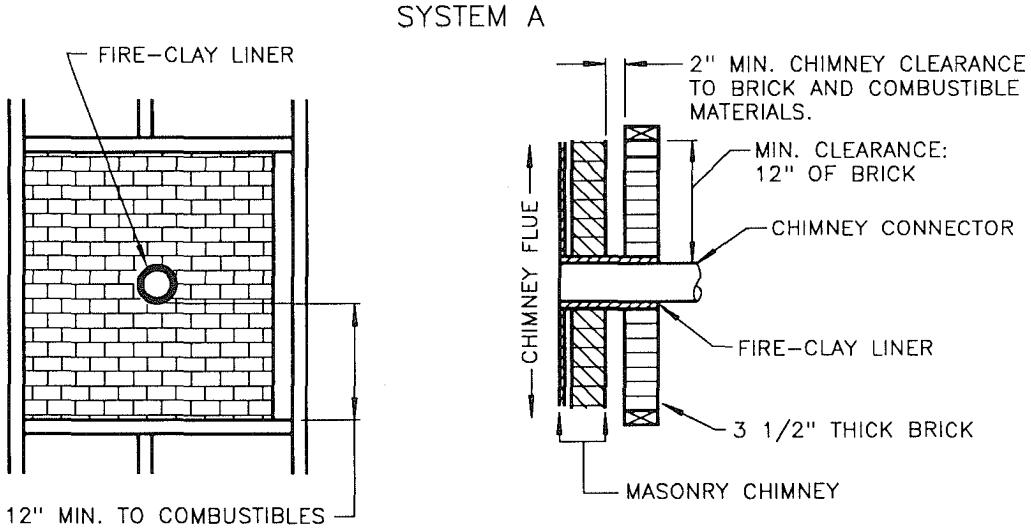

Figure M-1216.3.4.1
CHIMNEY CONNECTOR SYSTEMS

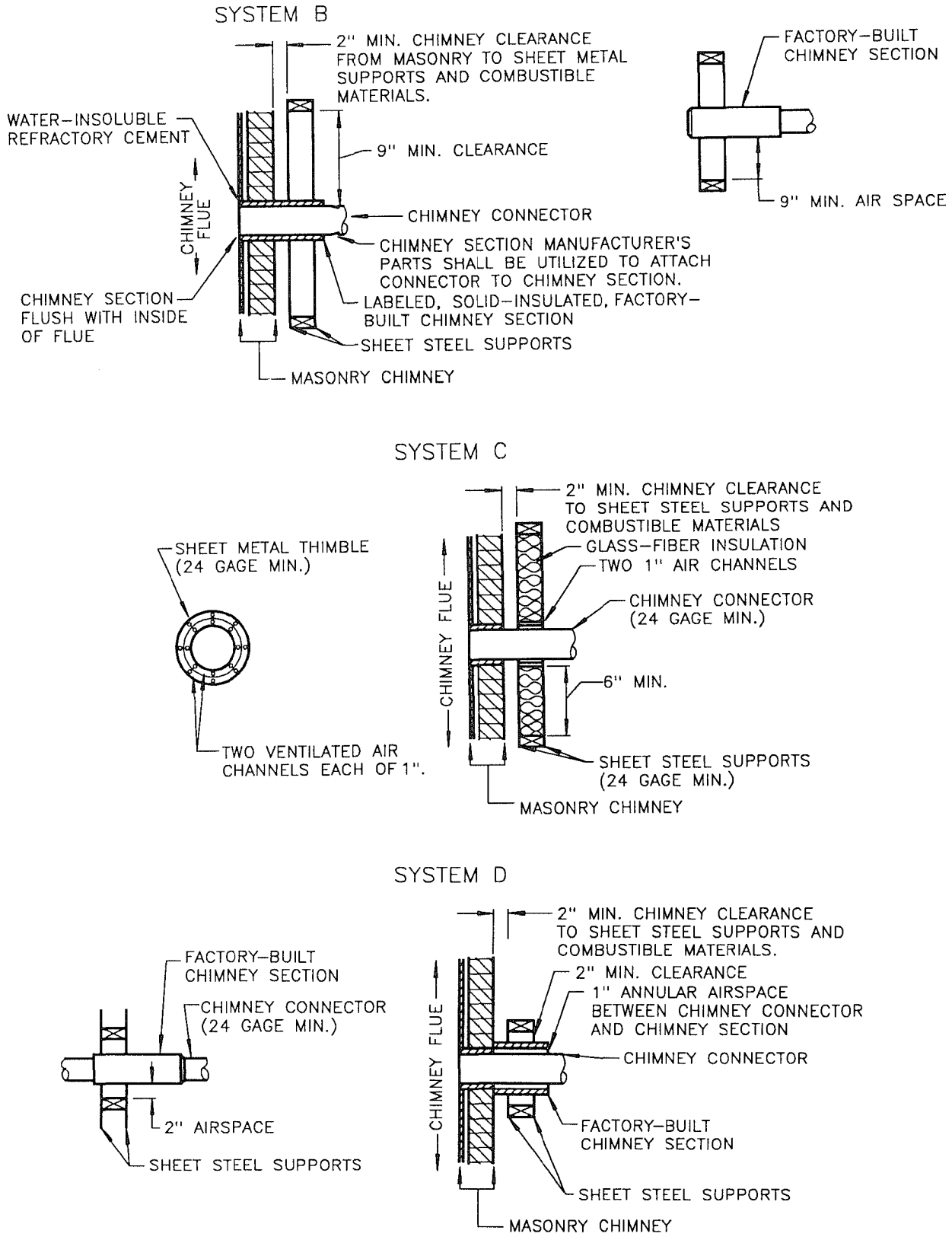

Figure M-1216.3.4.1 (cont'd.)
CHIMNEY CONNECTOR SYSTEMS

M-1216.3.7 Clearances: Connectors shall have a minimum clearance to *combustibles* in accordance with Table M-1216.3.7. The clearances specified in Table M-1216.3.7 apply, except where the *labeling* of an *appliance* specifies a different clearance, in which case the *labeled* clearance shall apply.

Table M-1216.3.7
CONNECTORS CLEARANCES TO COMBUSTIBLES

Type of appliance	Minimum clearance (inches)[a] (see Section M-1216.3.7)
Domestic-type appliances	
Chimney connectors	
Gas appliances without draft hoods	18
Electric, gas and oil incinerators	18
Oil and solid fuel appliances	18
Gas appliances with draft hoods	6
Vent connectors	
Gas appliances without draft hoods	9
Gas appliances with draft hoods	6
Oil appliances	3
Commercial, industrial-type appliances	
Low-heat appliances	
Chimney connectors	
Gas, oil and solid fuel boilers, furnaces and water heaters	18
Oil unit heaters	18
Gas unit heaters with draft hoods	6
Other low-heat industrial appliances	18
Medium-heat appliances	
Chimney connectors	
All gas, oil and solid fuel appliances	36
High-heat appliances	
Masonry or metal connectors	
All gas, oil and solid fuel appliances	(see Section M-1209.0)

Note a. 1 inch = 25.4 mm.

SECTION M-1217.0 DAMPERS

M-1217.1 Manual dampers: Manual dampers shall not be installed except in connectors or chimneys serving solid fuel-burning *appliances*.

M-1217.2 Automatic dampers: Automatic dampers shall bear the *label* of an approved agency. The dampers shall be installed in accordance with the manufacturer's installation instructions.

SECTION M-1218.0 TESTS

M-1218.1 General: Every chimney or *vent* system shall be tested. The tests shall indicate conformance to the requirements of this chapter without spillage of any products of combustion.

CHAPTER 13

MECHANICAL REFRIGERATION

SECTION M-1301.0 GENERAL

M-1301.1 Scope: This chapter shall govern the design, installation, construction and repair of refrigeration systems that vaporize and liquefy a fluid during the refrigerating cycle.

M-1301.2 Classification of refrigerants: Refrigerants shall be classified by hazard in accordance with ASHRAE 34 listed in Chapter 21. A list of typical refrigerants is contained in Appendix B.

M-1301.3 Factory-built equipment: Self-contained, factory-built equipment that bears the *label* of an approved agency shall conform to the installation requirements of Chapter 4.

SECTION M-1302.0 DEFINITIONS

M-1302.1 General: The following words and terms shall, for the purposes of this chapter and as stated elsewhere in this code, have the meanings shown herein.

Compressor: A specific machine, with or without accessories, for compressing a given refrigerant vapor.

Condenser: That part of the system designed to liquefy refrigerant vapor by removal of heat.

Evaporator: That part of the system designed to vaporize liquid refrigerant to produce refrigeration.

Fusible plug: A device having a predetermined temperature fusible member for the relief of pressure.

High-side pressure: The parts of a refrigerating system subjected to condenser pressure.

Low-side pressure: The parts of a refrigerating system subject to evaporator pressure.

Machinery room: A room in which a refrigerating system is permanently installed and operated, but not including evaporators located in a cold storage room, refrigerator box, air-cooled space or other enclosed space. Closets solely contained within, and opening only into, a machinery room shall not be considered machinery rooms but shall be considered a part of the machinery room in which said closets are contained. It is not the intent of this definition to cause the space in which a self-contained system is located to be classified as a machinery room.

Pressure-imposing element: Any device or portion of the equipment utilized for the purpose of increasing the refrigerant pressure.

Pressure-limiting device: A pressure-responsive mechanism designed to stop automatically the operation of the pressure-imposing element at a predetermined pressure.

Pressure relief device: A pressure-actuated valve or rupture member designed to relieve excessive pressure automatically.

Refrigerant: A substance utilized to produce refrigeration by its expansion or vaporization.

Refrigeration system: A combination of interconnected refrigerant-containing parts constituting one closed refrigerant circuit in which a refrigerant is circulated for the purpose of extracting heat.

Direct system: A direct system is one in which the evaporator is in direct contact with the material or space refrigerated, or is located in air-circulating passages communicating with such spaces.

Indirect system: An indirect system is one in which a brine cooled by the refrigerant is circulated to the material or space refrigerated or is utilized to cool the air so circulated. Indirect systems are distinguished by the type or method of application.

Stop valve: A shutoff valve for controlling the flow of liquid or gases.

SECTION M-1303.0 MAXIMUM QUANTITIES OF REFRIGERANT

M-1303.1 Group 1 refrigerants: The maximum amount of Group 1 refrigerants utilized in direct systems shall be as indicated in Table M-1303.1. The space indicated in the table shall equal the volume of the building intended to be occupied.

M-1303.1.1 Indirect systems: The amount of Group 1 refrigerants utilized in indirect systems shall not be limited.

M-1303.2 Group 2 refrigerants: The maximum amount of Group 2 refrigerants utilized in direct systems shall be 20 pounds (9 kg). Direct systems utilizing Group 2 refrigerants shall not be utilized for comfort cooling.

Exception: Direct systems, for other than comfort cooling, utilizing ammonia R-717 as the refrigerant shall not be limited in capacity where the system is designed and installed in accordance with ASHRAE 15 and IIAR 2 listed in Chapter 21.

Table M-1303.1
MAXIMUM PERMISSIBLE QUANTITIES OF GROUP 1 REFRIGERANTS FOR DIRECT SYSTEMS

Refrigerant	Maximum quantity in pounds per 1,000 cubic feet[b] of space intended for human occupancy[a]
R-11	35
R-12	31
R-13	27
R-13B1	38
R-14	23
R-21	13
R-22	22
R-30	6
R-113	24
R-114	44
R-115	40
R-C318	50
R-500	26
R-502	30
R-744	11

Note a. Volatile charge in a control shall not be considered as refrigerant.
Note b. 1 pound per 1,000 cubic feet = 0.016 kg/m^3.

M-1303.2.1 Indirect systems: The maximum amount of Group 2 refrigerants utilized in indirect systems shall be 1,000 pounds (454 kg). All indirect systems utilizing Group 2 refrigerants shall be installed in Class T *machinery rooms* or outdoors.

Exception: Indirect systems utilizing ammonia R-717 as the refrigerant shall not be limited in capacity where the system is designed and installed in accordance with ASHRAE 15 and IIAR 2 listed in Chapter 21.

M-1303.3 Group 3 refrigerants: The maximum amount of Group 3 refrigerants shall be as indicated in Table M-1303.3. Group 3 refrigerants shall be exclusively utilized in laboratories or occupancies in Use Groups F, H and S.

Table M-1303.3
MAXIMUM PERMISSIBLE QUANTITIES OF GROUP 3 REFRIGERANTS

Refrigerant	Group	Maximum quantity[a, b] in pounds per 1,000 cubic feet of room volume
R-170	3	2½
R-290	3	2½
R-600	3	2½
R-601	3	2½
R-1150	3	2

Note a. The maximum quantity shall not exceed 1,000 pounds.
Note b. 1 pound per 1,000 cubic feet = 0.016 kg/m^3; 1 pound = 0.454 kg.

M-1303.4 Alternative refrigerants: The refrigerants listed in Table M-1303.4 shall be permitted in air conditioning and refrigeration systems as substitutes for the refrigerants listed in Table M-1301.1. The maximum quantity of such alternative refrigerants utilized in direct systems shall be in accordance with Table M-1303.4.

M-1303.4.1 Indirect systems: All indirect systems utilizing refrigerants R-123 or R-134a shall be installed in general *machinery rooms* designed and constructed in accordance with Section M-1308.0, or shall be installed outdoors.

Table M-1303.4
ALTERNATIVE REFRIGERANTS

Refrigerant	Maximum quantity[a] in pounds per 1,000 cubic feet of room volume
R-123 2,2-Dichloro-1,1,1-Trifluoroethane (CF_3CHCl_2)	.004
R-134a 1,1,1,2-Tetrafluoroethane (CH_2FCF_3)	16

Note a. 1 pound per 1,000 cubic feet = 0.016 kg/m^3.

SECTION M-1304.0 REFRIGERATION PIPING AND EQUIPMENT

M-1304.1 Equipment: All refrigeration equipment shall be of an approved type and compatible with the type of refrigerant being utilized. The equipment shall be rated for the maximum operating pressure of the refrigeration system.

M-1304.1.1 Identification of system: A metal plate, tag or other device shall be permanently and prominently located near the refrigeration equipment indicating the type of refrigeration system, the type of refrigerant and the maximum amount of refrigerant.

M-1304.1.2 Minimum design pressure: The minimum design pressure of a refrigeration system shall be based on the type of refrigerant utilized in accordance with Table M-1304.1.2 unless otherwise approved.

Table M-1304.1.2
MINIMUM DESIGN PRESSURES

Refrigerant	Minimum design pressures (pounds per square inch gauge)[a, b]		
	Low side	High side	
		Water or evaporator cooled	Air cooled
R-11	15	15	21
R-12	85	127	169
R-13	521	547	547
R-13B1	230	321	410
R-14	544	544	544
R-21	15	29	46
R-22	144	211	278
R-30	15	15	15
R-40	72	112	151
R-113	15	15	15
R-114	18	35	53
R-115	152	194	252
R-123	15	15	21
R-134a	85	127	169
R-170	616	709	709
R-290	129	188	244
R-C318	34	59	85
R-500	102	153	203
R-502	162	232	302
R-600	23	42	61
R-601	39	63	88
R-611	15	15	15
R-717	139	215	293
R-744	955	1,058	1,058
R-764	45	78	115
R-1150	732	732	732

Note a. Corresponding to specified saturation pressure at 14.7 psi atmospheric pressure.
Note b. 1 pound per square inch = 6.895 kPa.

M-1304.2 Piping system: Refrigeration system piping shall conform to one of the standards listed in Table M-1304.2. The pipe shall be rated for the maximum operating pressure of the system.

Table M-1304.2
REFRIGERATING SYSTEM PIPE

Material	Standard (listed in Chapter 21)
Copper or copper-alloy tubing	ASTM B88; ASTM B280
Steel pipe	ASTM A53; ASTM A106

M-1304.2.1 Valves and fittings: All valves and fittings shall be of an approved type rated for the maximum operating pressure of the system.

M-1304.3 Pipe joints and connections: All joints between refrigeration system pipe or fittings shall be in accordance with one or more of the following Sections M-1304.3.1 through M-1304.3.5.

M-1304.3.1 Copper-brazed joints: All copper-joint surfaces shall be cleaned. An approved flux shall be applied where required. The joint shall be brazed with a filler metal conforming to AWS A5.8 listed in Chapter 21.

M-1304.3.2 Mechanical joints: *Mechanical joints* shall be installed in accordance with the manufacturer's instructions.

M-1304.3.3 Steel-threaded joints: Steel pipe threads shall conform to ASME B1.20.1 listed in Chapter 21. Pipe-joint compound or tape shall be applied on the male threads only.

M-1304.3.4 Steel-welded joints: All steel pipe-joint surfaces shall be cleaned by approved procedures. The joint shall be welded with an approved filler metal.

M-1304.3.5 Joints between different piping materials: Joints between different piping materials shall be made with approved adapter fittings.

M-1304.4 Support: All refrigeration system equipment and piping shall be supported in an approved manner.

M-1304.5 Cutting or notching: A structural member shall not be cut, notched or pierced in excess of the limitations specified in the building code listed in Chapter 21, unless proven safe by a structural analysis.

SECTION M-1305.0 PRESSURE-LIMITING DEVICES

M-1305.1 General: Pressure-limiting devices shall be provided on all systems containing more than 20 pounds (9 kg) of refrigerant and operating above atmospheric pressure and on all water-cooled systems capable of producing a pressure in excess of the high-side design pressure.

Exception: Water-cooled units containing less than 3 pounds (1.4 kg) of a Group 1 refrigerant.

M-1305.2 Maximum setting: The maximum setting to which a pressure-limiting device is capable of being set by the adjusting means provided shall not exceed 90 percent of the setting of the pressure relief device installed on the high side of a system. Where the high side of a system is not protected by a pressure relief device, the maximum setting shall not exceed the design pressure of the high side of the system, except as provided for in Section M-1305.2.1. The pressure-limiting device shall stop the action of the pressure-imposing element at a pressure not higher than this maximum setting.

M-1305.2.1 Systems with nonpositive-displacement compressors: For systems with nonpositive-displacement compressors, the pressure-limiting device is permitted to be set at the design pressure of the high side of the system, provided that the pressure relief device is subject to the low-side pressure, and stop valves are not on the system.

M-1305.3 Pressure-limiting devices: Pressure-limiting devices shall be connected between the pressure-imposing element and any stop valve on the discharge side without intervening stop valves in the line leading to the pressure-limiting device.

SECTION M-1306.0 PRESSURE RELIEF PROTECTION

M-1306.1 General: Every refrigeration system shall be protected by a pressure relief device.

M-1306.2 Pressure relief device: All pressure relief devices shall bear the *label* of an approved agency. The device shall be rated for the capacity of the refrigeration system. The pressure relief device shall be set at the maximum design pressure of the system or equipment.

M-1306.2.1 Discharge piping: Pressure relief devices and fusible plugs serving the following systems shall discharge to the atmosphere at a location not less than 15 feet (4572 mm) above the adjoining ground level and not less than 20 feet (6096 mm) from any window, *ventilation* opening or exit in any building.

1. Any system containing a Group 3 refrigerant.
2. Any system containing more than 6 pounds (2.72 kg) of a Group 2 refrigerant.
3. Any system containing more than 100 pounds (45.36 kg) of a Group 1 refrigerant.

Discharge piping connected to the discharge side of a fusible plug or rupture member shall have provisions to prevent plugging of the piping in the event that the fusible plug or rupture member functions.

M-1306.2.2 Sizing: Discharge piping shall be sized for simultaneous relief of the maximum quantity of refrigerant in the system, via the sum of the system's pressure relief devices and in accordance with the manufacturer's instructions. Where relief piping for more than one system is interconnected, such relief piping shall be sized for the largest system. Systems utilizing different classifications of refrigerant shall not have discharge piping interconnected.

M-1306.2.3 Optional ammonia discharge: Where ammonia is utilized, the preferred discharge is into the atmosphere. Alternatively, the ammonia shall discharge into a tank of water which shall not be utilized for any other purpose except ammonia absorption.

M-1306.2.3.1 Tank water: At least 1 gallon (0.004 m^3) of fresh water shall be provided for each pound (0.0083 m^3/kg) of ammonia in the system. Such water shall be prevented from freezing without the utilization of salt or chemicals.

M-1306.2.3.2 Tank construction: The tank shall be substantially constructed of iron or steel not less than 0.125-inch (3.2 mm) in thickness or No. 11 US Gage. The tank shall have a hinged cover or, if of the enclosed type, the tank shall have a *vent* hole at the top.

