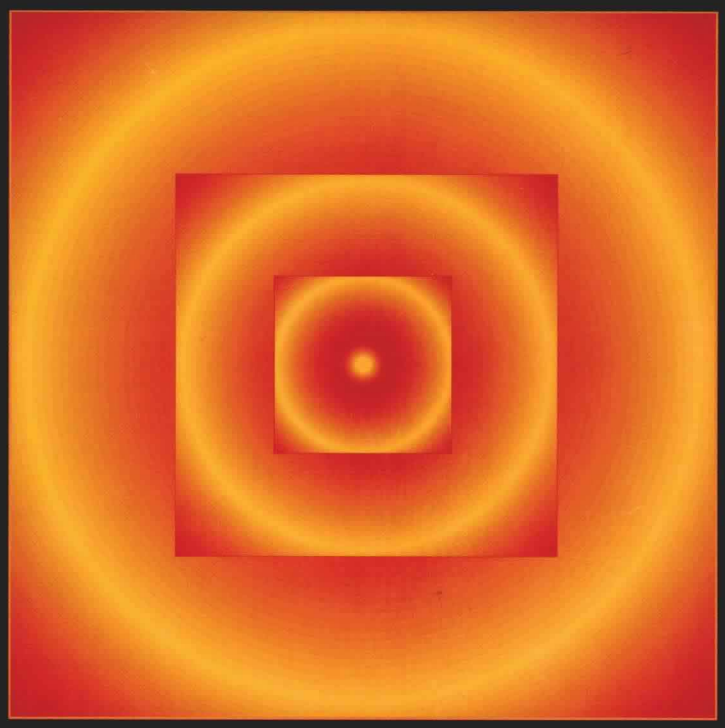
NFPA 72

National Fire Alarm Code

1996 Edition



National Fire Protection Association

An International Codes and Standards Organization

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Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

Statement on NFPA Procedures

This material has been developed under the published procedures of the National Fire Protection Association, which are designed to assure the appointment of technically competent Committees having balanced representation. While these procedures assure the highest degree of care, neither the National Fire Protection Association, its members, nor those participating in its activities accept 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.

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Errata

NFPA 72

National Fire Alarm Code

1996 Edition

Reference: Table 7-3.2, line 14

The Technical Correlating Committee on National Fire Alarm Code notes the following error in the 1996 edition of NFPA 72, *National Fire Alarm Code*. In the printing of the 1996 edition, the following error inadvertently occurred:

1. In Table 7-3.2, line 14, revise (j) and add a new subentry (j)1 as indicated below:

Component	Quarterly	Semiann.
j. Supervisory Signal Devices (except valve tamper switches)	X	
1. Valve Tamper Switches		X

Issue Date: October 8, 1996

Errata

NFPA 72

National Fire Alarm Code

1996 Edition

Reference: 1-5.7.4, A-1-5.7.4, A-7-3.2.1 and A-7-3.2
Errata No.: 72-96-1

The Technical Correlating Committee on National Fire Alarm Code notes the following errors in the 1996 edition of NFPA 72, *National Fire Alarm Code*.

1. In the printing of the 1996 edition, 1-5.7.4 should have been deleted.

2. Relocate and renumber A-1-5.7.4 as new paragraph A-1-5.7.1.2(e).

3. In the printing of the 1996 edition, A-7-3.2.1 was inadvertently omitted. Add as A-7-3.2 to read as follows:

A-7-3.2 It is suggested that the annual test be conducted in segments so that all devices are tested annually.

4. Add an asterisk to 7-3.2.1 and renumber present A-7-3.2 as A-7-3.2.1.

Issue Date: December 10, 1996

NFPA 72

National Fire Alarm Code

1996 Edition

This edition of NFPA 72, *National Fire Alarm Code*, was prepared by the Technical Committees on Fundamentals of Fire Alarm Systems, Household Fire Warning Equipment, Initiating Devices for Fire Alarm Systems, Notification Appliances for Fire Alarm Systems, Protected Premises Fire Alarm Systems, Supervising Station Fire Alarm Systems, and Testing and Maintenance of Fire Alarm Systems, released by the Technical Correlating Committee on the National Fire Alarm Code, and acted on by the National Fire Protection Association, Inc., at its Annual Meeting held May 20–23, 1996, in Boston, MA. It was issued by the Standards Council on July 18, 1996, with an effective date of August 9, 1996, and supersedes all previous editions.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

This edition of NFPA 72 was approved as an American National Standard on July 26,1996.

Origin and Development of NFPA 72

This code is a consolidation of the 1989 edition of NFPA 71, *Standard for the Installation, Maintenance, and Use of Signaling Systems for Central Station Service*; the 1990 edition of NFPA 72, *Standard for the Installation, Maintenance, and Use of Protective Signaling Systems*; the 1990 edition of NFPA 72E, *Standard on Automatic Fire Detectors;* the 1989 edition of NFPA 72G, *Guide for the Installation, Maintenance, and Use of Notification Appliances for Protective Signaling Systems*; the 1988 edition of NFPA 72H, *Guide for Testing Procedures for Local, Auxiliary, Remote Station, and Proprietary Protective Signaling Systems*; and the 1989 edition of NFPA 74, *Standard for the Installation, Maintenance, and Use of Household Fire Warning Equipment.* Many of the requirements of these standards were identical or very similar. The recommendations taken from the guides (NFPA 72G and NFPA 72H) were changed to mandatory requirements.

NFPA's signaling standards date back to 1898. The 1993 edition of NFPA 72 recognized improvements in the state of the art of the various types of signaling systems that have evolved in recent years.

This edition incorporates many changes that have taken place in the signaling industry, such as the Americans with Disabilities Act, software testing, fire modeling, and communications.

Technical Correlating Committee on the National Fire Alarm Code (NFA-AAC)

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Committee Scope: This Committee shall have primary responsibility for documents on the performance of alarm systems intended to alert occupants, off-site personnel, or both, of a fire, a condition normally associated with fire, or the operative condition of any system for the protection of life and property.

Technical Committee on Fundamentals of Fire Alarm Systems (NFA-FUN)

(Chapter 1)

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Rep. Nat'l Assn. of Fire Equipment Distributors, Inc.
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(Alt. to R. A. Grill)
Donald C. Tully, Orange County Fire Authority, CA
(Alt. to M. R. Schulman)
Lawrence J. Wenzel, Industrial Risk Insurers, CT
(Alt. to J. M. Freeman)

Committee Scope: This Committee shall have primary responsibility for documents on common system fundamentals for signaling systems, including definitions, requirements for approvals, installation, service, power supplies, equipment locations, compatibility, and system interfaces.

Technical Committee on Household Fire Warning Equipment (NFA-HOU)

(Chapter 2)

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H. Wayne Boyd, U.S. Safety & Engr Corp., CA
Rep. California Automatic Fire Alarm Assn., Inc.
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Rep. American Hotel & Motel Assn.
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Richard G. Bright, New Market, MD
(Member Emeritus)

Committee Scope: This Committee shall have primary responsibility for documents on the performance, selection, installation, operation, and use of fire warning equipment within dwelling units.

Technical Committee on Initiating Devices for Fire Alarm Systems (NFA-IDS)

(Chapter 5, Appendix B)

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North Carolina Dept. of Insurance, NC

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William P. Michna, Automatic Suppression Systems, Inc., IL
Ovid E. Morphew, Jr., Design/Systems Group, TX
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Committee Scope: This Committee shall have primary responsibility for documents on the installation and operation of initiating devices for signaling systems, including automatic fire detection devices, sprinkler waterflow detectors, manually activated fire alarm stations, supervisory signaling initiating devices, and guard's tour stations.

Technical Committee on Notification Appliances for Fire Alarm Systems (NFA-NAS)

(Chapter 6)

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Committee Scope: This Committee shall have primary responsibility for documents on the installation and operation of notification appliances for signaling systems.

Technical Committee on Protected Premises Fire Alarm Systems (NFA-PRO)

(Chapter 3)

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W. Allen Johnson, Schirmer Engr Corp., IL
J. R. Kern, HSB Professional Loss Control, TN
Thomas E. Kuhta, Willis Corroon Corp., NJ
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Stewart J. Levy, U.S. General Services Administration, DC
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Robert W. McPherson, Mansfield, OH
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Nonvoting

Benjamin B. Aycock, Charlotte - Mecklenburg Building Standards Dept., NC
(Member Emeritus)

Committee Scope: This Committee shall have primary responsibility for documents on the installation and operation of protected premises signaling systems, including their interconnection with initiating devices, notification appliances, and other related building control equipment, within the protected premises.

Technical Committee on Supervising Station Fire Alarm Systems (NFA-SSS)

(Chapter 4)

Robert V. Scholes, *Chair*
Kemper Nat'l Insurance Cos., CA

Charles Erichsen, *Secretary*
ADT Security Systems, Inc., NJ

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Rep. Int'l Municipal Signal Assn.
Allan M. Apo, American Insurance Services Group, Inc., NY
Robert Bitton, Supreme Security Systems, Inc., NJ
Rep. Central Station Alarm Assoc.
Art Black, Carmel-by-the-Sea Fire Dept., CA
Thomas C. Brown, Rolf Jensen & Assoc., Inc., VA
Gary Bullock, Alarm Center, Inc., WA
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Michael D. Cato, Delray Beach Fire Dept., FL
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Patrick M. Egan, Commonwealth Security Systems, PA
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Emerson B. Fisher, King-Fisher Co., IL
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Tom W. LeNay, Wells Fargo Alarm Services, CA
Eugene A. Monaco, Monaco Enterprises, Inc., WA
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(Vot. Alt. to FMANA Rep.)
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(Alt. to C. Erichsen)

Committee Scope: This Committee shall have primary responsibility for documents on the installation and operation of off-premises signaling systems, including the signal-receiving facility and the communications between the protected premises and the off-premises signal-receiving facility.

Technical Committee on Testing and Maintenance of Fire Alarm Systems (NFA-TMS)

(Chapter 7)

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Mark L. Rochholz, *Secretary*
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Brooke H. Baker, III, University of Alabama at Birmingham, AL
Rep. American Hospital Assn.
Charles H. Berry, U.S. Dept. of Veterans Affairs, MD
Jeffrey R. Brooks, Simplex Time Recorder Co., MA
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Robert E. Butchko, Cerberus Pyrotronics, NJ
Joseph T. Cavallari, Yale University, CT
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Scott Grieb, Kemper Nat'l Insurance Cos., IL
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Committee Scope: This Committee shall have primary responsibility for documents on the proper testing and maintenance of signaling systems, their components, and the interface equipment.

These lists represent the membership at the time each Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

NOTE: Membership on a Committee shall not in and of itself constitute an endorsement of the Association or any document developed by the Committee on which the member serves.

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NFPA 72

National Fire Alarm Code

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates explanatory material on that paragraph in Appendix A.

Information on referenced publications can be found in Chapter 8 and Appendix C.

Chapter 1 Fundamentals of Fire Alarm Systems

1-1 Scope. This code covers the application, installation, performance, and maintenance of fire alarm systems and their components.

1-2 Purpose.

1-2.1* The purpose of this code is to define the means of signal initiation, transmission, notification, and annunciation; the levels of performance; and the reliability of the various types of fire alarm systems. This code defines the features associated with these systems and also provides the information necessary to modify or upgrade an existing system to meet the requirements of a particular system classification. It is the intent of this code to establish the required levels of performance, extent of redundancy, and quality of installation but not to establish the methods by which these requirements are to be achieved.

1-2.2 Any reference or implied reference to a particular type of hardware is for the purpose of clarity and shall not be interpreted as an endorsement.

1-2.3 Unless otherwise noted, it is not intended that the provisions of this document be applied to facilities, equipment, structures, or installations that were existing or approved for construction or installation prior to the effective date of the document, except in those cases where it is determined by the authority having jurisdiction that the existing situation involves a distinct hazard to life or property

1-3 General.

1-3.1 This code classifies fire alarm systems as follows:

(a) Household fire warning systems;
(b) Protected premises fire alarm systems;
(c) Supervising station fire alarm systems:
  1. Auxiliary fire alarm systems
    a. Local energy type
    b. Parallel telephone type
    c. Shunt type
  2. Remote supervising station fire alarm systems
  3. Proprietary supervising station systems
  4. Central station fire alarm systems
  5. Municipal fire alarm systems.

1-3.2 A device or system having materials or forms that differ from those detailed in this code shall be permitted to be examined and tested according to the intent of the code and, if found equivalent, shall be approved.

1-3.3 The intent and meaning of the terms used in this code are, unless otherwise defined herein, the same as those of NFPA 70, *National Electrical Code®*.

1-4 Definitions. For the purposes of this code, the following terms are defined as follows:

Acknowledge. To confirm that a message or signal has been received, such as by the pressing of a button or the selection of a software command.

Active Multiplex System. A multiplexing system in which signaling devices such as transponders are employed to transmit status signals of each initiating device or initiating device circuit within a prescribed time interval so that lack of receipt of such signal may be interpreted as a trouble signal.

Addressable Device. A fire alarm system component with discrete identification that can have its status individually identified or that is used to individually control other functions.

Adverse Condition. Any condition occurring in a communications or transmission channel that interferes with the proper transmission or interpretation, or both, of status change signals at the supervising station. (*See also Trouble Signal.*)

Air Sampling-Type Detector. A detector that consists of a piping or tubing distribution network that runs from the detector to the area(s) to be protected. An aspiration fan in the detector housing draws air from the protected area back to the detector through air sampling ports, piping, or tubing. At the detector, the air is analyzed for fire products.

Alarm. A warning of fire danger.

Alarm Service. The service required following the receipt of an alarm signal.

Alarm Signal. A signal indicating an emergency requiring immediate action, such as a signal indicative of fire.

Alarm Verification Feature. A feature of automatic fire detection and alarm systems to reduce unwanted alarms wherein smoke detectors report alarm conditions for a minimum period of time, or confirm alarm conditions within a given time period after being reset, in order to be accepted as a valid alarm initiation signal.

Alert Tone. An attention-getting signal to alert occupants of the pending transmission of a voice message.

Analog Initiating Device (Sensor). An initiating device that transmits a signal indicating varying degrees of condition as contrasted with a conventional initiating device, which can only indicate an on/off condition.

Annunciator. A unit containing one or more indicator lamps, alphanumeric displays, or other equivalent means in which each indication provides status information about a circuit, condition, or location.

Approved.* Acceptable to the authority having jurisdiction.

Authority Having Jurisdiction.* The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

Automatic Extinguishing System Supervisory Device. A device that responds to abnormal conditions that could affect the proper operation of an automatic sprinkler system or other fire extinguishing system(s) or suppression system(s) including, but not limited to, control valves; pressure levels; liquid agent levels and temperatures; pump power and running; engine temperature and overspeed; and room temperature.

Automatic Fire Detector. A device designed to detect the presence of a fire signature and to initiate action. For the purpose of this code, automatic fire detectors are classified as follows:

Automatic Fire Extinguishing or Suppression System Operation Detector. A device that automatically detects the operation of a fire extinguishing or suppression system by means appropriate to the system employed.

Fire-Gas Detector. A device that detects gases produced by a fire.

Heat Detector. A fire detector that senses heat produced by burning substances. Heat is the energy produced by combustion that causes substances to rise in temperature.

Other Fire Detectors. Devices that detect a phenomenon other than heat, smoke, flame, or gases produced by a fire.

Radiant Energy-Sensing Fire Detector. A device that detects radiant energy (such as ultraviolet, visible, or infrared) that is emitted as a product of combustion reaction and obeys the laws of optics.

Smoke Detector. A device that detects visible or invisible particles of combustion.

Auxiliary Box. A fire alarm box that can be operated from one or more remote actuating devices.

Auxiliary Fire Alarm System. A system connected to a municipal fire alarm system for transmitting an alarm of fire to the public fire service communications center. Fire alarms from an auxiliary fire alarm system are received at the public fire service communications center on the same equipment and by the same methods as alarms transmitted manually from municipal fire alarm boxes located on streets.

Local Energy Type. An auxiliary system that employs a locally complete arrangement of parts, initiating devices, relays, power supply, and associated components to automatically trip a municipal transmitter or master box over electrical circuits that are electrically isolated from the municipal system circuits.

Parallel Telephone Type. An auxiliary system connected by a municipally controlled individual circuit to the protected property to interconnect the initiating devices at the protected premises and the municipal fire alarm switchboard.

Shunt Auxiliary Type. An auxiliary system electrically connected to an integral part of the municipal alarm system extending the municipal circuit into the protected premises to interconnect the initiating devices, which, when operated, open the municipal circuit shunted around the trip coil of the municipal transmitter or master box, which is thereupon energized to start transmission without any assistance whatsoever from a local source of power.

Average Ambient Sound Level. The root mean square, A-weighted sound pressure level measured over a 24-hour period.

Box Battery. The battery supplying power for an individual fire alarm box where radio signals are used for the transmission of box alarms.

Carrier. High frequency energy that can be modulated by voice or signaling impulses.

Carrier System. A means of conveying a number of channels over a single path by modulating each channel on a different carrier frequency and demodulating at the receiving point to restore the signals to their original form.

Ceiling. The upper surface of a space, regardless of height. Areas with a suspended ceiling have two ceilings, one visible from the floor and one above the suspended ceiling.

Ceiling Height. The height from the continuous floor of a room to the continuous ceiling of a room or space.

Ceiling Surfaces. Ceiling surfaces referred to in conjunction with the locations of initiating devices are defined as follows:

Beam Construction. Ceilings having solid structural or solid nonstructural members projecting down from the ceiling surface more than 4 in. (100 mm) and spaced more than 3 ft (0.9 m), center to center.

Girder. A support for beams or joists that runs at right angles to the beams or joists. Where the top of girders are within 4 in. (100 mm) of the ceiling, they are a factor in determining the number of detectors and are to be considered as beams. Where the top of the girder is more than 4 in. (100 mm) from the ceiling, it is not a factor in detector location.

Central Station. A supervising station that is listed for central station service.

Central Station Fire Alarm System. A system or group of systems in which the operations of circuits and devices are transmitted automatically to, recorded in, maintained by, and supervised from a listed central station having competent and experienced servers and operators who, upon receipt of a signal, take such action as required by this code. Such service is to be controlled and operated by a person, firm, or corporation whose business is the furnishing, maintaining, or monitoring of supervised fire alarm systems.

Central Station Service. The use of a system or a group of systems in which the operations of circuits and devices at a protected property are signaled to, recorded in, and supervised from a listed central station having competent and experienced operators who, upon receipt of a signal, take such action as required by this code. Related activities at the protected property such as equipment installation, inspection, testing, maintenance, and runner service are the responsibility of the central station or a listed fire alarm service-local company. Central station service is controlled and operated by a person, firm, or corporation whose business is the furnishing of such contracted services or whose properties are the protected premises.

Certification. A systematic program using randomly selected follow-up inspections of the certified systems installed under the program that allows the listing organization to verify that a fire alarm system complies with all the requirements of this code. A system installed under such a

program is identified by the issuance of a certificate and is designated as a certificated system.

Certification of Personnel. A formal program of related instruction and testing as provided by a recognized organization or the authority having jurisdiction.

NOTE: This definition applies only to municipal fire alarm systems.

Channel. A path for voice or signal transmission utilizing modulation of light or alternating current within a frequency band.

Circuit Interface. A circuit component that interfaces initiating devices or control circuits, or both, notification appliances or circuits, or both, system control outputs, and other signaling line circuits to a signaling line circuit.

Cloud Chamber Smoke Detection. The principle of using an air sample drawn from the protected area into a high humidity chamber combined with a lowering of chamber pressure to create an environment in which the resultant moisture in the air condenses on any smoke particles present, forming a cloud. The cloud density is measured by a photoelectric principle. The density signal is processed and used to convey an alarm condition when it meets preset criteria.

Coded. An audible or visible signal conveying several discrete bits or units of information. Notification signal examples are numbered strokes of an impact-type appliance and numbered flashes of a visible appliance.

Combination Detector. A device that either responds to more than one of the fire phenomenon or employs more than one operating principle to sense one of these phenomenon. Typical examples are a combination of a heat detector with a smoke detector or a combination rate-of-rise and fixed-temperature heat detector.

Combination Fire Alarm and Guard's Tour Box. A manually operated box for separately transmitting a fire alarm signal and a distinctive guard patrol tour supervisory signal.

Combination System. A fire alarm system whose components might be used, in whole or in part, in common with a nonfire signaling system, such as a paging system, a security system, a building automatic system, or a process monitoring system.

Communications Channel. A circuit or path connecting a subsidiary station(s) to a supervising station(s) over which signals are carried.

Compatibility Listed. A specific listing process that applies only to two-wire devices (such as smoke detectors) designed to operate with certain control equipment.

Compatible (Equipment). Equipment that interfaces mechanically or electrically as manufactured without field modification.

Contiguous Property. A single-owner or single-user protected premises on a continuous plot of ground, including any buildings thereon, that is not separated by a public thoroughfare, transportation right-of-way, property owned or used by others, or body of water not under the same ownership.

Control Unit. A system component that monitors inputs and controls outputs through various types of circuits.

Delinquency Signal. A signal indicating the need for action in connection with the supervision of guards or system attendants.

Derived Channel. A signaling line circuit that uses the local leg of the public switched network as an active multiplex channel while simultaneously allowing that leg's use for normal telephone communications.

Detector. A device suitable for connection to a circuit having a sensor that responds to a physical stimulus such as heat or smoke.

Digital Alarm Communicator Receiver (DACR). A system component that accepts and display signals from digital alarm communicator transmitters (DACTs) sent over the public switched telephone network.

Digital Alarm Communicator System (DACS). A system in which signals are transmitted from a digital alarm communicator transmitter (DACT) located at the protected premises through the public switched telephone network to a digital alarm communicator receiver (DACR).

Digital Alarm Communicator Transmitter (DACT). A system component at the protected premises to which initiating devices or groups of devices are connected. The DACT seizes the connected telephone line, dials a preselected number to connect to a DACR, and transmits signals indicating a status change of the initiating device.