M-1306.2.3.3 Piping connections: All piping connections shall be through the top of the tank only. The discharge pipe from the pressure relief valves shall discharge the ammonia into the center of the tank near the bottom.

M-1306.2.4 Discharge of sulfur dioxide: The point of discharge of sulfur dioxide R-764 shall be to a tank of sodium dichromate brine. The minimum quantity of brine shall equal 1 gallon (0.004 m^3) for each pound (0.0083 m^3/kg) of sulfur dioxide refrigerant in the system. The minimum concentration of brine shall be 2½ pounds of dichromate for each 1 gallon (300 kg/m^3) of water.

M-1306.3 Location: Pressure relief devices shall be located to relieve pressure of all piping and equipment when valves or pumps are in a closed position.

SECTION M-1307.0 CLASS T MACHINERY ROOMS

M-1307.1 Room enclosure: Class T *machinery rooms* shall be separated from the remainder of the building by a minimum 1-hour fire separation assembly. All doors shall be tight fitting. Every door shall be clearly labeled "Machinery Room."

M-1307.2 Emergency controls: Emergency controls capable of shutting down all of the refrigeration equipment shall be located outside Class T *machinery rooms* near the room entrance.

M-1307.3 Exhaust system: An independent mechanical exhaust system shall be provided for each Class T *machinery room.* The exhaust system shall operate when the refrigeration system is turned on. The exhaust system shall provide a minimum of six air changes per hour.

SECTION M-1308.0 GENERAL MACHINERY ROOMS

M-1308.1 General: General *machinery rooms* containing air conditioning and refrigeration equipment utilizing refrigerants R-123 or R-134a shall comply with Sections M-1308.1.1 through M-1308.1.7.

M-1308.1.1 Design: General *machinery rooms* shall be designed and constructed in accordance with ASHRAE 15 listed in Chapter 21.

M-1308.1.2 Ventilation: All general *machinery rooms* shall be provided with mechanical *ventilation* in accordance with ASHRAE 15 listed in Chapter 21.

M-1308.1.3 Detection and alarm: Where refrigerant R-123 is utilized, the general *machinery room* shall be equipped with an approved compound-specific refrigerant detection system that will sound an alarm when the refrigerant R-123 concentration in the room reaches the allowable exposure limit (AEL) of 10 parts per million.

M-1308.1.4 Oxygen monitoring: Where refrigerant R-134a is utilized, the general *machinery room* shall be equipped with an approved oxygen-sensing system that will sound an alarm when the oxygen level in the room falls below 19.5 percent of the room air volume.

M-1308.1.5 Access: Access to the general *machinery room* or rooms shall be restricted to authorized personnel.

M-1308.1.6 Self-contained breathing apparatus: At least one self-contained breathing apparatus shall be provided and located outside of the general *machinery room,* near the room entrance.

M-1308.1.7 Discharge piping: Pressure relief devices, fusible plugs and purge systems shall discharge to the outside atmosphere at a location not less than 15 feet above the adjoining ground level and not less than 20 feet from any window, *ventilation* opening, air intake opening or exit opening in any building. Discharge piping shall be designed and constructed in accordance with ASHRAE 15 listed in Chapter 21.

SECTION M-1309.0 TESTS

M-1309.1 General: All mechanical refrigeration systems, other than factory-assembled parts that have been tested in the factory, shall be tested to the maximum operating pressure of the system. The tests shall be conducted utilizing air or an inert gas.

CHAPTER 14

FIREPLACES, SOLID FUEL-BURNING AND GAS ACCESSORY APPLIANCES

SECTION M-1401.0 GENERAL

M-1401.1 Scope: This chapter shall govern the design, installation, construction and repair of fireplaces, solid fuel-burning *appliances* and decorative gas *appliances* accessory to fireplaces. Crematories and incinerators shall comply with the provisions of Chapter 15.

M-1401.2 Hazardous locations: Fireplaces, solid fuel-burning *appliances* and decorative gas *appliances* accessory to fireplaces shall not be installed in *hazardous locations*.

SECTION M-1402.0 ROOM HEATERS

M-1402.1 General: Solid fuel-burning room heaters shall be tested in accordance with UL 1482 listed in Chapter 21.

SECTION M-1403.0 FACTORY-BUILT FIREPLACES

M-1403.1 General: Factory-built fireplaces shall be tested in accordance with UL 127 listed in Chapter 21. Fireplace stoves shall be tested in accordance with UL 737 listed in Chapter 21.

SECTION M-1404.0 MASONRY FIREPLACES

M-1404.1 Dimensions: The firebox of a masonry fireplace shall have a minimum depth of 20 inches (508 mm). The size of the chimney connection shall be a minimum cross-sectional area of 50 square inches (32258 mm^2). The minimum cross-sectional area of the fireplace shall equal the cross-sectional area of the chimney connection.

M-1404.1.1 Rumford fireplaces: Rumford fireplaces shall be permitted provided that the depth of the fireplace is at least 12 inches (305 mm) and is at least one-third of the width of the fireplace opening; and that the throat is at least 12 inches (305 mm) above the lintel, and is at least 1/20th the cross-sectional area of the fireplace opening.

M-1404.2 Wall construction: Fireplace walls lined with a minimum of 2 inches of approved low-duty refractory brick shall have a minimum total thickness of 8 inches (203 mm) of solid masonry. Approved medium-duty fire-clay mortar or an equivalent shall be utilized with the low-duty refractory brick. Unlined fireplace walls shall be constructed of solid masonry having a minimum total thickness of 12 inches (305 mm).

M-1404.2.1 Extension of liners: The liner of the fireplace walls shall extend a minimum of 4 inches (102 mm) into the throat of the fireplace.

M-1404.2.2 Throat and smoke chamber: The walls of the throat and smoke chamber shall be constructed of solid masonry having a minimum total thickness of 8 inches (203 mm). The throat and smoke chamber walls are permitted to be reduced in thickness to 4 inches of solid masonry provided that such walls are lined with at least 1 inch of insulating refractory masonry so that the heat transferred through this wall is not more than the heat transferred through 8 inches (203 mm) of solid masonry.

M-1404.2.3 Heat exchangers: Gravity-fed heat exchangers installed in the walls of masonry fireplaces shall not reduce the total thickness of solid masonry.

M-1404.3 Foundation and hearth: The foundation of a fireplace shall be constructed of *noncombustible material* and shall conform to the requirements of the building code listed in Chapter 21. The hearth and hearth extension shall be constructed of solid masonry having a minimum thickness of 4 inches (102 mm).

M-1404.3.1 Hearth extension: The hearth shall extend a minimum of 16 inches (406 mm) beyond the face of the fireplace opening and a minimum of 8 inches (203 mm) on each side of the fireplace opening for fireplaces having an opening of less than 6 square feet (0.56 m^2). The hearth of larger-sized fireplaces shall extend a minimum of 20 inches (508 mm) beyond the face of the fireplace opening and a minimum of 12 inches (305 mm) on each side of the fireplace opening. *Combustible* forms utilized during the construction of the hearth and hearth extension shall be removed.

M-1404.4 Clearance to combustibles: The exterior surface of fireplace walls shall have a minimum clearance of 4 inches (102 mm) to *combustible materials*. *Combustible material*, including framing and sheathing, shall have a minimum clearance of 2 inches (51 mm) from the exterior surface of smoke chamber walls. *Combustible material* attached to a fireplace face, such as trim and mantels, shall have a minimum clearance of 6 inches (152 mm) from a fireplace opening. *Combustible material* above and projecting more than 1½ inches (38 mm) from a fireplace face shall have a minimum clearance of 12 inches (305 mm) above a fireplace opening.

M-1404.5 Opening to the chimney: Means shall be provided to shut off the opening to the chimney when the fireplace is not in operation.

M-1404.5.1 Dampers: Dampers shall be constructed of metal having a minimum thickness of No. 12 Manufacturers Standard Gage (0.105 inch).

M-1404.6 Chimneys with metal hoods: Metal hoods shall extend a minimum of 6 inches (152 mm) beyond the firebox. The hoods shall comply with the requirements for metal chimneys.

M-1404.7 Existing masonry chimneys: Existing masonry chimneys are permitted to vent open fireplaces only — even if the existing chimneys lack the clearances to *combustibles* as required by Section M-1207.4 — provided that such chimneys otherwise meet the requirements of Chapter 12 of this code or are made to conform to such requirements through repair or relining.

SECTION M-1405.0 BARBECUE PITS

M-1405.1 Wall construction: Barbecue pit walls lined with a minimum of 2 inches (51 mm) of approved low-duty refractory brick shall have a minimum total thickness of 8 inches (203 mm) of solid masonry. Approved medium-duty fire-clay mortar or an equivalent shall be utilized with the low-duty refractory brick. Unlined barbecue pit walls shall be constructed of solid masonry having a minimum total thickness of 12 inches (305 mm).

M-1405.2 Foundation: The foundation of a barbecue pit shall be constructed of *noncombustible material* and shall conform to the requirements of the building code listed in Chapter 21.

M-1405.3 Clearance to combustibles: The exterior walls of a barbecue pit shall have a minimum clearance of 4 inches (102 mm) to *combustible materials*.

M-1405.4 Kitchen exhaust and suppression: A commercial kitchen exhaust system shall be installed in accordance with Chapter 5. The suppression system for the kitchen exhaust system shall be designed and approved for barbecue pits.

SECTION M-1406.0 GAS ACCESSORIES

M-1406.1 Labeled: Gas-burning *appliances* designed for installation in approved fireplaces, such as decorative gas *appliances*, shall bear the *label* of an approved agency and shall be installed in accordance with the manufacturer's instructions for the *labeled* equipment.

M-1406.2 Flame safeguard device: Gas *appliances* installed in fireplaces shall have the main burner ignition by means of a direct ignition device, an ignitor or a pilot flame to ignite the fuel at the main burner, and shall be equipped with a flame safeguard device. The flame safeguard device shall automatically shut off the fuel supply to a main burner or group of burners when the means of ignition of such burners becomes inoperative.

M-1406.3 Fixed dampers: Manual fireplace dampers are required to be fixed in a manner that maintains the gas appliance manufacturer's required minimum permanent *vent* opening at all times.

CHAPTER 15

INCINERATORS AND CREMATORIES

SECTION M-1501.0 GENERAL

M-1501.1 Scope: This chapter shall govern the installation, repair, maintenance and approval of all incinerators and crematories.

M-1501.2 Annual inspection: All crematories and all incinerators, except Class I, Class IA and domestic incinerators, shall be inspected annually by the code official.

M-1501.3 Prohibited locations: Installation of any type of incinerator in garages or in areas containing explosive or *flammable liquids* or fumes shall be prohibited.

M-1501.4 Factory-built incinerators and crematories: Factory-built incinerators and crematories shall conform to the requirements of Chapter 4.

SECTION M-1502.0 DEFINITIONS

M-1502.1 General: The following words and terms shall, for the purposes of this chapter and as stated elsewhere in this code, have the meanings shown herein.

Auxiliary fuel-firing equipment (incinerator): Equipment to supply additional heat, by the combustion of an auxiliary fuel, for the purpose of attaining temperatures that are sufficiently high enough to:

1. Dry and ignite waste material;
2. Maintain ignition thereof; and
3. Promote complete combustion of *combustible* solids, vapors and gases.

Curtain wall (incinerator): A partition wall between chambers under which pass the products of combustion.

Damper, barometric: A device to admit air to the breeching or flue connection, thereby automatically maintaining a constant draft in the equipment.

Damper, guillotine: An adjustable blade installed vertically in a breeching or flue connection, counterbalanced for easy operation.

Damper, sliding: An adjustable blade installed in a duct, breeching or flue connection.

Downpass: A gas passage placed between two chambers of an incinerator to carry the products of combustion in a downward direction.

Excess air: The air remaining after a fuel has been completely burned, or that air supplied in addition to the theoretical quantity required for combustion.

Flue connection (breeching): A passage for conducting the products of combustion from a fuel-fired *appliance* to the *vent* or chimney.

Flue gases: Products of combustion and excess air.

Incinerator, domestic gas-fired type: An approved, directly fed, gas-fired-type incinerator for the burning of ordinary waste material, having a capacity of not more than 5 cubic feet (0.14 m^3), generally located within a structure, and designed primarily for utilization in one- and two-family dwellings.

Primary air: Any air which is mixed with the fuel at or in the burner or fuel bed for the purpose of promoting combustion of the fuel or *combustible materials*.

Secondary air: Any air brought in around the burner or through openings in the combustion chamber for the purpose of completing combustion.

Theoretical air: The exact amount of air required to supply oxygen for complete combustion of a given quantity of a specific fuel.

Underfire air: Any air controlled with respect to quantity and direction, forced or induced, supplied beneath the grate that passes through the fuel bed.

SECTION M-1503.0 WASTE CLASSIFICATION

M-1503.1 Waste analysis: The basis for satisfactory incinerator operation is the proper analysis of the waste to be destroyed, and the selection of proper equipment to best destroy that particular waste. For the purposes of this chapter, all types of waste to be destroyed shall be classified as indicated in Sections M-1503.2 through M-1503.9 and Table M-1503.1.

M-1503.2 Type 00 waste: Type 00 waste is trash, consisting of a mixture of highly *combustible* waste such as paper, paper products, cardboard, cartons, wood boxes and *combustible* floor sweepings from commercial and industrial activities. The mixture contains up to 10 percent by weight of plastic bags, coated paper, laminated paper, treated corrugated cardboard, oily rags and plastic or rubber scrap. This type of waste contains up to 10 percent moisture, 5 percent *noncombustible* solids, has a bulk density of less than 8 pounds per cubic foot (128 kg/m^3) and has a heating value of 8,500 British thermal units (Btu) per pound (1.98×10^7 J/kg) as fired.

Table M-1503.1
CLASSIFICATION OF WASTES TO BE INCINERATED

Type of waste		Principal components	Approximate composition percent by weight and density	Moisture content (percent)	Noncombustible solids (percent)	Btu[c] value/pound of refuse as fired[d]	Btu[c] of auxiliary fuel per pound of waste to be included in combustion calculations[d]	Mininum Btuh[c] burner input per pound waste primary chamber unless otherwise specified[d]
Type	Description							
00 and 0[a]	Trash	Combustible waste, paper, paper products, cartons, rags, wood scraps, floor sweepings; with domestic, commercial and industrial sources The mixture contains up to 10-percent plastic bags, coated or treated paper products, and rubber or plastic scrap[b]	Waste containing less than 10% plastic or rubber scrap Density of 00 trash less than 8 pounds per cubic foot, and 0 trash 8 to 10 pounds per cubic foot	10	5	8,500	0	0 (see Section M-1509.4)
1[a]	Rubbish	Combustible waste, paper, paper products, cartons, rags, wood scraps, floor sweepings; with domestic, commercial and industrial sources	Rubbish 100% Garbage up to 20% Density 8 to 10 pounds per cubic foot	25	10	6,500	0	0 (see Section M-1509.4)
2[a]	Refuse	Rubbish and garbage; residential sources	Rubbish 50% Garbage 50% Density 15 to 20 pounds per cubic foot	50	7	4,300	0	1,500 (see Section M-1509.4)
3[a]	Garbage	Animal and vegetable wastes; restaurants, hotels, markets, institutional, commercial and club sources	Garbage 100% Rubbish up to 35% Density 30 to 35 pounds per cubic foot	70	5	2,500	1,500	3,000
4	Animal solids and organic wastes	Carcasses, organs, solid organic wastes; hospital, laboratory, abattoirs, animal pounds and similar sources	100% animal and human tissue Density 45 to 55 pounds per cubic foot	85	5	1,000	3,000	5,000 Primary 3,000 Secondary
5	Gaseous liquid or semi-liquid wastes	Industrial process wastes	Variable	Dependent on predominant components	Variable according to wastes survey	Variable according to wastes survey	Variable according to wastes survey	Variable according to wastes survey
6	Semisolid and solid wastes	Combustibles requiring hearth, retort or grate-burning equipment	Variable	Dependent on predominant components	Variable according to wastes survey	Variable according to wastes survey	Variable according to wastes survey	Variable according to wastes survey

Note a. The above figures on moisture content, ash and British thermal units as fired have been determined by analysis of many samples to compute heat release, burning rate, velocity and other details of incinerator design. Any design based on these calculations accommodates minor variations.

Note b. Where trash composition is such that any single charge to the incinerator will contain more than 10-percent plastic or rubber scrap by weight, the waste shall be classified as Type 6 waste.

Note c. Btu = British thermal units; Btuh = British thermal units per hour.

Note d. 1 Btu per pound = 2.329 J/kg.

M-1503.3 Type 0 waste: Type 0 waste is trash, consisting of a mixture of highly *combustible* waste such as paper, paper products, cardboard, cartons, wood boxes and *combustible* floor sweepings from commercial and industrial activities. The mixtures contain up to 10 percent by weight of plastic bags, coated paper, laminated paper, treated corrugated cardboard, oily rags and plastic or rubber scrap. This type of waste contains up to 10 percent moisture, 5 percent *noncombustible* solids, has a bulk density of 8 to 10 pounds per cubic foot (128 to 160 kg/m^3) and has a heating value of 8,500 Btu per pound (1.98×10^7 J/kg) as fired.

M-1503.4 Type 1 waste: Type 1 waste is rubbish, consisting of *combustible* waste such as paper, paper products, cartons, rags, wood scraps, sawdust, foliage and floor sweepings from domestic, commercial and industrial activities. This type of waste contains up to 25 percent moisture, up to 10 percent *noncombustible* solids, has a bulk density of 8 to 10 pounds per cubic foot (128 to 160 kg/m^3) and has a heating value of 6,500 Btu per pound (1.51×10^7 J/kg) as fired.

M-1503.5 Type 2 waste: Type 2 waste is refuse consisting of an approximately even mixture of rubbish and garbage by weight. This type of waste consists of up to 50 percent moisture, 7 percent *noncombustible* solids, has a bulk density of 15 to 20 pounds per cubic foot (240 to 320 kg/m^3) and has a heating value of 4,300 Btu per pound (1.00×10^7 J/kg) as fired.

M-1503.6 Type 3 waste: Type 3 waste is garbage consisting of animal and vegetable wastes. This type of waste contains up to 70 percent moisture, up to 5 percent *noncombustible* solids, has a bulk density of 30 to 35 pounds per cubic foot (480 to 520 kg/m^3) and has a heating value of 2,500 Btu per pound (0.58×10^7 J/kg) as fired.

M-1503.7 Type 4 waste: Type 4 waste is human parts and animal remains consisting of carcasses, organs and solid organic wastes. This type of waste contains up to 85 percent moisture, 5 percent *noncombustible* solids, has a bulk density of 45 to 55 pounds per cubic foot (720 to 817 kg/m^3) and has a heating value of 1,000 Btu per pound (0.23×10^7 J/kg) as fired.

M-1503.8 Type 5 waste: Type 5 waste is byproduct waste, gaseous, liquid or semiliquid, such as tar, paints, solvents, sludge, fumes and similar materials. Btu values shall be determined for the individual materials to be incinerated.

M-1503.9 Type 6 waste: Type 6 waste is solid byproduct waste, such as rubber, plastics, wood waste and similar materials. Btu values shall be determined for the individual materials to be incinerated.

SECTION M-1504.0 INCINERATOR CLASSIFICATION

M-1504.1 Classification: Incinerators shall be classified in accordance with Sections M-1504.2 through M-1504.9. Section M-1505.3 shall apply to incinerators designed to burn a combination of wastes not included in the classification provided for herein.

M-1504.2 Class I: Class I shall include portable, packaged or job-assembled direct-fed incinerators of 5 cubic feet (0.14 m^3) storage capacity, or 25 pounds per hour (31.5×10^{-4} kg/s) burning rate, for Type 1 or Type 2 waste.

M-1504.3 Class IA: Class IA shall include portable, packaged or job-assembled direct-fed incinerators of 5 to 15 cubic feet (0.14 to 0.42 m^3) primary chamber volume of up to, but not including, 100 pounds per hour (126×10^{-4} kg/s) burning rate, for Type 1 or Type 2 waste.

M-1504.4 Class IIA: Class IIA shall include flue-fed incinerators served by two flues, one for charging waste and one for carrying the products of combustion.

M-1504.5 Class III: Class III shall include direct-fed incinerators with a burning rate of 100 pounds per hour (126×10^{-4} kg/s) or over, for Type 00, Type 0, Type 1 or Type 2 waste.

M-1504.6 Class IV: Class IV shall include direct-fed incinerators with a burning rate of 75 pounds per hour (94.5×10^{-4} kg/s) or over, for Type 3 waste.

M-1504.7 Class V: Class V shall include municipal incinerators.

M-1504.8 Class VI: Class VI shall include crematory and pathological incinerators, for Type 4 waste.

M-1504.9 Class VII: Class VII shall include incinerators designed for specific byproduct wastes, for Type 5 or Type 6 waste.

SECTION M-1505.0 DESIGN

M-1505.1 Design requirements: Incinerators shall be designed in accordance with the requirements of Sections M-1505.2 through M-1505.17.

M-1505.2 Incinerator volume: The interior incinerator volume shall be calculated by measuring the inside distance between the side walls, and from the front end to the rear wall and from paving to roof, excluding ash pit, interior walls, grates and hearth. Door openings, chutes or charging hoods or flue connections shall not be considered a part of the incinerator volume. The volume of the charging door opening, through which the refuse is placed in the incinerator, shall be considered a part of the incinerator volume.

M-1505.2.1 Roof height: Roof height above the grate shall not be less than four-thirds of the grate area to the power of four-elevenths ($4/3\ AG^{4/11}$) plus or minus 10 percent, except Class VI incinerators.

M-1505.2.2 Heat release: Total heat release in the entire incinerator shall not exceed 25,000 British thermal units per hour (Btuh) per cubic foot (258 kW/m^3).

M-1505.3 Incinerator for combination waste: Any incinerator which is designed to burn a combination of wastes and where such combination does not fall into a category of "Incinerator classification" as set forth in Section M-1504.0, shall be classified as Class VI or Class VII. In the design, the specific wastes shall be classified into the standard categories for such wastes, and the portion of the incinerator chamber burning such waste shall conform to the minimum and maximum requirements set forth for that category. The total products of combustion and the total heat release and burner capacities shall be utilized in determining the sizes of the downpass, final combustion chamber, flue connection and stack.

M-1505.4 Secondary burners: All new incinerators shall provide for a secondary burner or burners (see Section M-1509.4). Primary burners shall be provided as required in Table M-1503.1.

M-1505.5 Settling chamber: A chamber shall be provided in which the products of combustion are reduced in velocity to 9 feet per second (2.7 m/s) at 1,400 degrees F. (760 degrees C.) while traveling in a vertical direction. The length of gas travel at 9 feet per second (2.7 m/s) shall be a distance at least the square root of the horizontal cross-sectional area of the settling chamber, measured from the top of the opening under the curtain wall to the roof of the incinerator, or to the top of the breeching connection, whichever is lower.

M-1505.6 Flame port: The flame port shall be designed to provide a velocity of not less than 50 feet per second (15.2 m/s) calculated at 1,000 degrees F. (538 degrees C.).

Exception: This requirement shall not apply to Class I and Class IA domestic gas-fired incinerators.

M-1505.7 Downpass: All incinerators, except gas-fired domestic, shall include a downpass or other means of creating turbulence for the gases of combustion to assure thorough mixing of the gases prior to their entering the secondary combustion chamber.

M-1505.8 Refractory lining: A refractory lining that is 4½ inches (114 mm) in thickness shall be required except where the area of any wall exceeds 35 square feet (3.22 m^2). Every wall over 4 feet (1219 mm) in height shall be anchored every 4 feet (1219 mm). Castable or plastic refractory shall be anchored every 18 inches (457 mm).

M-1505.8.1 Exceeded area: Where the area specified in Section M-1505.8 is exceeded, the lining of all walls and the roof shall be at least 9 inches (228 mm) in thickness.

M-1505.8.2 Approval: Walls of greater thicknesses shall be provided where required to provide structural stability.

M-1505.9 Roofs, arches and lintels: All roofs or arches shall be designed so that metal supports or lintels are not directly exposed to heat or flame.

M-1505.10 Barometric damper: A barometric damper shall be provided, and for natural draft stacks, the free area of the damper shall be at least the percentage of the cross-sectional area of the flue connections, breeching or stack in which the damper is located as indicated in Figure M-1505.10.

M-1505.11 Dampers: All incinerators shall be provided with a guillotine or sliding damper. Design criteria shall provide at least 10-percent free opening when the damper is in the fully closed position.

M-1505.11.1 Damper construction: The dampers shall be constructed of steel frames with refractory lining or of alloy steel to withstand the high temperature. Guillotine dampers provided for draft regulation shall be counterbalanced.

M-1505.11.2 Damper box: All guillotine and sliding dampers shall be provided with a damper box to house completely the damper when in its full open position. The damper box shall be constructed of steel having a minimum nominal thickness of 0.105 inch (No. 12 Manufacturers Standard Gage).

M-1505.11.3 Locking: All guillotine and sliding dampers shall be provided with an approved locking device.

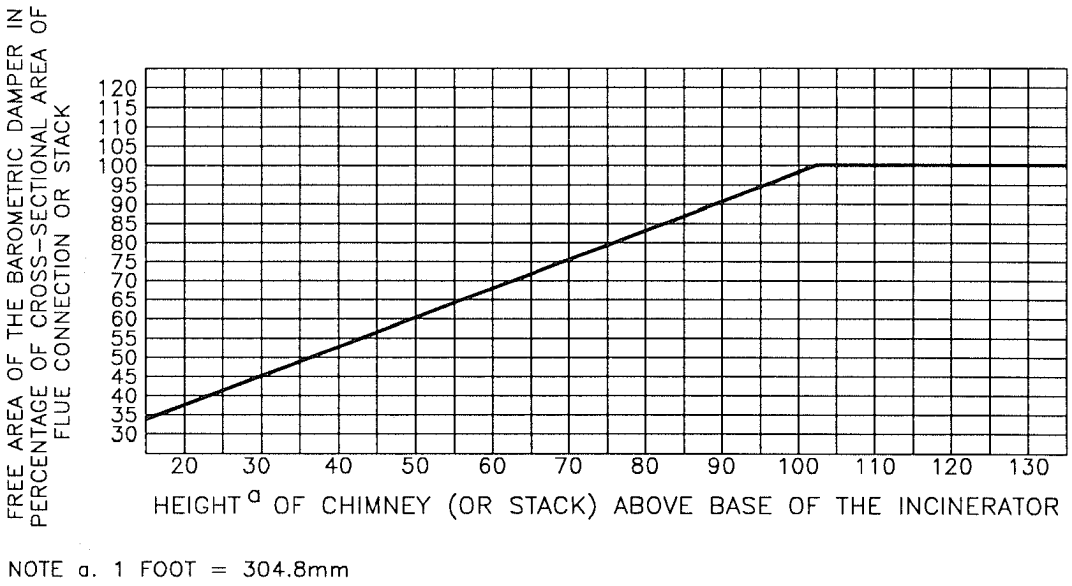

Figure M-1505.10
DETERMINATION OF BAROMETRIC DAMPER FREE AREA
(For natural draft stacks only)

M-1505.12 Mortar: All refractory brick shall be laid in an approved high-temperature, air-setting refractory mortar. Such mortar shall be for the same service as the refractory brick.

M-1505.13 Metal casing: A metal casing shall be required for all incinerators.

M-1505.14 Insulation: Insulation shall not be less than 2 inches (51 mm) in thickness, and shall provide a shell temperature not in excess of 90 degrees F. (32 degrees C.) after the incinerator is fired for the maximum normal operation time. The shell temperature shall not exceed a temperature of 180 degrees F. (82 degrees C.).

M-1505.15 Refuse charging: Refuse charging shall be direct, side, end or top. The charging chutes shall not exceed 6 feet (1829 mm) in length measured from the floor opening above the incinerator to the outside roof of the incinerator. The charging chute shall be constructed of steel casing having a minimum thickness of 0.105 inch (No. 12 Manufacturers Standard Gage), lined with at least 4½ inches (114 mm) of refractory. Where the incinerator is top charged, an induced draft fan shall be provided.

M-1505.16 Combustion air: Air for combustion shall be calculated at 15 pounds (6.5 kg) for 10,000 British thermal units (Btu) (10.5 kJ) total heat release, based on the theoretical air required for complete combustion of liquid and solid fuels of 7 pounds air (3.17 kg) to 7½ pounds air (3.40 kg) per 10,000 Btu (10.5 kJ) in such fuels.

M-1505.17 Underfire air: Underfire air shall not exceed 10 percent of the total air.

SECTION M-1506.0 CONSTRUCTION

M-1506.1 Materials: High-temperature block insulation shall be required for its high-insulating qualities and resistance to deformation under high temperature. High-heat-duty refractory brick shall be required for its resistive qualities to temperature, spalling, abrasion and disintegration.

M-1506.2 High-temperature block: The high-temperature block insulation required by this chapter shall meet ASTM C612, Class 2, listed in Chapter 21.

M-1506.3 Refractory brick: The high-heat-duty refractory brick required by this chapter shall be an approved material.

M-1506.4 Hydraulic setting castable refractory: The hydraulic setting castable refractory required by this chapter shall be an approved material.

M-1506.4.1 Installation: All castable refractory walls shall be installed to form a monolithic structure and shall be anchored to the exterior shell of the incinerator. Arches of the suspended type shall be constructed so that their weight is not supported by refractory walls. Alloy steel or refractory anchors shall be spaced not more than 18 inches (457 mm) horizontally and vertically and in accordance with the refractory manufacturer's instructions.

SECTION M-1507.0 COMMERCIAL AND INDUSTRIAL INCINERATORS

M-1507.1 General: Commercial and industrial incinerators shall conform to the requirements of Sections M-1507.1.1 through M-1507.1.6.

M-1507.1.1 Location: Inside incinerators and waste material bins or containers shall be located either in a room or compartment not utilized for any other purpose or in a *boiler room*. The room shall be enclosed by a 1-hour fireresistance rated assembly but not less than the fireresistance rating required by the building code listed in Chapter 21. Openings between a high-hazard occupancy and an incinerator room shall not be permitted.

M-1507.1.2 Fire suppression system: Every incinerator room shall be provided with an approved automatic fire suppression system installed in accordance with the building code listed in Chapter 21.

Exception: This requirement shall not apply to rooms where the incinerator burns only Type 4 waste.

M-1507.1.3 Operating instructions: The incinerator operator shall follow the written instructions of the manufacturer. One copy of the instructions shall be furnished to the code official, and one copy shall be protected from soiling and posted in the incinerator room.

M-1507.1.4 Nameplate: A nameplate shall be conspicuously fastened to the incinerator indicating the manufacturer's name, model number, rated capacity of the unit, the type of waste for which the incinerator is designed and the date of installation.

M-1507.1.5 Scrubbers: Alkaline scrubbers, or other approved devices, shall be required for incinerators that burn halogenated compounds.

M-1507.1.6 Prohibited installations: In-line incinerators with a burning capacity less than 750 pounds (340 kg) per hour shall not be installed.

SECTION M-1508.0 REQUIREMENTS BY CLASS OF INCINERATOR

M-1508.1 General: The requirements of Sections M-1508.2 through M-1508.9 apply in addition to the requirements of Section M-1504.0.

M-1508.2 Class I: Class I incinerators are for Type 1 or Type 2 waste.

M-1508.2.1 Shell temperature: Class I incinerators shall have a sufficient thickness of refractory lining and insulation to prevent the shell temperature from exceeding 100 degrees F. (38 degrees C.) above normal room temperature, but shall not exceed 180 degrees F. (82 degrees C.). Provisions shall be made for expansion to reduce or eliminate damage to the incinerator.

M-1508.2.2 Internal temperature: Class I incinerators shall be constructed to withstand intermittent internal temperatures of 1,800 degrees F. (982 degrees C.) without failure of structural parts, such as cracking or warping, so as to permit flame passage or emission of combustion gases or sparks to the exterior.

M-1508.3 Class IA: Class IA incinerators are for Type 1 or Type 2 waste.

M-1508.3.1 Shell temperature: The design shall be such that when the incinerator is fired with normal waste to be burned at the rated capacity of the incinerator (in pounds per hour of Type 1 or Type 2 waste), the shell temperature at any point

shall not exceed 180 degrees F. (82 degrees C.). This maximum temperature shall not apply at the surface of the doors and frames and at the breeching outlet. The incinerator shall be constructed of steel exterior casing having a minimum thickness of 0.060 inch (No. 16 Manufacturers Standard Gage), a 1-inch thickness of high-temperature block insulation, and a 2½-inch thickness of high-heat-duty firebrick or a 2½-inch thickness of castable or plastic refractory. The castable or plastic refractory shall be anchored to the exterior steel casing in an approved manner.

M-1508.3.2 Internal temperatures: The incinerator shall be constructed to withstand intermittent internal temperatures of 1,880 degrees F. (1027 degrees C.) without failure of structural parts, such as cracking or warping, so as to permit flame passage or emission of combustion gases or sparks to the exterior.

M-1508.4 Class IIA: Class IIA incinerators are for Type 1 or Type 2 waste fed in small compact packages from two or more floors above the incinerator. This class of incinerator shall be provided with automatic sequence of operation.

M-1508.4.1 Flues: Class IIA incinerators shall be served by two flues, one for charging waste and one for carrying the products of combustion. A positive method shall be employed to prevent smoke and fumes from escaping into the charging flue, and provisions shall be made to ensure that the charging flue remains free from vermin and odor.

M-1508.4.2 Burning area: The minimum burning area shall be 0.10 square feet (0.0093 m^2) per sleeping room and combustion calculations shall be based on 3 hours burning per day. Where the burning area consists of a combination drying hearth and cast-iron grate, the hearth area shall not exceed 50 percent of the total burning area.

M-1508.4.3 Shell temperature: The primary chamber shall have a volume of at least 4 cubic feet per square foot (1.22 m^3/m^2) of burning area. The shell temperature shall not exceed 90 degrees F. (32 degrees C.) above normal room temperature, and shall not exceed 180 degrees F. (82 degrees C.).

M-1508.4.4 Combustion air: Primary (underfire), secondary and overfire air shall be provided through adjustable openings to meet the minimum requirements as set forth in Section M-1505.17.

M-1508.4.5 Service opening: Service openings at each floor shall not have a daylight opening that exceeds one-third the cross-sectional area of the charging flue. The daylight opening shall not exceed 160 square inches (0.103 m^2). Such service opening or other charging device shall be designed without projection into the flue and with the opening to the flue interior closed off while the service opening door is fully open. This door shall close automatically upon release.

M-1508.4.6 Refractory lining: Refractory lining of the incinerators shall meet the requirements of Section M-1505.8.

M-1508.4.7 Gas velocities and emissions: Incinerators under this class shall contain a system to control gas velocities and emissions. This system shall include secondary combustion chambers, burners, settling chambers and gas washers or scrubbers.

M-1508.5 Class III: Class III incinerators are for Type 1 or Type 2 waste.

M-1508.5.1 Type 1 waste: Where designed to burn Type 1 waste, the incinerator shall contain cast-iron grates, stationary or dump, or a combination thereof with air openings of at least 40 percent of the total burning area. In lieu of 100 percent of the grate area, up to 20 percent of the total burning area shall be solid hearth.

M-1508.5.2 Type 2 waste: Where designed to burn Type 2 waste, the incinerator shall contain a combination drying hearth and cast-iron grate area, each approximately 50 percent of the total burning area. Where step grates or sloping grates are utilized in lieu of the hearth, such grates shall provide at least 50 percent of the grate surface.

M-1508.5.3 Burning rate: Maximum burning rate per square foot of primary area shall be as indicated in Table M-1508.5.3. The areas of grate and hearth shall be calculated on a horizontal projected area and not on the line of the slope or the area of individual steps.

Table M-1508.5.3
MAXIMUM BURNING RATE VARIOUS TYPE WASTES

Capacity (pounds per hour[b])	Logarithm	Burning rate (pounds per square foot per hour[b])		
		Types 00, 0, 1 and 2 waste, factor 10	Type 3 waste, factor 8	Type 4 waste, no factor
100	2.00	20	16	10
200	2.30	23	18	12[a]
300	2.48	25	20	14[a]
400	2.60	26	21	15[a]
500	2.70	27	22	16[a]
600	2.78	28	22	17[a]
700	2.85	28	23	18[a]
800	2.90	29	23	18[a]
900	2.95	30	24	18[a]
1,000	3.00	30	24	18[a]

Note a. The maximum burning rate in pounds per square foot per hour for Type 4 waste depends on the size of the largest animal to be incinerated. Whenever the largest animal to be incinerated exceeds one-third of the hourly capacity of the incinerator, a rating of 10 pounds per square foot per hour shall be utilized for the design of the incinerator.

Note b. 1 pound per hour = 0.0002159 kg/s; 1 pound per square foot per hour = 0.000812 $kg/m^2 \cdot s$.

M-1508.6 Class IV: Class IV incinerators are for burning Type 3 waste on a hot drying hearth.

M-1508.6.1 Burning rate: Maximum burning rate per square foot of primary area shall be as indicated in Table M-1508.5.3. The area of the hearth shall be calculated on a horizontal projected area and not on the line of the slope or the area of individual steps.

M-1508.6.2 Burners: Gas burners shall be provided as required in Table M-1503.1. Burners shall comply with Section M-1505.4.

M-1508.7 Class V: Class V equipment shall be of an approved type.

M-1508.7.1 Automatic feeding and firing: The incinerator shall provide for automatic feeding and firing.

M-1508.8 Class VI: Class VI incinerators are for Type 4 waste.

M-1508.8.1 Burning rate: The incinerator shall be designed to burn the refuse on a hot refractory hearth. The maximum burning rate per square foot of hearth shall be as indicated in Table M-1508.5.3.

M-1508.8.2 Burners: The incinerator shall have burners in both the primary and the secondary chambers, and the British thermal unit inputs shall be as required in Table M-1503.1. Burners shall comply with the requirements of Section M-1505.4.

M-1508.8.3 Curtain wall: The curtain wall shall be designed to direct the hot gases beneath the hearth.

M-1508.8.4 Chamber volume: The volume of the primary chamber shall not be more than 60 percent of the total incinerator volume.

M-1508.9 Class VII: Class VII incinerators shall be the same as Class III, Class IV and Class VI incinerators, except that the heat release, burning rate and velocities shall be determined from an analysis of waste to be incinerated in each instance.

SECTION M-1509.0 CHIMNEYS

M-1509.1 Chimney termination height: Unless otherwise required in Chapter 12, every incinerator chimney, except those for domestic gas-fired incinerators, shall extend above the roof as follows:

1. Natural draft chimneys shall extend at least 8 feet (2438 mm) above the roof and not less than 2 feet (610 mm) above the elevation of any part of the building within 20 feet (6096 mm) of the chimney;
2. Chimneys serving incinerators provided with an induced draft fan shall extend at least 3 feet (914 mm) above the roof and above the elevation of any part of the building within 20 feet (6096 mm) of the chimney; and
3. Where a taller obstruction is within 100 feet (30480 mm) of the chimney, the chimney shall extend at least 8 feet (2438 mm) above the highest part of the obstruction, unless an induced draft fan is installed.

M-1509.2 Chimney casing: Incinerator chimneys erected within a building shall be encased in steel having a minimum thickness of 0.135 inch (No. 10 Manufacturers Standard Gage). All joints shall be sealed in an approved manner.

Table M-1509.1(1)
NATURAL DRAFT STACKS OR CHIMNEYS[c]

Incinerator capacity in pounds per hour	Class III incinerators						Class IV incinerators			Class VI incinerators		
	Type 1 waste			Type 2 waste			Type 3 waste			Type 4 waste		
	Air supply[a]	Stack		Air supply[a]	Stack		Air supply[b]	Stack		Air supply[a]	Stack	
		Diameter (inches)[c]	Height[b] (feet)[c]		Diameter (inches)[c]	Height[b] (feet)[c]		Diameter (inches)[c]	Height[b] (feet)[c]		Diameter (inches)[c]	Height[b] (feet)[c]
50	—	—	—	—	—	—	—	—	—	90	9	25
100	350	14	30	250	12	25	200	12	30	180	10	25
150	525	16	30	375	14	30	300	14	30	270	12	25
200	700	18	35	500	16	30	400	14	35	360	14	25
300	1,050	20	35	750	18	35	600	16	40	540	16	30
400	1,400	22	40	1,000	20	40	800	18	40	720	18	30
500	1,750	24	40	1,250	22	40	1,000	20	45	900	20	30
600	2,100	26	40	1,500	24	40	1,200	22	45	—	—	—
700	2,450	28	45	1,750	26	45	1,400	24	50	—	—	—
800	2,800	30	45	2,000	28	45	1,600	26	50	—	—	—
900	3,150	32	45	2,250	30	45	1,800	28	50	—	—	—
1,000	3,500	34	45	2,500	32	45	2,000	30	50	—	—	—

Note a. Air supply is given in cubic feet per minute at 70 degrees F. and is the minimum that shall be available at all times in the incinerator room at atmospheric or a slight positive pressure. The incinerator room or rooms shall not be under a negative or minus pressure. If the incinerator is charged from a room other than the incinerator room, the quantity of air shown shall be available in both rooms.