Digital Alarm Radio Receiver (DARR). A system component composed of two subcomponents: one that receives and decodes radio signals, and another that annunciates the decoded data. These two subcomponents can be coresident at the central station or separated by means of a data transmission channel.

Digital Alarm Radio System (DARS). A system in which signals are transmitted from a digital alarm radio transmitter (DART) located at a protected premises through a radio channel to a digital alarm radio receiver (DARR).

Digital Alarm Radio Transmitter (DART). A system component that is connected to or an integral part of a DACT that is used to provide an alternate radio transmission channel.

Display. The visual representation of output data as opposed to printed copy.

Double Doorway. A single opening that has no intervening wall space or door trim separating the two doors. (*See Figure 5-10.7.4.3.1.*)

Dual Control. The use of two primary trunk facilities over separate routes or different methods to control one communications channel.

Ember.* A particle of solid material that emits radiant energy due either to its temperature or the process of combustion on its surface. (*See definition of Spark.*)

Emergency Voice/Alarm Communications. Dedicated manual or automatic facilities for originating and distributing voice instructions, as well as alert and evacuation signals pertaining to a fire emergency, to the occupants of a building.

Evacuation. The withdrawal of occupants from a building.

NOTE: Evacuation does not include relocation of occupants within a building.

Evacuation Signal. A distinctive signal intended to be recognized by the occupants as requiring evacuation of the building.

Exit Plan. A plan for the emergency evacuation of the premises.

Family Living Unit. One or more rooms in a single-family detached dwelling, single-family attached dwelling, multifamily dwelling, or mobile home for the use of one or more persons as a housekeeping unit with space for eating, living, and sleeping and permanent provisions for cooking and sanitation. This definition covers living areas only and not common usage areas in multifamily dwellings such as corridors, lobbies, or basements.

Field of View. The solid cone extending out from the detector within which the effective sensitivity of the detector is at least 50 percent of its on-axis, listed, or approved sensitivity.

Fire Alarm Control Unit (Panel). A system component that receives inputs from automatic and manual fire alarm devices and might supply power to detection devices and a transponder(s) or an off-premises transmitter(s). The control unit might also provide transfer of power to the notification appliances and transfer of condition to relays or devices connected to the control unit. The fire alarm control unit can be a local fire alarm control unit or master control unit.

Fire Alarm/Evacuation Signal Tone Generator. A device that, upon command, produces a fire alarm/evacuation tone.

Fire Alarm Signal. A signal initiated by a fire alarm-initiating device such as a manual fire alarm box, automatic fire detector, waterflow switch, or other device whose activation is indicative of the presence of a fire or fire signature.

Fire Alarm System. A system or portion of a combination system consisting of components and circuits arranged to monitor and annunciate the status of fire alarm or supervisory signal-initiating devices and to initiate the appropriate response to those signals.

Fire Command Center. The principal attended or unattended location where the status of the detection, alarm communications, and control systems is displayed and from which the system(s) can be manually controlled.

Fire Rating. The classification indicating in time (hours) the ability of a structure or component to withstand fire conditions.

Fire Safety Function Control Device. The fire alarm system component that directly interfaces with the control system that controls the fire safety function.

Fire Safety Functions. Building and fire control functions that are intended to increase the level of life safety for occupants or to control the spread of the harmful effects of fire.

Fire Warden. A building staff member or a tenant trained to perform assigned duties in the event of a fire emergency.

Fixed Temperature Detector.* A device that responds when its operating element becomes heated to a predetermined level.

Flame. A body or stream of gaseous material involved in the combustion process and emitting radiant energy at specific wavelength bands determined by the combustion chemistry of the fuel. In most cases, some portion of the emitted radiant energy is visible to the human eye.

Flame Detector. A radiant energy-sensing fire detector that detects the radiant energy emitted by a flame. (*See A-5-4.2.*)

NOTE: Flame detectors are categorized as ultraviolet, single wavelength infrared, ultraviolet infrared, or multiple wavelength infrared.

Flame Detector Sensitivity. The distance along the optical axis of the detector at which the detector can detect a fire of specified size and fuel within a given time frame.

Guard Signal. A supervisory signal monitoring the performance of guard patrols.

Guard's Tour Reporting Station. A device that is manually or automatically initiated to indicate the route being followed and the timing of a guard's tour.

Heat Alarm. A single or multiple station alarm responsive to heat.

Household. The family living unit in single-family detached dwellings, single-family attached dwellings, multifamily buildings, and mobile homes.

Household Fire Alarm System. A system of devices that produces an alarm signal in the household for the purpose of notifying the occupants of the presence of a fire so that they will evacuate the premises.

Hunt Group. A group of associated telephone lines within which an incoming call is automatically routed to an idle (not busy) telephone line for completion.

Initiating Device. A system component that originates transmission of a change of state condition, such as in a smoke detector, manual fire alarm box, or supervisory switch.

Initiating Device Circuit. A circuit to which automatic or manual initiating devices are connected where the signal received does not identify the individual device operated.

Intermediate Fire Alarm or Fire Supervisory Control Unit. A control unit used to provide area fire alarm or area fire supervisory service that, where connected to the proprietary fire alarm system, becomes a part of that system.

Ionization Smoke Detection.* The principle of using a small amount of radioactive material to ionize the air between two differentially charged electrodes to sense the presence of smoke particles. Smoke particles entering the ionization volume decrease the conductance of the air by reducing ion mobility. The reduced conductance signal is processed and used to convey an alarm condition when it meets preset criteria.

Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an

organization that is acceptable to the authority having jurisdiction and concerned with product evaluation that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Leg Facility. The portion of a communications channel that connects not more than one protected premises to a primary or secondary trunk facility. The leg facility includes the portion of the signal transmission circuit from its point of connection with a trunk facility to the point where it is terminated within the protected premises at one or more transponders.

Level Ceilings. Ceilings that are actually level or have a slope of $1\frac{1}{2}$ in./ft (41.7 mm/m) or less.

Line-Type Detector. A device in which detection is continuous along a path. Typical examples are rate-of-rise pneumatic tubing detectors, projected beam smoke detectors, and heat-sensitive cable.

Listed.* Equipment, materials, or services included in a list published by an organization acceptable to the authority having jurisdiction and concerned with evaluation of products or services that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services and whose listing states either that the equipment, material, or service meets identified standards or has been tested and found suitable for a specified purpose.

Loading Capacity. The maximum number of discrete elements of fire alarm systems permitted to be used in a particular configuration.

Loss of Power. The reduction of available voltage at the load below the point at which equipment can function as designed.

Low Power Radio Transmitter. Any device that communicates with associated control/receiving equipment by low power radio signals.

Maintenance. Repair service, including periodic inspections and tests, required to keep the fire alarm system and its component parts in an operative condition at all times, together with replacement of the system or its components when they become undependable or inoperable for any reason.

Manual Fire Alarm Box. A manually operated device used to initiate an alarm signal.

Master Box. A municipal fire alarm box that can also be operated by remote means.

Master Control Unit (Panel). A control unit that serves the protected premises or portion of the protected premises as a local control unit and accepts inputs from other fire alarm control units.

Multiple Station Alarm. A single station alarm capable of being interconnected to one or more additional alarms so that the actuation of one causes the appropriate alarm signal to operate in all interconnected alarms.

Multiple Station Alarm Device. Two or more single station alarm devices that can be interconnected so that actuation of one causes all integral or separate audible alarms to operate. It also can consist of one single station alarm device having connections to other detectors or to a manual fire alarm box.

Multiplexing. A signaling method characterized by simultaneous or sequential transmission, or both, and reception of multiple signals on a signaling line circuit, a transmission channel, or a communications channel, including means for positively identifying each signal.

Municipal Fire Alarm Box (Street Box). An enclosure housing a manually operated transmitter used to send an alarm to the public fire service communications center.

Municipal Fire Alarm System. A system of alarm-initiating devices, receiving equipment, and connecting circuits (other than a public telephone network) used to transmit alarms from street locations to the public fire service communications center.

Municipal Transmitter. A transmitter that can only be tripped remotely that is used to send an alarm to the public fire service communications center.

Noncoded. An audible or visible signal conveying one discrete bit of information.

Noncontiguous Property. An owner- or user-protected premises where two or more protected premises, controlled by the same owner or user, are separated by a public thoroughfare, body of water, transportation right-of-way, or property owned or used by others.

Nonrestorable Initiating Device. A device whose sensing element is designed to be destroyed in the process of operation.

Notification Appliance. A fire alarm system component such as a bell, horn, speaker, light, or text display that provides audible, tactile, or visible outputs, or any combination thereof.

Audible Notification Appliance. A notification appliance that alerts by the sense of hearing.

Audible Textual Notification Appliance. A notification appliance that conveys a stream of audible information. An example of an audible textual appliance is a speaker that reproduces a voice message.

Olfactory Notification Appliance. A notification appliance that alerts by the sense of smell.

Tactile Notification Appliance. A notification appliance that alerts by the sense of touch or vibration.

Visible Notification Appliance. A notification appliance that alerts by the sense of sight.

Visible Textual Notification Appliance. A notification appliance that conveys a stream of visible information. An example of a visible textual appliance is a monitor that displays an alphanumeric or pictorial message.

Notification Appliance Circuit. A circuit or path directly connected to a notification appliance(s).

Notification Zone. An area covered by notification appliances that are activated simultaneously.

Nuisance Alarm. Any alarm caused by mechanical failure, malfunction, improper installation, or lack of proper maintenance, or any alarm activated by a cause that cannot be determined.

Off-Hook. To make connection with the public switched telephone network in preparing to dial a telephone number.

On-Hook. To disconnect from the public switched telephone network.

Open Area Detection (Protection). Protection of an area such as a room or space with detectors to provide early warning of fire.

Operating Mode, Private. Audible or visible signaling only to those persons directly concerned with the implementation and direction of emergency action initiation and procedure in the area protected by the fire alarm system.

Operating Mode, Public. Audible or visible signaling to occupants or inhabitants of the area protected by the fire alarm system.

Operating System Software. The basic operating system software that is alterable only by the equipment manufacturer or its authorized representative. This software is sometimes referred to as "firmware," "BIOS," or "executive program."

Ownership. Any property or building or its contents under legal control by the occupant, by contract, or by holding of a title or deed.

Paging System. A system intended to page one or more persons by such means as voice over loudspeaker, coded audible signals or visible signals, or lamp annunciators.

Parallel Telephone System. A telephone system in which an individually wired circuit is used for each fire alarm box.

Path (Pathways). Any conductor, optic fiber, radio carrier, or other means for transmitting fire alarm system information between two or more locations.

Permanent Visual Record (Recording). An immediately readable, not easily alterable, print, slash, or punch record of all occurrences of status change.

Photoelectric Light Obscuration Smoke Detection.* The principle of utilizing a light source and a photosensitive sensor onto which the principal portion of the source emissions is focused. When smoke particles enter the light path, some of the light is scattered and some is absorbed, thereby reducing the light reaching the receiving sensor. The light reduction signal is processed and used to convey an alarm condition when it meets preset criteria.

Photoelectric Light-Scattering Smoke Detection.* The principle of utilizing a light source and a photosensitive sensor arranged in a manner so that the rays from the light source do not normally fall onto the photosensitive sensor. When smoke particles enter the light path, some of the light is scattered by reflection and refraction onto the sensor. The light signal is processed and used to convey an alarm condition when it meets preset criteria.

Plant. One or more buildings under the same ownership or control on a single property.

Positive Alarm Sequence. An automatic sequence that results in an alarm signal, even when manually delayed for investigation, unless the system is reset.

Power Supply. A source of electrical operating power including the circuits and terminations connecting it to the dependent system components.

Primary Battery (Dry Cell). A nonrechargeable battery requiring periodic replacement.

Primary Trunk Facility. That part of a transmission channel connecting all leg facilities to a supervising or subsidiary station.

Prime Contractor. The one company contractually responsible for providing central station services to a subscriber as required by this code. This can be either a listed central station or a listed fire alarm service-local company.

Private Radio Signaling. A radio system under control of the proprietary supervising station.

Projected Beam-Type Detector. A type of photoelectric light obscuration smoke detector wherein the beam spans the protected area.

Proprietary Supervising Station. A location to which alarm or supervisory signaling devices on proprietary fire alarm systems are connected and where personnel are in attendance at all times to supervise operation and investigate signals.

Proprietary Supervising Station Fire Alarm System. An installation of fire alarm systems that serves contiguous and noncontiguous properties, under one ownership, from a proprietary supervising station located at the protected property, at which trained, competent personnel are in constant attendance. This includes the proprietary supervising station; power supplies; signal-initiating devices; initiating device circuits; signal notification appliances; equipment for the automatic, permanent visual recording of signals; and equipment for initiating the operation of emergency building control services.

Protected Premises. The physical location protected by a fire alarm system.

Protected Premises (Local) Control Unit (Panel). A control unit that serves the protected premises or a portion of the protected premises and indicates the alarm via notification appliances inside the protected premises.

Protected Premises (Local) Fire Alarm System. A protected premises system that sounds an alarm at the protected premises as the result of the manual operation of a fire alarm box or the operation of protection equipment or systems, such as water flowing in a sprinkler system, the discharge of carbon dioxide, the detection of smoke, or the detection of heat.

Public Fire Service Communications Center. The building or portion of the building used to house the central operating part of the fire alarm system; usually the place where the necessary testing, switching, receiving, transmitting, and power supply devices are located.

Public Switched Telephone Network. An assembly of communications facilities and central office equipment operated jointly by authorized common carriers that provides the general public with the ability to establish communications channels via discrete dialing codes.

Radio Alarm Repeater Station Receiver (RARSR). A system component that receives radio signals. This component resides at a repeater station that is located at a remote receiving location.

Radio Alarm Supervising Station Receiver (RASSR). A system component that receives data and annunciates that data at the supervising station.

Radio Alarm System (RAS). A system in which signals are transmitted from a radio alarm transmitter (RAT) located at a protected premises through a radio channel to two or more radio alarm repeater station receivers (RARSR) and are annunciated by a radio alarm supervising station receiver (RASSR) located at the central station.

Radio Alarm Transmitter (RAT). A system component at the protected premises to which initiating devices or groups of devices are connected. The RAT transmits signals indicating a status change of the initiating devices.

Radio Channel. A band of frequencies of a width sufficient to allow its use for radio communications.

NOTE: The width of the channel depends on the type of transmissions and the tolerance for the frequency of emission. Channels normally are allocated for radio transmission in a specified type for service by a specified transmitter.

Rate Compensation Detector.* A device that responds when the temperature of the air surrounding the device reaches a predetermined level, regardless of the rate of temperature rise.

Rate-of-Rise Detector.* A device that responds when the temperature rises at a rate exceeding a predetermined value.

Record Drawings. Drawings (as-built) that document the location of all devices, appliances, wiring sequences, wiring methods, and connections of the components of the fire alarm system as installed.

Record of Completion. A document that acknowledges the features of installation, operation (performance), service, and equipment with representation by the property owner, system installer, system supplier, service organization, and the authority having jurisdiction.

Relocation. The movement of occupants from a fire zone to a safe area within the same building.

Remote Supervising Station Fire Alarm System. A system installed in accordance with this code to transmit alarm, supervisory, and trouble signals from one or more protected premises to a remote location at which appropriate action is taken.

Repeater Facility. Equipment needed to relay signals between supervisory stations, subsidiary stations, and protected premises.

Repeater Station. The location of the equipment needed for a repeater facility.

Reset. A control function that attempts to return a system or device to its normal, nonalarm state.

Restorable Initiating Device. A device whose sensing element is not ordinarily destroyed in the process of operation. Restoration can be manual or automatic.

Runner. A person other than the required number of operators on duty at central, supervising, or runner stations (or otherwise in contact with these stations) available for prompt dispatching, when necessary, to the protected premises.

Runner Service. The service provided by a runner at the protected premises, including resetting and silencing of all equipment transmitting fire alarm or supervisory signals to an off-premises location.

Satellite Trunk. A circuit or path connecting a satellite to its central or proprietary supervising station.

Scanner. Equipment located at the telephone company wire center that monitors each local leg and relays status changes to the alarm center. Processors and associated equipment might also be included.

Secondary Trunk Facility. That part of a transmission channel connecting two or more, but fewer than all, leg facilities to a primary trunk facility.

Separate Sleeping Area. An area of the family living unit in which the bedrooms (or sleeping rooms) are located. Bedrooms (or sleeping rooms) separated by other use areas, such as kitchens or living rooms (but not bathrooms), are considered as separate sleeping areas.

Shall. Indicates a mandatory requirement.

Shapes of Ceilings. The shapes of ceilings are classified as follows:

Sloping Ceiling. A ceiling having a slope of more than 1½ in./ft (41.7 mm/m). Sloping ceilings are further classified as follows:

Sloping-Peaked Type. A ceiling in which the ceiling slopes in two directions from the highest point. Curved or domed ceilings can be considered peaked with the slope figured as the slope of the chord from highest to lowest point. (*See Figure A-5-2.4.4.1.*)

Sloping-Shed Type. A ceiling in which the high point is at one side with the slope extending toward the opposite side. (*See Figure A-5-2.4.4.2.*)

Smooth Ceiling. A ceiling surface uninterrupted by continuous projections, such as solid joists, beams, or ducts, extending more than 4 in. (100 mm) below the ceiling surface.

NOTE: Open truss constructions are not considered to impede the flow of fire products unless the upper member in continuous contact with the ceiling projects below the ceiling more than 4 in. (100 mm).

Should. Indicates a recommendation or that which is advised but not required.

Signal. A status indication communicated by electrical or other means.

Signaling Line Circuit. A circuit or path between any combination of circuit interfaces, control units, or transmitters over which multiple system input signals or output signals, or both, are carried.

Signaling Line Circuit Interface. A system component that connects a signaling line circuit to any combination of initiating devices, initiating device circuits, notification appliances, notification appliance circuits, system control outputs, and other signaling line circuits.

Signal Transmission Sequence. A DACT that obtains dial tone, dials the number(s) of the DACR, obtains verification that the DACR is ready to receive signals, transmits the signals, and receives acknowledgment that the DACR has accepted that signal before disconnecting (going on-hook).

Single Station Alarm. A detector comprising an assembly incorporating a sensor, control components, and an alarm notification appliance in one unit operated from a power source either located in the unit or obtained at the point of installation.

Single Station Alarm Device. An assembly incorporating the detector, the control equipment, and the alarm-sounding device in one unit operated from a power supply either in the unit or obtained at the point of installation.

Site-Specific Software. Software that defines the specific operation and configuration of a particular system. Typically, it defines the type and quantity of hardware modules, customized labels, and specific operating features of a system.

Smoke Alarm. A single or multiple station alarm responsive to smoke.

Solid Joist Construction. Refers to ceilings having solid structural or solid nonstructural members projecting down from the ceiling surface for a distance of more than 4 in. (100 mm) and spaced at intervals 3 ft (0.9 m) or less, center to center.

Spacing. A horizontally measured dimension related to the allowable coverage of fire detectors.

Spark.* A moving ember.

Spark/Ember Detector. A radiant energy fire detector that is designed to detect sparks or embers, or both. These devices are normally intended to operate in dark environments and in the infrared part of the spectrum.

Spark/Ember Detector Sensitivity. The number of watts (or the fraction of a watt) of radiant power from a point source radiator, applied as a unit step signal at the wavelength of maximum detector sensitivity, necessary to produce an alarm signal from the detector within the specified response time.

Spot-Type Detector. A device whose detecting element is concentrated at a particular location. Typical examples are bimetallic detectors, fusible alloy detectors, certain pneumatic rate-of-rise detectors, certain smoke detectors, and thermoelectric detectors.

Story. The portion of a building included between the upper surface of a floor and the upper surface of the floor or roof next above.

Stratification. The phenomenon where the upward movement of smoke and gases ceases due to the loss of buoyancy.

Subscriber. The recipient of contractual supervising station signal service(s). In case of multiple, noncontiguous properties having single ownership, the term refers to each protected premises or its local management.

Subsidiary Station. A subsidiary station is a normally unattended location that is remote from the supervising station and linked by a communications channel(s) to the supervising station. Interconnection of signals on one or more transmission channels from protected premises with a communications channel(s) to the supervising station is performed at this location.

Supervising Station. A facility that receives signals and at which personnel are in attendance at all times to respond to these signals.

Supervisory Service. The service required to monitor performance of guard tours and the operative condition of fixed suppression systems or other systems for the protection of life and property.

Supervisory Signal. A signal indicating the need of action in connection with the supervision of guard tours, the fire suppression systems or equipment, or the maintenance features of related systems.

Supervisory Signal-Initiating Device. An initiating device such as a valve supervisory switch, water level indicator, or low-air pressure switch on a dry-pipe sprinkler system whose change of state signals an off-normal condition and its restoration to normal of a fire protection or life safety system; or a need for action in connection with guard tours, fire suppression systems or equipment, or maintenance features of related systems.

Supplementary. As used in this code, supplementary refers to equipment or operations not required by this code and designated as such by the authority having jurisdiction.

Switched Telephone Network. An assembly of communications facilities and central office equipment operated jointly by authorized service providers that provides the general public with the ability to establish transmission channels via discrete dialing.

System Unit. The active subassemblies at the central station utilized for signal receiving, processing, display, or recording of status change signals; a failure of one of these subassemblies causes the loss of a number of alarm signals by that unit.

Transmission Channel. A circuit or path connecting transmitters to supervising stations or subsidiary stations on which signals are carried.

Transmitter. A system component that provides an interface between signaling line circuits, initiating device circuits, or control units and the transmission channel.

Transponder. A multiplex alarm transmission system functional assembly located at the protected premises.

Trouble Signal. A signal initiated by the fire alarm system or device indicative of a fault in a monitored circuit or component.

WATS (Wide Area Telephone Service). Telephone company service allowing reduced costs for certain telephone call arrangements; it can be in-WATS or 800-number service where calls can be placed from anywhere in the continental U.S. to the called party at no cost to the calling party, or out-WATS, a service whereby, for a flat-rate charge, dependent on the total duration of all such calls, a subscriber can make an unlimited number of calls within a prescribed area from a particular telephone terminal without the registration of individual call charges.

Wavelength.* The distance between the peaks of a sinusoidal wave. All radiant energy can be described as a wave

having a wavelength. Wavelength serves as the unit of measure for distinguishing between different parts of the spectrum. Wavelengths are measured in microns (μM), nanometers (nM), or angstroms (Å).

Wireless Protection System. A system or a part of a system that can transmit and receive signals without the aid of wire. It may consist of any of the following components:

Wireless Control Panel. A component that transmits/receives and processes wireless signals.

Wireless Repeater. A component used to relay signals between wireless receivers or wireless control panels, or both.

Zone. A defined area within the protected premises. A zone can define an area from which a signal can be received, an area to which a signal can be sent, or an area in which a form of control can be executed.

1-5 Fundamentals.

1-5.1 Common System Fundamentals. The provisions of this chapter shall apply to Chapters 3 through 7.

1-5.1.1 The provisions of this chapter cover the basic functions of a complete fire alarm system. These systems are primarily intended to provide notification of fire alarm, supervisory, and trouble conditions, alert the occupants, summon appropriate aid, and control fire safety functions.

1-5.1.2 Equipment. Equipment constructed and installed in conformity with this code shall be listed for the purpose for which it is used.

1-5.1.3 System Design. Fire alarm system plans and specifications shall be developed in accordance with this code by persons experienced in the proper design, application, installation, and testing of fire alarm systems.

1-5.2 Power Supplies.

1-5.2.1 Scope. The provisions of this section apply to power supplies used for fire alarm systems.

1-5.2.2 Code Conformance. All power supplies shall be installed in conformity with the requirements of NFPA 70, *National Electrical Code*, for such equipment and with the requirements indicated in this subsection.

1-5.2.3 Power Sources. Fire alarm systems shall be provided with at least two independent and reliable power supplies, one primary and one secondary (standby), each of which shall be of adequate capacity for the application.

Exception No. 1: Where the primary power is supplied by a dedicated branch circuit of an emergency system in accordance with NFPA 70, National Electrical Code, Article 700, or a legally required standby system in accordance with NFPA 70, National Electrical Code, Article 701, a secondary supply shall not be required.

Exception No. 2: Where the primary power is supplied by a dedicated branch circuit of an optional standby system in accordance with NFPA 70, National Electrical Code, Article 702, which also meets the performance requirements of Article 700 or Article 701, a secondary supply shall not be required.

NOTE to 1-5.2.3, Exceptions No. 1 and No. 2: A trouble signal is not required where operating power is being supplied by either of the two sources of power indicated in Exceptions No. 1 and No. 2, if they are capable of providing the hours of operation required by 1-5.2.6 and loss of primary power is otherwise indicated (e.g., loss of building lighting).

Where dc voltages are employed, they shall be limited to no more than 350 volts above earth ground.

1-5.2.4 Primary Supply. The primary supply shall have a high degree of reliability, shall have adequate capacity for the intended service, and shall consist of one of the following:

(a) Light and power service arranged in accordance with 1-5.2.5;

(b) Where a person specifically trained in its operation is on duty at all times, an engine-driven generator or equivalent arranged in accordance with 1-5.2.10.

1-5.2.5 Light and Power Service.

1-5.2.5.1 A light and power service employed to operate the system under normal conditions shall have a high degree of reliability and capacity for the intended service. This service shall consist of one of the following:

(a) **Two-Wire Supplies.** A two-wire supply circuit shall be permitted to be used for either the primary operating power supply or the trouble signal power supply of the signaling system.

(b) **Three-Wire Supplies.** A three-wire ac or dc supply circuit having a continuous unfused neutral conductor, or a polyphase ac supply circuit having a continuous unfused neutral conductor where interruption of one phase does not prevent operation of the other phase, shall be permitted to be used with one side or phase for the primary operating power supply and the other side or phase for the trouble signal power supply of the fire alarm system.

1-5.2.5.2 Connections to the light and power service shall be on a dedicated branch circuit(s). The circuit(s) and connections shall be mechanically protected. Circuit disconnecting means shall have a red marking, shall be accessible only to authorized personnel, and shall be identified as "FIRE ALARM CIRCUIT CONTROL." The location of the circuit disconnecting means shall be permanently identified at the fire alarm control unit.

1-5.2.5.3 Overcurrent Protection. An overcurrent protective device of suitable current-carrying capacity and capable of interrupting the maximum short-circuit current to which it may be subject shall be provided in each ungrounded conductor. The overcurrent protective device shall be enclosed in a locked or sealed cabinet located immediately adjacent to the point of connection to the light and power conductors.

1-5.2.5.4 Circuit breakers or engine stops shall not be installed in such a manner as to cut off the power for lighting or for operating elevators.

1-5.2.6 Secondary Supply Capacity and Sources. The secondary supply shall automatically supply the energy to the system within 30 seconds, and without loss of signals, wherever the primary supply is incapable of providing the minimum voltage required for proper operation. The secondary (standby) power supply shall supply energy to the system in the event of total failure of the primary (main) power supply or when the primary voltage drops to a level insufficient to maintain functionality of the control equipment and system components. Under maximum normal

load, the secondary supply shall have sufficient capacity to operate a protected premises, central station, or proprietary system for 24 hours, or an auxiliary or remote station system for 60 hours; and, at the end of that period, shall be capable of operating all alarm notification appliances used for evacuation or to direct aid to the location of an emergency for 5 minutes. The secondary power supply for emergency voice/alarm communications service shall be capable of operating the system under maximum normal load for 24 hours and then shall be capable of operating the system during a fire or other emergency condition for a period of 2 hours. Fifteen minutes of evacuation alarm operation at maximum connected load shall be considered the equivalent of 2 hours of emergency operation.

The secondary supply shall consist of one of the following:

(a) A storage battery arranged in accordance with 1-5.2.9;

(b) An automatic starting, engine-driven generator arranged in accordance with 1-5.2.10 and storage batteries with 4 hours of capacity arranged in accordance with 1-5.2.9;

(c) Multiple engine-driven generators, one of which is arranged for automatic starting, arranged in accordance with 1-5.2.10, and capable of supplying the energy required herein, with the largest generator out of service. The second generator shall be permitted to be started by pushbutton.

Operation on secondary power shall not affect the required performance of a fire alarm system. The system shall produce the same alarm, supervisory, and trouble signals and indications (excluding the ac power indicator) when operating from the standby power source as are produced when the unit is operating from the primary power source.

1-5.2.7 Continuity of Power Supplies.

(a) Where signals could be lost on transfer of power between the primary and secondary sources, rechargeable batteries of sufficient capacity to operate the system under maximum normal load for 15 minutes shall assume the load in such a manner that no signals are lost where either of the following conditions exists:

1. Secondary power is supplied in accordance with 1-5.2.6(a) or 1-5.2.6(b), and the transfer is made manually; or

2. Secondary power is supplied in accordance with 1-5.2.6(c).

(b) Where signals will not be lost due to transfer of power between the primary and secondary sources, one of the following arrangements shall be made:

1. The transfer shall be automatic.

2. Special provisions shall be made to allow manual transfer within 30 seconds of loss of power.

3. The transfer shall be arranged in accordance with 1-5.2.6(a).

(c)* Where a computer system of any kind or size is used to receive or process signals, an uninterruptible power supply (UPS) with sufficient capacity to operate the system for at least 15 minutes, or until the secondary supply is capable of supplying the UPS input power requirements, shall be required where either of the following conditions apply:

1. The status of signals previously received will be lost upon loss of power.

2. The computer system cannot be restored to full operation within 30 seconds of loss of power.

(d)* A positive means for disconnecting the input and output of the UPS system while maintaining continuity of power supply to the load shall be provided.

1-5.2.8 Power Supply for Remotely Located Control Equipment.

1-5.2.8.1 Additional power supplies, where provided for control units, circuit interfaces, or other equipment essential to system operation, located remote from the main control unit, shall be comprised of a primary and secondary power supply that shall meet the same requirements as those of 1-5.2.1 through 1-5.2.8 and 1-5.8.6.

1-5.2.8.2 Power supervisory devices shall be arranged so as not to impair the receipt of fire alarm or supervisory signals.

1-5.2.9* Storage Batteries.

1-5.2.9.1 Location. Storage batteries shall be so located that the fire alarm equipment, including overcurrent devices, are not adversely affected by battery gases and shall conform to the requirements of NFPA 70, *National Electrical Code*, Article 480. Cells shall be suitably insulated against grounds and crosses and shall be mounted securely in such a manner as not to be subject to mechanical injury. Racks shall be suitably protected against deterioration. Where not located in or adjacent to the fire alarm control panel, the batteries and their charger location shall be permanently identified at the fire alarm control unit.

1-5.2.9.2 Battery Charging.

(a) Adequate facilities shall be provided to automatically maintain the battery fully charged under all conditions of normal operation and, in addition, to recharge batteries within 48 hours after fully charged batteries have been subject to a single discharge cycle as specified in 1-5.2.6. Upon attaining a fully charged condition, the charge rate shall not be so excessive as to result in battery damage.

(b) Supervising stations shall maintain spare parts or units available, which shall be employed to restore failed charging capacity prior to the consumption of ½ of the capacity of the batteries for the supervising station equipment.

(c)* Batteries shall be either trickle- or float-charged.

(d) A rectifier employed as a battery charging supply source shall be of adequate capacity. A rectifier employed as a charging means shall be energized by an isolating transformer.

1-5.2.9.3 Overcurrent Protection. The batteries shall be protected against excessive load current by overcurrent devices having a rating not less than 150 percent and not more than 250 percent of the maximum operating load in the alarm condition. The batteries shall be protected from excessive charging current by overcurrent devices or by automatic current-limiting design of the charging source.

1-5.2.9.4 Metering. The charging equipment shall provide either integral meters or readily accessible terminal facilities for the connection of portable meters by which the battery voltage and charging current can be determined.

1-5.2.9.5 Under-Voltage Detection. An under-voltage detection device shall be provided to detect a failure of the charging source and initiate a trouble signal.

1-5.2.10 Engine-Driven Generator.

1-5.2.10.1 The installation of engine-driven generators shall conform to the provisions of NFPA 110, *Standard for Emergency and Standby Power Systems*.

Exception: Where restricted by the provisions of this section.

1-5.2.10.2 Capacity. The unit shall be of a capacity sufficient to operate the system under the maximum normal load conditions in addition to all other demands placed upon the unit, such as those of emergency lighting.

1-5.2.10.3 Fuel. Fuel shall be stored in outside underground tanks wherever possible, and gravity feed shall not be used. Gasoline deteriorates with age. Where gasoline-driven generators are used, fuel shall be supplied from a frequently replenished "working" tank, or other means provided, to ensure that the gasoline is always fresh.

1-5.2.10.4 Sufficient fuel shall be available in storage for 6 months of testing plus the capacity specified in 1-5.2.6. (*For public fire alarm reporting systems, see 4-6.7.3.4.*)

Exception No. 1: Where a reliable source of supply is available at any time on 2-hours' notice, sufficient fuel shall be in storage for 12 hours of operation at full load.

Exception No. 2: Fuel systems using natural or manufactured gas supplied through reliable utility mains shall not be required to have fuel storage tanks unless located in seismic risk zone 3 or greater as defined in ANSI A-58.1, Building Code Requirements for Minimum Design Loads in Buildings and Other Structures.

1-5.2.10.5 A separate storage battery and separate automatic charger shall be provided for starting the engine-driven generator and shall not be used for any other purpose.

1-5.3 Compatibility.

1-5.3.1 All initiating devices, notification appliances, and control equipment constructed and installed in conformity with this code shall be listed for the purpose for which they are intended.

1-5.3.2 All fire detection devices that receive their power from the initiating device circuit or signaling line circuit of a fire alarm control unit shall be listed for use with the control unit.

1-5.4 System Functions.

1-5.4.1 Protected Premises Fire Safety Functions.

1-5.4.1.1 Fire safety functions shall be permitted to be performed automatically. The performance of automatic fire safety functions shall not interfere with power for lighting or for operating elevators. This shall not preclude the combination of fire alarm services with other services requiring monitoring of operations.

1-5.4.1.2 The time delay between the activation of an initiating device and the automatic activation of a local fire safety function shall not exceed 90 seconds.

1-5.4.2 Alarm Signals.

1-5.4.2.1* Coded Alarm Signal. A coded alarm signal shall consist of not less than three complete rounds of the number transmitted, and each round shall consist of not less than three impulses.

1-5.4.2.2 Actuation of alarm notification appliances or emergency voice communications shall occur within 90 seconds after the activation of an initiating device.

1-5.4.3 Supervisory Signals.

1-5.4.3.1 Coded Supervisory Signal. A coded supervisory signal shall be permitted to consist of two rounds of the number transmitted to indicate a supervisory off-normal condition, and one round of the number transmitted to indicate the restoration of the supervisory condition to normal.

1-5.4.3.2 Combined Coded Alarm and Supervisory Signal Circuits. Where both coded sprinkler supervisory signals and coded fire or waterflow alarm signals are transmitted over the same signaling line circuit, provision shall be made either to obtain alarm signal precedence or sufficient repetition of the alarm signal to prevent the loss of an alarm signal.

1-5.4.3.3 Visible and audible supervisory signals and visible indication of their restoration to normal shall be indicated within 90 seconds at the following locations:

(a) Control unit (central equipment) for local fire alarm systems;

(b) Building fire command center for emergency voice/alarm communications systems;

(c) Supervising station location for systems installed in compliance with Chapter 4.

1-5.4.4 Fire alarms, supervisory signals, and trouble signals shall be distinctively and descriptively annunciated.

1-5.4.5* Where status indicators are required to be provided for emergency equipment or fire safety functions, they shall be arranged to reflect the actual status of the associated equipment or function accurately.

1-5.4.6 Trouble Signal.

1-5.4.6.1 General. Trouble signals and their restoration to normal shall be indicated within 200 seconds at the locations identified in 1-5.4.6.2 or 1-5.4.6.3. Trouble signals required to indicate at the protected premises shall be indicated by distinctive audible signals. These audible trouble signals shall be distinctive from alarm signals. Where an intermittent signal is used, it shall sound at least once every 10 seconds, with a minimum duration of $\frac{1}{2}$ second. An audible trouble signal shall be permitted to be common to several supervised circuits. The trouble signal(s) shall be located in an area where it is likely to be heard.

1-5.4.6.2 Visible and audible trouble signals and visible indication of their restoration to normal shall be indicated at the following locations:

(a) Control unit (central equipment) for local fire alarm systems;

(b) Building fire command center for emergency voice/alarm communications systems;

(c) Central station or remote station location for systems installed in compliance with Chapter 4.

1-5.4.6.3 Trouble signals and their restoration to normal shall be visibly and audibly indicated at the proprietary supervising station for systems installed in compliance with Chapter 4.

1-5.4.6.4 Audible Trouble Signal Silencing Switch.

1-5.4.6.4.1 A means for silencing the trouble notification appliance(s) shall be permitted only where it is key-operated, located within a locked enclosure, or arranged to provide equivalent protection against unauthorized use.

Such a means shall be permitted only where it transfers the trouble indication to a suitably identified lamp or other acceptable visible indicator. The visible indication shall persist until the trouble condition has been corrected. The audible trouble signal shall sound when the silencing means is in its silence position and no trouble exists.

1-5.4.6.4.2 Where an audible trouble notification appliance is also used to indicate a supervisory condition, as permitted in 1-5.4.7(b), a trouble signal silencing switch shall not prevent subsequent sounding of supervisory signals. An audible trouble signal that has been silenced at the protected premises shall automatically re-sound every 24 hours or less until fault conditions are restored to normal.

1-5.4.7 Distinctive Signals. Audible alarm notification appliances for a fire alarm system shall produce signals that are distinctive from other similar appliances used for other purposes in the same area. The distinction among signals shall be as follows:

(a) Fire alarm signals shall be distinctive in sound from other signals, and their sound shall not be used for any other purpose. (*See 3-7.2.*)

(b)* Supervisory signals shall be distinctive in sound from other signals. Their sound shall not be used for any other purpose.

Exception: A supervisory signal sound shall be permitted to be used to indicate a trouble condition. Where the same sound is used for both supervisory signals and trouble signals, the distinction between signals shall be by other appropriate means such as visible annunciation.

(c) Fire alarm, supervisory, and trouble signals shall take precedence, in that respective order of priority, over all other signals.

Exception: Signals from hold-up alarms or other life threatening signals shall be permitted to take precedence over supervisory and trouble signals where acceptable to the authority having jurisdiction.

1-5.4.8 Alarm Signal Deactivation. A means for turning off the alarm notification appliances shall be permitted only where it is key-operated, located within a locked cabinet, or arranged to provide equivalent protection against unauthorized use. Such means shall be permitted only if a visible zone alarm indication or the equivalent has been provided as specified in 1-5.7.1 and subsequent alarms on other initiating devices or circuits cause the notification appliances to reactivate. A means that is left in the "off" position when there is no alarm shall operate an audible trouble signal until the means is restored to normal. Where automatically turning off the alarm notification appliances is permitted by the authority having jurisdiction, the alarm shall not be turned off in less than 5 minutes.

Exception: Where otherwise permitted by the authority having jurisdiction, the 5-minute requirement shall not apply.

1-5.4.9 Supervisory Signal Silencing. A means for silencing a supervisory signal notification appliance(s) shall be permitted only where it is key-operated, located within a locked enclosure, or arranged to provide equivalent protection against unauthorized use. Such a means shall be permitted only where it transfers the supervisory indication to a lamp or other visible indicator and subsequent supervisory signals in other zones cause the supervisory notification appliance(s) to re-sound. A means that is left in the "silence" position where there is no supervisory off-normal signal shall operate a visible signal silence indicator and cause the trouble signal to sound until the silencing means is restored to normal position.

1-5.4.10 Presignal Feature. Where permitted by the authority having jurisdiction, systems shall be permitted to have a feature that allows initial fire alarm signals to sound only in department offices, control rooms, fire brigade stations, or other constantly attended central locations and for which human action is subsequently required to activate a general alarm, or a feature that allows the control equipment to delay the general alarm by more than 1 minute after the start of the alarm processing. Where there is a connection to a remote location, it shall activate upon the initial alarm signal.

NOTE: *A system provided with an alarm verification feature as permitted by 3-8.2.3 is not considered a presignal system, since the delay in the signal produced is 60 seconds or less and requires no human intervention.*

1-5.4.11 Positive Alarm Sequence.

1-5.4.11.1 Systems having positive alarm features complying with the following shall be permitted where approved by the authority having jurisdiction.

1-5.4.11.1.1 The signal from an automatic fire detection device selected for positive alarm sequence operation shall be acknowledged at the control unit by trained personnel within 15 seconds of annunciation in order to initiate the alarm investigation phase. If the signal is not acknowledged within 15 seconds, all building and remote signals shall be activated immediately and automatically.

1-5.4.11.1.2 Trained personnel shall have up to 180 seconds during the alarm investigation phase to evaluate the fire condition and reset the system. If the system is not reset during this investigation phase, all building and remote signals shall be activated immediately and automatically.

1-5.4.11.2 If a second automatic fire detector selected for positive alarm sequence is actuated during the alarm investigation phase, all normal building and remote signals shall be activated immediately and automatically.

1-5.4.11.3 If any other initiating device is actuated, all building and remote signals shall be activated immediately and automatically.

1-5.4.11.4* The system shall provide means to bypass the positive alarm sequence.

1-5.5 Performance and Limitations.

1-5.5.1 Voltage, Temperature, and Humidity Variation. Equipment shall be designed so that it is capable of performing its intended functions under the following conditions:

(a)* At 85 percent and at 110 percent of the nameplate primary (main) and secondary (standby) input voltage(s);

(b) At ambient temperatures of 32°F (0°C) and 120°F (49°C);

(c) At a relative humidity of 85 percent and an ambient temperature of 86°F (30°C).

1-5.5.2 Installation and Design.

1-5.5.2.1* All systems shall be installed in accordance with the specifications and standards approved by the authority having jurisdiction.

1-5.5.2.2 Devices and appliances shall be so located and mounted that accidental operation or failure is not caused by vibration or jarring.

1-5.5.2.3 All apparatus requiring rewinding or resetting to maintain normal operation shall be restored to normal as promptly as possible after each alarm and kept in normal condition for operation.

1-5.5.2.4 Equipment shall be installed in locations where conditions do not exceed the voltage, temperature, and humidity limits specified in 1-5.5.1.

Exception: Equipment specifically listed for use in locations where conditions can exceed the upper and lower limits specified in 1-5.5.1.

1-5.5.3 To reduce the possibility of damage by induced transients, circuits and equipment shall be properly protected in accordance with the requirements set forth in NFPA 70, *National Electrical Code*, Article 800.

1-5.5.4* Wiring. The installation of all wiring, cable, and equipment shall be in accordance with NFPA 70, *National Electrical Code*, and specifically with Article 760, Article 770, and Article 800, where applicable. Optical fiber cables shall be protected against mechanical injury in accordance with Article 760.

1-5.5.5 Grounding. All systems shall test free of grounds.

Exception: Parts of circuits or equipment that are intentionally and permanently grounded to provide ground-fault detection, noise suppression, emergency ground signaling, and circuit protection grounding.

1-5.5.6 Initiating Devices.

1-5.5.6.1 Initiating devices of the manual or automatic type shall be selected and installed so as to minimize nuisance alarms.

1-5.5.6.2 Fire alarm boxes of the manually operated type shall comply with 3-8.1.

1-5.6 Protection of Control Equipment. In areas that are not continuously occupied, automatic smoke detection shall be provided at each control unit(s) location to provide notification of fire at that location.

Exception: Where ambient conditions prohibit installation of automatic smoke detection, automatic heat detection shall be permitted.

1-5.7 Zoning and Annunciation.

1-5.7.1 Visible Zone Alarm Indication. Where required, the location of an operated initiating device shall be visibly indicated by building, floor, fire zone, or other approved subdivision by annunciation, printout, or other approved means. The visible indication shall not be canceled by the operation of an audible alarm silencing means.