The quantity of air shown shall be increased to satisfy the following:

1. If stack or chimney is higher than minimum to satisfy the larger barometric damper involved.
2. If any other equipment requiring air supply is located in the incinerator room or charging room.

Note b. The stack heights are based upon the following:

1. Installation made at or near sea level.
2. Stack heights measured from base of the incinerator.
3. Incinerator is side charged.
4. Breeching or flue connection not exceeding 10 feet in length in a straight run or 3 feet, including not more than one 90-degree bend or two 45-degree bends.
5. Stack terminates as provided for in Section M-1509.1.

The stack height shall be increased or is permitted to be decreased as follows:

1. Increase height 5 percent per 1,000 feet above sea level.
2. Decrease height 25 percent if stack is directly on top of incinerator eliminating any breeching or flue connection.
3. Increase height 15 percent if incinerator is top charged.
4. Increase height 15 percent for each additional 10 feet of straight breeching and 15 percent for each additional 90-degree bend.

Note c. 1 pound per hour = 0.0001259 kg/s; 1 cubic foot per minute = 0.0004719 m^3/s; 1 foot = 304.8 mm; 1 inch = 25.4 mm; 1 degree = 0.01745 rad.; Degrees C. = [(degrees F.)-32]/1.8.

Table M-1509.1(2)
INDUCED DRAFT FANS

Incinerator capacity in pounds[g] per hour	Class III incinerators									
	Type 3 waste					Type 4 waste				
		Pounds per hour [g]		Fan[e]		Pounds per hour [g]			Fan[e]	
	Air[f,g] supply	Flue gases[a]	Cooling air[b]	Cubic feet per minute[c,g] at 700° F.	"Cold" static pressure[d]	Air[f,g] supply	Flue gases[a]	Cooling air[b]	Cubic feet per minute[c,g] at 700° F.	"Cold" static pressure[d]
100	850	1,080	2,160	1,630	.7	600	768	1,540	1,130	.68
150	1,275	1,620	3,420	2,160	.7	900	1,152	2,310	1,700	.7
200	1,700	2,160	4,320	3,260	.72	1,200	1,536	3,080	2,250	.7
300	2,550	3,240	6,480	4,320	.72	1,800	2,304	4,610	3,380	.72
400	3,400	4,320	8,640	6,520	.75	2,400	3,072	6,150	4,500	.75
500	4,250	5,400	10,800	7,580	.75	3,000	3,840	7,680	5,680	.75
600	5,100	6,480	12,960	8,640	.75	3,600	4,608	9,220	6,750	.75
700	5,950	7,560	15,120	10,840	.8	4,200	5,376	10,750	7,880	.8
800	6,800	8,640	17,280	13,040	.8	4,800	6,144	12,290	9,000	.8
900	7,650	9,720	19,440	14,100	.8	5,400	6,912	13,830	10,130	.8
1,000	8,500	10,800	21,600	15,160	.8	6,000	7,680	15,360	11,250	.8

Incinerator capacity in pounds [g] per hour	Class IV incinerators					Class VI incinerators				
	Type 3 waste					Type 4 waste				
		Pounds per hour [g]		Fan[e]		Pounds per hour [g]			Fan[e]	
	Air[f,g] supply	Flue gases[a]	Cooling air[b]	Cubic feet per minute[c,g] at 700° F.	"Cold" static pressure[d]	Air[f,g] supply	Flue gases[a]	Cooling air[b]	Cubic feet per minute[c,g] at 700° F.	"Cold" static pressure[d]
50	—	—	—	—	—	200	262	525	385	68
100	485	625	1,250	920	.7	400	523	1,050	770	.68
150	728	938	1,875	1,380	.7	600	785	1,570	1,155	.68
200	970	1,250	2,500	1,840	.72	800	1,046	2,100	1,540	.68
300	1,455	1,875	3,750	2,760	.75	1,200	1,569	3,050	2,310	.7
400	1,940	2,500	5,000	3,680	.75	1,600	2,092	4,200	3,080	.7
500	2,425	3,125	6,250	4,600	.8	2,000	2,615	5,250	3,850	.7
600	2,910	3,750	7,500	5,520	.8	—	—	—	—	—
700	3,395	4,375	8,750	6,440	.85	—	—	—	—	—
800	3,880	5,000	9,000	7,360	.85	—	—	—	—	—
900	4,365	5,625	10,250	8,280	.85	—	—	—	—	—
1,000	4,850	6,250	12,500	9,200	.85	—	—	—	—	—

Note a. The total flue gases or total products of combustion are given in pounds per hour.

Note b. The cooling air is given in pounds per hour and is the air required to be bled into and mixed with the flue gases before entering the induced draft fan and unlined breeching section.

Note c. The fan capacity is given in cubic feet per minute at 700 degrees F., which is the anticipated temperature of the air-gas mixture entering the induced draft fan.

Note d. The static pressure of the fan is given as the "cold" (70 degrees F.) static pressure with the installation made at or near sea level. The static pressure at 700 degrees F. is 45 percent of the "cold" static pressure. Increase the "cold" static pressure 3.5 percent for every 1,000 feet above sea level.

Note e. The cubic feet per minute capacity of the fan reduces, but the static pressure of the fan increases, to overcome the resistance created by the gas washer or scrubber used.

Note f. Air supply is given in cubic feet per minute at 70 degrees F. and is the minimum that shall be available at all times in the incinerator room for combustion and fan cooling air. See also notes regarding air supply in Table M-1509.1(1).

Note g. 1 pound per hour = 0.0001259 kg/s; 1 cubic foot per minute = 0.0004719 m^3/s; Degrees C. = [(degrees F.)-32]/1.8.

M-1509.3 Flue connections or breechings: Flue connections or breechings shall meet the requirements for stacks, except where flue gas temperature reduction is affected. The minimum for unlined breeching shall be Type 316 stainless steel having a minimum thickness of 0.105 inch (No. 12 Manufacturers Standard Gage), with clearances as required in Section M-1211.0.

M-1509.4 Combustion calculation: Table M-1503.1 includes a column headed "Btu of auxiliary fuel per pound of waste to be included in combustion calculations." The figures in this column shall be included when determining total heat release within the furnace and shall also be included, together with the theoretical air required for the fuel, when determining the total products of combustion. The figures in the column headed "Minimum Btuh burner input per pound waste" shall be utilized to determine minimum capacity of the burner or burners. Secondary burners shall be sized to raise the products of combustion at least 200 degrees F. (93 degrees C.) for Type 00, Type 0, Type 1 and Type 2 wastes, and at least 400 degrees F. (204 degrees C.) for waste containing over 10 percent plastics, wax-coated or impregnated paper or other dense smoke-producing materials.

M-1509.5 Flue gas washers: Where flue gas washers are installed, a pressure switch and flow switch or thermocouple shall be interlocked with the gas supply to the main burner to interrupt the gas supply in the event of water failure.

SECTION M-1510.0 CREMATORIES

M-1510.1 General: A crematory shall include any device utilized to incinerate human bodies, for which burial permits are required by other statutes or regulations. Pathological incinerators shall be classified as commercial incinerators.

M-1510.2 Firebox: The firebox of every crematory shall be enclosed with walls and ceilings with at least 6 inches of super-duty refractory brick set in an approved super-duty refractory mortar, backed with 2½ inches of insulating firebrick in accordance with the requirements for Group 20 of ASTM C155 listed in Chapter 21 or other approved material. The outside covering for such firebox shall be constructed of steel having a minimum nominal thickness of at least 0.105 inch (No. 12 Manufacturers Standard Gage).

M-1510.2.1 Combustion chamber: The lining of a crematory combustion chamber shall be of an approved super-duty refractory brick pyrometric cone equivalent to at least a No. 33 cone. The lining of secondary combustion chambers connecting passageways and breechings, shall be of an approved high-duty refractory brick pyrometric cone equivalent to at least a No. 31.5 cone. Super- or high-duty refractory bricks, where utilized, shall be laid in an approved high-temperature mortar.

M-1510.3 Burners: Burners for crematories shall conform to the requirements of Sections M-1510.3.1 through M-1510.3.4.

M-1510.3.1 Oil: Oil burners shall not utilize oil heavier than No. 2 fuel oil.

M-1510.3.2 Limiting controls: Crematory burners shall be provided with indicating high-temperature limiting controls with thermocouples mounted in both primary and secondary chambers.

M-1510.3.3 Primary and secondary chambers: Burners shall be provided in both the primary and secondary chambers.

M-1510.3.4 Heat release: Total heat release within the combustion chamber shall not exceed 40,000 British thermal units per cubic foot per hour (38429 W/m^3).

M-1510.4 Location requirements: Crematories shall be installed in a room enclosed by construction having a minimum fireresistance rating of 1 hour.

M-1510.5 Nameplate: Every crematory shall be provided with a metal plate or plates permanently attached to the crematory in a conspicuous location such that the plate is easily read. The plate shall bear the manufacturer's name, the trade name of the crematory (if any), the model number, the rated capacity for which the crematory is designed and the date of incinerator installation.

M-1510.6 Operating instructions: Complete instructions for the proper operation of the crematory and all necessary equipment shall be posted on a card adjacent to the crematory and shall include the following:

1. Steps required to start and stop burners.
2. Operation of controls and instruments.
3. Routine maintenance requirements.

CHAPTER 16

VENTILATION AIR

SECTION M-1601.0 GENERAL

M-1601.1 Scope: This chapter shall govern the *ventilation* of spaces within a building intended to be occupied. This chapter does not govern the requirements for smoke control systems.

M-1601.2 Ventilation required: Every occupied space shall be *ventilated* by natural or mechanical means.

M-1601.3 When required: *Ventilation* shall be provided during the periods that the room or space is occupied.

SECTION M-1602.0 DEFINITIONS

M-1602.1 General: The following words and terms shall, for the purposes of this chapter and as stated elsewhere in this code, have the meanings shown herein.

Mechanical exhaust system: A system for removing air from a room or space by mechanical means.

Natural ventilation: The movement of air into and out of a space through intentionally provided openings, such as windows and doors, or through nonpowered ventilators.

Outdoor air: Air taken from the outdoors and therefore not previously circulated through the system.

Recirculated air: Air removed from a conditioned space and intended for reuse as supply air.

Ventilation: The natural or mechanical process of supplying conditioned or unconditioned air to, or removing such air from, any space.

Ventilation air: That portion of supply air which comes from the outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space.

SECTION M-1603.0 NATURAL VENTILATION

M-1603.1 General: Natural *ventilation* of an occupied space shall be through windows, doors, louvers or other openings to the outdoor air.

M-1603.2 Ventilation area required: The minimum openable area to the outdoors shall be 4 percent of the floor area being *ventilated.*

M-1603.2.1 Adjoining spaces: Where rooms and spaces without openings to the outdoors are *ventilated* through an adjoining room, the unobstructed opening to the adjoining rooms shall be at least 8 percent of the floor area of the interior room or space, but not less than 25 square feet (2.33 m^2). The *ventilation* openings to the outdoors shall be based on the total floor area being *ventilated.*

M-1603.2.2 Openings below grade: Where openings below grade provide required natural *ventilation,* the outside horizontal clear space measured perpendicular to the opening shall be one and one-half times the depth below the average adjoining ground level.

M-1603.3 Contaminants exhausted: Naturally *ventilated* spaces having contaminants present shall comply with the requirements of Section M-1605.0.

M-1603.4 Openings on yards or courts: Natural *ventilation* shall be provided by openings onto yards or courts which comply with the requirements of the building code listed in Chapter 21 or by other approved means.

M-1603.5 LP-gas distribution facilities: LP-gas distribution facilities shall be provided with air inlets and outlets arranged to provide uniform air movement across the floor of the facility. The total area of both inlet and outlet openings shall be at least 1 square inch (645 mm^2) for each square foot (0.093 m^2) of floor area. The bottom of such openings shall not be more than 6 inches (152 mm) above the floor.

SECTION M-1604.0 MECHANICAL VENTILATION

M-1604.1 Ventilation system: Mechanical *ventilation* shall be provided by a method of supply air and return or exhaust air. The amount of supply air shall be approximately equal to the amount of return and exhaust air. The system shall not be prohibited from producing a negative or positive pressure. The *ventilation* system shall be designed and installed in accordance with Chapter 3.

The required rate of *ventilation* shall be continuous during the period the building is occupied, except where otherwise stated.

M-1604.2 Ventilation air required: The minimum *ventilation* rate required shall be determined in accordance with Section M-1604.3.

M-1604.3 Ventilation rate: The minimum amount of outdoor air required for *ventilation* shall be determined in accordance with Table M-1604.3 based on the occupancy of the space and the occupant load or other parameter as stated therein. The occupant load utilized for design of the *ventilation* system shall not be less than the number determined from the estimated maximum occupant load rate indicated in Table M-1604.3.

Table M-1604.3
REQUIRED MECHANICAL VENTILATION AIR

Occupancy classification	Estimated maximum occupant load, persons per 1,000 square feet[a]	Outdoor air [cubic feet per minute (cfm)[f] per person] unless noted[e]
Correctional facilities		
Cells	20	20
Dining Halls	100	15
Guard stations	40	15
Dry cleaners, laundries		
Coin-operated dry cleaner	20	15
Coin-operated laundries	20	15
Commercial dry cleaner	30	30
Commercial laundry	10	25
Storage, pick up	30	35
Education		
Auditoriums	150	15
Classroom	50	15
Corridors		0.10 cfm/ft.^{2}
Laboratories	30	20
Libraries	20	15
Locker rooms		0.50 cfm/ft.^{2}
Music rooms	50	15
Smoking lounges[b]	70	60
Training shops	30	20
Food and beverage service		
Bars, cocktail lounges	100	30
Cafeteria, fast food	100	20
Dining rooms	70	15
Kitchens (cooking)	20	15
Hospitals, nursing and convalescent homes		
Autopsy rooms[b]		0.50 cfm/ft.^{2}
Medical procedure rooms	20	15
Operating rooms	20	30
Patient rooms	10	25
Physical therapy	20	15
Recovery and ICU	20	15
Hotels, motels, resorts, dormitories		
Assembly rooms	120	15
Baths[b]		35 cfm per room
Bedrooms		30 cfm per room
Conference rooms	50	20
Dormitory sleeping areas	20	15
Gambling casinos	120	30
Living rooms		30 cfm per room
Lobbies	30	15
Offices		
Conference rooms	50	20
Office spaces	7	20
Reception areas	60	20
Telecommunication centers and data entry	60	20
Private dwellings, single and multiple		
Living areas[c]	Based upon number of bedrooms. First bedroom: 2; each additional bedroom: 1	0.35 air changes per hour[a] or 15 cfm per person, whichever is greater
Kitchens		100 cfm intermittent; 25 cfm continuous; or openable windows

Table M-1604.3 (cont'd.)
REQUIRED MECHANICAL VENTILATION AIR

Occupancy classification	Estimated maximum occupant load, persons per 1,000 square feet[a]	Outdoor air [cubic feet per minute (cfm)[f] per person] unless noted[e]
Private dwellings, single and multiple (cont'd.)		
Baths, toilets		50 cfm intermittent; 20 cfm continuous; or openable windows
Garages, separate for each dwelling		100 cfm per car
Garages, common for multiple units[b]		1.5 cfm/ft.^{2}
Public spaces		
Corridors & utilities		0.05 cfm/ft.^{2}
Elevators		1.00 cfm/ft.^{2}
Locker and dressing rooms[b]		0.5 cfm/ft.^{2}
Public restrooms[b]		75 cfm per water closet or urinal
Smoking lounges[b]	70	60
Retail stores, sales floors and showroom floors		
Basement and street	30	0.30 cfm/ft.^{2}
Dressing rooms		0.20 cfm/ft.^{2}
Malls and arcades		0.20 cfm/ft.^{2}
Shipping and receiving		0.15 cfm/ft.^{2}
Smoking lounges[b]	70	60
Storage rooms		0.15 cfm/ft.^{2}
Upper floors		0.20 cfm/ft.^{2}
Warehouses		0.05 cfm/ft.^{2}
Specialty shops		
Automotive service stations		1.5 cfm/ft.^{2}
Barber	25	15
Beauty	25	25
Clothiers, furniture		0.30 cfm/ft.^{2}
Florists	8	15
Hardware, drugs, fabrics	8	15
Pet shops		1.00 cfm/ft.^{2}
Reducing salons	20	15
Supermarkets	8	15
Sports and amusement		
Ballrooms and discos	100	25
Bowling alleys (seating areas)	70	25
Game rooms	70	25
Ice arenas		0.50 cfm/ft.^{2}
Playing floors (gymnasiums)	30	20
Spectator areas	150	15
Swimming pools (pool and deck area)		0.50 cfm/ft.^{2}
Storage		
Repair garages, public garages (enclosed)[d]		1.5 cfm/ft.^{2}
Warehouses	5	10
Theaters		
Auditoriums	150	15
Lobbies	150	20
Stages, studios	70	15
Ticket booths	60	20
Transportation		
Platforms	100	15
Vehicles	150	15
Waiting rooms	100	15
Workrooms		
Bank vaults	5	15
Darkrooms		0.50 cfm/ft.^{2}

Table M-1604.3 (cont'd.)
REQUIRED MECHANICAL VENTILATION AIR

Occupancy classification	Estimated maximum occupant load, persons per 1,000 square feet[a]	Outdoor air [cubic feet per minute (cfm)[f] per person] unless noted[e]
Workrooms (cont'd.)		
Duplicating, printing		0.50 cfm/ft.^{2}
Meat processing[c]	10	15
Pharmacy	20	15
Photo studios	10	15

Note a. Based upon net occupied heated or conditioned space.
Note b. Mechanical exhaust required (see Section M-1605.0).
Note c. Spaces unheated or maintained below 50 degrees F. (10 degrees C.) are not covered by these requirements unless the occupancy is continuous.
Note d. Public parking garages shall be ventilated in accordance with Section M-1605.6 where the ventilation system is operated by an automatic carbon monoxide detection device.
Note e. Where the ventilation rate is expressed in cfm/ft.^{2}, such rate is based upon cubic feet per minute per square foot of the floor area being ventilated.
Note f. 1 cubic foot per minute = 0.00472 m^3/s; 1 cubic foot per minute per square foot = 0.000508 $m^3/(s \cdot m^2)$

M-1604.3.1 System operation: The minimum amount of outdoor air supplied during the period the building is occupied shall be permitted to be based upon the rate per person indicated in Table M-1604.3 and the actual number of occupants present.

M-1604.4 Air temperature: The temperature differential between *ventilation air* and air in the conditioned space shall not exceed 10 degrees F. (6 degrees C.).

Exception: *Ventilation air* that is part of the air conditioning system.

M-1604.5 Supply air: *Ventilation* supply systems shall deliver the required rate of supply air to the zone within the occupied space between 3 inches (760 mm) and 72 inches (1830 mm) above the floor and more than 2 feet (610 mm) from the enclosing walls. The total supply air rate shall not be less than, nor limited to, that required by Table M-1604.3. Supply air in excess of the required outdoor air rate shall be permitted to be recirculated in spaces supplied by the *ventilation* system. Air shall not be recirculated to another dwelling or to a dissimilar occupancy.

M-1604.5.1 Transfer air: Except where recirculation from such spaces is prohibited by Table M-1604.3, air transferred from occupied spaces shall be permitted to serve as makeup air for required exhaust systems in such spaces as kitchens, baths, toilet rooms, elevators and smoking lounges.

M-1604.5.2 Swimming pool area recirculation: Supply air to a swimming pool and deck area shall be permitted to be recirculated, in accordance with Section M-1604.5, where such air is dehumidified to maintain the relative humidity of the area at 60 percent or less. Air from this area shall not be recirculated to other spaces.

M-1604.6 Outdoor air quality: The concentration of common contaminants in the outdoor air shall not exceed the levels indicated in Table M-1604.6. Air filtration, other means for the removal of contaminants, or a combination of air filtration and other means of removal of contaminants shall be employed where necessary to bring the outdoor air quality into compliance with this section. *

SECTION M-1605.0 MECHANICAL EXHAUST

M-1605.1 General: Stationary local sources producing airborne particulates, heat, odors, fumes, spray, vapors, smoke or gases in such quantities as to be irritating or injurious to health shall be provided with an exhaust system or a means of collection and removal of the contaminants. All air supplied or transferred to spaces designated by Note b of Table M-1604.3 shall be exhausted directly to the outdoors without recirculation. All exhaust required by this section shall discharge directly to an approved location at the exterior of the building.