1-5.7.1.1 The primary purpose of fire alarm system annunciation is to enable responding personnel to identify the location of a fire quickly and accurately and to indicate the status of emergency equipment or fire safety functions that might affect the safety of occupants in a fire situation. All required annunciation means shall be readily accessible to responding personnel and shall be located as required by the authority having jurisdiction to facilitate an efficient response to the fire situation.

1-5.7.1.2* Zone of Origin. Fire alarm systems serving two or more zones shall identify the zone of origin of the alarm initiation by annunciation or coded signal.

1-5.7.1.3 Visual annunciators shall be capable of displaying all zones in alarm. Where all zones in alarm are not displayed simultaneously, there shall be visual indication that other zones are in alarm.

1-5.7.2 Alarm annunciation at the fire command center shall be by means of audible and visible indicators.

1-5.7.3 For the purpose of alarm annunciation, each floor of the building shall be considered as a separate zone. Where a floor is subdivided by fire or smoke barriers and the fire plan for the protected premises allows relocation of occupants from the zone of origin to another zone on the same floor, each zone on the floor shall be annunciated separately for purposes of alarm location.

1-5.7.4 Where the system serves more than one building, each building shall be indicated separately.

1-5.8 Monitoring Integrity of Installation Conductors and Other Signaling Channels.

1-5.8.1 All means of interconnecting equipment, devices, and appliances and wiring connections shall be monitored for the integrity of the interconnecting conductors or equivalent path so that the occurrence of a single open or a single ground-fault condition in the installation conductors or other signaling channels and their restoration to normal shall be automatically indicated within 200 seconds.

NOTE: The provision of a double loop or other multiple path conductor or circuit to avoid electrical monitoring is not acceptable.

Exception No. 1: Styles of initiating device circuits, signaling line circuits, and notification appliance circuits tabulated in Tables 3-5, 3-6, and 3-7.1 that do not have an "X" under "Trouble" for the abnormal condition indicated.

Exception No. 2: Shorts between conductors, other than as required by 1-5.8.3, 1-5.8.4, and 1-5.8.5.2 and Tables 3-5, 3-6, and 3-7.1, shall not be subject to this requirement.

Exception No. 3: A noninterfering shunt circuit, provided that a fault circuit condition on the shunt circuit wiring results only in the loss of the noninterfering feature of operation.

Exception No. 4: Connections to and between supplementary system components, provided that single open, ground, or short circuit conditions of the supplementary equipment or interconnecting means, or both, do not affect the required operation of the fire alarm system.

Exception No. 5: The circuit of an alarm notification appliance installed in the same room with the central control equipment, provided that the notification appliance circuit conductors are installed in conduit or equivalently protected against mechanical injury.

Exception No. 6: A trouble signal circuit.

Exception No. 7: Interconnection between equipment within a common enclosure.

NOTE: This code does not have jurisdiction over the monitoring integrity of conductors within equipment, devices, or appliances.

Exception No. 8: Interconnection between enclosures containing control equipment located within 20 ft (6 m) where the conductors are installed in conduit or equivalently protected against mechanical injury.

Exception No. 9: Conductors for ground detection where a single ground does not prevent the required normal operation of the system.

Exception No. 10: Central station circuits serving notification appliances within a central station.

Exception No. 11: Pneumatic rate-of-rise systems of the continuous line type in which the wiring terminals of such devices are connected in multiple across electrically supervised circuits.

1-5.8.2 Interconnection means shall be arranged so that a single break or single ground fault does not cause an alarm signal.

1-5.8.3 An open, ground, or short circuit fault on the installation conductors of one alarm notification appliance circuit shall not affect the operation of any other alarm notification circuit.

1-5.8.4 The occurrence of a wire-to-wire short circuit fault on any alarm notification appliance circuit shall result in a trouble signal at the protected premises.

Exception No. 1: A circuit employed to produce a supplementary local alarm signal, provided that the occurrence of a short circuit on the circuit in no way affects the required operation of the fire alarm system.

Exception No. 2: The circuit of an alarm notification appliance installed in the same room with the central control equipment, provided that the notification appliance circuit conductors are installed in conduit or equivalently protected against mechanical injury.

Exception No. 3: Central station circuits serving notification appliances within a central station.

1-5.8.5 Monitoring Integrity of Emergency Voice/Alarm Communications Systems.

1-5.8.5.1* Monitoring Integrity of Speaker Amplifier and Tone-Generating Equipment. Where speakers are used to produce audible fire alarm signals, the following shall apply:

(a) Failure of any audio amplifier shall result in an audible trouble signal.

(b) Failure of any tone-generating equipment shall result in an audible trouble signal.

Exception: Tone-generating and amplifying equipment enclosed as integral parts and serving only a single, listed loudspeaker shall not be required to be monitored.

1-5.8.5.2 Where a two-way telephone communications circuit is provided, its installation wires shall be monitored for a short circuit fault that would cause the telephone communications circuit to become inoperative.

1-5.8.6 Monitoring Integrity of Power Supplies.

1-5.8.6.1 All primary and secondary power supplies shall be monitored for the presence of voltage at the point of connection to the system. Failure of either supply shall result in a trouble signal in accordance with 1-5.4.6. The trouble signal also shall be visually and audibly indicated at the protected premises. Where the DACT is powered from a protected premises fire alarm system control unit, power failure indication shall be in accordance with this paragraph.

Exception No. 1: A power supply for supplementary equipment.

Exception No. 2: The neutral of a three-, four-, or five-wire ac or dc supply source.

Exception No. 3: In a central station, the main power supply, provided the fault condition is otherwise indicated so as to be obvious to the operator on duty.

Exception No. 4: The output of an engine-driven generator that is part of the secondary power supply, provided the generator is tested weekly in accordance with Chapter 7.

1-5.8.6.2 Power supply sources and electrical supervision for digital alarm communications systems shall be in accordance with 1-5.2 and 1-5.8.1.

NOTE: Since digital alarm communicator systems establish communications channels between the protected premises and the central station via the public switched telephone network, the requirement to supervise circuits between the protected premises and the central station (*see 1-5.8.1*) is considered to be met where the communications channel is periodically tested in accordance with 4-5.3.2.1.10.

1-5.8.6.3 The primary power failure trouble signal for the DACT shall not be transmitted until the actual battery capacity is depleted by at least 25 percent, but by not more than 50 percent.

1-6 System Interfaces. The requirements by which fire alarm systems interface with other fire protective systems and fire safety functions can be found in Chapter 3.

1-7 Documentation.

1-7.1 Approval and Acceptance.

1-7.1.1 The authority having jurisdiction shall be notified prior to installation or alteration of equipment or wiring. At its request, complete information regarding the system or system alterations, including specifications, wiring diagrams, battery calculation, and floor plans shall be submitted for approval.

1-7.1.2 Before requesting final approval of the installation, where required by the authority having jurisdiction, the installing contractor shall furnish a written statement to the effect that the system has been installed in accordance with approved plans and tested in accordance with the manufacturer's specifications and the appropriate NFPA requirements.

1-7.2 Completion Documents.

1-7.2.1* A record of completion (*see Figure 1-7.2.1*) shall be prepared for each system. Parts 1, 2, and 4 through 10 shall be completed after the system is installed and the installation wiring has been checked. Part 3 shall be completed after the operational acceptance tests have been completed. A preliminary copy of the record of completion shall be given to the system owner and, where requested, to other authorities having jurisdiction after completion of the installation wiring tests, and a final copy shall be provided after completion of the operational acceptance tests.

1-7.2.2 Every system shall include the following documentation, which shall be delivered to the owner or the owner's representative upon final acceptance of the system.

(a)* An owner's manual and installation instructions covering all system equipment; and

(b) Record drawings.

Record of Completion

Name of Protected Property: _____

Address: _____

Rep. of Protected Prop. (name/phone): _____

Authority Having Jurisdiction: _____

Address/Phone Number: _____

1. Type(s) of System or Service

_____ NFPA 72, Chapter 3 — Local

If alarm is transmitted to location(s) off premises, list where received:

_____

_____ NFPA 72, Chapter 3 — Emergency Voice/Alarm Service

Quantity of voice/alarm channels: _____ Single: _____ Multiple: _____

Quantity of speakers installed: _____ Quantity of speaker zones: _____

Quantity of telephones or telephone jacks included in system: _____

_____ NFPA 72, Chapter 4 — Auxiliary

Indicate type of connection:

Local energy: _____ Shunt: _____ Parallel telephone: _____

Location and telephone number for receipt of signals:

_____

_____ NFPA 72, Chapter 4 — Remote Station

Alarm: _____

Supervisory: _____

_____ NFPA 72, Chapter 4 — Proprietary

If alarms are retransmitted to public fire service communications center or others, indicate location and telephone number of the organization receiving alarm:

_____

Indicate how alarm is retransmitted:

_____

_____ NFPA 72, Chapter 4 — Central Station

The Prime Contractor:

_____

Central Station Location:

_____

Means of transmission of signals from the protected premises to the central station:

_____ McCulloh _____ Multiplex _____ One-Way Radio

_____ Digital Alarm Communicator _____ Two-Way Radio _____ Others

Means of transmission of alarms to the public fire service communications center:

(a) _____

(b) _____

System Location: _____

	Organization Name/Phone	Representative Name/Phone
Installer	_____	_____
Supplier	_____	_____
Service Organization	_____	_____

Location of Record (As-Built) Drawings:

_____

Location of Owners Manuals:

_____

Location of Test Reports:

_____

A contract, dated _____, for test and inspection in accordance with NFPA standard(s) No(s). _____, dated _____, is in effect.

Figure 1-7.2.1 Record of Completion.

2. Record of System Installation

(Fill out after installation is complete and wiring checked for opens, shorts, ground faults, and improper branching, but prior to conducting operational acceptance tests.)

This system has been installed in accordance with the NFPA standards as shown below, was inspected by _____ on _____, includes the devices shown below, and has been in service since _____

_____ NFPA 72, Chapters 1 3 4 5 6 7 (circle all that apply)
_____ NFPA 70, *National Electrical Code*, Article 760
_____ Manufacturer's Instructions
_____ Other (specify): _____

Signed: _____ Date: _____
Organization: _____

3. Record of System Operation

All operational features and functions of this system were tested by _____ on _____, and found to be operating properly in accordance with the requirements of:

_____ NFPA 72, Chapters 1 3 4 5 6 7 (circle all that apply)
_____ NFPA 70, *National Electrical Code*, Article 760
_____ Manufacturer's Instructions
_____ Other (specify): _____

Signed: _____ Date: _____
Organization: _____

4. Alarm-Initiating Devices and Circuits (use blanks to indicate quantity of devices)

MANUAL

(a) _____ Manual Stations _____ Noncoded, Activating _____ Transmitters _____ Coded
(b) _____ Combination Manual Fire Alarm and Guard's Tour Coded Stations

AUTOMATIC

Coverage: Complete: _____ Partial: _____

(a) _____ Smoke Detectors _____ Ion _____ Photo
(b) _____ Duct Detectors _____ Ion _____ Photo
(c) _____ Heat Detectors _____ FT _____ RR _____ FT/RR _____ RC
(d) _____ Sprinkler Waterflow Switches: _____ Transmitters _____ Noncoded, Activating _____ Coded
(e) _____ Other (list): _____

5. Supervisory Signal-Initiating Devices and Circuits (use blanks to indicate quantity of devices)

GUARD'S TOUR

(a) _____ Coded Stations
(b) _____ Noncoded Stations, Activating _____ Transmitters
(c) _____ Compulsory Guard Tour System Comprised of _____ Transmitter Stations and _____ Intermediate Stations

NOTE: Combination devices recorded under 4(b) and 5(a).

SPRINKLER SYSTEM

(a) _____ Coded Valve Supervisory Signaling Attachments
Valve Supervisory Switches, Activating _____ Transmitters
(b) _____ Building Temperature Points
(c) _____ Site Water Temperature Points
(d) _____ Site Water Supply Level Points

Electric Fire Pump:

(e) _____ Fire Pump Power
(f) _____ Fire Pump Running
(g) _____ Phase Reversal

Engine-Driven Fire Pump:

(h) _____ Selector in Auto Position
(i) _____ Engine or Control Panel Trouble
(j) _____ Fire Pump Running

Engine-Driven Generator:

(k) _____ Selector in Auto Position
(l) _____ Control Panel Trouble
(m) _____ Transfer Switches
(n) _____ Engine Running

Figure 1-7.2.1 Record of Completion (*continued*).

Other Supervisory Function(s) (specify): _____

_____

_____

_____

_____

6. Alarm Notification Appliances and Circuits
   Quantity of indicating appliance circuits connected to the system: _____
   Types and quantities of alarm indicating appliances installed:
   (a) _____ Bells _____ Inch
   (b) _____ Speakers
   (c) _____ Horns
   (d) _____ Chimes
   (e) _____ Other: _____
   (f) _____ Visual Signals Type: _____
   _____ with audible _____ w/o audible
   (g) _____ Local Annunciator
7. Signaling Line Circuits
   Quantity and Style (*see NFPA 72, Table 3-6*) of signaling line circuits connected to system:
   Quantity: _____ Style: _____
8. System Power Supplies
   (a) Primary (Main): Nominal Voltage: _____ Current Rating: _____
   Overcurrent Protection: Type: _____ Current Rating: _____
   Location: _____
   (b) Secondary (Standby):
   _____ Storage Battery: Amp-Hour Rating _____
   _____ Calculated capacity to drive system, in hours: _____ 24 _____ 60
   _____ Engine-driven generator dedicated to fire alarm system:
   Location of fuel storage: _____
   (c) Emergency or Standby System used as backup to Primary Power Supply, instead of using a Secondary Power Supply:
   _____ Emergency System described in NFPA 70, Article 700
   _____ Legally Required Standby System described in NFPA 70, Article 701
   _____ Optional Standby System described in NFPA 70, Article 702, which also meets the performance requirements of Article 700 or 701
9. System Software
   (a) Operating System Software Revision Level(s): _____
   (b) Application Software Revision Level(s): _____
   (c) Revision Completed by: _____
   (name) (firm)
10. Comments:

_____

(signed) for Central Station or Alarm Service Company (title) (date)
Frequency of routine tests and inspections, if other than in accordance with the referenced NFPA standards(s):

_____

_____

_____

System deviations from the referenced NFPA standard(s) are: _____

_____

_____

_____

(signed) for Central Station or Alarm Service Company (title) (date)
Upon completion of the system(s) satisfactory test(s) witnessed (if required by the authority having jurisdiction):

_____

(signed) representative of the authority having jurisdiction (title) (date)

Figure 1-7.2.1 Record of Completion (*continued*).

1-7.2.3 Central Station Fire Alarm Systems. It shall be conspicuously indicated by the prime contractor (*see Chapter 4*) that the fire alarm system providing service at a protected premises complies with all applicable requirements of this code by providing a means of verification as specified in either 1-7.2.3.1 or 1-7.2.3.2.

1-7.2.3.1 The installation shall be certificated.

1-7.2.3.1.1 Central station fire alarm systems providing service that complies with all requirements of this code shall be certificated by the organization that has listed the prime contractor, and a document attesting to this certification shall be located on or near the fire alarm system control unit or, where no control unit exists, on or near a fire alarm system component.

1-7.2.3.1.2 A central repository of issued certification documents, accessible to the authority having jurisdiction, shall be maintained by the organization that has listed the central station.

1-7.2.3.2 The installation shall be placarded.

1-7.2.3.2.1 Central station fire alarm systems providing service that complies with all requirements of this code shall be conspicuously marked by the prime contractor to indicate compliance. The marking shall be by means of one or more securely affixed placards.

1-7.2.3.2.2 The placard(s) shall be 20 in.^{2} (130 cm^2) or larger, shall be located on or near the fire alarm system control unit or, where no control unit exists, on or near a fire alarm system component, and shall identify the central station and, where applicable, the prime contractor by name and telephone number.

1-7.3 Records. A complete unalterable record of the tests and operations of each system shall be kept until the next test and for 1 year thereafter. The record shall be available for examination and, where required, reported to the authority having jurisdiction. Archiving of records by any means shall be permitted if hard copies of the records can be provided promptly when requested.

Exception: Where off-premises monitoring is provided, records of all signals, tests, and operations recorded at the supervising station shall be maintained for not less than 1 year.

Chapter 2* Household Fire Warning Equipment

2-1 Introduction.

2-1.1* Scope. This chapter contains minimum requirements for the selection, installation, operation, and maintenance of fire warning equipment for use within family living units. The requirements of the other chapters shall not apply.

Exception: Where specifically indicated.

2-1.2 Purpose.

2-1.2.1 Household fire warning systems shall be designed and installed to provide sufficient warning of a fire to enable occupants to escape. It is recognized that household fire warning systems might not be of material assistance to all occupants, such as persons intimate with the ignition of a fire.

2-1.2.2 This chapter is primarily concerned with life safety, not with protection of property. It presumes that a family has an exit plan.

2-1.3 General.

2-1.3.1 A control and associated equipment, a multiple or single station alarm(s), or any combination thereof shall be permitted to be used as a household fire warning system, provided the requirements of 2-1.3.7 are met.

2-1.3.2 Detection and alarm systems for use within the protected household are covered by this chapter.

2-1.3.3 Supplementary functions, including the extension of an alarm beyond the household, shall be permitted and shall not interfere with the performance requirements of this chapter.

2-1.3.4 Where the authority having jurisdiction requires a household fire warning system to comply with the requirements of Chapter 4 or any other chapters of this code, the requirements of Section 2-2 shall still apply.

2-1.3.5 The definitions of Secton 1-4 shall apply.

2-1.3.6 This chapter does not exclude the use of fire alarm systems complying with other chapters of this code in household applications, provided all of the requirements of this chapter are met or exceeded.

2-1.3.7 All devices, combinations of devices, and equipment to be installed in conformity with this chapter shall be approved or listed for the purposes for which they are intended.

2-1.3.8 A device or system of devices having materials or forms that differ from those detailed in this chapter shall be permitted to be examined and tested according to the intent of the chapter and, if found equivalent, shall be permitted to be approved.

2-1.3.9 Equivalency. Nothing in this code is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this code, provided technical documentation is submitted to the authority having jurisdiction to demonstrate equivalency and the system, method, or device is approved for the intended purpose.

2-2 Basic Requirements.

2-2.1 Required Protection.

2-2.1.1* This code requires the following detectors within the family living unit.

2-2.1.1.1 Smoke detectors shall be installed outside of each separate sleeping area in the immediate vicinity of the bedrooms and on each additional story of the family living unit, including basements and excluding crawl spaces and unfinished attics. In new construction, a smoke detector also shall be installed in each sleeping room.

2-2.1.1.2* For family living units with one or more split levels (i.e., adjacent levels with less than one full story separation between levels), a smoke detector required by 2-2.1.1.1 shall be permitted for an adjacent lower level, including basements. (*See Figure A-2-2.1.1.2.*)

Exception: Where there is an intervening door between one level and the adjacent lower level, a smoke detector shall be installed on the lower level.

2-2.1.1.3 Automatic sprinkler systems provided in accordance with NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, or NFPA 13R, *Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height*, shall be interconnected to sound alarm notification appliances throughout the dwelling where a fire warning system is provided.

2-2.2* Alarm Notification Appliances. Each automatic alarm-initiating device shall cause the operation of an alarm that shall be clearly audible in all bedrooms over background noise levels with all intervening doors closed. The tests of audibility level shall be conducted with all household equipment that might be in operation at night in full operation.

Examples of such equipment are window air conditioners and room humidifiers. (*See A-2-2.2 for additional information.*)

2-2.2.1 In new construction, where more than one smoke detector is required by 2-2.1, detectors shall be arranged so that operation of any smoke detector causes the alarm in all smoke detectors within the dwelling to sound.

Exception: Configurations that provide equivalent distribution of the alarm signal.

2-2.2.2* Standard Signal. Newly installed alarm notification appliances used with a household fire warning system and single and multiple station smoke alarms shall produce the audible emergency evacuation signal described in ANSI S3.41, *Audible Emergency Evacuation Signal*. Signals from different notification appliances shall not be required to be synchronized.

2-2.3 Alarm Notification Appliances for the Hearing Impaired. In a household occupied by one or more hearing impaired persons, each initiating device shall cause the operation of a visible alarm signal(s) in accordance with 2-4.4.2. Since hearing deficits are often not apparent, the responsibility for advising the appropriate persons shall be that of the hearing impaired party. The responsibility for compliance shall be that of the occupants of the family living unit.

Exception: A listed tactile signal shall be permitted to be employed.

2-3 Power Supplies.

2-3.1 General.

2-3.1.1 All power supplies shall have sufficient capacity to operate the alarm signal(s) for at least 4 continuous minutes.

2-3.1.2 There shall be a primary (main) and a secondary (standby) power source. For electrically powered household fire warning equipment, the primary (main) power source shall be ac; the secondary (standby) power source shall be a battery.

Exception No. 1: Where the primary (main) power source is an emergency circuit or a legally required standby circuit capable of operating the system for at least 24 hours in the normal condition, followed by not less than 4 minutes of alarm, a secondary (standby) source shall not be required.

Exception No. 2: Where the primary (main) power source is a circuit of an optional standby system capable of operating the system for at least 24 hours, followed by not less than 4 minutes of alarm, that meets the requirements for either an emergency system or a legally required standby system as defined in NFPA 70, National Electrical Code, Articles 700 and 701, respectively, a secondary (standby) supply shall not be required.

Exception No. 3: Detectors and alarms powered from a monitored dc circuit of a control unit where power for the control unit meets the requirements of Section 2-3 and the circuit remains operable upon loss of primary (main) ac power.

Exception No. 4: A detector and a wireless transmitter that serves only that detector shall be permitted to be powered from a monitored battery primary (main) source where part of a listed, monitored low power radio (wireless) system. A secondary (standby) source shall not be required.

Exception No. 5: In existing construction, either an ac primary power source, as described in 2-3.2, or a monitored battery primary (main) power source, as described in 2-3.3, shall be permitted. A secondary (standby) source shall not be required.

Exception No. 6: Visible notification appliances required by 2-4.4.2.

Exception No. 7: Where the primary (main) power source is nonelectrical, a secondary (standby) source shall not be required. The requirements of 2-3.5 shall apply.

2-3.2 Primary Power Supply — AC.

2-3.2.1 An ac primary (main) power source shall be a dependable commercial light and power supply source. A visible "power on" indicator shall be provided.

2-3.2.2 All electrical systems designed to be installed by other than a qualified electrician shall be powered from a source not in excess of 30 volts that meets the requirements for power limited fire alarm circuits as defined in NFPA 70, *National Electrical Code*, Article 760.

2-3.2.3 A restraining means shall be used at the plug-in of any cord connected installation.

2-3.2.4 AC primary (main) power shall be supplied either from a dedicated branch circuit or the unswitched portion of a branch circuit also used for power and lighting. Operation of a switch (other than a circuit breaker) or a ground-fault circuit-interrupter shall not cause loss of primary (main) power.

Exception No. 1: Single or multiple station alarms with a supervised rechargeable standby battery that provides at least 4 months of operation with a fully charged battery.

Exception No. 2: Where a ground-fault circuit-interrupter serves all electrical circuits within the household.

2-3.2.5 Neither loss nor restoration of primary (main) power shall cause an alarm signal.

Exception: An alarm signal shall be permitted within the household but shall not exceed 2 seconds.

2-3.2.6 Where a secondary (standby) battery is provided, the primary (main) power supply shall be of sufficient capacity to operate the system under all conditions of loading with any secondary (standby) battery disconnected or fully discharged.

2-3.3 Primary Power Supply — Monitored Battery. Household fire warning equipment shall be permitted to be powered by a battery, provided that the battery is monitored to ensure that the following conditions are met:

(a) All power requirements are met for at least 1 year of battery life, including monthly testing.

(b) A distinctive audible trouble signal sounds before the battery is incapable of operating (from causes such as aging or terminal corrosion) the device(s) for alarm purposes.

(c) For a unit employing a lock-in alarm feature, automatic transfer is provided from alarm to a trouble condition.

(d) The unit is capable of producing an alarm signal for at least 4 minutes at the battery voltage at which a trouble signal is normally obtained, followed by not less than 7 days of trouble signal operation.

(e) The audible trouble signal is produced at least once every minute for 7 consecutive days.

(f) Acceptable replacement batteries are clearly identified by the manufacturer's name and model number on the unit near the battery compartment.

(g) A readily noticeable, visible indication is displayed when a primary battery is removed from the unit.

(h) Any unit that uses a nonrechargeable battery as a primary power supply that is capable of a 10-year or greater service life, including testing, and meets the requirements of 2-3.3(b) through (e) shall not be required to have a replaceable battery.

2-3.4 Secondary (Standby) Power Supply.

2-3.4.1 Removal or disconnection of a battery used as a secondary (standby) power source shall cause a distinctive audible or visible trouble signal.

2-3.4.2 Acceptable replacement batteries shall be clearly identified by manufacturer's name and model number on the unit near the battery compartment.

2-3.4.3 Where required by law for disposal reasons, rechargeable batteries shall be removable.

2-3.4.4 Automatic Recharging.

2-3.4.4.1 Automatic recharging shall be provided where a rechargeable battery is used as the secondary (standby) supply. The supply shall be capable of operating the system for at least 24 hours in the normal condition, followed by not less than 4 minutes of alarm. Loss of the secondary (standby) source shall sound an audible trouble signal at least once every minute.

2-3.4.4.2 The battery shall be recharged within 4 hours where power is provided from a circuit that can be switched on or off by means other than a circuit breaker, or within 48 hours where power is provided from a circuit that cannot be switched on or off by means other than a circuit breaker.

2-3.4.5 Where automatic recharging is not provided, the battery shall be monitored to ensure that the following conditions are met:

(a) All power requirements are met for at least 1 year of battery life.

(b) A distinctive audible trouble signal sounds before the battery capacity has been depleted below the level required to produce an alarm signal for 4 minutes.

2-3.5 Primary Power — Nonelectrical. A suitable spring-wound mechanism shall provide power for the nonelectrical portion of a listed single station alarm. A visible indication shall be provided to show that sufficient operating power is not available.

2-4 Equipment Performance.

2-4.1 General. The failure of any nonreliable or short-life component that renders the detector inoperable shall be readily apparent to the occupant of the living unit without the need for test.

2-4.2 Smoke Detectors. Each smoke detector shall detect abnormal quantities of smoke that can occur in a dwelling, shall properly operate in the normal environmental conditions of a household, and shall be in compliance with ANSI/UL 268, *Standard for Safety Smoke Detectors for Fire Protective Signaling Systems*, or ANSI/UL 217, *Standard for Safety Single and Multiple Station Smoke Detectors*.

2-4.3* Heat Detectors.

2-4.3.1 Each heat detector, including a heat detector integrally mounted on a smoke detector, shall detect abnormally high temperature or rate-of-temperature rise, and all such detectors shall be listed for not less than 50-ft (15-m) spacing.

2-4.3.2* Fixed temperature detectors shall have a temperature rating at least 25°F (14°C) above the normal ambient temperature and shall not be rated 50°F (28°C) higher than the maximum anticipated ambient temperature in the room or space where installed.

2-4.4 Alarm Signaling Intensity.

2-4.4.1 All alarm-sounding appliances shall have a minimum rating of 85 dBA at 10 ft (3 m).

Exception: An additional sounding appliance intended for use in the same room as the user, such as a bedroom, may have a sound pressure level as low as 75 dBA at 10 ft (3 m).

2-4.4.2 Visible notification appliances used in rooms where a hearing impaired person(s) sleeps shall have a minimum rating of 177 candela for a maximum room size of 14 ft × 16 ft (4.27 m × 4.88 m). For larger rooms, the visible notification appliance shall be located within 16 ft (4.88 m) of the pillow. Visible notification appliances in other areas shall have a minimum rating of 15 candela.

Exception: Where a visible notification appliance in a sleeping room is mounted more than 24 in. (610 mm) below the ceiling, a minimum rating of 110 candela shall be permitted.

2-4.5 Control Equipment.

2-4.5.1 The control equipment shall be automatically restoring upon restoration of electrical power.

2-4.5.2 The control equipment shall be of a type that "locks in" on an alarm condition. Smoke detection circuits shall not be required to lock in.

2-4.5.3 If a reset switch is provided, it shall be of a self-restoring type.

2-4.5.4 An alarm-silencing switch or an audible trouble-silencing switch shall not be required to be provided.

Exception: Where the switch's silenced position is indicated by a readily apparent signal.

2-4.5.5 Each electrical fire warning system and each single station smoke detector shall have an integral test means to allow the householder to check the system and the sensitivity of the detector(s).

2-4.6 Monitoring Integrity of Installation Conductors. All means of interconnecting initiating devices or notification appliances shall be monitored for the integrity of the interconnecting pathways up to the connections to the device or appliance so that the occurrence of a single open or single ground fault, which prevents normal operation of the system, is indicated by a distinctive trouble signal.

Exception No. 1: Conductors connecting multiple station alarms, provided a single fault on the wiring cannot prevent single station operation of any of the interconnected detectors.

Exception No. 2: Circuits extending from single or multiple station alarms to required remote notification appliances, provided operation of the test feature on any detector causes all connected appliances to activate.

2-4.7 Combination System.

2-4.7.1 Where common wiring is employed for a combination system, the equipment for other than the fire warning signaling system shall be connected to the common wiring of the system so that short circuits, open circuits, grounds, or any fault in this equipment or interconnection between this equipment and the fire warning system wiring does not interfere with the supervision of the fire warning system or prevent alarm or trouble signal operation.

2-4.7.2 In a fire/burglar system, the operation shall be as follows:

(a) A fire alarm signal shall take precedence or be clearly recognizable over any other signal even when the nonfire alarm signal is initiated first.

(b) Distinctive alarm signals shall be used so that fire alarms can be distinguished from other functions such as burglar alarms. The use of a common sounding appliance for fire and burglar alarms shall be permitted where distinctive signals are used. (*See 2-2.2.2.*)

2-4.8 Low Power Wireless Systems. Household fire warning systems utilizing low power wireless transmission of signals within the protected household shall comply with the requirements of Section 3-13.

Exception: Paragraph 3-13.4.5 shall not apply.

2-4.9 Supervising Station Systems.

2-4.9.1 Any communications method described in Section 4-5 shall be permitted for transmission of signals from household fire warning equipment to a supervising station. All of the provisions of Section 4-5 shall apply, as appropriate.

Exception No. 1: Only one telephone line shall be required for one- and two-family residences.

Exception No. 2: Each DACT shall be required to be programmed to call a single DACR number only.

Exception No. 3: Each DACT serving a one- or two-family residence shall transmit a test signal to its associated receiver at least monthly.

2-4.9.2* On receipt of an alarm signal from household fire warning equipment, the supervising station shall immediately (within 90 seconds) retransmit the alarm to the public fire communications center.

Exception: The supervising station shall be permitted to contact the residence for verification of an alarm condition and, where acceptable assurance is provided within 90 seconds that the fire service is not needed, retransmission of an alarm to the public service fire communications center shall not be required.

2-5 Installation.

2-5.1 General.

2-5.1.1 General Provisions.

2-5.1.1.1* All equipment shall be installed in a workmanlike manner.

2-5.1.1.2 All devices shall be so located and mounted that accidental operation is not caused by jarring or vibration.

2-5.1.1.3 All installed household fire warning equipment shall be mounted so as to be supported independently of its attachment to wires.

2-5.1.1.4 All equipment shall be restored to normal as promptly as possible after each alarm or test.

2-5.1.1.5 The supplier or installing contractor shall provide the owner with:

(a) An instruction booklet illustrating typical installation layouts.

(b) Instruction charts describing the operation, method and frequency of testing, and proper maintenance of household fire warning equipment.

(c) Printed information for establishing a household emergency evacuation plan.

(d) Printed information to inform owners where they can obtain repair or replacement service, and where and how parts requiring regular replacement (such as batteries or bulbs) can be obtained within 2 weeks.

2-5.1.2 Interconnection of Detectors or Multiple Station Alarms.

(a) Where the interconnected wiring is unsupervised, no more than 18 multiple station alarms shall be interconnected in a multiple station configuration.

(b) Where the interconnecting wiring is supervised, the number of interconnected detectors shall be limited to 64.

2-5.1.2.1* Interconnection that causes other alarms to sound shall be limited to an individual family living unit. Remote annunciation from single or multiple station alarms shall be permitted.

2-5.1.2.2 No more than 12 smoke alarms shall be interconnected in a multiple station connection. The remainder of the alarms shall be permitted to be of other types.

2-5.2* Detector Location and Spacing.

2-5.2.1* Smoke Detectors.

2-5.2.1.1 Smoke detectors in rooms with ceiling slopes greater than 1 ft in 8 ft (1 m in 8 m) horizontally shall be located at the high side of the room.

2-5.2.1.2 A smoke detector installed in a stairwell shall be so located as to ensure that smoke rising in the stairwell cannot be prevented from reaching the detector by an intervening door or obstruction.

2-5.2.1.3 A smoke detector installed to detect a fire in the basement shall be located in close proximity to the stairway leading to the floor above.

2-5.2.1.4 The smoke detector installed to comply with 2-2.1.1.1 on a story without a separate sleeping area shall be located in close proximity to the stairway leading to the floor above.

2-5.2.1.5* Smoke detectors shall be mounted on the ceiling at least 4 in. (102 mm) from a wall or on a wall with the top of the detector not less than 4 in. (102 mm) nor more than 12 in. (305 mm) below the ceiling.

Exception: Where the mounting surface might become considerably warmer or cooler than the room, such as a poorly insulated ceiling below an unfinished attic or an exterior wall, the detectors shall be mounted on an inside wall.

2-5.2.1.6 Smoke detectors shall not be located within kitchens or garages, or in other spaces where temperatures can fall below 40°F (4°C) or exceed 100°F (38°C). Smoke detectors shall not be located closer than 3 ft (0.9 m) horizontally from:

(a) The door to a kitchen.

(b) The door to a bathroom containing a tub or shower.

(c) The supply registers of a forced air heating or cooling system, and outside of the airflow from those registers.

Exception: Detectors specifically listed for the application.

2-5.2.2* Heat Detectors.

2-5.2.2.1 On smooth ceilings, heat detectors shall be installed within the strict limitations of their listed spacing.

2-5.2.2.2 For sloped ceilings having a rise greater than 1 ft in 8 ft (1 m in 8 m) horizontally, the detector shall be located on or near the ceiling at or within 3 ft (0.9 m) of the peak. The spacing of additional detectors, if any, shall be based on a horizontal distance measurement, not on a measurement along the slope of the ceiling.

2-5.2.2.3* Heat detectors shall be mounted on the ceiling at least 4 in. (102 mm) from a wall or on a wall with the top of the detector not less than 4 in. (102 mm) nor more than 12 in. (305 mm) below the ceiling.

Exception: Where the mounting surface might become considerably warmer or cooler than the room, such as a poorly insulated ceiling below an unfinished attic or an exterior wall, the detectors shall be mounted on an inside wall.

2-5.2.2.4 In rooms with open joists or beams, all ceiling-mounted detectors shall be located on the bottom of such joists or beams.

2-5.2.2.5* Detectors installed on an open-joisted ceiling shall have their smooth ceiling spacing reduced where this spacing is measured at right angles to solid joists; in the case of heat detectors, this spacing shall not exceed $\frac{1}{2}$ of the listed spacing.

2-5.3 Wiring and Equipment. The installation of wiring and equipment shall be in accordance with the requirements of NFPA 70, *National Electrical Code*, Article 760.

2-6 Maintenance and Tests.

2-6.1* Maintenance. Where batteries are used as a source of energy, they shall be replaced in accordance with the recommendations of the alarm equipment manufacturer.

Exception: Batteries described in 2-3.3(h).

2-6.2* Tests.

2-6.2.1 Single and Multiple Station Smoke Alarms. Homeowners shall inspect and test smoke alarms and all connected appliances in accordance with the manufacturer's instructions at least monthly.

2-6.2.2 Fire Alarm Systems. Homeowners shall test systems in accordance with the manufacturer's instructions and shall have every household fire alarm system having a control panel tested by a qualified service technician at least every 3 years. This test shall be conducted according to the methods of Chapter 7.

2-7 Markings and Instructions. All household fire warning equipment or systems shall be plainly marked with the following information on the unit:

(a) Manufacturer's or listee's name, address, and model number;

(b) A mark or certification that the unit has been approved or listed by a testing laboratory;

(c) Electrical rating (where applicable);

(d) Temperature rating (where applicable);

(e) Spacing rating (where applicable);

(f) Operating instructions;

(g) Test instructions;

(h) Maintenance instructions;

(i) Replacement and service instructions.

Exception: Where space limitations prohibit inclusion of 2-7 (g), (h), and (i), a label or plaque suitable for permanent attachment within the living unit, or a manufacturer's manual, shall be provided with the equipment and referenced on the equipment. In the case of a household fire warning system, the required information shall be prominently displayed at the control panel.

Chapter 3 Protected Premises Fire Alarm Systems

3-1 Scope. This chapter provides requirements for the application, installation, and performance of fire alarm systems, including fire alarm and supervisory signals, within protected premises.

3-2 General. The systems covered in this chapter are intended to be used for the protection of life by automatically indicating the necessity for evacuation of the building or fire area, and for the protection of property through the automatic notification of responsible persons and for the automatic activation of fire safety functions. The requirements of the other chapters shall also apply.

Exception No. 1: Where the requirements of other chapters conflict with the requirements of this chapter.

Exception No. 2: For household fire warning equipment protecting a single living unit, see Chapter 2.

Exception No. 3: For the performance, installation, and operation requirements of continuously attended fire alarm system supervising

stations and subsidiary stations and the transmission and communications channels used to convey signals between the protected premises and the supervising station, see Chapter 4.

3-2.1 Systems requiring transmission of signals to continuously attended locations providing supervising station service (e.g., central station, proprietary, remote station) shall also comply with the applicable requirements of Chapter 4.

3-2.2 All protected premises fire alarm systems shall be maintained and tested in accordance with Chapter 7.

3-2.3 Fire alarm systems provided for evacuation of occupants shall have one or more notification appliances listed for the purpose on each floor of the building and so located that they have the characteristics for public mode described in Chapter 6.

3-2.4* The system shall be so designed and installed that attack by fire:

(a) In an evacuation zone, causing loss of communications to this evacuation zone, shall not result in loss of communications to any other evacuation zone.

(b) Causing failure of equipment or a fault on one or more installation wiring conductors of one communications path shall not result in total loss of communications to any evacuation zone.

Exception No. 1 to (a) and (b): Systems that, on alarm, automatically sound evacuation signals throughout the protected premises.

Exception No. 2 to (a) and (b): Where there is a separate means acceptable to the authority having jurisdiction for voice communications to each floor or evacuation zone.

Exception No. 3 to (b): The fire command center and the central control equipment.

Exception No. 4 to (b): Where the installation wiring is enclosed in a 2-hour rated cable assembly or enclosed in a 2-hour rated enclosure, other than a stairwell.

Exception No. 5 to (b): Where the installation wiring is enclosed within a 2-hour rated stairwell in a fully sprinklered building in accordance with NFPA 13, Standard for the Installation of Sprinkler Systems.

Exception No. 6 to (b): When the evacuation zone is directly attacked by fire within the zone.

3-2.5 Software and Firmware Control.

3-2.5.1 All software and firmware provided with a fire alarm system shall be listed for use with the fire alarm control unit.

3-2.5.2 A record of installed software and firmware version numbers shall be maintained at the location of the fire alarm control unit.

3-2.5.3 All software and firmware shall be protected from unauthorized changes through the use of "access levels."

3-2.5.4 All changes shall be tested in accordance with 7-1.6.2.

3-3 Applications. Protected premises fire alarm systems include one or more of the following features:

(a) Manual alarm signal initiation;

(b) Automatic alarm signal initiation;

(c) Monitoring of abnormal conditions in fire suppression systems;

(d) Activation of fire suppression systems;

(e) Activation of fire safety functions;

(f) Activation of alarm notification appliances;

(g) Emergency voice/alarm communications;

(h) Guard's tour supervisory service;

(i) Process monitoring supervisory systems;

(j) Activation of off-premises signals;

(k) Combination systems;

(l) Integrated systems.

3-4 System Performance and Integrity.

3-4.1 The purpose of this section is to provide information to be used in the design and installation of protected premises fire alarm systems for the protection of life and property.

3-4.2 Notification zones shall be consistent with the emergency response or evacuation plan for the protected premises. The boundaries of notification zones shall be coincident with building outer walls, building fire or smoke compartment boundaries, floor separations, or other fire safety subdivisions.

3-4.3* Circuit Designations. Initiating device, notification appliance, and signaling line circuits shall be designated by class or style, or both, depending on the circuits' capability to continue to operate during specified fault conditions.

3-4.3.1 Class. Initiating device, notification appliance, and signaling line circuits shall be permitted to be designated as either Class A or Class B, depending on the capability of the circuit to transmit alarm and trouble signals during nonsimultaneous single circuit fault conditions as specified by the following:

(a) Circuits capable of transmitting an alarm signal during a single open or a nonsimultaneous single ground fault on a circuit conductor shall be designated as Class A.

(b) Circuits not capable of transmitting an alarm beyond the location of the fault conditions specified in 3-4.3.1(a) shall be designated as Class B.

Faults on both Class A and Class B circuits shall result in a trouble condition on the system in accordance with the requirements of 1-5.8.

3-4.3.2 Style. Initiating device, notification appliance, and signaling line circuits shall be permitted to be designated by style also, depending on the capability of the circuit to transmit alarm and trouble signals during specified simultaneous multiple circuit fault conditions in addition to the single circuit fault conditions considered in the designation of the circuits by class.

(a) An initiating device circuit shall be permitted to be designated as either Style A, B, C, D, or E, depending on its ability to meet the alarm and trouble performance requirements shown in Table 3-5, during a single open, single ground, wire-to-wire short, and loss of carrier fault condition.

(b) A notification appliance circuit shall be permitted to be designated as either Style W, X, Y, or Z, depending on its ability to meet the alarm and trouble performance requirements shown in Table 3-7.1, during a single open, single ground, and wire-to-wire short fault condition.

(c) A signaling line circuit shall be permitted to be designated as either Style 0.5, 1, 2, 3, 3.5, 4, 4.5, 5, 6, or 7, depending on its ability to meet the alarm and trouble performance requirements shown in Table 3-6, during a single open, single ground, wire-to-wire short, simultaneous wire-to-wire short and open, simultaneous wire-to-wire short and ground, simultaneous open and ground, and loss of carrier fault conditions.

3-4.4* All styles of Class A circuits using physical conductors (e.g., metallic, optical fiber) shall be installed such that the outgoing and return conductors, exiting from and returning to the control unit, respectively, are routed separately. The outgoing and return (redundant) circuit conductors shall not be run in the same cable assembly (i.e., multiconductor cable), enclosure, or raceway.

Exception No. 1: For a distance not to exceed 10 ft (3 m) where the outgoing and return conductors enter or exit the initiating device, notification appliance, or control unit enclosures; or

Exception No. 2: Where the vertically run conductors are contained in a 2-hour rated cable assembly or enclosed (installed) in a 2-hour rated enclosure other than a stairwell; or

Exception No. 3: Where permitted and where the vertically run conductors are enclosed (installed) in a 2-hour rated stairwell in a building fully sprinklered in accordance with NFPA 13, Standard for the Installation of Sprinkler Systems.

Exception No. 4: Where looped conduit/raceway systems are provided, single conduit/raceway drops to individual devices or appliances shall be permitted.

Exception No. 5: Where looped conduit/raceway systems are provided, single conduit/raceway drops to multiple devices or appliances installed within a single room not exceeding 1000 ft² (92.9 m²) in area shall be permitted.

3-4.5 Signaling Paths.

3-4.5.1 The class or style of signaling paths (circuits) shall be determined from an evaluation based on the path performance detailed in this code and on engineering judgment.