M-1605.2 Exhaust location: The inlet to the exhaust system shall be located in the area of heaviest concentration of contaminants.

M-1605.3 System operation: The mechanical exhaust system shall be sized to remove all of the air required to be exhausted in Section M-1605.1. The system shall operate when air is required to be exhausted.

M-1605.4 Special areas: A mechanical exhaust system shall be installed in areas and locations in accordance with Sections M-1605.4.1 through M-1605.4.6.2.

Table M-1604.6
MAXIMUM CONTAMINANT CONCENTRATIONS IN OUTDOOR AIR

Contaminant	Long term			Short term		
	Concentration averaging			Concentration averaging		
	Microgram per cubic meter	Parts per million	Time periods	Microgram per cubic meter	Parts per million	Time periods
Sulfur dioxide	80	0.03	1 year	365[a]	0.14[a]	24 hours
Particles[d] (PM10)	50[b]	—	1 year	150[a]	—	24 hours
Carbon monoxide	—	—	—	40,000[a]	35[a]	1 hour
Carbon monoxide	—	—	—	10,000[a]	9[a]	8 hours
Oxidants (ozone)	—	—	—	235[c]	0.12[c]	1 hour
Nitrogen dioxide	100	0.055	1 year	—	—	—
Lead	1.5	—	3 months	—	—	—

Note a. Not to be exceeded more than once per year.
Note b. Arithmetic mean.
Note c. Compliance is attained where the number of days per calendar year with hourly average concentrations above 0.12 parts per million (235 micrograms/m^3) does not exceed 1.
Note d. Particulate matter smaller than 10 micrometers (PM10).

M-1605.4.1 Motor vehicle operation: In areas where motor vehicles operate for a period of time exceeding 10 seconds, the *ventilation* return air shall be exhausted. In motor vehicle repair areas, an exhaust system shall be provided to connect directly to the motor vehicle exhaust. In fuel-dispensing areas, the bottom of the air inlet or exhaust opening shall be located not more than 18 inches (457 mm) above the floor.

Exception: This section shall not apply where the motor vehicles being operated or repaired are electrically powered.

M-1605.4.2 Spray-painting and dipping rooms: Rooms or booths for spray painting or dipping shall have a mechanical exhaust system which provides a minimum cross-sectional air velocity of 100 feet per minute (0.508 m/s). The system shall provide a uniform exhaust of air across the width and height of the room or booth. The exhaust system shall operate while spray painting or dipping is being conducted.

M-1605.4.3 Motion picture projectors: Projectors equipped with an exhaust discharge shall be directly connected to a mechanical exhaust system. The exhaust system shall operate at an exhaust rate as indicated by the manufacturer's installation instructions.

M-1605.4.3.1 Projectors without exhaust connection: Projectors without an exhaust connection shall have contaminants exhausted through a mechanical exhaust system. The exhaust rate for electric arc projectors shall be a minimum of 200 cubic feet per minute (cfm) per lamp. The exhaust rate for xenon projectors shall be a minimum of 300 cfm per lamp. The xenon projector exhaust shall be at a rate such that the exterior temperature of the lamp housing shall not exceed 130 degrees F. (54 degrees C.). The lamp and projection room exhaust systems, if combined or independent, shall not be interconnected with any other exhaust or return system within the building.

M-1605.4.3.2 Nitrate film: Where cellulose nitrate film is utilized, *ventilation* shall be provided in accordance with NFiPA 40 listed in Chapter 21.

M-1605.4.4 Dry cleaning equipment: Dry cleaning equipment shall be provided with an exhaust system capable of maintaining a minimum air velocity of 100 feet per minute (0.508 m/s) across the face of the loading door.

M-1605.4.5 LP-gas distribution facilities: LP-gas distribution facilities that are not provided with natural *ventilation* in accordance with Section M-1603.5 shall have an exhaust system that produces a *ventilation* rate of 1 cfm per square foot (0.00502 $m^3/s \cdot m^2$) of floor area. Such exhaust system shall operate continuously. The bottom of air inlet and outlet openings shall not be more than 6 inches (152 mm) above the floor.

M-1605.4.6 Hazardous materials: All structures in which hazardous materials are stored shall be provided with a mechanical exhaust system where required by the fire prevention code listed in Chapter 21. The mechanical exhaust *ventilation* rate shall not be less than 1 cfm per square foot of floor area utilized for storage, and not less than 150 cfm total.

M-1605.4.6.1 Design: The mechanical exhaust system shall be designed with consideration for the potential fumes or vapors released. Where fumes and vapors are heavier than air, the exhaust shall be taken from a point within 12 inches above the floor. The exhaust and supply air openings shall be located to provide uniform air movement across all portions of the floor, room or space. The mechanical exhaust system shall be designed for continuous operation.

M-1605.4.6.2 Controls: A manual shutoff control shall be provided outside the hazardous material storage room adjacent to the access door into the room or in an approved remote location. The shutoff control shall be of the break-glass type and shall be identified by the words "Ventilation System Emergency Shut Off."

M-1605.5 Hazardous exhaust: The mechanical exhaust of high concentrations of dust or hazardous vapors shall conform to the requirements of Section M-311.0.

M-1605.6 Public garages: Mechanical *ventilation* systems for public garages are not required to operate continuously where the system is arranged to operate automatically upon detection of a concentration of carbon monoxide of 25 parts per million by approved automatic detection devices.

M-1605.6.1 Minimum ventilation: Automatic operation of the system shall not reduce the *ventilation* rate below 5 cfm (0.0024 m^3/s) per person and the system shall be capable of producing a *ventilation* rate of 1.5 cfm per square foot (0.0076 $m^3/s \cdot m^2$) of floor area.

SECTION M-1606.0 VENTILATION OF UNINHABITED SPACES

M-1606.1 General: Uninhabited spaces, such as crawl spaces and attics, shall be provided with natural *ventilation* openings as required by the building code listed in Chapter 21 or such spaces shall be mechanically *ventilated* in accordance with Sections M-1606.2 and M-1606.3.

M-1606.2 Type of system: The *ventilation* system shall be a mechanical exhaust and supply air system. The exhaust rate shall be 0.02 cubic feet per minute per square foot (0.0001 $m^3/s \cdot m^2$) of horizontal area.

M-1606.3 System operation: The *ventilation* system shall operate when the relative humidity in the space exceeds 60 percent.

CHAPTER 17

AIR QUALITY

SECTION M-1701.0 GENERAL

M-1701.1 Scope: This chapter shall govern the emission of air pollutants within the jurisdiction to maintain a standard of air quality in the breathing atmosphere that is free from smoke, pollutants and synergistic agents.

M-1701.2 Equipment failure: Emissions are permitted to exceed the limitations required in this chapter for a short duration of time resulting from failure of the controlling equipment.

SECTION M-1702.0 DEFINITIONS

M-1702.1 General: The following words and terms shall, for the purposes of this chapter and as stated elsewhere in this code, have the meanings shown herein.

Air pollutants: Any particulate matter, gas or odor, including but not limited to, smoke, dust, soot, vapor, mist or irritating, noxious or obnoxious acids, alkalies, fumes or gases or any combination of these. Uncombined water vapor is not an air pollutant.

Air pollution: The presence in the out-of-doors atmosphere of one or more air pollutants in such quantities as to be, or tend to be, injurious to human, plant or animal life, or to property, or as to interfere unreasonably with the enjoyment of life and property.

Emission: The discharge or escape into the atmosphere of one or more air pollutants.

Nuisance: Public nuisance as known in common law or in equity jurisprudence; whatever is dangerous to human life or detrimental to health; whatever structure or premises is not sufficiently *ventilated*, sewered, drained, cleaned or lighted, with respect to its intended or actual occupancy; and whatever renders the air or human food or drink or water supply unwholesome.

Particulate: Any suspended ash particles, soot or any material, except uncombined water, which is suspended in a gas stream as a liquid or solid at standard conditions.

Ringelmann: The standard of smoke density described in the DOI Bureau of Mines Information Circular No. 8333, *Ringelmann Smoke Chart*, listed in Chapter 21, and the equivalent opacity of all other visible emissions.

SECTION M-1703.0 PARTICULATE MATTER IN GASES

M-1703.1 Combustion gases: Particulates, in gases from the combustion of any fuel, shall not exceed 0.20 pounds per 1,000 pounds of gas (0.20 kg per 1000 kg), adjusted to 12 percent CO_2 measured at any point in the stack or stack breeching, or downstream of the final air pollution control device, if such device exists. Particulates shall not be larger in any dimension than 20-mesh Tyler Standard Screen Scale, 1/32 inch (0.8 mm).

M-1703.2 Noncombustion gases: Particulates in noncombustion gases shall not exceed 0.20 pounds per 1,000 pounds of gas (0.20 kg per 1000 kg) of undiluted gas, measured at any point in the discharge system or downstream of all air pollution control devices. Particulates shall not be larger in any dimension than 20-mesh Tyler Standard Screen Scale, 1/32 inch (0.8 mm).

SECTION M-1704.0 RINGELMANN STANDARDS

M-1704.1 General: The emissions from a single source, other than water in uncombined form, shall have a shade and opacity less than shade Number 1 on the DOI Bureau of Mines Information Circular No. 8333, *Ringelmann Smoke Chart*, listed in Chapter 21.

SECTION M-1705.0 SULFUR DIOXIDE

M-1705.1 Emissions concentration: Emissions shall not have a concentration of sulfur dioxide exceeding 2,000 parts per million. Sulfur and oxygen present in the emissions shall be considered as sulfur dioxides. The emissions analysis shall be taken over a 15-minute period.

SECTION M-1706.0 NUISANCE

M-1706.1 Nuisance pollutants prohibited: Emissions shall not contain any nuisance pollutants in an amount that is detrimental to health, safety or welfare, or that causes damage to property.

CHAPTER 18

SOLAR HEATING AND COOLING SYSTEMS

SECTION M-1801.0 GENERAL

M-1801.1 Scope: This chapter shall govern the construction, installation, alteration and repair of all systems and equipment intended to utilize solar energy for space heating or cooling, domestic hot water heating, swimming pool heating or processing.

M-1801.2 Solar energy equipment: Solar energy equipment shall conform to the requirements of this chapter and shall be installed in accordance with the manufacturer's installation instructions.

SECTION M-1802.0 INSTALLATION

M-1802.1 Access: *Access* shall be provided to solar energy equipment for maintenance.

M-1802.2 Controlling condensation: Where attics or structural spaces are part of a passive solar system, *ventilation* of such spaces is not required where other approved means of controlling condensation are provided.

M-1802.3 Roof-mounted collectors: Roof-mounted solar collectors that also serve as a roof covering shall conform to the requirements for roof coverings in accordance with the building code listed in Chapter 21.

Exception: Approved plastic is permitted to be utilized as solar collector covers in the same manner as permitted for plastic roof panels in the building code listed in Chapter 21.

M-1802.3.1 Collectors mounted above the roof: Where mounted on or above the roof covering, the collector array and supportive construction shall be constructed of *noncombustible materials* or fireretardant-treated wood conforming to the building code listed in Chapter 21, to the extent required for the type of roof construction of the building to which the collectors are accessory.

Exception: Approved plastic is permitted to be utilized as solar collector covers in the same manner as permitted for skylights in the building code listed in Chapter 21.

M-1802.4 Equipment: The solar energy system shall be equipped in accordance with the requirements of Sections M-1802.4.1 through M-1802.4.4.

M-1802.4.1 Pressure and temperature: The solar energy system components containing pressurized fluids shall be protected against pressures and temperatures exceeding design limitations with a pressure and temperature relief valve. Each section of the system where excessive pressures are capable of developing shall have a relief device such that a section cannot be valved off or otherwise isolated from a relief device. Relief valves shall comply with the requirements of Section M-605.3 and discharge in accordance with Section M-605.5.

M-1802.4.2 Vacuum: The solar energy system components that are subjected to a vacuum in operation or during shutdown shall be designed to withstand such vacuum or shall be protected with vacuum relief valves.

M-1802.4.3 Protection from freezing: System components shall be protected from damage by freezing of heat transfer liquids at the lowest ambient temperatures that will be encountered during the operation of the system.

M-1802.4.4 Expansion tanks: Liquid single-phase solar energy systems shall be equipped with expansion tanks sized in accordance with Section M-609.0.

M-1802.5 Roof penetrations: All roof penetrations shall be adequately waterproofed.

M-1802.6 Filtering: Air transported through rock or dust-producing materials by means other than natural convection to occupied spaces shall be filtered at the outlet of the heat storage system.

SECTION M-1803.0 HEAT TRANSFER FLUIDS

M-1803.1 Flash point: The *flash point* of heat transfer liquids utilized in solar system equipment shall not be less than the highest temperature determined from the following:

1. Fifty degrees F. (28 degrees C.) above the design maximum operating (flow) temperature of the fluid in the solar system.
2. Two hundred degrees F. (111 degrees C.) below the design maximum nonoperating (no-flow) temperature of the fluid attained in the collector, provided that the collector manifold assembly is located outside of the building and is exposed to the weather, and provided that relief valves located adjacent to the collector or collector manifold do not discharge directly into the building.
3. The design maximum no-flow temperature in all other collector manifold and relief valve configurations.

M-1803.2 Definitions: The following words and terms shall, for the purposes of this section and as stated elsewhere in this code, have the meanings shown herein.

Heat transfer liquid: The operating or thermal storage liquid utilized in a solar energy system, including water or other

liquid base, and all additives at the concentration present under operating conditions.

M-1803.3 Flammable gases and liquids: A *flammable liquid* or gas shall not be utilized as a heat transfer fluid. The *flash point* of liquids used in occupancies classified in Use Group H or F shall not be lower unless approved.

SECTION M-1804.0 MATERIALS

M-1804.1 Collectors: Collectors shall be *labeled* to show the manufacturer's name and address, model number, collector dry weight, maximum allowable operating and nonoperating temperatures and pressures, minimum allowable temperatures and the types of heat transfer fluid allowed.

M-1804.2 Thermal storage units: Pressurized thermal storage units shall be *labeled* to show the manufacturer's name and address, model number, serial number, maximum and minimum allowable operating temperatures, maximum and minimum operating pressures and the types of heat transfer fluid allowed.

CHAPTER 19

ENERGY CONSERVATION

SECTION M-1901.0 GENERAL

M-1901.1 Scope: Heating, *ventilating* and air conditioning systems of all structures shall be designed and installed for efficient utilization of energy as herein provided. Calculations of heating and cooling loads shall be in accordance with ASHRAE 90A listed in Chapter 21.

For special applications, such as hospitals, laboratories, thermally sensitive equipment, computer rooms and manufacturing processes, the design concepts and parameters shall conform to the requirements of the application at minimum energy levels.

SECTION M-1902.0 DEFINITIONS

M-1902.1 General: The following words and terms shall, for the purposes of this chapter and as stated elsewhere in this code, have the meanings shown herein.

Air conditioning: The treatment of air so as to control simultaneously the temperature, humidity, cleanness and distribution of the air to meet the requirements of a conditioned space.

Air conditioning system: An air conditioning system consists of heat exchangers, blowers, filters, supply, exhaust and return ducts, and shall include any apparatus installed in connection therewith.

Air distribution system: Any system of ducts, plenums and air-handling equipment which circulates air within a space or spaces and includes systems made up of one or more air-handling units.

Coefficient of performance (*COP*), cooling: 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.

Coefficient of performance (*COP*), heat pump, heating: The ratio of the rate of net heat output to the rate of total 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 contents of the air entering and leaving the equipment, not including supplementary heat.

Total energy input shall be determined by combining the energy inputs to all elements, except supplementary heaters, of the heat pump, including but not limited to, compressors, supply air fans, return air fans, outdoor air fans, cooling tower fans, and the heating, *ventilating* and air conditioning system equipment control circuit.

Energy efficiency ratio (*EER*): The ratio of net cooling capacity in British thermal units per hour to the total rate of electrical input in watts under designated operating conditions.

New energy: Energy, other than recovered energy, utilized for the purpose of heating or cooling.

Reheat: The application of sensible heat to supply air that has been previously cooled below the temperature of the conditioned space by either mechanical refrigeration or the introduction of outdoor air to provide cooling.

Thermostat: An instrument that measures changes in temperature and which controls devices utilized for maintaining a desired temperature.

Zone: A space or group of spaces within a structure with heating and cooling requirements sufficiently similar so that comfort conditions are capable of being maintained throughout by a single controlling device.

SECTION M-1903.0 DESIGN CONDITIONS

M-1903.1 Parameters: For calculations under this section, the design conditions specified in Sections M-1903.1.1 through M-1903.1.3 shall apply.

M-1903.1.1 Outdoor temperature: Outdoor design temperatures shall be based on the 97½-percent value for heating and the 2½-percent value for cooling as determined from Appendix A or other approved source.

M-1903.1.2 Indoor temperature: Indoor design temperature shall be 70 degrees F. (21 degrees C.) for heating and 78 degrees F. (25 degrees C.) for cooling.

M-1903.1.3 Humidity: Indoor design relative humidity for heating shall not exceed 30 percent. For cooling, the actual design relative humidity within the comfort envelope as defined in ASHRAE 55 listed in Chapter 21 shall be selected for the minimum total heating, *ventilating* and air conditioning system energy utilization.

M-1903.2 Cooling with outdoor air: Each fan system shall be designed to utilize up to and including 100 percent of the fan system capacity for cooling with outdoor air automatically whenever the utilization of outdoor air will result in lower usage

of energy than is required under normal operation of the fan system.

Exception: Cooling with outdoor air is not required under any one or more of the following conditions:

1. Where the fan system capacity is less than 5,000 cubic feet per minute (cfm) (2.35 m^3/s) or 134,000 British thermal units per hour (Btuh) (39.3 kW) total cooling capacity.
2. Where the quality of the outdoor air is so poor as to require extensive treatment of the air.
3. Where the need for humidification or dehumidification requires the utilization of more energy than is conserved by outdoor air cooling on an annual basis.
4. Where the utilization of outdoor air cooling would affect the operation of other systems (such as return or exhaust air fans or supermarket refrigeration) so as to increase the overall energy consumption of the building.
5. Where energy recovered from an internal/external zone heat-recovery system exceeds the energy conserved by outdoor air cooling on an annual basis.
6. Where the annual heating degree days are less than 1,200 Fahrenheit heating degree days (760 Celsius heating degree days).
7. Where all space cooling is accomplished by a circulating liquid that transfers space heat directly or indirectly to a heat-rejection device, such as a cooling tower, without the utilization of a refrigeration system.
8. Where the outdoor wet-bulb design conditions are more than 72 degrees F. (22 degrees C.) and the annual Fahrenheit heating degree days are less than 2,000 (1110 Celsius heating degree days).
9. Where the utilization of 100-percent outside air will cause coil frosting, controls are permitted to be added to reduce the quantity of outside air. The intent of this exception is to utilize 100-percent outside air in lieu of mechanical cooling when cooling with outdoor air will utilize less energy. This exception applies only to direct expansion systems when the compressor is running.
10. Where the fan system will regularly be operated for less than 30 hours per week.
11. Where the total design sensible cooling load is less than 6.8 Btuh/$ft.^2$ (21.6 W/m^2) of floor area.
12. In occupancies in Use Groups R-2 and R-3.

M-1903.3 Mechanical ventilation: Each mechanical *ventilation* system shall be equipped with a means for either shutoff or volume reduction, and for shutoff when *ventilation* is not required. *Ready access* shall be provided to the required controls. Automatic or gravity dampers that close when the system is not operating shall be provided for outdoor air intakes and exhausts.

Exceptions

1. Manual dampers for outdoor air intakes shall be permitted where the system capacity is less than 5,000 cfm (2.3 m^3/s) or where installed in occupancies in Use Groups R-2 and R-3.
2. Dampers are not required where *ventilation* airflow is less than 100 cfm (0.047 m^3/s).

M-1903.4 Simultaneous heating and cooling: Systems that employ both heating and cooling simultaneously in order to achieve comfort conditions within a space shall be limited to those situations where more efficient methods of heating and air conditioning are not capable of effectively meeting the system objectives. 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 specified in Sections M-1903.4.1 through M-1903.4.7.