3-4.5.2 Where determining the integrity and reliability of the interconnecting signaling paths (circuits) installed within the protected premises, the following influences shall be considered:

(a) The transmission media utilized;

(b) The length of the circuit conductors;

(c) The total building area covered by and the quantity of initiating devices and notification appliances connected to a single circuit;

(d) The nature of the hazard present within the protected premises;

(e) The functional requirements of the system necessary to provide the level of protection required for the system;

(f) The size and nature of the population of the protected premises.

3-5* Performance of Initiating Device Circuits (IDC). The assignment of class designations or style designations, or both, to initiating device circuits shall be based on their performance capabilities under abnormal (fault) conditions in accordance with the requirements of Table 3-5.

Table 3-5 Performance of Initiating Device Circuits (IDC)

Class	B			B			B			A			A		
Style	A			B			C			D			Eα		
R = Required capability X = Indication required at protected premises and as required by Chapter 4 α = Style exceeds minimum requirements for Class A	Alarm	Trouble	Alarm receipt capability during abnormal condition	Alarm	Trouble	Alarm receipt capability during abnormal condition	Alarm	Trouble	Alarm receipt capability during abnormal condition	Alarm	Trouble	Alarm receipt capability during abnormal condition	Alarm	Trouble	Alarm receipt capability during abnormal condition
Abnormal Condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A. Single open		X			X			X			X	X		X	X
B. Single ground		R			X	R		X	R		X	R		X	R
C. Wire-to-wire short	X			X				X		X				X	
D. Loss of carrier (if used)/channel interface								X						X	

3-6* Performance of Signaling Line Circuits (SLC). The assignment of class designations or style designations, or both, to signaling line circuits shall be based on their performance capabilities under abnormal (fault) conditions in accordance with the requirements of Table 3-6.

3-7 Notification Appliance Circuits (NAC).

3-7.1 Performance. The assignment of class designations or style designations, or both, to notification appliance circuits shall be based on their performance capabilities under abnormal (fault) conditions in accordance with the requirements of Table 3-7.1.

3-7.2 Distinctive Evacuation Signal.

(a)* Paragraph 1-5.4.7 requires that fire alarm signals be distinctive in sound from other signals and that this sound not be used for any other purpose. To meet this requirement, the fire alarm signal used to notify building occupants of the need to evacuate (leave the building) shall be in accordance with ANSI S3.41, *Audible Emergency Evacuation Signal.*

(b) The use of the American National Standard Audible Emergency Evacuation Signal shall be restricted to situations where it is desired that all occupants hearing the signal evacuate the building immediately. It shall not be used where, with the approval of the authority having jurisdiction, the planned action during a fire emergency is not evacuation, but relocation, of the occupants from the affected area to a safe area within the building, or their protection in place (e.g., high-rise buildings, health care facilities, penal institutions).

3-8 System Requirements. See also Section 5-8.

3-8.1 Manual Fire Alarm Signal Initiation.

3-8.1.1 Fire alarm boxes shall be listed for the intended application, installed in accordance with Chapter 5, and tested in accordance with Chapter 7.

3-8.1.2 For fire alarm systems employing automatic fire detectors or waterflow detection devices, at least one fire alarm box shall be provided to initiate a fire alarm signal. This fire alarm box shall be located where required by the authority having jurisdiction.

Exception: Fire alarm systems dedicated to elevator recall control and supervisory service as permitted in 3-8.14.1.

3-8.1.3 Where signals from fire alarm boxes and other fire alarm initiating devices within a building are transmitted over the same signaling line circuit, there shall be no interference with fire alarm box signals when both types of initiating devices are operated at or near the same time. Provision of the shunt noninterfering method of operation shall be permitted for this performance.

Table 3-6 Performance of Signaling Line Circuits (SLC)

Class	B			B			A			B			B			B			B			A			A			A		
Style	0.5			1			2α			3			3.5			4			4.5			5α			6α			7α		
M = May be capable of alarm with wire-to-wire short R = Required capability X = Indication required at protected premises and as required by Chapter 4 α = Style exceeds minimum requirements for Class A	Alarm	Trouble	Alarm receipt capability during abnormal condition	Alarm	Trouble	Alarm receipt capability during abnormal condition	Alarm	Trouble	Alarm receipt capability during abnormal condition	Alarm	Trouble	Alarm receipt capability during abnormal condition	Alarm	Trouble	Alarm receipt capability during abnormal condition	Alarm	Trouble	Alarm receipt capability during abnormal condition	Alarm	Trouble	Alarm receipt capability during abnormal condition	Alarm	Trouble	Alarm receipt capability during abnormal condition	Alarm	Trouble	Alarm receipt capability during abnormal condition	Alarm	Trouble	Alarm receipt capability during abnormal condition
Abnormal Condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
A. Single open		X			X			X	R		X			X			X			X	R		X	R		X	R		X	R
B. Single ground		X			X	R		X	R		X	R		X			X	R		X			X	R		X	R		X	R
C. Wire-to-wire short									M		X			X			X			X			X			X			X	R
D. Wire-to-wire short & open									M		X			X			X			X			X			X			X	
E. Wire-to-wire short & ground								X	M		X			X			X			X			X			X			X	
F. Open and ground								X	R		X			X			X			X			X		X	X			X	R
G. Loss of carrier (if used)/ channel interface														X			X			X			X			X			X	

Table 3-7.1 Notification Appliance Circuits (NAC)

Class	B		B		B		A	
Style	W		X		Y		Z	
X = Indication required at protected premises	Trouble indication at protected premises	Alarm capability during abnormal conditions	Trouble indication at protected premises	Alarm capability during abnormal conditions	Trouble indication at protected premises	Alarm capability during abnormal conditions	Trouble indication at protected premises	Alarm capability during abnormal condition
Abnormal condition	1	2	3	4	5	6	7	8
Single open	X		X	X	X		X	X
Single ground	X		X		X	X	X	X
Wire-to-wire short	X		X		X		X	

3-8.2 Automatic Fire Alarm Signal Initiation.

3-8.2.1 Automatic alarm-initiating devices shall be listed for the intended application and installed in accordance with Chapter 5.

3-8.2.2 Automatic alarm-initiating devices having integral trouble contacts shall be wired on the initiating device circuit so that a trouble condition within a device does not impair the alarm transmission from any other initiating device.

NOTE: Although a trouble signal is required when a plug-in initiating device is removed from its base, it is not considered as a trouble condition within the device and the requirement of 3-8.2.2 does not apply.

3-8.2.3* Systems equipped with alarm verification features shall be permitted, provided:

(a) A smoke detector continuously subjected to a smoke concentration above alarm threshold magnitude initiates a system alarm within 1 minute.

(b) Actuation of an alarm-initiating device other than a smoke detector causes a system alarm signal within 15 seconds.

3-8.2.4 Where individual alarm-initiating devices are used to control the operation of equipment as permitted by 1-5.4.1.1, this control capability shall remain operable even when all of the initiating devices connected to the same circuit are in an alarm state.

3-8.2.5* Systems that require the operation of two automatic detection devices to initiate the alarm response shall be permitted, provided:

(a) They are not prohibited by the authority having jurisdiction.

(b) There are at least two automatic detection devices in each protected space.

(c)* The area protected by an automatic detection device is no more than 1/2 the maximum area for the detector as determined by the application of Chapter 5.

(d) The alarm verification feature is not used.

3-8.3* Concealed Detectors. Where a remote alarm indicator is provided of an automatic fire detector in a concealed location, the location of the detector and the area protected by the detector shall be prominently indicated at the remote alarm indicator by a permanently attached placard or by other approved means.

3-8.4 Automatic Drift Compensation. Where automatic drift compensation of sensitivity for a fire detector is provided, the control unit shall identify the affected detector when the limit of compensation is reached.

3-8.5 Waterflow Alarm Signal Initiation.

3-8.5.1 The provisions of 3-8.5 shall apply to sprinkler system signaling attachments that initiate an alarm indicating a flow of water in the system. Waterflow initiating devices shall be listed for the intended application and installed in accordance with Chapter 5.

3-8.5.2 A dry-pipe or preaction sprinkler system that is supplied with water by a connection beyond the alarm initiating device of a wet-pipe system shall be equipped with a separate waterflow alarm initiating pressure switch or other approved means to initiate a waterflow alarm.

3-8.5.3 The number of waterflow switches permitted to be connected to a single initiating device circuit shall not exceed five.

3-8.6 Supervisory Signal Initiation.

3-8.6.1 General. The provisions of 3-8.6 shall apply to the monitoring of sprinkler systems, other fire suppression systems, and other systems for the protection of life and property for the initiation of a supervisory signal indicating an off-normal condition that could adversely affect the performance of the system.

3-8.6.1.1 Supervisory devices shall be listed for the intended application and installed in accordance with Chapter 5.

3-8.6.1.2 The number of supervisory devices permitted to be connected to a single initiating device circuit shall not exceed 20.

3-8.6.2* Provisions shall be made for supervising the conditions that are essential for the proper operation of sprinkler and other fire suppression systems.

Exception: Those conditions related to water mains, tanks, cisterns, reservoirs, and other water supplies controlled by a municipality or a public utility.

3-8.6.3 Signals shall distinctively indicate the particular function (e.g., valve position, temperature, or pressure) of the system that is off-normal and also indicate its restoration to normal.

NOTE: Cancellation of the off-normal signal may be permitted as a restoration signal, unless separate recording of all changes of state is a specific requirement. (*See Chapter 4.*)

3-8.6.4 A dry-pipe sprinkler system equipped for waterflow alarm signaling shall be supervised for off-normal system air pressure.

3-8.6.5 A control valve shall be supervised to initiate a distinctive signal indicating movement of the valve from its normal position. The off-normal signal shall remain until the valve is restored to its normal position. The off-normal signal shall be obtained during the first two revolutions of the hand wheel or during 1/5 of the travel distance of the valve control apparatus from its normal position.

3-8.6.6 An initiating device for supervising the position of a control valve shall not interfere with the operation of the valve, obstruct the view of its indicator, or prevent access for valve maintenance.

3-8.6.7 Pressure Supervision. Pressure sources shall be supervised to obtain two separate and distinct signals, one indicating that the required pressure has been increased or decreased, and the other indicating restoration of the pressure to its required value.

(a) A pressure supervisory signal-initiating device for a pressure tank shall indicate both high and low pressure conditions. A signal shall be obtained where the required pressure is increased or decreased 10 psi (70 kPa) from the required pressure value.

(b) A pressure supervisory signal-initiating device for a dry-pipe sprinkler system shall indicate both high and low pressure conditions. A signal shall be obtained when the required pressure is increased or decreased 10 psi (70 kPa) from the required pressure value.

(c) A steam pressure supervisory initiating device shall indicate a low pressure condition. A signal shall be obtained where the pressure is reduced to a value that is 110 percent of the minimum operating pressure of the steam operated equipment supplied.

(d) An initiating device for supervising the pressure of sources other than those specified in 3-8.6.7(a) through (c) shall be provided as required by the authority having jurisdiction.

3-8.6.8 Water Temperature Supervision. Exposed water storage containers shall be supervised to obtain two separate and distinct signals, one indicating that the temperature of the water has been lowered to 40°F (4.4°C), and the other indicating restoration to a temperature above 40°F (4.4°C).

3-8.7 Signal Annunciation. Protected premises fire alarm systems shall be arranged to annunciate alarm, supervisory, and trouble signals in accordance with 1-5.7.

3-8.8 Signal Initiation from Automatic Fire Suppression System Other than Waterflow.

3-8.8.1 The operation of an automatic fire suppression system installed within the protected premises shall cause an alarm signal at the protected premises fire alarm control unit.

3-8.8.2 A supervisory signal shall indicate the off-normal condition and its restoration to normal as appropriate to the system employed.

3-8.8.3 The integrity of each fire suppression system actuating device and its circuit shall be supervised in accordance with 1-5.8.1 and with other applicable NFPA standards.

3-8.9 Pump Supervision. Automatic fire pumps and special service pumps shall be supervised in accordance with NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps*, and the authority having jurisdiction.

3-8.9.1 Supervision of electric power supplying the pump shall be made on the line side of the motor starter. All phases and phase reversal shall be supervised.

3-8.9.2 Where both sprinkler supervisory signals and pump running signals are transmitted over the same signaling circuits, provisions shall be made to obtain pump running signal preference.

Exception: Where the circuit is so arranged that no signals can be lost.

3-8.10 Tampering.

3-8.10.1 Automatic fire suppression system alarm-initiating devices and supervisory signal-initiating devices and their circuits shall be so designed and installed that they cannot be readily subject to tampering, opening, or removal without initiating a signal. This provision specifically includes junction boxes installed outside of buildings to facilitate access to the initiating device circuit.

3-8.10.2* Where a valve is installed in the connection between a signal attachment and the fire suppression system to which it is attached, such a valve shall be supervised in accordance with the requirements of Chapter 5.

3-8.11 Guard's Tour Supervisory Service.

3-8.11.1 Guard's tour reporting stations shall be listed for the application.

3-8.11.2 The number of guard's tour reporting stations, their locations, and the route to be followed by the guard for operating the stations shall be approved for the particular installation in accordance with NFPA 601, *Standard for Security Services in Fire Loss Prevention*.

3-8.11.3 A permanent record indicating every time each signal-transmitting station is operated shall be made at the main control unit. Where intermediate stations that do not transmit a signal are employed in conjunction with signal-transmitting stations, distinctive signals shall be transmitted at the beginning and end of each tour of a guard, and a signal-transmitting station shall be provided at intervals not exceeding 10 stations. Intermediate stations that do not transmit a signal shall be capable of operation only in a fixed sequence.

3-8.12 Suppressed (Exception Reporting) Signal System.

3-8.12.1 The system shall comply with the provisions of 3-8.11.2.

3-8.12.2 The system shall transmit a start signal to the signal-receiving location and shall be initiated by the guard at the start of continuous tour rounds.

3-8.12.3 The system shall automatically transmit a delinquency signal within 15 minutes after the predetermined actuation time if the guard fails to actuate a tour station as scheduled.

3-8.12.4 A finish signal shall be transmitted within a predetermined interval after the guard's completion of each tour of the premises.

3-8.12.5 For periods of over 24 hours during which tours are continuously conducted, a start signal shall be transmitted at least every 24 hours.

3-8.12.6 The start, delinquency, and finish signals shall be recorded at the signal-receiving location.

3-8.13 Combination Systems.

3-8.13.1* Fire alarm systems shall be permitted to share components, equipment, circuitry, and installation wiring with nonfire alarm systems.

3-8.13.2 Where common wiring is employed for combination systems, the equipment for other than fire alarm systems shall be permitted to be connected to the common wiring of the system. Short circuits, open circuits, or grounds in this equipment or between this equipment and the fire alarm system wiring shall not interfere with the monitoring for integrity of the fire alarm system or prevent alarm or supervisory signal transmissions.

3-8.13.3 To maintain the integrity of fire alarm system functions, the removal, replacement, failure, or maintenance procedure on any hardware, software, or circuit not required to perform any of the fire alarm system functions shall not cause loss of any of these functions.

Exception: Where the hardware, software, and circuits are listed for fire alarm use.

3-8.13.4 Speakers used as alarm notification appliances on fire alarm systems shall not be used for nonemergency purposes.

Exception: Where the fire command center is constantly attended by a trained operator, selective paging shall be permitted.

3-8.13.5 In combination systems, fire alarm signals shall be distinctive, clearly recognizable, and take precedence over any other signal even when a nonfire alarm signal is initiated first.

3-8.13.6 Where the authority having jurisdiction determines that the information being displayed or annunciated on a combination system is excessive and could cause confusion and delay response to a fire emergency, the authority having jurisdiction shall be permitted to require that the display or annunciation of information for the fire alarm system be separate from and have priority over information for the nonfire alarm systems.

3-8.14 Elevator Recall for Fire Fighters' Service.

3-8.14.1* System-type smoke detectors located in elevator lobbies, elevator hoistways, and elevator machine rooms used to initiate fire fighters' service recall shall be connected to the building fire alarm system. In facilities without a building fire alarm system, these smoke detectors shall be connected to a dedicated fire alarm system control unit that shall be designated as "elevator recall control and supervisory panel" on the record drawings. Unless otherwise required by the authority having jurisdiction, only the elevator lobby, elevator hoistway, and the elevator machine room smoke detectors shall be used to recall elevators for fire fighters' service.

3-8.14.2 Each elevator lobby, elevator hoistway, and elevator machine room smoke detector shall be capable of initiating elevator recall when all other devices on the same initiating device circuit have been manually or automatically placed in the alarm condition.

3-8.14.3 Smoke detectors shall not be installed in elevator hoistways.

Exception: Where the top of the elevator hoistway is protected by automatic sprinklers.

3-8.14.4 Where ambient conditions prohibit installation of automatic smoke detection, other appropriate automatic fire detection shall be permitted.

3-8.14.5 When actuated, each elevator lobby, elevator hoistway, and elevator machine room smoke detector shall initiate an alarm condition on the building fire alarm system and shall visibly indicate, at the control unit and required remote annunciators, the alarm initiation circuit or zone from which the alarm originated. Actuation from elevator hoistway and elevator machine room smoke detectors shall cause separate and distinct visible annunciation at the control unit and required annunciators to alert fire fighters and other emergency personnel that the elevators are no longer safe to use. Actuation of these detectors shall not be required to sound the building evacuation alarm where the alarm condition is indicated at a constantly attended location.

Exception: Where approved by the authority having jurisdiction, the elevator hoistway and machine room detectors shall be permitted to initiate a supervisory signal.

3-8.14.6* For each group of elevators within a building, three separate elevator control circuits shall be terminated at the designated elevator controller within the group's elevator machine room(s). The operation of the elevators shall be in accordance with ANSI/ASME A17.1, *Safety Code for Elevators and Escalators*, Rules 211.3 through 211.8. The smoke detectors shall actuate the three elevator control circuits as follows:

(a) The smoke detector located in the designated elevator recall lobby shall actuate the first elevator control circuit. In addition, where the elevator is equipped with front and rear doors, the smoke detectors in both lobbies at the designated level shall actuate the first elevator control circuit.

(b) The smoke detectors in the remaining elevator lobbies shall actuate the second elevator control circuit.

(c) The smoke detectors in elevator hoistways and the elevator machine room(s) shall actuate the third elevator control circuit. In addition, where the elevator machine room is located at the designated level, that elevator machine room smoke detector shall also actuate the first elevator control circuit.

3-8.15 Elevator Shutdown.

3-8.15.1* Where heat detectors are used to shut down elevator power prior to sprinkler operation, the detector shall have both a lower temperature rating and a higher sensitivity [often characterized by a lower response time index (RTI)] as compared to the sprinkler.

3-8.15.2 Where heat detectors are used for elevator power shutdown prior to sprinkler operation, they shall be placed within 2 ft (610 mm) of each sprinkler head and be installed in accordance with the requirements of Chapter 5. Alternatively, engineering methods (such as specified in Appendix B) shall be permitted to be used to select and place heat detectors to ensure response prior to any sprinkler head operation under a variety of fire growth rate scenarios.

3-8.15.3* Where pressure or waterflow switches are used to shut down elevator power immediately upon or prior to the discharge of water from sprinklers, the use of devices with time delays shall not be permitted.

3-8.16 Trouble Signals to Supervising Station.

3-8.16.1 Relays or modules providing transmission of trouble signals to a supervising station shall be arranged to provide fail-safe operation.

3-8.16.2 Means provided to transmit trouble signals to supervising stations shall be so arranged to transmit a trouble signal to the supervising station for any trouble condition received at the protected premises control unit, including loss of primary or secondary power.

3-9 Fire Safety Control Functions.

3-9.1 Scope. The provisions of this section cover the minimum requirements for the interconnection of fire safety control functions (e.g., fan control, door control) to the fire alarm system. These fire safety functions are not intended to provide notification of alarm, supervisory, or trouble conditions; to alert or control occupants; or to summon aid.

3-9.2 General.

3-9.2.1 An auxiliary relay connected to the fire alarm system used to initiate control of fire safety functions shall be located within 3 ft (1 m) of the controlled circuit or device. The auxiliary relay shall function within the voltage and current limitations of the control unit. The installation wiring between the fire alarm system control unit and the auxiliary relay shall be monitored for integrity.

Exception: Control devices that operate on loss of power or on loss of power to the auxiliary relay shall be considered self-monitoring for integrity.

3-9.2.2 Fire safety functions shall not interfere with other operations of the fire alarm control system.

3-9.2.3 Transfer of data over listed serial communications ports shall be permitted to be a means of interfacing between the fire alarm control unit and fire safety function control devices.

3-9.2.4 The fire safety function control devices shall be listed as compatible with the fire alarm control unit so as not to interfere with the control unit's operation.

3-9.2.5 The interfaced systems shall be acceptance tested together in the presence of the authority having jurisdiction to ensure proper operation of the fire alarm system and the interfaced system(s).

3-9.2.6 Where manual controls for emergency control functions are required to be provided, they shall provide visible indication of the status of the associated control circuits.

3-9.3 Heating, Ventilation, and Air Conditioning (HVAC) Systems.

3-9.3.1 The provisions of 3-9.3 apply to the basic method by which a fire alarm system interfaces with the HVAC systems.

3-9.3.2 All detection devices used to cause the operation of smoke dampers, fire dampers, fan control, smoke doors, and fire doors shall be monitored for integrity in accordance with 1-5.8 where connected to the fire alarm system serving the protected premises.

3-9.3.3 Connections between fire alarm systems and the HVAC system for the purpose of monitoring and control shall operate and be monitored in accordance with applicable NFPA standards.

3-9.3.4 Where the fire alarm control unit activates the HVAC system for the purpose of smoke control, the automatic alarm-initiating zones shall be coordinated with the smoke-control zones they actuate.

3-9.4 Door Release Service.

3-9.4.1 The provisions of 3-9.4 apply to the methods of connection of door hold release devices and to integral door hold release, closer, and smoke detection devices.

3-9.4.2 All detection devices used for door hold release service, whether integral or stand alone, shall be monitored for integrity in accordance with 1-5.8 where connected to the fire alarm system serving the protected premises.

3-9.4.3 All door hold release and integral door release and closure devices used for release service shall be monitored for integrity in accordance with 3-9.2.

3-9.4.4 Magnetic door holders that allow doors to close upon loss of operating power shall not be required to have a secondary power source.

3-9.5 Door Unlocking Devices.

3-9.5.1 Any device or system intended to effect the locking/unlocking of emergency exits shall be connected to the fire alarm system serving the protected premises.

3-9.5.2 All emergency exits connected in accordance with 3-9.5.1 shall unlock upon receipt of any fire alarm signal by means of the fire alarm system serving the protected premises.

3-9.5.3 All emergency exits connected in accordance with 3-9.5.1 shall unlock upon loss of the primary power to the fire alarm system serving the protected premises. The secondary power supply shall not be utilized to maintain these doors in the locked condition.

3-10 Suppression System Actuation.

3-10.1 Fire alarm systems listed for releasing service shall be permitted to provide automatic or manual actuation of fire suppression systems.

3-10.2 The integrity of each releasing device (e.g., solenoid, relay) shall be supervised in accordance with applicable NFPA standards.

3-10.3 The integrity of the installation wiring shall be monitored in accordance with the requirements of Chapter 1.

3-10.4 Fire alarm systems used for fire suppression releasing service shall be provided with a disconnect switch to allow system testing without activating the fire suppression systems. Operation of the disconnect switch shall cause a trouble signal at the fire alarm control unit.

3-10.5 Sequence of operation shall be consistent with the applicable suppression system standards.

3-10.6* Each space protected by an automatic fire suppression system actuated by the fire alarm system shall contain one or more automatic fire detectors installed in accordance with Chapter 5.

3-10.7 Suppression systems or groups of systems shall be controlled by a single control unit that monitors the associated initiating devices, actuates the associated releasing device(s), and controls the associated agent release notification appliances. Where the releasing panel is located in a protected premises having a separate fire alarm system, it shall be monitored by, but shall not be dependent on or affected by, the operation or failure of the protected premises fire alarm system.

Exception: Where the configuration of multiple control units is listed for releasing device service, and where a trouble condition or manual disconnect on either control unit causes a trouble or supervisory signal, the initiating devices on one control unit shall be permitted to actuate releasing devices on another control unit.

3-11* Interconnected Fire Alarm Control Units. Fire alarm systems shall be permitted to be either integrated systems combining all detection, notification, and auxiliary functions in a single system or a combination of component subsystems. Fire alarm system components shall be permitted to share control equipment or shall be able to operate as stand alone subsystems, but, in any case, they shall be arranged to function as a single system. All component subsystems shall be capable of simultaneous, full load operation without degradation of the required, overall system performance.

3-11.1 The method of interconnection of control units shall meet the monitoring requirements of 1-5.8 and NFPA 70, *National Electrical Code*, Article 760, and shall be achieved by the following recognized means:

(a) Properly rated electrical contacts;
(b) Compatible digital data interfaces;
(c) Other listed methods.

3-11.2 Where approved by the authority having jurisdiction, interconnected control units providing localized detection, evacuation signaling, and auxiliary functions shall be permitted to be monitored by a fire alarm system as initiating devices.

3-11.2.1 Each interconnected control unit shall be separately monitored for alarm, trouble, and supervisory conditions.

3-11.2.2 Interconnected control unit alarm signals shall be permitted to be monitored by zone or combined as common signals, as appropriate.

3-11.3 Protected premises fire alarm control units shall be capable of being reset or silenced only from the control unit at the protected premises.

Exception: Where otherwise specifically permitted by the authority having jurisdiction.

3-12 Emergency Voice/Alarm Communications.

3-12.1 Emergency Voice/Alarm Communications Service. Emergency voice/alarm communications service shall be provided by a system with automatic or manual voice capability that is installed to provide voice instructions to the building occupants where it is intended that there be only partial or selective evacuation or directed relocation of building occupants in the event of a fire.

Exception: Where emergency voice/alarm communications are used to automatically and simultaneously notify all occupants to evacuate the protected premises during a fire emergency, manual or selective paging shall not be required but, where provided, shall meet the requirements of Section 3-12.

3-12.2 Application. This section describes the requirements for emergency voice/alarm communications. The primary purpose is to provide dedicated manual and automatic facilities for the origination, control, and transmission of information and instructions pertaining to a fire alarm emergency to the occupants (including fire department personnel) of the building. It is the intent of this section to establish the minimum requirements for emergency voice/alarm communications.

3-12.3 Monitoring of the integrity of speaker amplifiers, tone-generating equipment, and two-way telephone communications circuits shall be in accordance with 1-5.8.5.

3-12.4 Survivability.

3-12.4.1 A fire command center shall be provided in accordance with 3-12.6.5.

Exception: Where emergency voice/alarm communications are used to automatically and simultaneously notify all occupants to evacuate the protected premises during a fire emergency, a fire command center shall not be required, but, where provided, shall meet the requirements of Section 3-12.

3-12.4.2 The fire command center and the central control unit shall be located within a minimum 1-hour rated fire-resistive area and shall have a minimum 3-ft (1-m) clearance about the face of the fire command center control equipment.

Exception: Where approved by the authority having jurisdiction, the fire command center control equipment shall be permitted to be located in a lobby or other approved space.

3-12.4.3 Where the fire command center control equipment is remote from the central control equipment:

(a) The interconnecting wiring shall be provided with mechanical protection by installing the wiring in metal conduit or metal raceway.

(b) The interconnecting wiring shall be provided with resistance to attack from a fire by routing the wiring through areas whose characteristics are at least equal to the limited combustible characteristics defined in NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*.

(c) Where the interconnecting wiring exceeds 100 ft (30 m), additional resistance to attack from a fire shall be provided by either:

1. Installing the wiring in metal conduit or metal raceway in a 2-hour fire rated enclosure; or
2. Enclosing the wiring in a 2-hour fire rated cable assembly and installing the cable in metal conduit or metal raceway.

3-12.5 Power Supplies.

3-12.5.1 The wiring between the central control equipment and the primary power supply also shall be routed through areas whose characteristics are at least equal to the limited-combustible characteristics as defined in NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*.

3-12.5.2 The secondary (standby) power supply shall be provided in accordance with 1-5.2.6.

Exception: Where emergency voice/alarm communications are used to notify all occupants automatically and simultaneously to evacuate the protected premises during a fire emergency in meeting the requirements of 1-5.2.6, the secondary supply shall be required to be capable of operating the system during a fire or other emergency condition for a period of 5 minutes rather than 2 hours.

3-12.6 Voice/Alarm Signaling Service.

3-12.6.1* General. The purpose of the voice/alarm signaling service is to provide an automatic response to the receipt of a signal indicative of a fire emergency. Subsequent manual control capability of the transmission and audible reproduction of evacuation tone signals, alert tone signals, and voice directions on a selective and all-call basis, as

determined by the authority having jurisdiction, is also required from the fire command center.

Exception No. 1: Where the fire command center or remote monitoring location is constantly attended by trained operators, and operator acknowledgment of receipt of a fire alarm signal is received within 30 seconds, automatic response shall not be required.

Exception No. 2: Where emergency voice/alarm communications are used to notify all occupants automatically and simultaneously to evacuate the protected premises during a fire emergency, the ability to give voice directions on a selective basis shall not be required but, where provided, shall meet the requirements of Section 3-12.

3-12.6.2 Multichannel Capability. Where required by the authority having jurisdiction, the system shall allow the application of an evacuation signal to one or more zones and, at the same time, shall allow voice paging to the other zones selectively or in any combination.

3-12.6.3 Functional Sequence.

3-12.6.3.1 In response to an initiating signal indicative of a fire emergency, the system shall automatically transmit, either immediately or after a delay acceptable to the authority having jurisdiction, the following:

(a) An alert tone of 3 seconds' to 10 seconds' duration followed by a message (or messages where multichannel capability is provided) shall be repeated at least three times to direct the occupants of the alarm signal initiation zone and other zones in accordance with the building's fire evacuation plan; or

(b) An evacuation signal to the alarm signal initiation zone and other zones in accordance with the building's fire evacuation plan.

Exception: Where emergency voice/alarm communications are used to notify all occupants automatically and simultaneously to evacuate the protected premises during a fire emergency, and the functional sequence described in 3-12.6.3.1(a) is provided, the capability to notify portions of the protected premises selectively shall not be required but, where provided, shall meet the requirements of Section 3-12.

3-12.6.3.2 Failure of the message described by 3-12.6.3.1(a), where used, shall sound the evacuation signal automatically. Provisions for manual initiation of voice instructions or evacuation signal generation shall be provided.

Exception No. 1: Other functional sequences shall be permitted where approved by the authority having jurisdiction.

Exception No. 2: Where emergency voice/alarm communications are used to notify all occupants automatically and simultaneously to evacuate the protected premises during a fire emergency, provision for manual initiation of voice instructions shall not be required but, where provided, shall meet the requirements of Section 3-12.

3-12.6.3.3 Live voice instructions shall override all previously initiated signals on that channel and shall have priority over any subsequent automatically initiated signals on that channel. Where multichannel application is required, subsequent alarms shall be activated in accordance with 3-12.6.2.

Exception: Where emergency voice/alarm communications are used to notify all occupants automatically and simultaneously to evacuate the protected premises during a fire emergency, the ability to give live voice instructions shall not be required but, where provided, shall meet the requirements of Section 3-12.

3-12.6.3.4 Where provided, manual controls for emergency voice/alarm communications shall be arranged to provide visible indication of the on/off status for their associated evacuation zones.

3-12.6.4 Voice and Tone Devices. The alert tone preceding any message shall be permitted to be a part of the voice message or to be transmitted automatically from a separate tone generator.

3-12.6.5 Fire Command Center.

3-12.6.5.1* A fire command center shall be provided near a building entrance or other location approved by the authority having jurisdiction. The fire command center shall provide a communications center for the arriving fire department and shall provide for control and display of the status of detection, alarm, and communications systems. The fire command center shall be permitted to be physically combined with other building operations and security centers as permitted by the authority having jurisdiction. Operating controls for use by the fire department shall be clearly marked.

3-12.6.5.2 The fire command center shall control the emergency voice/alarm communications signaling service and, where provided, the two-way telephone communications service. All controls for manual initiation of voice instructions and evacuation signals shall be located or secured to restrict access to trained and authorized personnel.

3-12.6.5.3 Where there are multiple fire command centers, the center in control shall be identified by a visible indication at that center.

3-12.6.6 Loudspeakers.

3-12.6.6.1 Loudspeakers and their enclosures shall be listed for voice/alarm signaling service and installed in accordance with Chapter 6.

3-12.6.6.2* There shall be at least two loudspeakers in each paging zone of the building, so located that signals can be clearly heard regardless of the maximum noise level produced by machinery or other equipment under normal conditions of occupancy. (*See Section 6-3.*)

3-12.6.6.3 Each elevator car shall be equipped with a single loudspeaker connected to the paging zone serving the elevator group in which the elevator car is located.

3-12.6.6.4 Each enclosed stairway shall be equipped with loudspeakers connected to a separate paging zone.

Exception: Stairwells not exceeding two stories in height.

3-12.7 Evacuation Signal Zoning.

3-12.7.1 Where two or more evacuation signaling zones are provided, such zones shall be arranged consistent with the fire or smoke barriers within the protected premises. Undivided fire or smoke areas shall not be divided into multiple evacuation signaling zones.

NOTE: This section does not prohibit provision of multiple notification appliance circuits within a single evacuation signaling zone (i.e., separate circuits for audible and visible signals, redundant circuits provided to enhance survivability, or multiple circuits necessary to provide sufficient power/capacity).

3-12.7.2 Where multiple notification appliance circuits are provided within an single evacuation signaling zone, all of the notification appliances within the zone shall be arranged to activate simultaneously, either automatically or by actuation of a common, manual control.

Exception: Where the different notification appliance circuits within an evacuation signaling zone perform separate functions (e.g., presignal and general alarm signals, predischarge and discharge signals).

3-12.8 Two-Way Telephone Communications Service.

3-12.8.1 Two-way telephone communications equipment shall be listed for two-way telephone communications service and installed in accordance with 3-12.8.

3-12.8.2 Two-way telephone communications service, where provided, shall be available for use by the fire service. Additional uses, where specifically permitted by the authority having jurisdiction, shall be permitted to include signaling and communications for a building fire warden organization, signaling and communications for reporting a fire and other emergencies (e.g., voice call box service, signaling, and communications for guard's tour service), and other uses. Variation of equipment and system operation provided to facilitate additional use of the two-way telephone communications service shall not adversely affect performance where used by the fire service.

3-12.8.3* Two-way telephone communications service shall be capable of permitting the simultaneous operation of any five telephone stations in a common talk mode.

3-12.8.4 A notification signal at the fire command center, distinctive from any other alarm or trouble signal, shall indicate the off-hook condition of a calling telephone circuit. Where a selective talk telephone communications service is supplied, a distinctive visible indicator shall be furnished for each selectable circuit so that all circuits with telephones off-hook are continuously and visibly indicated.

Exception: Where emergency voice/alarm communications are used to notify all occupants automatically and simultaneously to evacuate the protected premises during a fire emergency, signals from the two-way telephone system shall be required to indicate only at a location approved by the authority having jurisdiction.

3-12.8.5 A switch for silencing the audible call-in signal sounding appliance shall be permitted, provided it is key-operated, in a locked cabinet, or provided with equivalent protection from use by unauthorized persons. Such a switch shall be permitted, provided that it operates a visible indicator and sounds a trouble signal whenever the switch is in the silence position where there are no telephone circuits in an off-hook condition. Where a selective talk telephone system is used, such a switch shall be permitted, provided subsequent telephone circuits going off-hook operate the distinctive off-hook audible signal sounding appliance.

3-12.8.6 Minimum Systems. As a minimum (for fire service use only), two-way telephone systems shall be common talk (i.e., a conference or party line circuit) providing at least one telephone station or jack per floor and at least one telephone station or jack per exit stairway. In buildings equipped with a fire pump(s), a telephone station or jack shall be provided in each fire pump room.

3-12.8.7 Fire Warden Use. Where the two-way telephone system is intended to be used by fire wardens in addition to the fire service, the minimum requirement shall be a selective talk system (where phones are selected from the fire command center). Systems intended for fire warden use shall provide telephone stations or jacks as required for fire service use and additional telephone stations or jacks as necessary to provide at least one telephone station or jack in each voice paging zone. Telephone circuits shall be selectable from the fire command center either individually or, where approved by the authority having jurisdiction, by floor or stairwell.

3-12.8.8 Where the control equipment provided does not indicate the location of the caller (common talk systems), each telephone station or phone jack shall be clearly and permanently labeled to allow the caller to readily identify his/her location to the fire command center by voice.

3-12.8.9 Where telephone jacks are provided, a sufficient quantity of portable handsets, as determined by the authority having jurisdiction, shall be stored at the fire command center for distribution during an incident to responding personnel.

3-13* Special Requirements for Low Power Radio (Wireless) Systems.

3-13.1 Compliance with this section shall require the use of low power radio equipment specifically listed for the purpose.

NOTE: Equipment listed solely for household use does not comply with this requirement.

3-13.2 Power Supplies. A primary battery (dry cell) shall be permitted to be used as the sole power source of a low power radio transmitter where all of the following conditions are met:

(a) Each transmitter shall serve only one device and shall be individually identified at the receiver/control unit.

(b) The battery shall be capable of operating the low power radio transmitter for not less than 1 year before the battery depletion threshold is reached.

(c) A battery depletion signal shall be transmitted before the battery has depleted to a level insufficient to support alarm transmission after 7 additional days of normal operation. This signal shall be distinctive from alarm, supervisory, tamper, and trouble signals; shall visibly identify the affected low power radio transmitter; and, when silenced, shall automatically re-sound at least once every 4 hours.

(d) Catastrophic (open or short) battery failure shall cause a trouble signal identifying the affected low power radio transmitter at its receiver/control unit. When silenced, the trouble signal shall automatically re-sound at least once every 4 hours.

(e) Any mode of failure of a primary battery in a low power radio transmitter shall not affect any other low power radio transmitter.

3-13.3 Alarm Signals.

3-13.3.1 When actuated, each low power radio transmitter shall automatically transmit an alarm signal.

NOTE: This requirement is not intended to preclude verification and local test intervals prior to alarm transmission.

3-13.3.2 Each low power radio transmitter shall automatically repeat alarm transmission at intervals not exceeding 60 seconds until the initiating device is returned to its normal condition.

3-13.3.3 Fire alarm signals shall have priority over all other signals.

3-13.3.4 The maximum allowable response delay from activation of an initiating device to receipt and display by the receiver/control unit shall be 90 seconds.

3-13.3.5 An alarm signal from a low power radio transmitter shall latch at its receiver/control unit until manually reset and shall identify the particular initiating device in alarm.

3-13.4 Supervision.

3-13.4.1 The low power radio transmitter shall be specifically listed as using a transmission method that shall be highly resistant to misinterpretation of simultaneous transmissions and to interference (e.g., impulse noise and adjacent channel interference).

3-13.4.2 The occurrence of any single fault that disables transmission between any low power radio transmitter and the receiver/control unit shall cause a latching trouble signal within 200 seconds.

Exception: Where Federal Communications Commission (FCC) regulations prevent meeting the 200-second requirement, the time period for a low power radio transmitter with only a single, connected alarm-initiating device shall be permitted to be increased to four times the minimum time interval permitted for a 1-second transmission up to:

(a) Four hours maximum for a transmitter serving a single initiating device.

(b) Four hours maximum for a retransmission device (repeater) where disabling of the repeater or its transmission does not prevent the receipt of signals at the receiver/control unit from any initiating device transmitter.

3-13.4.3 A single fault on the signaling channel shall not cause an alarm signal.

3-13.4.4 The normal periodic transmission from a low power radio transmitter shall ensure successful alarm transmission capability.

3-13.4.5 Removal of a low power radio transmitter from its installed location shall cause immediate transmission of a distinctive supervisory signal that indicates its removal and individually identifies the affected device.

Exception: This requirement shall not apply to household fire warning systems.

3-13.4.6 Reception of any unwanted (interfering) transmission by a retransmission device (repeater) or by the main receiver/control unit, for a continuous period of 20 seconds or more, shall cause an audible and visible trouble indication at the main receiver/control unit. This indication shall identify the specific trouble condition as an interfering signal.

Chapter 4 Supervising Station Fire Alarm Systems

4-1 Scope. This chapter covers the requirements for the proper performance, installation, and operation of fire alarm systems at a continuously attended supervising station and between the protected premises and the continuously attended supervising station.

4-2 Fire Alarm Systems for Central Station Service.

NOTE: The requirements of Chapters 1 and 7 and Section 4-5 shall apply to central station fire alarm systems, unless they conflict with the requirements of this section.

4-2.1 Scope. This section describes the general requirements and use of fire alarm systems to provide central station service as defined in Section 1-4.

4-2.2 General.

4-2.2.1 These systems include the central station physical plant, exterior communications channels, subsidiary stations, and signaling equipment located at the protected premises.

4-2.2.2* This section applies to central station service, which consists of the following elements: installation of fire alarm transmitters; alarm, guard, supervisory, and trouble signal monitoring; retransmission; associated record keeping and reporting; testing and maintenance; and runner service. These services shall be provided under contract to a subscriber by one of the following:

(a) A listed central station that provides all of the elements of central station service with its own facilities and personnel.

(b) A listed central station that provides, as a minimum, the signal monitoring, retransmission, and associated record keeping and reporting with its own facilities and personnel and that might subcontract all or any part of the installation, testing and maintenance, and runner service.

(c) A listed fire alarm service-local company that provides the installation and testing and maintenance with its own facilities and personnel and that subcontracts the monitoring, retransmission, and associated record keeping and reporting to a listed central station. The required runner service shall be provided by the listed fire alarm service-local company with its own personnel or the listed central station with its own personnel.

4-2.2.3 The prime contractor shall conspicuously indicate that the fire alarm system providing service at a protected premises complies with all the requirements of this code by providing a means of third party verification, as specified in 4-2.2.3.1 or 4-2.2.3.2.

4-2.2.3.1 The installation shall be certificated.

4-2.2.3.1.1 Fire alarm systems providing service that complies with all requirements of this code shall be certified by the organization that has listed the central station, and a document attesting to this certification shall be located on or near the fire alarm system control unit or, if no control unit exists, on or near a fire alarm system component.

4-2.2.3.1.2 A central repository of issued certification documents, accessible to the authority having jurisdiction, shall be maintained by the organization that has listed the central station.

4-2.2.3.2 The installation shall be placarded.

4-2.2.3.2.1 Fire alarm systems providing service that complies with all requirements of this code shall be conspicuously marked by the central station to indicate compliance. The marking shall be by one or more securely affixed placards that meet the requirements of the organization that has listed the central station and requires the placard.

4-2.2.3.2.2 The placard(s) shall be 20 in.^{2} (130 cm^2) or larger, shall be located on or near the fire alarm system control unit or, if no control unit exists, on or near a fire alarm system component, and shall identify the central station by name and telephone number.

4-2.2.4* Fire alarm system service not complying with all requirements of Section 4-2 shall not be designated as central station service.

4-2.2.5* For the purpose of Section 4-2, the subscriber shall notify the prime contractor in writing of the identity of the authority(ies) having jurisdiction.

4-2.3 Facilities.

4-2.3.1 The central station building or that portion of a building occupied by a central station shall conform to the construction, fire protection, restricted access, emergency lighting, and power facilities requirements of the latest edition of ANSI/UL 827, *Standard for Safety Central-Station for Watchman, Fire-Alarm and Supervisory Services.*

4-2.3.2 Subsidiary station buildings or those portions of buildings occupied by subsidiary stations shall conform to the construction, fire protection, restricted access, emergency lighting, and power facilities requirements of the latest edition of ANSI/UL 827, *Standard for Safety Central-Station for Watchman, Fire-Alarm and Supervisory Services.*

4-2.3.2.1 All intrusion, fire, power, and environmental control systems for subsidiary station buildings shall be monitored by the central station in accordance with 4-2.3.

4-2.3.2.2 The subsidiary facility shall be inspected at least monthly by central station personnel for the purpose of verifying the operation of all supervised equipment, all telephones, all battery conditions, and all fluid levels of batteries and generators.