M-1903.4.1 New energy for humidity control: New energy shall not to be utilized to control humidity except where necessary to prevent relative humidity from rising above 60 percent for comfort control or to prevent condensation on terminal units or outlets.

M-1903.4.2 New energy for temperature control: New energy shall not be utilized for control of temperature unless minimized as specified in Sections M-1903.4.3 through M-1903.4.7.

M-1903.4.3 Reheat systems: Systems employing reheat and serving multiple zones, except those employing variable air volume for temperature control, shall be provided with controls that automatically reset the system's cold air supply to the highest temperature that satisfies the zone requiring the coolest air. Single-zone reheat systems shall be controlled to sequence reheat and cooling.

M-1903.4.4 Dual-duct and multiple-zone systems: Dual-duct and multiple-zone systems shall be provided with a control that automatically resets the cold deck air supply to the highest temperature that satisfies the zone requiring the coolest air, and that automatically resets the hot deck air supply to the lowest temperature that satisfies the zone requiring the warmest air.

Exception: Systems employing variable air volume for temperature control.

M-1903.4.5 Recooling systems: Systems in which heated air is recooled, directly or indirectly, to maintain space temperature, shall be provided with a control that automatically resets the temperature to which the supply air is heated to the lowest level that satisfies the zone requiring the warmest air.

M-1903.4.6 Multiple-zone systems: For systems with multiple zones, one or more zones are permitted to be chosen to represent a number of zones with similar heating/cooling characteristics. A multiple-zone heating, *ventilating* and air conditioning system that employs reheating or recooling for control of not more than 5,000 cfm (2.35 m^3/s) or 20 percent of the total supply air of the system, whichever is less, shall be exempt from the supply air temperature reset requirements of Sections M-1903.4.3 through M-1903.4.5.

M-1903.4.7 Independent systems: Concurrent operation of independent heating and cooling systems serving common spaces, and requiring the utilization of new energy for heating or cooling, shall be minimized by one or both of the following:

1. Providing sequential temperature control of both heating and cooling capacity in each zone.
2. Limiting the heating energy input, through automatic reset control of the heating medium temperature (or

energy input rate), 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.

SECTION M-1904.0 EQUIPMENT PERFORMANCE REQUIREMENTS

M-1904.1 General: The requirements of this section shall 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 an approved certification program or rating procedure shall be utilized to satisfy these requirements.

M-1904.1.1 Abbreviations: The efficiency ratings required by this section shall be hereafter referred to by the following abbreviations: Annual Fuel Utilization Efficiency (*AFUE*); Heating Seasonal Performance Factor (*HSPF*); Integrated Part Load Value (*IPLV*); and Seasonal Energy Efficiency Ratio (*SEER*).

M-1904.2 System equipment: Heating, *ventilating* and air conditioning system equipment whose energy input in the cooling mode is entirely electric shall show efficiency levels not less than the values specified in Sections M-1904.2.1 through M-1904.2.7.

These requirements apply to, but are not limited to, unitary cooling equipment (air cooled, water cooled and evaporatively cooled), the cooling mode of unitary (central) and packaged terminal heat pumps (air source and water source), packaged air conditioners and room air conditioners.

Exception: These requirements shall not apply to equipment serving areas such as supermarkets having open refrigerated food display cases or to areas with computers or other equipment contributing a large amount of heat to the area served.

M-1904.2.1 Air-cooled air conditioners and heat pumps: The standard rating conditions and minimum performance requirements for unitary air conditioners and heat pumps that are air cooled, electrically operated and have a cooling capacity of less than 135,000 British thermal units per hour (Btuh) (39.6 kW), except packaged terminal units and room air conditioners, shall be as follows.

1. Cooling capacity of less than 65,000 Btuh (19 kW) in cooling mode.
   1.1. Split systems: *SEER* of 10.0.
   1.2. Single-package units: *SEER* of 9.7.
2. Cooling capacity of 65,000 Btuh (19 kW) and greater but less than 135,000 Btuh (39.6 kW) in cooling mode.
   2.1. *EER*: 8.9 *EER* based on standard rating condition of 95 degrees F. (35 degrees C.) dry-bulb outdoor temperature.
   2.2. *IPLV*: 8.3 *IPLV* based on rating condition of 80 degrees F. (27 degrees C.) dry-bulb outdoor temperature.

M-1904.2.2 Evaporatively cooled air conditioners and heat pumps: The standard rating conditions and minimum performance requirements for unitary air conditioners and heat pumps that are evaporatively cooled, electrically operated and have a cooling capacity of less than 135,000 Btuh (39.6 kW), except packaged terminal units and room air conditioners, shall be as follows.

1. Cooling capacity of less than 65,000 Btuh (19 kW).
   1.1. *EER*: 9.3 *EER* based on standard rating conditions of 80 degrees F. (27 degrees C.) dry-bulb and 67 degrees F. (19 degrees C.) wet-bulb indoor temperatures; and 95 degrees F. (35 degrees C.) dry-bulb and 75 degrees F. (24 degrees C.) wet-bulb outdoor temperatures.
   1.2. *IPLV*: 8.5 *IPLV* based on rating conditions of 80 degrees F. (27 degrees C.) dry-bulb and 67 degrees F. (19 degrees C.) wet-bulb indoor temperatures.
2. Cooling capacity of 65,000 Btuh (19 kW) and greater but less than 135,000 Btuh (39.6 kW).
   2.1. *EER*: 10.5 *EER* based on standard rating conditions indicated in 1.1.
   2.2. *IPLV*: 9.7 *IPLV* based on rating conditions indicated in 1.2.

M-1904.2.3 Water-cooled air conditioners and heat pumps: The standard rating conditions and minimum performance requirements in the cooling mode for water-cooled air conditioners and heat pumps that are electrically operated and have a cooling capacity of less than 135,000 Btuh (39.6 kW) shall be as follows.

1. Water-source heat pumps with a cooling capacity of less than 65,000 Btuh (19 kW).
   1.1. *EER*, standard rating: 9.3 *EER* based on standard rating conditions of 80 degrees F. (27 degrees C.) dry-bulb and 67 degrees F. (19 degrees C.) wet-bulb indoor air temperatures; and 85 degrees F. (29 degrees C.) entering water temperature.
   1.2. *EER*, low-temperature rating: 10.2 *EER* based on rating conditions of 80 degrees F. (27 degrees C.) dry-bulb and 67 degrees F. (19 degrees C.) wet-bulb indoor air temperatures; and 75 degrees F. (24 degrees C.) entering water temperature.
2. Water-source heat pumps with a cooling capacity of 65,000 Btuh (19 kW) and greater but less than 135,000 Btuh (39.6 kW).
   2.1. *EER*: 10.5 *EER* based on standard rating conditions indicated in 1.1.
3. Ground-water-cooled heat pumps with a cooling capacity of less than 135,000 Btuh (39.6 kW).
   3.1. *EER*, standard rating: 11.0 *EER* based on 70 degrees F. (21 degrees C.) entering water temperature.
   3.2. *EER*, low-temperature rating: 11.5 *EER* based on 50 degrees F. (10 degrees C.) entering water temperature.
4. Water-cooled unitary air conditioners with a cooling capacity of less than 65,000 Btuh (19 kW).
   4.1. *EER*: 9.3 *EER* based on standard rating condition indicated in 1.1.
   4.2. *IPLV*: 8.3 *IPLV* based on 75 degrees F. (24 degrees C.) entering water temperature.

5. Water-cooled unitary air conditioners with a cooling capacity of 65,000 Btuh (19 kW) and greater but less than 135,000 Btuh (39.6 kW).
   5.1. *EER*: 10.5 *EER* based on the standard rating conditions indicated in 1.1.

M-1904.2.4 Packaged terminal air conditioners: The standard rating conditions and minimum performance requirements in the cooling mode for air-cooled, electrically operated, packaged terminal air conditioners shall be as follows.

1. *EER*, standard rating: *EER* of 10.0-(0.16 × capacity/1,000) based on 95 degrees F. (35 degrees C.) dry-bulb outdoor temperature.
2. *EER*, low-temperature rating: *EER* of 12.0-(0.20 × capacity/1,000) based on 82 degrees F. (28 degrees C.) dry-bulb outdoor temperature.

M-1904.2.5 Room air conditioners and heat pumps: The standard rating conditions and minimum performance requirements for room air conditioners and room air conditioner heat pumps shall be as follows.

1. Equipment without reverse cycle and with louvered sides.
   1.1. *EER* of 8.0 for less than 6,000 Btuh (1.8 kW).
   1.2. *EER* of 8.5 for greater than or equal to 6,000 Btuh (1.8 kW) but less than 8,000 Btuh (2.3 kW).
   1.3. *EER* of 9.0 for greater than or equal to 8,000 Btuh (2.3 kW) but less than 14,000 Btuh (4.1 kW).
   1.4. *EER* of 8.8 for greater than or equal to 14,000 Btuh (4.1 kW) but less than 20,000 Btuh (5.9 kW).
   1.5. *EER* of 8.2 for greater than or equal to 20,000 Btuh (5.9 kW).
2. Equipment without reverse cycle and without louvered sides.
   2.1. *EER* of 8.0 for less than 6,000 Btuh (1.8 kW).
   2.2. *EER* of 8.5 for greater than or equal to 6,000 Btuh (1.8 kW) but less than 20,000 Btuh (5.9 kW).
   2.3. *EER* of 8.2 for greater than or equal to 20,000 Btuh (5.9 kW).
3. Equipment with reverse cycle and with louvered sides.
   3.1. *EER* of 8.5.
4. Equipment with reverse cycle and without louvered sides.
   4.1. *EER* of 8.0.

M-1904.2.6 Water-source heat pumps: The standard rating conditions and minimum performance requirements for water-source and ground-water-source heat pumps that are electrically operated and have a cooling capacity of less than 135,000 Btuh (39.6 kW) shall be as follows.

The rating conditions shall be based on a maximum air temperature entering the indoor section of 70 degrees F. (21 degrees C.) dry-bulb and 60 degrees F. (16 degrees C.) wet-bulb in addition to the standard rating conditions indicated in 1 and 2.

1. Water-source heat pumps, *COP*: 3.8 *COP* based on standard rating condition of 70 degrees F. (21 degrees C.) entering water temperature.
2. Ground-water-source heat pumps.
   2.1. *COP*, high-temperature rating: 3.4 *COP* based on 70 degrees F. (21 degrees C.) entering water temperature.
   2.2. *COP*, low-temperature rating: 3.0 *COP* based on 50 degrees F. (10 degrees C.) entering water temperature.

M-1904.2.7 Large unitary air conditioners and heat pumps: The standard rating conditions and minimum performance requirements for unitary air conditioners and heat pumps that are electrically operated and have a cooling capacity greater than 135,000 Btuh (39.6 kW) shall be as follows.

1. Air conditioners, air cooled.
   1.1. *EER* of 8.5 for 760,000 Btuh (222.8 kW) and less.
   1.2. *EER* of 8.2 for greater than 760,000 Btuh (222.8 kW).
   1.3. *IPLV* of 7.5.
2. Air conditioners, water or evaporatively cooled.
   2.1. *EER* of 9.6.
   2.2. *IPLV* of 9.0.
3. Heat pumps, air cooled, cooling mode.
   3.1. *EER* of 8.5 for less than 760,000 Btuh (222.8 kW).
   3.2. *EER* of 8.2 for 760,000 Btuh (222.8 kW) and greater.
   3.3. *IPLV* of 7.5.
4. Heat pumps, air cooled, heating mode.
   4.1. *COP* of 2.9 at 47 degrees F. (8 degrees C.).
   4.2. *COP* of 2.0 at 17 degrees F. (-8 degrees C.).
5. Condensing units, air cooled.
   5.1. *EER* of 9.9.
   5.2. *IPLV* of 11.0.
6. Condensing units, water or evaporatively cooled.
   6.1. *EER* of 12.9.
   6.2. *IPLV* of 12.9.

M-1904.3 System components: The minimum performance requirements for water-chilling packages which have an energy input that is entirely electric in the cooling mode and which are water or air cooled shall be as follows.

1. Water cooled, 300 tons (1055.2 kW) and greater in capacity.
   1.1 *COP* of 5.2.
   1.2. *IPLV* of 5.3.

   Exception: Where R-22 refrigerant or a chlorofluorocarbon refrigerant with an ozone depletion factor not greater than R-22 refrigerant is utilized, the minimum *COP* shall be 4.7 and the minimum *IPLV* shall be 4.8.

2. Water cooled, greater than or equal to 150 tons (527.6 kW) but less than 300 tons (1055.2 kW) in capacity.
   2.1. *COP* of 4.2.
   2.2. *IPLV* of 4.5.
3. Water cooled, less than 150 tons (527.6 kW) in capacity.
   3.1. *COP* of 3.8.
   3.2. *IPLV* of 3.9.
4. Air cooled with condenser, 150 tons (527.6 kW) and greater in capacity.
   4.1. *COP* of 2.5.
   4.2. *IPLV* of 2.5.

5. Air cooled with condenser, less than 150 tons (527.6 kW) in capacity.
   5.1. *COP* of 2.7.
   5.2. *IPLV* of 2.8.
6. Air cooled without condenser, all capacities.
   6.1. *COP* of 3.1.
   6.2. *IPLV* of 3.2.

M-1904.4 Heat pumps: Heat pumps having an energy input that is entirely electric shall comply with Sections M-1904.4.1 and M-1904.4.2.

M-1904.4.1 Heating seasonal performance factor: The standard rating conditions and minimum performance requirements in the heating mode for heat pumps that are air cooled, electrically operated and have a cooling capacity of less than 135,000 Btuh (39.6 kW) shall be as follows.

1. Cooling capacity of less than 65,000 Btuh (19 kW).
   1.1. Split systems: *HSPF* of 6.8.
   1.2. Single-package units: *HSPF* of 6.6.
2. Cooling capacity of 65,000 Btuh (19 kW) and greater but less than 135,000 Btuh (39.6 kW) in heating mode; split systems and single-package units.
   2.1. High-temperature rating: *COP* of 3.0 based on 47 degrees F. (8 degrees C.) dry-bulb and 43 degrees F. (6 degrees C.) wet-bulb outdoor temperatures.
   2.2. Low-temperature rating: *COP* of 2.0 based on 17 degrees F. (-8 degrees C.) dry-bulb and 15 degrees F. (-9 degrees C.) wet-bulb outdoor temperatures.

M-1904.4.2 Coefficient of performance: Air-cooled, electrically operated, packaged terminal heat pumps shall show a minimum *COP* in the heating mode of 2.9-(0.026 × capacity/1,000) based on 47 degrees F. (8 degrees C.) dry-bulb and 43 degrees F. (6 degrees C.) wet-bulb outdoor temperatures.

M-1904.5 Supplementary heater: The heat pump shall be installed with a control to prevent electric supplementary heater operation when the operating load is capable of being met by the heat pump alone. Supplementary heater operation is permitted during transient periods, such as startups, following room thermostat set-point advance, and during defrost. The cut-on temperature for the compression heating shall be higher than the cut-on temperature for the supplementary heat, and the cutoff temperature for the compression heating shall be higher than the cutoff temperature for the supplementary heat.

M-1904.6 Combustion heating equipment: Minimum *AFUE* and thermal efficiency for warm air furnaces and combination warm air furnaces/air conditioning units shall be in accordance with Table M-1904.6(1). Minimum thermal efficiency for warm air duct furnaces and unit heaters shall be in accordance with Table M-1904.6(2). Minimum *AFUE* and combustion efficiency for *boilers* shall be in accordance with Table M-1904.6(3).

M-1904.7 Air-transport factor: The air-transport factor for each all-air system shall not be less than 5.5. The factor shall be based on design system air flow for constant volume systems. The factor for variable air volume systems shall be based on not less than the average conditions of operation. Energy for transfer of air through heat-recovery devices shall not be included in determining the factor. Such energy shall be included in the evaluation of the effectiveness of the heat-recovery system.

$$\text{Air–transport factor} = \frac{\text{Space–sensible heat removal}}{\text{Supply + return fan(s) power input}}$$

where the space-sensible heat removal value and the supply plus return fan(s) power input value are expressed in Btuh or watts.

Space-sensible heat removal is equivalent to the maximum coincident design sensible cooling load of all spaces served for which the system provides cooling. Fan power input is the rate of energy delivered to the fan prime mover.

M-1904.7.1 Other systems: Air-and-water, all-water and unitary systems employing chilled, hot, dual-temperature or condenser water transport systems to space terminals shall not require greater transport energy (including central and terminal fan power and pump power) than an equivalent all-air system, providing the same space-sensible heat removal and having an air-transport factor of not less than 5.5.

M-1904.8 Balancing: The heating, ventilating and air conditioning system design shall provide means for balancing the air and water systems. In doing so, considerations shall include, but not be limited to, dampers, temperature and pressure-test connections and balancing valves.

SECTION M-1905.0 CONTROLS

M-1905.1 General: All heating, *ventilating* and air conditioning systems shall be provided with controls as specified in this section.

M-1905.2 Temperature: Each heating, *ventilating* and air conditioning system shall be provided with at least one thermostat for temperature regulation.

M-1905.2.1 Settings: Each thermostat shall be capable of being set from 55 degrees F. (13 degrees C.) or lower to 75 degrees F. (24 degrees C.) or higher where utilized to control heating only, and from 70 degrees F. (21 degrees C.) or lower to 85 degrees F. (29 degrees C.) or higher where utilized to control cooling only. Where utilized to control both heating and cooling, the thermostat shall be capable of being set from 55 degrees F. (13 degrees C.) or lower to 85 degrees F. (29 degrees C.) or higher and shall be capable of operating the system's heating and cooling in sequence.

M-1905.2.2 Deadband range: The thermostat shall have an adjustable deadband temperature range of at least 10 degrees F. (6 degrees C.) between full heating and full cooling, except as allowed in Section M-1903.4.7.

M-1905.3 Humidity: A humidistat shall be provided for a heating, *ventilating* and air conditioning system that is equipped with a means for adding moisture to maintain specific selected relative humidities in spaces or zones. The humidistat shall be capable of being set to prevent new energy from being utilized to produce space relative humidity above 30 percent. Where a humidistat is utilized in a heating, *ventilating* and air conditioning system for controlling moisture removal to maintain specific selected relative humidities in spaces or zones, the humidistat shall be capable of being set to prevent new energy from being utilized to produce a space relative humidity below 60 percent.

Table M-1904.6(1)
STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE WARM AIR FURNACES AND COMBINATION WARM AIR FURNACES/AIR CONDITIONING UNITS

Category[c]	Rating conditions		Minimum performance[c] (percent)
Gas-fired less than 225,000 Btuh[d]	Seasonal rating		*AFUE* 78[a] E_t 80
Oil-fired less than 225,000 Btuh[d]			
Gas-fired greater than or equal to 225,000 Btuh[d]	Rated capacity[a] steady state	Maximum	E_t 80
		Minimum	E_t 78
Oil-fired greater than or equal to 225,000 Btuh[d]	Maximum and minimum rated capacity[b] steady state		E_t 81

Note a. This is consistent with the National Appliance Energy Conservation Act (NAECA) of 1987. These values apply to furnace and combination units covered by NAECA.
Note b. Minimum and maximum ratings as provided for and allowed by the unit's controls.
Note c. E_t = Thermal efficiency (100 percent minus flue losses); Annual fuel utilization efficiency (AFUE); British thermal units per hour (Btuh).
Note d. 1 Btuh = 0.2931 W.

Table M-1904.6(2)
STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE WARM AIR DUCT FURNACES AND UNIT HEATERS

Category	Rating conditions		Minimum performance E_t[b] (percent)
Duct furnaces gas-fired	Rated capacity[a] steady state	Maximum	78
		Minimum	75
Unit heaters gas-fired	Rated capacity[a] steady state	Maximum	78
		Minimum	74
Unit heaters oil-fired	Maximum and minimum rated capacity[a] steady state		81

Note a. Provided and allowed by the controls.
Note b. E_t = Thermal efficiency (100 percent minus flue losses).

Table M-1904.6(3)
STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE GAS- AND OIL-FIRED BOILERS

Category[d]	Rating conditions	Minimum performance (percent)[d]
Gas-fired less than 300,000 Btuh[e]	Seasonal rating	*AFUE* 80[a,c]
Oil-fired less than 300,000 Btuh[e]		*AFUE* 80[a]
Gas-fired greater than or equal to 300,000 Btuh[e]	Maximum and minimum rated capacity[b] steady state	E_c 80
Oil-fired greater than or equal to 300,000 Btuh[e]	Maximum and minimum rated capacity[b] steady state	E_c 83
Oil-fired (residual) greater than or equal to 300,000 Btuh[e]	Maximum and minimum rated capacity[b] steady state	E_c 83

Note a. This is consistent with the National Appliance Energy Conservation Act of 1987.
Note b. Provided and allowed by the controls.
Note c. Except for gas-fired steam boilers for which minimum annual fuel utilization efficiency is 75 percent.
Note d. E_c = Combustion efficiency (100 percent minus flue losses); Annual fuel utilization efficiency (*AFUE*); British thermal units per hour (Btuh).
Note e. 1 Btuh = 0.2931 W.

M-1905.4 Temperature zoning: In all occupancies in Use Group R-3, at least one thermostat for the regulation of space temperature shall be provided for each separate heating, *ventilating* and air conditioning system. Additionally, a manual or automatic means, with *ready access* thereto, shall be provided to restrict partially or shut off the heating or cooling input to each zone or floor, excluding unheated or uncooled basements and garages.

M-1905.4.1 Use Groups R-2: In all occupancies in Use Group R-2, each individual dwelling unit shall be considered separately and shall meet the requirements for occupancies in Use Group R-3.

M-1905.4.2 Other occupancies: In all occupancies except those in Use Group R-3 and in spaces other than dwelling units in occupancies in Use Group R-2, at least one thermostat for the regulation of space temperature shall be provided for each separate heating, *ventilating* and air conditioning system and for each floor of the building.

M-1905.5 Setback and shutoff: In all occupancies in Use Group R-3, the thermostat or an alternative means, such as a switch or a clock, shall provide a manual or automatic means for reducing the energy required for heating and cooling during periods of reduced need.

M-1905.5.1 Other occupancies: In all other occupancies, each heating, *ventilating* and air conditioning system shall be equipped with a means for reducing the energy utilized for heating, *ventilating* and air conditioning during unoccupied periods, periods of reduced need or periods of alternate occupancy of the building spaces or zones served by the system. The means of reducing energy utilization shall include manually adjustable automatic timing devices, manual devices utilized by operating personnel and automatic control systems.

M-1905.5.2 Lowered settings: Lowering thermostat set points to reduce energy consumption of heating systems shall not cause energy to be expended to reach the reduced setting.

M-1905.5.3 Access: *Ready access* shall be provided to the controls required by Sections M-1905.5 and M-1905.5.1.

CHAPTER 20

BOILERS AND PRESSURE VESSELS, MAINTENANCE AND INSPECTION

SECTION M-2001.0 GENERAL

M-2001.1 Scope: This chapter shall govern the maintenance and safety of all new and existing *boilers* and pressure vessels. This chapter shall also govern the annual inspection of *boilers*.

M-2001.2 Equipment: *Boilers* and pressure vessels shall be maintained in accordance with this code and the ASME *Boiler and Pressure Vessel Code* listed in Chapter 21.

M-2001.3 Fuel conversion: Gas and oil *appliances* shall not be converted from the fuel intended to a different fuel, except where converted in accordance with the manufacturer's instructions and approved.

M-2001.4 Boiler operator certificate of fitness: A steam *boiler* of more than 10 boiler horsepower (bhp) (98.1 kW) and a *boiler* designed to carry a steam pressure of more than 15 psi (103.4 kPa) shall not be operated without a certificate of fitness from the code official or authorized jurisdictional agency.

M-2001.4.1 Renewal of certificate: The certificate of fitness shall continue in force for a period of one year unless revoked or suspended, and applications shall be made for renewal annually.

M-2001.5 Combustion air: Combustion air shall be provided in accordance with Chapter 10.

M-2001.6 Boiler rooms: *Boiler rooms* shall be maintained free from rubbish and storage.

SECTION M-2002.0 INSPECTIONS

M-2002.1 Periodic inspections: All *boilers* and pressure vessels subject to the provisions of this code shall be inspected by the code official, by other municipal authority or by an approved agency in accordance with Sections M-2002.1.1 through M-2002.1.4.

Exception: Heating *boilers* or pressure vessels which are located in occupancies classified in Use Group R-2 or R-3 having less than six dwelling units.

M-2002.1.1 Power boilers: Power *boilers* shall receive an internal inspection annually where construction permits; otherwise, the inspection shall be as complete as possible. Such *boilers* shall also be externally inspected while under pressure, if possible.

M-2002.1.2 Low-pressure steam boilers: Low-pressure steam *boilers* shall receive an inspection biennially, with an internal inspection every four years where construction permits.

M-2002.1.3 Hot water boilers: Hot water heating and hot water supply *boilers* shall receive an inspection biennially, with an internal inspection at the discretion of the code official.

M-2002.1.4 Pressure vessels: Pressure vessels shall receive an inspection triennially, with an internal inspection at the discretion of the code official.

M-2002.2 Certificate of inspection: A *boiler* or unfired pressure vessel subject to the provisions of this code shall not be placed in operation until a certificate of inspection and approval has been issued.

M-2002.2.1 Boiler record: The code official shall maintain a file of all *boilers* and unfired pressure vessels subject to the provisions of this code, with a record of all inspections and the official actions thereon.

M-2002.3 Major repairs: Equipment shall not be utilized after major repairs until an inspection has been made by the code official to ascertain that such repairs have been completed in an approved manner.

M-2002.4 Owners to provide facilities: Every person owning or having possession or control of any equipment subject to inspection shall provide, at such person's own expense, proper arrangements and facilities for attaching the instruments of inspection. Immediately before the time set for such inspection, every such person shall remove all scale, dirt, soot and sediment in, beneath and around such equipment, and shall fill the same with water where required to do so by the code official, and shall have all main stop valves and other valves and connections on such equipment tight, so as to enable the application of hydrostatic pressure, leaving all said equipment in clean condition for inspection.

M-2002.5 Equipment testing: All equipment, where required to be tested by hydrostatic pressure, shall be filled with water by the owners or operators, and the owners or operators shall furnish the necessary labor required to work and handle the pumps in applying the test. Where leaks occur which prevent a successful test, the code official shall make a second test upon receiving notice that all leaks have been repaired. A certificate of inspection shall not be issued until testing has been successfully completed.

M-2002.6 Hydrostatic pressure: The code official shall conduct a hydrostatic pressure test where such test shall be deemed necessary and shall perform, where possible, an external and internal examination after testing. The hydrostatic pressure for such test shall not exceed the maximum working pressure of the tested equipment by more than 50 percent.

M-2002.7 Test formulas: In certifying the working pressure permitted on tested equipment, the code official shall utilize approved test formulas in accordance with the ASME *Boiler and Pressure Vessel Code* listed in Chapter 21.

M-2002.8 Inspection to determine remaining thickness: Where a *boiler* or pressure vessel shows deterioration such that more detailed information as to thickness is required, the remaining thickness shall be determined by nondestructive (ultrasonic) testing methods or, if such methods are not available, by drilling. The drilled hole shall be filled by plugging or by welding, in such a manner that will prevent leakage, corrosion and other damage to the *boiler* or pressure vessel.

M-2002.9 Seller's inspection: All manufacturers or other persons selling *boilers* or pressure vessels, either new or preowned and operated, shall, before painting the same, have such equipment inspected by the code official and shall have in their possession a certificate issued by the code official indicating the amount of pressure per square inch that the equipment is permitted to carry. The certificate shall be furnished by the seller to the buyer.

SECTION M-2003.0 CONDEMNATION

M-2003.1 General: Any *boiler* or pressure vessel which, in the opinion of the code official, constitutes a hazard shall be condemned in accordance with Section M-119.0.

CHAPTER 21

REFERENCED STANDARDS

This chapter lists the standards that are referenced in various sections of this document. The standards are listed herein by the promulgating agency of the standard, the standard identification, the effective date and title, and the section or sections of this document that reference the standard. The application of the referenced standards shall be as specified in Section M-102.5.

ANSI

American National Standards Institute
11 West 42nd Street
New York, NY 10036

Standard reference number	Title	Referenced in code Section number
A21.52 – 91	Ductile-Iron Pipe, Centrifugally Cast, in Metal Molds or Sand-Lined Molds for Gas	Table M-803.2

API

American Petroleum Institute
1220 L Street, NW
Washington, DC 20005

Standard reference number	Title	Referenced in code Section number
12B – 90	Specification for Bolted Tanks for Storage of Production Liquids — 1985 Supplement	Table M-903.3
12D – 82	Specification for Field Welded Tanks for Storage of Production Liquids — 1985 Supplement	Table M-903.3
12F – 88	Specification for Shop Welded Tanks for Storage of Production Liquids	Table M-903.3
650 – 88	Welded Steel Tanks for Oil Storage	Table M-903.3

ASHRAE

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
1791 Tullie Circle, NE
Atlanta, GA 30329-2305

Standard reference number	Title	Referenced in code Section number
15 – 89	Safety Code for Mechanical Refrigeration	M-1303.2 M-1303.2.1, M-1308.1.1, M-1308.1.2, M-1308.1.7
34 – 89	Number Designation of Refrigerants	M-1301.2
55 – 81	Thermal Environmental Conditions for Human Occupancy	M-1903.1.3
90A – 80	Energy Conservation in New Building Design — with Addendum 90A-a-1987	M-1901.1

ASME

American Society of Mechanical Engineers
345 East 47th Street
New York, NY 10017

Standard reference number	Title	Referenced in code Section number
B1.20.1 – 83	Pipe Threads, General Purpose (inch)	M-704.3.5 M-804.3.4, M-904.3.3, M-1304.3.3
B16.1 – 89	Cast Iron Pipe Flanges and Flanged Fittings	M-803.8.1
B16.3 – 85	Malleable Iron Threaded Fittings	Table M-703.5
B16.5 – 88	Pipe Flanges and Flanged Fittings	Table M-703.5 M-803.8.1
B16.9 – 86	Factory Made Wrought Steel Buttwelding Fittings	Table M-703.5
B16.11 – 91	Forged Steel Fittings, Socket-Welding and Threaded	Table M-703.5
B16.15 – 85	Cast Bronze Threaded Fittings	Table M-703.5
B16.18 – 84	Cast Copper Alloy Solder Joint Pressure Fittings	Table M-703.5
B16.22 – 89	Wrought Copper and Copper Alloy Solder Joint Pressure Fittings	Table M-703.5
B16.23 – 84	Cast Copper Alloy Solder Joint Drainage Fittings (DWV)	Table M-703.5
B16.24 – 91	Bronze Pipe Flanges and Flanged Fittings	Table M-703.5
B16.26 – 88	Cast Copper Alloy Fittings for Flared Copper Tubes	Table M-703.5
B16.28 – 86	Wrought Steel Buttwelding Short Radius Elbows and Returns	Table M-703.5
B16.29 – 86	Wrought Copper and Wrought Copper Alloy Solder Joint Fittings for Sovent Drainage Systems	Table M-703.5
ASME – 89	Boiler & Pressure Vessel Code, Sections IV, VI & VIII; Divisons 1 & 2	M-2001.2 M-2002.7

ASTM

American Society for Testing and Materials
1916 Race Street
Philadelphia, PA 19103-1187

Standard reference number	Title	Referenced in code Section number
A53 – 90b	Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless	Table M-703.4 Table M-803.2, Table M-903.4, Table M-1304.2
A106 – 91	Specification for Seamless Carbon Steel Pipe for High-Temperature Service	Table M-703.4 Table M-803.2, Table M-903.4, Table M-1304.2

ASTM (cont'd.)

A126 – 84	Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings	Table M-703.5
A240 – 91b	Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels	Table M-803.2
A254 – 91	Specification for Copper Brazed Steel Tubing	Table M-703.4 Table M-803.2, Table M-903.4
A420 – 92	Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Low-Temperature Service	Table M-703.5
A525 – 91b	Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process	M-311.6
A539 – 90a	Specification for Electric-Resistance-Welded Coiled Steel Tubing for Gas and Fuel Oil Lines	Table M-803.2 Table M-903.4
B32 – 91	Specification for Solder Metal	M-704.3.3
B42 – 92	Specification for Seamless Copper Pipe, Standard Sizes	Table M-703.4 Table M-803.2, Table M-903.4
B43 – 91	Specification for Seamless Red Brass Pipe, Standard Sizes	Table M-703.4 Table M-803.2, Table M-903.4
B75 – 92a	Specification for Seamless Copper Tube	Table M-703.4 Table M-803.2, Table M-903.4
B88 – 92	Specification for Seamless Copper Water Tube	Table M-703.4 Table M-803.2, Table M-903.4, Table M-1304.2
B135 – 91b	Specification for Seamless Brass Tube	Table M-703.4 Table M-903.4
B210 – 92a	Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes	Table M-803.2
B241 – 92a	Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube	Table M-803.2
B251 – 88	Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube	Table M-703.4
B280 – 92a	Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service	Table M-803.2 Table M-903.4, Table M-1304.2
B302 – 88	Specification for Threadless Copper Pipe	Table M-703.4 Table M-803.2, Table M-903.4
C155 – 88	Classification of Insulating Firebrick	M-1510.2
C315 – 91	Specification for Clay Flue Linings	M-1207.2 Table M-1216.3.4.1
C411 – 82	Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation	M-306.1.1
C612 – 83	Specification for Mineral Fiber Block and Board Thermal Insulation	M-1506.2
D56 – 87	Test Method for Flash Point by Tag Closed Tester	M-902.1
D93 – 90	Test Method for Vapor Pressure of Pensky-Martens Closed Tester	M-902.1
D1527 – 89	Specification for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe, Schedules 40 and 80	Table M-703.4
D1784 – 90	Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds	M-304.3
D1785 – 91	Specification for Poly (Vinyl Chloride)(PVC) Plastic Pipe, Schedules 40, 80 and 120	Table M-703.4
(Note: D1788 – 81 has been discontinued and not replaced by ASTM)		
D2235 – 89	Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings	M-704.3.4
D2241 – 89	Specification for Poly (Vinyl Chloride)(PVC) Pressure-Rated Pipe (SDR-Series)	Table M-703.4
D2282 – 89	Specification for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe (SDR-PR)	Table M-703.4

ASTM (cont'd.)

D2412 – 92	Test Method for Determination of External Loading Properties of Plastic Pipe By Parallel Plate Loading	M-304.3
D2466 – 90a	Specification for Poly (Vinyl Chloride)(PVC) Plastic Pipe Fittings, Schedule 40	Table M-703.5
D2467 – 92	Specification for Socket-Type Poly (Vinyl Chloride)(PVC) Plastic Pipe Fittings, Schedule 80	Table M-703.5
D2468 – 90	Specification for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe Fittings, Schedule 40	Table M-703.5
D2513 – 91a	Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings	Table M-803.2
D2517 – 81	Specification for Reinforced Epoxy Resin Gas Pressure Pipe and Fittings	Table M-803.2
D2564 – 91a	Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings	M-704.3.4
D2846 – 92	Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Hot and Cold Water Distribution Systems	Table M-703.4 M-704.3.4
D2996 – 88	Specification for Filament-Wound, "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin Pipe)	Table M-903.4
D3309 – 92	Specification for Polybutylene (PB) Plastic Hot Water Distribution Systems	Table M-703.4 M-704.11.1
D4021 – 92	Specification for Glass-Fiber-Reinforced Polyester Underground Petroleum Storage Tanks	Table M-903.3
E84 – 91a	Test Method for Surface Burning Characteristics of Building Materials	M-303.2.2 M-306.1, M-708.2
E136 – 92b	Test Method for Behavior of Materials in a Vertical Tube Furnace at 750° C.	M-202.0
F438 – 90	Specification for Socket Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40	Table M-703.5
F439 – 90	Specification for Socket Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80	Table M-703.5
F441 – 89	Specification for Chlorinated Poly (Vinyl Chloride)(CPVC) Plastic Pipe, Schedules 40 and 80	Table M-703.4
F442 – 89	Specification for Chlorinated Poly (Vinyl Chloride)(CPVC) Plastic Pipe (SDR-PR)	Table M-703.4
F493 – 89	Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride)(CPVC) Plastic Pipe and Fittings	M-704.3.4
F876 – 90	Specification for Crosslinked Polyethylene (PEX) Tubing	Table M-703.4
F877 – 89	Specification for Crosslinked Polyethylene (PEX) Plastic Hot and Cold-Water Distribution Systems	Table M-703.4 Table M-703.5

AWS

American Welding Society
550 N.W. LeJeune Road
P.O. Box 351040
Miami, FL 33135

Standard reference number	Title	Referenced in code Section number
A5.8 – 92	Specifications for Filler Metals for Brazing	M-704.3.1 M-804.3.1, M-904.3.1, M-1304.3.1

BOCA

Building Officials and Code Administrators, International, Inc.
4051 West Flossmoor Road
Country Club Hills, IL 60478-5795

Standard reference number	Title	Referenced in code Section number
BNBC – 93	BOCA National Building Code	M-201.3, M-303.2, M-303.3.1, M-303.4, M-307.1, M-307.1.1, M-307.3, M-309.2.2, M-311.3.1, M-311.4, M-312.5, M-313.2, M-314.1, M-315.1.6, M-402.1, M-405.2, M-408.1, M-506.4, M-506.7.2, M-506.8, M-507.1, M-508.1, M-707.1.2, M-707.4, M-708.2.1, M-807.2.2, M-809.7, M-901.2.2, M-903.3, M-907.3.1, M-910.4, M-1201.5, M-1204.3.2, M-1205.2.2, M-1207.5, M-1211.3.1, M-1212.4.1, M-1304.5, M-1404.3, M-1405.2, M-1507.1.1, M-1507.1.2, M-1603.4, M-1606.1, M-1802.3, M-1802.3.1
BNPC – 93	BOCA National Plumbing Code	M-201.3, M-603.1, M-604.2, M-605.5, M-608.2, M-609.3, M-701.1, M-707.2, M-707.3
BNFPC – 93	BOCA National Fire Prevention Code	M-508.5, M-901.1, M-1605.4.6

DOI

United States Department of the Interior
Bureau of Mines
2401 E Street, N.W.
Washington, DC 20241

Standard reference number	Title	Referenced in code Section number
Circular No. 8333 – 67	Ringelmann Smoke Chart	M-1702.1, M-1704.1

FS

Federal Specification*
General Service Administration
7th & D Streets
Specification Section
Room 6039
Washington, DC 20407

Standard reference number	Title	Referenced in code Section number
WW-P-325B – 76	Federal Specification for Pipe, Bends, Traps, Caps and Plugs; Lead (for Industrial Pressure, and Soil and Waste Applications)	Table M-703.4

* Standards are available from the Supt. of Documents, U.S. Government Printing Office, Washington, DC 20402-9325.

IIAR

International Institute of Ammonia Refrigeration
1101 Connecticut Avenue, NW
Suite 700
Washington, DC 20036

Standard reference number	Title	Referenced in code Section number
IIAR-2 – 84	Equipment, Design, and Installation of Ammonia Mechanical Refrigeration Systems	M-1303.2, M-1303.2.1

MSS

Manufacturers Standardization Society of the Valve & Fittings Industry, Inc.
127 Park Street, N.E.
Vienna, VA 22180

Standard reference number	Title	Referenced in code Section number
SP-69 – 91	Pipe Hangers and Supports — Selection and Application	M-706.2

NFiPA

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269

Standard reference number	Title	Referenced in code Section number
30 – 90	Flammable and Combustible Liquids Code	M-901.2, M-910.1
30A – 90	Automotive and Marine Service Station Code	M-910.1
31 – 92	Installation of Oil Burning Equipment	M-901.2, M-901.2.1
40 – 88	Cellulose Nitrate Motion Picture Film	M-1605.4.3.2
52 – 92	Compressed Natural Gas (CNG) Vehicular Fuel Systems	M-813.3
54 – 92	National Fuel Gas Code	M-815.1, M-816.1
58 – 92	Storage and Handling of Liquified Petroleum Gases	M-801.2, M-805.5.1
70 – 93	National Electrical Code	M-303.2.5, M-409.1
72E – 90	Automatic Fire Detectors	M-309.3
88B – 91	Repair Garages	M-406.3.3

SMACNA

Sheet Metal & Air Conditioning Contractors Nat'l Assoc., Inc.
4021 Lafayette Center Road
Chantilly, VA 22021

Standard reference number	Title	Referenced in code Section number
SMACNA – 85	HVAC Duct Construction Standards — Metal and Flexible	M-304.1
SMACNA – 79	Fibrous Glass Duct Construction Standards	M-304.2

STI

Steel Tank Institute
570 Oakwood Road
Lake Zurich, IL 60047

Standard reference number	Title	Referenced in code Section number
F841 – 91	Standard for Dual Wall Underground Steel Storage Tanks	Table M-903.3
P3 – 90	Specification and Manual for External Corrosion Protection of Underground Steel Storage Tanks	M-905.1

UL

Underwriters Laboratories Inc.
333 Pfingsten Road
Northbrook, IL 60062-2096

Standard reference number	Title	Referenced in code Section number
58 – 86	Standard for Safety for Steel Underground Tanks for Flammable and Commbustible Liquids — with Revisions thru August 1990	Table M-903.3
80 – 80	Standard for Safety for Steel Inside Tanks for Oil-Burner Fuel — with Revisions thru August 1992	Table M-903.3
94 – 91	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances — with Revisions thru June 1991	M-307.6.1
103 – 89	Standard for Safety Chimneys, Factory-Built, Residential Type and Building Heating Appliance — with Revisions thru February 1989	M-1205.1 M-1205.3
127 – 88	Standard for Safety Factory-Built Fireplaces — with Revisions thru June 1992	M-1205.3 M-1403.1
142 – 87	Standard for Safety for Steel Aboveground Tanks for Flammable and Combustible Liquids — with Revisions thru September 1987	Table M-903.3
144 – 85	Pressure Regulating Valves for LP-Gas	M-806.1.1
181 – 90	Factory-made Air Ducts and Air Connectors — with Revisions thru November 1990	M-304.1 M-304.2, M-305.1, M-305.2
441 – 91	Gas Vents — with Revisions thru September 1991	M-1204.1
443 – 90	Standard for Safety for Steel Auxiliary Tanks for Oil-Burner Fuel	Table M-903.3
555 – 90	Fire Dampers and Ceiling Dampers	M-313.1
641 – 86	Low-Temperature Venting Systems, Type L — with Revisions thru August 1989	M-1204.1
710 – 90	Exhaust Hoods for Commercial Cooking Equipment	M-503.1 M-503.2
737 – 88	Fireplace Stoves — with Revisions thru June 1991	M-1205.3 M-1403.1
910 – 91	Standard for Safety Test for Flame-Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environment	M-303.2.5
959 – 86	Medium Heat Appliance Factory-Built Chimneys — with Revisions thru June 1992	M-1205.1
1316 – 83	Standard for Safety for Glass-Fiber-Reinforced Plastic Underground Storage Tanks for Petroleum Products — with Revisions thru May 1991	Table M-903.3
1482 – 88	Room Heaters, Solid-Fuel Type — with Revisions thru June 1991	M-1402.1
1746 – 89	External Corrosion Protection Systems for Steel Underground Storage Tanks — with Revisions thru November 1990	M-905.1
1777 – 88	Chimney Liners — with Revisions thru June 1992	M-1207.4
1820 – 89	Fire Test of Pneumatic Tubing for Flame and Smoke Characteristics with Revisions thru April 1991	M-303.2.6
1887 – 89	Fire Tests of Plastic Sprinkler Pipe for Flame and Smoke Characteristics	M-303.2.1

ULC

Underwriters' Laboratories of Canada
7 Crouse Road
Scarborough, Ontario, Canada M1R 3A9

Standard reference number	Title	Referenced in code Section number
CAN/ULC-S603.1 – 92	Standard for Galvanic Corrosion Protection Systems for Steel Underground Tanks for Flammable and Combustible Liquids	M-905.1

APPENDIX A

DEGREE DAY AND DESIGN TEMPERATURE TABLE

DEGREE DAY AND DESIGN TEMPERATURES[a] FOR CITIES IN THE UNITED STATES

State	Station[c]	Heating degree days (yearly total)	Design temperatures			Degrees north latitude[b]
			Winter	Summer		
			97½%	Dry bulb 2½%	Wet bulb 2½%	
AL	Birmingham	2,551	21	94	77	33°3′
	Huntsville	3,070	16	93	77	34°4′
	Mobile	1,560	29	93	79	30°4′
	Montgomery	2,291	25	95	79	32°2′
AK	Anchorage	10,864	-18	68	59	61°1′
	Fairbanks	14,279	-47	78	62	64°5′
	Juneau	9,075	1	70	59	58°2′
	Nome	14,171	-27	62	56	64°3′
AZ	Flagstaff	7,152	4	82	60	35°1′
	Phoenix	1,765	34	107	75	33°3′
	Tuscon	1,800	32	102	71	33°1′
	Yuma	974	39	109	78	32°4′
AR	Fort Smith	3,292	17	98	79	35°2′
	Little Rock	3,219	20	96	79	34°4′
	Texarkana	2,533	23	96	79	33°3′
CA	Fresno	2,611	30	100	71	36°5′
	Long Beach	1,803	43	80	69	33°5′
	Los Angeles	2,061	43	80	69	34°0′
	Los Angeles[d]	1,349	40	89	71	34°0′
	Oakland	2,870	36	80	64	37°4′
	Sacramento	2,502	32	98	71	38°3′
	San Diego	1,458	44	80	70	32°4′
	San Francisco	3,015	38	77	64	37°4′
	San Francisco[d]	3,001	40	71	62	37°5′
CO	Alamosa	8,529	-16	82	61	37°3′
	Colorado Springs	6,423	2	88	62	38°5′
	Denver	6,283	1	91	63	39°5′
	Grand Junction	5,641	7	94	63	39°1′
	Pueblo	5,462	0	95	66	38°2′
CT	Bridgeport	5,617	9	84	74	41°1′
	Hartford	6,235	7	88	75	41°5′
	New Haven	5,897	7	84	75	41°2′
DE	Wilmington	4,930	14	89	76	39°4′
DC	Washington	4,224	17	91	77	38°5′
FL	Daytona	879	35	90	79	29°1′
	Fort Myers	442	44	92	79	26°4′
	Jacksonville	1,239	32	94	79	30°3′
	Key West	108	57	90	79	24°3′
	Miami	214	47	90	79	25°5′
	Orlando	766	38	93	78	28°3′
	Pensacola	1,463	29	93	79	30°3′
	Tallahassee	1,485	30	92	78	30°2′
	Tampa	683	40	91	79	28°0′
	West Palm Beach	253	45	91	79	26°4′

DEGREE DAY AND DESIGN TEMPERATURES[a] FOR CITIES IN THE UNITED STATES (cont'd.)

State	Station[c]	Heating degree days (yearly total)	Design temperatures			Degrees north latitude[b]
			Winter	Summer		
			97½%	Dry bulb 2½%	Wet bulb 2½%	
GA	Athens	2,929	22	92	77	34°0′
	Atlanta	2,961	22	92	76	33°4′
	Augusta	2,397	23	95	79	33°2′
	Columbus	2,383	24	93	78	32°3′
	Macon	2,136	25	93	78	32°4′
	Rome	3,326	22	93	78	34°2′
	Savannah	1,819	27	93	79	32°1′
HI	Hilo	0	62	83	74	19°4′
	Honolulu	0	63	86	75	21°2′
ID	Boise	5,809	10	94	66	43°3′
	Lewiston	5,542	6	93	66	46°2′
	Pocatello	7,033	-1	91	63	43°0′
IL	Chicago (Midway)	6,155	0	91	75	41°5′
	Chicago (O'Hare)	6,639	-4	89	76	42°0′
	Chicago[d]	5,882	2	91	77	41°5′
	Moline	6,408	-4	91	77	41°3′
	Peoria	6,025	-4	89	76	40°4′
	Rockford	6,830	-4	89	76	42°1′
	Springfield	5,429	2	92	77	39°5′
IN	Evansville	4,435	9	93	78	38°0′
	Fort Wayne	6,205	1	89	75	41°0′
	Indianapolis	5,699	2	90	76	39°4′
	South Bend	6,439	1	89	75	41°4′
IA	Burlington	6,114	-3	91	77	40°5′
	Des Moines	6,588	-5	91	77	41°3′
	Dubuque	7,376	-7	88	75	42°2′
	Sioux City	6,951	-7	92	77	42°2′
	Waterloo	7,320	-10	89	77	42°3′
KS	Dodge City	4,986	5	97	73	37°5′
	Goodland	6,141	0	96	70	39°2′
	Topeka	5,182	4	96	78	39°0′
	Wichita	4,620	7	98	76	37°4′
KY	Covington	5,265	6	90	75	39°0′
	Lexington	4,683	8	91	76	38°0′
	Louisville	4,660	10	93	77	38°1′
LA	Alexandria	1,921	27	94	79	31°2′
	Baton Rouge	1,560	29	93	80	30°3′
	Lake Charles	1,459	31	93	79	30°1′
	New Orleans	1,385	33	92	80	30°0′
	Shreveport	2,184	25	96	79	32°3′
ME	Caribou	9,767	-13	81	69	46°5′
	Portland	7,511	-1	84	72	43°4′
MD	Baltimore	4,654	13	91	77	39°1′
	Baltimore[d]	4,111	17	89	78	39°2′
	Frederick	5,087	12	91	77	39°2′

DEGREE DAY AND DESIGN TEMPERATURES[a] FOR CITIES IN THE UNITED STATES (cont'd.)

State	Station[c]	Heating degree days (yearly total)	Design temperatures			Degrees north latitude[b]
			Winter	Summer		
			97½%	Dry bulb 2½%	Wet bulb 2½%	
MA	Boston	5,634	9	88	74	42°2′
	Pittsfield	7,578	-3	84	72	42°3′
	Worcester	6,969	4	84	72	42°2′
MI	Alpena	8,506	-6	85	72	45°0′
	Detroit (City)	6,232	6	88	74	42°2′
	Escanaba[d]	8,481	-7	83	71	45°4′
	Flint	7,377	1	87	74	43°0′
	Grand Rapids	6,894	5	88	74	42°5′
	Lansing	6,909	1	87	74	42°5′
	Marquette[d]	8,393	-8	81	70	46°3′
	Muskegon	6,696	6	84	73	43°1′
	Sault Ste. Marie	9,048	-8	81	70	46°3′
MN	Duluth	10,000	-16	82	70	46°5′
	Minneapolis	8,382	-12	89	75	44°5′
	Rochester	8,295	-12	87	75	44°0′
MS	Jackson	2,239	25	95	78	32°2′
	Meridian	2,289	23	95	79	32°2′
	Vicksburg[d]	2,041	26	95	80	32°2′
MO	Columbia	5,046	4	94	77	39°0′
	Kansas City	4,711	6	96	77	39°1′
	St. Joseph	5,484	2	93	79	39°5′
	St. Louis	4,900	6	94	77	38°5′
	St. Louis[d]	4,484	8	94	77	38°4′
	Springfield	4,900	9	93	77	37°1′
MT	Billings	7,049	-10	91	66	45°5′
	Great Falls	7,750	-15	88	62	47°3′
	Helena	8,129	-16	88	62	46°4′
	Missoula	8,125	-6	88	63	46°5′
NE	Grand Island	6,530	-3	94	74	41°0′
	Lincoln[d]	5,864	-2	95	77	40°5′
	Norfolk	6,979	-4	93	77	42°0′
	North Platte	6,684	-4	94	72	41°1′
	Omaha	6,612	-3	91	77	41°2′
	Scottsbluff	6,673	-3	92	68	41°5′
NV	Elko	7,433	-2	92	62	40°5′
	Ely	7,733	-4	87	59	39°1′
	Las Vegas	2,709	28	106	70	36°1′
	Reno	6,332	10	92	62	39°3′
	Winnemucca	6,761	3	94	62	40°5′
NH	Concord	7,383	-3	87	73	43°1′
NJ	Atlantic City	4,812	13	89	77	39°3′
	Newark	4,589	14	91	76	40°4′
	Trenton[d]	4,980	14	88	76	40°1′
NM	Albuquerque	4,348	16	94	65	35°0′
	Raton	6,228	1	89	64	36°5′
	Roswell	3,793	18	98	70	33°2′
	Silver City	3,705	10	94	64	32°4′

DEGREE DAY AND DESIGN TEMPERATURES[a] FOR CITIES IN THE UNITED STATES (cont'd.)

State	Station[c]	Heating degree days (yearly total)	Design temperatures			Degrees north latitude[b]
			Winter	Summer		
			97½%	Dry bulb 2½%	Wet bulb 2½%	
NY	Albany	6,875	-1	88	74	42°5′
	Albany[d]	6,201	1	88	74	42°5′
	Binghamton	7,286	1	83	72	42°1′
	Buffalo	7,062	6	85	73	43°0′
	NY (Cent. Park)[d]	4,871	15	89	75	40°5′
	NY (Kennedy)	5,219	15	87	75	40°4′
	NY(LaGuardia)	4,811	15	89	75	40°5′
	Rochester	6,748	5	88	73	43°1′
	Schenectady[d]	6,650	1	87	74	42°5′
	Syracuse	6,756	2	87	73	43°1′
NC	Charlotte	3,181	22	93	76	35°1′
	Greensboro	3,805	18	91	76	36°1′
	Raleigh	3,393	20	92	77	35°5′
	Winston-Salem	3,595	20	91	75	36°1′
ND	Bismarck	8,851	-19	91	71	46°5′
	Devils Lake[d]	9,901	-21	88	71	48°1′
	Fargo	9,226	-18	89	74	46°5′
	Williston	9,243	-21	88	70	48°1′
OH	Akron-Canton	6,037	6	86	73	41°0′
	Cincinnati[d]	4,410	6	90	75	39°1′
	Cleveland	6,351	5	88	74	41°2′
	Columbus	5,660	5	90	75	40°0′
	Dayton	5,622	4	89	75	39°5′
	Mansfield	6,403	5	87	74	40°5′
	Sandusky[d]	5,796	6	91	74	41°3′
	Toledo	6,494	1	88	75	41°4′
	Youngstown	6,417	4	86	73	41°2′
OK	Oklahoma City	3,725	13	97	77	35°2′
	Tulsa	3,860	13	98	78	36°1′
OR	Eugene	4,726	22	89	67	44°1′
	Medford	5,008	23	94	68	42°2′
	Portland	4,635	23	85	67	45°4′
	Portland[d]	4,109	24	86	67	45°3′
	Salem	4,754	23	88	68	45°0′
PA	Allentown	5,810	9	88	75	40°4′
	Erie	6,451	9	85	74	42°1′
	Harrisburg	5,251	11	91	76	40°1′
	Philadelphia	5,144	14	90	76	39°5′
	Pittsburgh	5,987	5	86	73	40°3′
	Pittsburgh[d]	5,053	7	88	73	40°3′
	Reading[d]	4,945	13	89	75	40°2′
	Scranton	6,254	5	87	73	41°2′
	Williamsport	5,934	7	89	74	41°1′
RI	Providence	5,954	9	86	74	41°4′
SC	Charleston	2,033	27	91	80	32°5′
	Charleston[d]	1,794	28	92	80	32°5′
	Columbia	2,484	24	95	78	34°0′
SD	Huron	8,223	-14	93	75	44°3′
	Rapid City	7,345	-7	92	69	44°0′
	Sioux Falls	7,839	-11	91	75	43°4′

DEGREE DAY AND DESIGN TEMPERATURES[a] FOR CITIES IN THE UNITED STATES (cont'd.)

State	Station[c]	Heating degree days (yearly total)	Design temperatures			Degrees north latitude[b]
			Winter	Summer		
			97½%	Dry bulb 2½%	Wet bulb 2½%	
TN	Bristol	4,143	14	89	75	36°3′
	Chattanooga	3,254	18	93	77	35°0′
	Knoxville	3,494	19	92	76	35°5′
	Memphis	3,232	18	95	79	35°0′
	Nashville	3,578	14	94	77	36°1′
TX	Abilene	2,624	20	99	74	32°3′
	Austin	1,711	28	98	77	30°2′
	Dallas	2,363	22	100	78	32°5′
	El Paso	2,700	24	98	68	31°5′
	Houston	1,396	32	94	79	29°4′
	Midland	2,591	21	98	72	32°0′
	San Angelo	2,255	22	99	74	31°2′
	San Antonio	1,546	30	97	76	29°3′
	Waco	2,030	26	99	78	31°4′
	Wichita Falls	2,832	18	101	76	34°0′
UT	Salt Lake City	6,052	8	95	65	40°5′
VT	Burlington	8,269	-7	85	72	44°3′
VA	Lynchburg	4,166	16	90	76	37°2′
	Norfolk	3,421	22	91	78	36°5′
	Richmond	3,865	17	92	78	37°3′
	Roanoke	4,150	16	91	74	37°2′
WA	Olympia	5,236	22	83	66	47°0′
	Seattle-Tacoma	5,145	26	80	64	47°3′
	Seattle[d]	4,424	27	82	67	47°4′
	Spokane	6,655	2	90	64	47°4′
WV	Charleston	4,476	11	90	75	38°2′
	Elkins	5,675	6	84	72	38°5′
	Huntington	4,446	10	91	77	38°2′
	Parkersburg[d]	4,754	11	90	76	39°2′
WI	Green Bay	8,029	-9	85	74	44°3′
	La Crosse	7,589	-9	88	75	43°5′
	Madison	7,863	-7	88	75	43°1′
	Milwaukee	7,635	-4	87	74	43°0′
WY	Casper	7,410	-5	90	61	42°5′
	Cheyenne	7,381	-1	86	62	41°1′
	Lander	7,870	-11	88	63	42°5′
	Sheridan	7,680	-8	91	65	44°5′

Note a. All data was extracted from the 1985 ASHRAE Handbook, Fundamentals Volume.

Note b. Latitude is given to the nearest 10 minutes. For example, the latitude for Miami, Florida, is given as 25°5′ or 25 degrees 50 minutes.

Note c. Design data developed from airport temperature observations unless noted.

Note d. Design data developed from office locations within an urban area, not from airport temperature observations.

APPENDIX B

REFRIGERANTS AND PIPE EXPANSION

Table B-1
REFRIGERANTS

Refrigerant[a]	Name	Chemical formula
	GROUP 1 REFRIGERANTS	
R-11	Trichloromonofluoromethane	CCl_3F
R-12	Dichlorodifluoromethane	CCl_2F_2
R-13	Chlorotrifluoromethane	$CClF_3$
R-13B1	Bromotrifluoromethane	CF_3Br
R-14	Tetrafluoromethane	CF_4
R-21	Dichloromonofluoromethane	$CHCl_2F$
R-22	Chlorodifluoromethane	$CHClF_2$
R-30	Dichloromethane (Methylene chloride)	CH_2Cl_2
R-113	Trichlorotrifluoroethane	$C_2Cl_3F_3$
R-114	Dichlorotetrafluoroethane	$C_2Cl_2F_4$
R-115	Chloropentafluoroethane	C_2ClF_5
R-C318	Octafluorocyclobutane	C_4F_8
R-500	Dichlorodifluoromethane, 73.8% and Ethylidene fluoride, 26.2%	Azeotrope of CCl_2F_2 and $C_2H_4F_2$
R-502	Chlorodifluoromethane, 48.8% and Chloropentafluoroethane, 51.2%	Azeotrope of $CHClF_2$ and C_2ClF_5
R-744	Carbon dioxide	CO_2
	GROUP 2 REFRIGERANTS	
R-40	Chloromethane (Methyl chloride)	CH_3Cl
R-611	Methyl formate	$HCOOCH_3$
R-717	Ammonia	NH_3
R-764	Sulphur dioxide	SO_2
	GROUP 3 REFRIGERANTS	
R-170	Ethane	C_2H_6
R-290	Propane	C_3H_8
R-600	Butane	$CH_3(CH_2)_2CH_3$
R-601	Isobutane	$(CH_3)_3CH$
R-1150	Ethylene	C_2H_4

Note a. Numerical refrigerant designation, see ASHRAE 34.

Table B-2
PIPE EXPANSION

Material	Coefficient of linear expansion	Expansion per 100 feet Δ 100 degrees F. (inches)
Cast iron	0.00000595	0.714
Steel	0.0000065	0.780
Copper	0.0000095	1.140
ABS	0.0000560	6.720
PVC Type I	0.0000280	3.360
PVC Type II	0.0000555	6.600
Polyethylene	0.0001000	12.000
Polybutylene	0.0000710	8.520

INDEX

By section number

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

tested to a minimum of 3 psi (21 kPa) and a maximum of 5 psi (34 kPa). The tank shall maintain the test pressure without the addition of air or other test gas for a minimum of 60 minutes.

M-912.3 Test gauge: The pressure gauge utilized to measure the test pressure shall have a maximum reading of 15 psi (103 kPa) and have a minimum gauge diameter of 3 inches (76 mm). Where the test pressure exceeds 5 psi (34 kPa), the pressure gauge shall have a maximum reading of three times the test pressure.