4-2.3.2.3 In the event of the failure of equipment at the subsidiary station or the communications channel to the central station, a backup shall be operational within 90 seconds. Restoration of a failed unit shall be accomplished within 5 days.

4-2.3.2.4 There shall be continuous supervision of each communications channel between the subsidiary station and the central station.

4-2.3.2.5 When the communications channel between the subsidiary station and the supervising station fails, the communications shall be switched to an alternate path. Public switched telephone network facilities shall be used only as an alternate path.

4-2.3.2.6 In the subsidiary station, there shall be either a cellular telephone or an equivalent communications path that is independent of the telephone cable between the subsidiary station and the serving wire center.

4-2.3.2.7 A plan of action to provide for restoration of services specified by this code shall exist for each subsidiary station.

4-2.3.2.7.1 This plan shall provide for restoration of services within 4 hours of any impairment causing loss of signals from the subsidiary station to the central station.

4-2.3.2.7.2 There shall be an exercise to demonstrate the adequacy of the plan at least annually.

4-2.4 Equipment.

4-2.4.1 The central station and all subsidiary stations shall be so equipped to receive and record all signals in accordance with 4-5.4. Circuit-adjusting means for emergency operation shall be permitted to be automatic or to be provided through manual operation upon receipt of a trouble signal. Computer aided alarm and supervisory signal processing hardware and software shall be listed for the specific application.

4-2.4.2 Power supplies shall comply with the requirements of Chapter 1.

4-2.4.3 Transmission means shall comply with the requirements of Section 4-5.

4-2.4.4* Two independent means shall be provided to retransmit a fire alarm signal to the appropriate public fire service communications center.

NOTE: The use of a universal emergency number (e.g., 911 public safety answering point) does not meet the intent of this code for the principal means of retransmission.

4-2.4.4.1 Where the principal means of retransmission is not equipped to allow the center to acknowledge receipt of each fire alarm report, both means shall be used to retransmit.

4-2.4.4.2* Where required by the authority having jurisdiction, one of the means of retransmission shall be supervised so that interruption of retransmission circuit (channel) communications integrity results in a trouble signal at the central station.

4-2.4.4.3 The retransmission means shall be tested in accordance with Chapter 7.

4-2.4.4.4 The retransmission signal and the time and date of retransmission shall be recorded at the central station.

4-2.5 Personnel.

4-2.5.1 The central station shall have sufficient personnel (a minimum of two persons) on duty at the central station at all times to ensure attention to signals received.

4-2.5.2 Operation and supervision shall be the primary functions of the operators, and no other interest or activity shall take precedence over the protective service.

4-2.6 Operations.

4-2.6.1 Disposition of Signals.

4-2.6.1.1 Alarm signals initiated by manual fire alarm boxes, automatic fire detectors, waterflow from the automatic sprinkler system, or actuation of other fire suppression system(s) or equipment shall be treated as fire alarms.

The central station shall:

(a)* Immediately retransmit the alarm to the public fire service communications center.

(b) Dispatch a runner or technician to the protected premises to arrive within 1 hour after receipt of a signal where equipment needs to be manually reset by the prime contractor.

(c) Notify the subscriber by the quickest available method.

(d) Provide notice to the subscriber or authority having jurisdiction, or both, where required.

Exception: Where the alarm signal results from a prearranged test, the actions specified by 4-2.6.1.1(a) and (c) shall not be required.

4-2.6.1.2 Guard's Signal.

4-2.6.1.2.1 Upon failure to receive a guard's regular signal within a 15-minute maximum grace period, the central station shall:

(a) Communicate without unreasonable delay with personnel at the protected premises.

(b) Dispatch a runner to the protected premises to arrive within 30 minutes of the delinquency where communications cannot be established.

(c) Report all delinquencies to the subscriber or authority having jurisdiction, or both, where required.

4-2.6.1.2.2 Failure of the guard to follow a prescribed route in transmitting signals shall be handled as a delinquency.

4-2.6.1.3* Upon receipt of a supervisory signal from a sprinkler system, other fire suppression system(s), or other equipment, the central station shall:

(a)* Communicate immediately with the person(s) designated by the subscriber.

(b) Dispatch a runner or maintenance person (arrival time not to exceed 1 hour) to investigate.

Exception: Where an abnormal condition is restored to normal in accordance with a scheduled procedure determined by 4-2.6.1.3(a).

(c) Notify the fire department or law enforcement agency, or both, where required.

(d) Notify the authority having jurisdiction when sprinkler systems or other fire suppression system(s) or equipment has been wholly or partially out of service for 8 hours.

(e) When service has been restored, provide notice, where required, to the subscriber or the authority having jurisdiction, or both, as to the nature of the signal, time of occurrence, and restoration of service when equipment has been out of service for 8 hours or more.

Exception: Where the supervisory signal results from a prearranged test, the actions specified by 4-2.6.1.3(a), (c), and (e) shall not be required.

4-2.6.1.4 Upon receipt of trouble signals or other signals pertaining solely to matters of equipment maintenance of the fire alarm systems, the central station shall:

(a)* Communicate immediately with persons designated by the subscriber.

(b) Dispatch personnel to arrive within 4 hours to initiate maintenance, if necessary.

(c) Provide notice, where required, to the subscriber or the authority having jurisdiction, or both, as to the nature of the interruption, time of occurrence, and restoration of service, when the interruption is more than 8 hours.

4-2.6.1.5 All test signals received shall be recorded to indicate date, time, and type.

(a) Test signals initiated by the subscriber, including those for the benefit of an authority having jurisdiction, shall be acknowledged by central station personnel whenever the subscriber or authority inquires.

(b)* Any test signal not received by the central station shall be investigated immediately and appropriate action taken to reestablish system integrity.

(c) The central station shall dispatch personnel to arrive within 1 hour where protected premises equipment needs to be manually reset after testing.

4-2.6.2 Record Keeping and Reporting.

4-2.6.2.1 Complete records of all signals received shall be retained for at least 1 year.

4-2.6.2.2 The central station shall make arrangements to furnish reports of signals received to the authority having jurisdiction in a form it finds acceptable.

4-2.7 Testing and Maintenance.

4-2.7.1 Testing and maintenance for central station service shall be performed in accordance with Chapter 7.

4-2.7.2 The prime contractor shall provide each of its representatives and each alarm system user with a unique personal identification code.

4-2.7.3 In order to authorize the placing of an alarm system into test status, a representative of the prime contractor or an alarm system user shall first provide the central station with his or her personal identification code.

4-3 Proprietary Supervising Station Systems.

NOTE: The requirements of Chapters 1 and 7 and Section 4-5 apply to proprietary fire alarm systems, unless they conflict with the requirements of this section.

4-3.1 Scope. This section describes the operational procedures for the supervising facilities of proprietary fire alarm systems. It provides the minimum requirements for the facilities, equipment, personnel, operation, and testing and maintenance of the proprietary supervising station.

4-3.2 General.

4-3.2.1 Proprietary supervising stations shall be operated by trained, competent personnel in constant attendance who are responsible to the owner of the protected property. (*See 4-3.5.3.*)

4-3.2.2 The protected property shall be either a contiguous property or noncontiguous properties under one ownership.

4-3.2.3 Where a protected premises master control unit is integral to or collocated with the supervising station equipment, the requirements of Section 4-5 shall not apply.

4-3.2.4* The systems of this section shall be permitted to be interconnected to other systems intended to make the premises safer in the event of fire or other emergencies indicative of hazards to life or property.

4-3.3 Facilities.

4-3.3.1 The proprietary supervising station shall be located in a fire-resistive, detached building or in a suitable cut-off room and shall not be near or exposed to the hazardous parts of the premises protected.

4-3.3.2 Access to the proprietary supervising station shall be restricted to those persons directly concerned with the implementation and direction of emergency action and procedure.

4-3.3.3 The proprietary supervising station, as well as remotely located power rooms for batteries or engine-driven generators, shall be provided with portable fire extinguishers that comply with the requirements of NFPA 10, *Standard for Portable Fire Extinguishers.*

4-3.3.4 Emergency Lighting System.

4-3.3.4.1 The proprietary supervising station shall be provided with an automatic emergency lighting system. The emergency source shall be independent of the primary lighting source.

4-3.3.4.2 The emergency lighting shall be sufficient to carry on operation of the supervising station for a 26-hour period and shall be tested monthly.

4-3.3.5 Where 25 or more protected buildings or premises are connected to a subsidiary station, both of the following shall be provided at the subsidiary station:

(a) Automatic means for receiving and recording signals under emergency-staffing conditions;

(b) A telephone.

4-3.4 Equipment.

4-3.4.1 This section shall apply to signal-receiving equipment in a proprietary supervising station.

4-3.4.2 Provision shall be made to designate the building in which a signal originates. The floor, section, or other subdivision of the building shall be designated at the proprietary supervising station or at the building protected.

Exception: Where the area, height, or special conditions of occupancy make detailed designation unessential as approved by the authority having jurisdiction. This detailed designation shall utilize indicating appliances acceptable to the authority having jurisdiction.

4-3.4.3 The proprietary supervising station shall have, in addition to a recording device, two different means for alerting the operator when each signal is received indicating a change of state of any connected initiating device circuit. One of these means shall be an audible signal and shall persist until manually acknowledged. This shall include the receipt of alarm signals, supervisory signals, and trouble signals, including signals indicating restoration to normal.

4-3.4.4 Where suitable means is provided in the proprietary supervising station to identify readily the type of signal received, a common audible indicating appliance shall be permitted to be used for alarm, supervisory, and trouble indication.

4-3.4.5 At a proprietary supervising station, an audible trouble signal shall be permitted to be silenced, provided the act of silencing does not prevent the signal from operating immediately upon receipt of a subsequent trouble signal.

4-3.4.6 All signals required to be received by the proprietary supervising station that show a change in status shall be automatically and permanently recorded, including time and date of occurrence. This record shall be in a form that expedites operator interpretation in accordance with any one of the following:

(a) In the event that a visual display is used that automatically provides change of status information for each required signal, including type and location of occurrence, any form of automatic permanent visual record shall be permitted. The recorded information shall include the content described above. The visual display shall show status information content at all times and shall be distinctly different after the operator has manually acknowledged each signal. Acknowledgment shall produce recorded information indicating the time and date of acknowledgment.

(b) In the event that a visual display is not provided, required signal content information shall be automatically recorded on duplicate permanent visual recording instruments.

One recording instrument shall be used for recording all incoming signals, while the other shall be used for required fire, supervisory, and trouble signals only. Failure to acknowledge a signal shall not prevent subsequent signals from recording. Restoration of the signal to its prior or normal condition shall be recorded.

(c) In the event that a system combines the use of a sequential visual display and recorded permanent visual presentation, the required signal content information shall be displayed and recorded. The visual information component shall be either retained on the display until manually acknowledged or periodically repeated at intervals not greater than 5 seconds, for durations of 2 seconds each, until manually acknowledged. Each new displayed status change shall be accompanied by an audible indication that shall persist until manual acknowledgment of the signal is performed.

There shall be a means provided for the operator to redisplay the status of required signal initiating inputs that have been acknowledged but not yet restored to a normal condition. Where the system retains the signal on the visual display until manually acknowledged, subsequent recorded presentations shall not be inhibited upon failure to acknowledge. Fire alarm signals shall be segregated on a separate visual display in this configuration.

Exception: Fire alarm signals shall not be required to be segregated on a separate display where given priority status on the common visual display.

4-3.4.7 The maximum elapsed time from sensing a fire alarm at an initiating device or initiating device circuit until it is recorded or displayed at the proprietary supervising station shall not exceed 90 seconds.

4-3.4.8 To facilitate the prompt receipt of fire alarm signals from systems handling other types of signals that can produce multiple simultaneous status changes, the requirements of either of the following shall be met:

(a) In addition to the maximum processing time for a single alarm, the system shall record simultaneous status changes at a rate not slower than either a quantity of 50, or 10 percent of the total number of initiating device circuits connected, within 90 seconds, whichever number is smaller, without loss of any signal.

(b) In addition to the maximum processing time, the system shall either display or record fire alarm signals at a rate not slower than one every 10 seconds, regardless of the rate or number of status changes occurring, without loss of any signals.

Exception: Where fire alarm, waterflow alarm, and sprinkler supervisory signals and their associated trouble signals are the only signals processed by the system, the rate of recording shall not be slower than one signal every 30 seconds.

4-3.4.9 Trouble signals required in 1-5.8 and their restoration to normal shall be automatically indicated and recorded at the proprietary supervising station within 200 seconds.

4-3.4.10 The recorded information for the occurrence of any trouble condition of signaling line circuit, leg facility, or trunk facility that prevents receipt of alarm signals at the proprietary supervising station shall be such that the operator is able to determine the presence of the trouble condition. Trouble conditions in a leg facility shall not affect or delay receipt of signals at the proprietary supervising station from other leg facilities on the same trunk facility.

4-3.5 Personnel.

4-3.5.1 At least two operators, one of whom shall be permitted to be a runner, shall be on duty at all times.

Exception: Where the means for transmitting alarms to the fire department is automatic, at least one operator shall be on duty at all times.

4-3.5.2 When the runner is not in attendance at the proprietary supervising station, the runner shall establish two-way communications with the station at intervals not exceeding 15 minutes.

4-3.5.3 The primary duties of the operator(s) shall be to monitor signals, operate the system, and take such action as shall be required by the authority having jurisdiction. The operator(s) shall not be assigned any additional duties that would take precedence over the primary duties.

4-3.6 Operations.

4-3.6.1 Communications and Transmission Channels.

4-3.6.1.1 All communications and transmission channels between the proprietary supervising station and the protected premises master control unit (panel) shall be operated manually or automatically once every 24 hours to verify operation.

4-3.6.1.2 When a communications or transmission channel fails to operate, the operator shall immediately notify the person(s) identified by the owner or authority having jurisdiction.

4-3.6.2 All operator controls at the proprietary supervising station(s) designated by the authority having jurisdiction shall be operated at each change of shift.

4-3.6.3 If operator controls fail, the operator shall immediately notify the person(s) identified by the owner or authority having jurisdiction.

4-3.6.4 Indication of a fire shall be promptly retransmitted to the public fire service communications center or other locations acceptable to the authority having jurisdiction, indicating the building or group of buildings from which the alarm has been received.

4-3.6.5* The means of retransmission shall be acceptable to the authority having jurisdiction and shall be in accordance with Section 4-2, 4-4, 4-6, or 4-7.

Exception: Secondary power supply capacity shall be as required in Chapter 1.

4-3.6.6* Retransmission by coded signals shall be confirmed by two-way voice communications indicating the nature of the alarm.

4-3.6.7 Dispositions of Signals.

4-3.6.7.1 Alarms. Upon receipt of a fire alarm signal, the proprietary supervising station operator shall initiate action to:

(a) Immediately notify the fire department, the plant fire brigade, and such other parties as the authority having jurisdiction requires.

(b) Promptly dispatch a runner to the alarm location (travel time shall not exceed 1 hour).

(c) Restore the system to its normal operating condition as soon as possible after disposition of the cause of the alarm signal.

4-3.6.7.2 Guard's Tour Delinquency. Where a regular signal is not received from a guard within a 15-minute maximum grace period, or where a guard fails to follow a prescribed route in transmitting the signals (where a prescribed route has been established), it shall be treated as a delinquency signal. When a guard's tour delinquency occurs, the proprietary supervising station operator shall initiate action to:

(a) Communicate at once with the protected areas or premises by telephone, radio, calling back over the system circuit, or other means acceptable to the authority having jurisdiction.

(b) Dispatch a runner to investigate the delinquency, where communications with the guard cannot be promptly established (travel time shall not exceed ½ hour).

4-3.6.7.3 Supervisory Signals. Upon receipt of sprinkler system and other supervisory signals, the proprietary supervising station operator shall initiate action to:

(a) Where required, communicate immediately with the designated person(s) to ascertain the reason for the signal.

(b) Where required, dispatch a runner or maintenance person (travel time not to exceed 1 hour) to investigate, unless supervisory conditions are promptly restored to normal.

(c) Where required, notify the fire department.

(d) Where required, notify the authority having jurisdiction when sprinkler systems are wholly or partially out of service for 8 hours or more.

(e) Where required, provide written notice to the authority having jurisdiction as to the nature of the signal, time of occurrence, and restoration of service, when equipment has been out of service for 8 hours or more.

4-3.6.7.4 Trouble Signals. Upon receipt of trouble signals or other signals pertaining solely to matters of equipment maintenance of the fire alarm system, the proprietary supervising station operator shall initiate action to:

(a) Where required, communicate immediately with the designated person(s) to ascertain reason for the signal.

(b) Where required, dispatch a runner or maintenance person (travel time not to exceed 1 hour) to investigate.

(c) Where required, notify the fire department.

(d) Where required, notify the authority having jurisdiction when interruption of normal service will exist for 4 hours or more.

(e) Where required, provide written notice to the authority having jurisdiction as to the nature of the signal, time of occurrence, and restoration of service, when equipment has been out of service for 8 hours or more.

4-3.6.8 Record Keeping and Reporting.

4-3.6.8.1 Complete records of all signals received shall be retained for at least 1 year.

4-3.6.8.2 The proprietary supervising station shall make arrangements to furnish reports of signals received to the authority having jurisdiction in a form it finds acceptable.

4-3.7 Testing and Maintenance. Testing and maintenance of proprietary fire alarm systems shall be performed in accordance with Chapter 7.

4-4 Remote Supervising Station Fire Alarm Systems.

NOTE: The requirements of Chapters 1 and 7 and Section 4-5 shall apply to remote supervising station fire alarm systems, unless they conflict with the requirements of this section.

4-4.1 Scope. This section is intended to apply where central station service is neither required nor elected. It describes the installation, maintenance, testing, and use of a remote supervising station fire alarm system that serves properties under various ownership from a remote supervising station where trained, competent personnel are in constant attendance. It covers the minimum requirements for the remote supervising station physical facilities, equipment, operating personnel, response, retransmission, signals, reports, and testing.

4-4.2 General.

4-4.2.1 Remote supervising station fire alarm systems shall provide an automatic audible and visible indication of alarm and, where required, of supervisory and trouble conditions at a location remote from the protected premises and a manual or automatic permanent record of these conditions.

4-4.2.2 This section does not require the use of audible signal notification appliances other than those required at the remote supervising station. If it is desired to provide fire alarm evacuation signals in the protected premises, the alarm signals, circuits, and controls shall comply with the provisions of Chapter 3 and Chapter 6 in addition to the provisions of this section.

4-4.2.3 The loading capacities of the remote supervising station equipment for any approved method of transmission shall be as designated in Section 4-5.

4-4.3* Facilities.

4-4.3.1 Where a remote supervising station connection is used to transmit an alarm signal, the signal shall be received at the public fire service communications center, at a fire station, or at the similar governmental agency that has a public responsibility for taking prescribed action to ensure response upon receipt of a fire alarm signal.

Exception: Where such an agency is unwilling to receive alarm signals or will permit the acceptance of another location by the authority having jurisdiction, such alternate location shall have personnel on duty at all times who are trained to receive the alarm signal and immediately retransmit it to the fire department.

4-4.3.2 Supervisory and trouble signals shall be handled at a constantly attended location having personnel on duty who are trained to recognize the type of signal received and to take prescribed action. This shall be permitted to be a location other than that at which alarm signals are received.

4-4.3.3 Where locations other than the public fire service communications center are used for the receipt of signals, access to receiving equipment shall be restricted in accordance with requirements of the authority having jurisdiction.

4-4.4 Equipment.

4-4.4.1 Signal-receiving equipment shall indicate receipt of each signal both audibly and visibly.

4-4.4.1.1 Audible signals shall meet the requirements of Chapter 6 for the private operating mode.

4-4.4.1.2 Means for silencing alarm, supervisory, and trouble signals shall be provided and shall be so arranged that subsequent signals shall re-sound.

4-4.4.1.3 A trouble signal shall be received when the system or any portion of the system at the protected premises is placed in a bypass or test mode.

4-4.4.1.4 An audible and visible indication shall be provided upon restoration from any off-normal condition.

4-4.4.1.5 Where suitable visible means are provided in the remote supervising station to identify readily the type of signal received, a common audible notification appliance shall be permitted to be used.

4-4.4.2 Power supplies shall comply with the requirements of Chapter 1.

Exception: In a remote supervising station fire alarm system where the alarm and supervisory signals are transmitted over a listed supervised one-way radio system, 24 hours of secondary (standby) power shall be permitted in lieu of 60 hours, as required in 1-5.2.6, at the radio alarm repeater station receivers (RARSR), provided that personnel are dispatched to arrive within 4 hours after detection of failure to initiate maintenance.

4-4.4.3 Transmission means shall comply with the requirements of Section 4-5.

4-4.4.4 Retransmission of an alarm signal, where required, shall be by one of the following methods, which appear in descending order of preference as follows:

(a) A dedicated circuit that is independent of any switched telephone network. This circuit shall be permitted to be used for voice or data communications.

(b) A one-way (outgoing only) telephone at the remote supervising station that utilizes the public switched telephone network. This telephone shall be used primarily for voice transmission of alarms to a telephone at the public fire service communications center that cannot be used for outgoing calls.

(c) A private radio system using the fire department frequency, where permitted by the fire department.

(d) Other methods acceptable to the authority having jurisdiction.

4-4.5 Personnel. Sufficient personnel shall be available at all times to receive alarm signals at the remote supervising station and to take immediate appropriate action. Duties pertaining to other than operation of the remote supervising station receiving and retransmitting equipment shall be permitted subject to the approval of the authority having jurisdiction.

4-4.6 Operations.

4-4.6.1 Where the remote supervising station is at a location other than the public fire service communications center, alarm signals shall be immediately retransmitted to the public fire service communications center.

4-4.6.2 Upon receipt of an alarm, supervisory, or trouble signal by the remote supervising station other than the public fire service communications center, it shall be the responsibility of the operator on duty to notify the owner or the owner's designated representative immediately.

4-4.6.3 A permanent record of the time, date, and location of all signals and restorations received; the action taken; and the results of all tests shall be maintained for at least 1 year and made available to the authority having jurisdiction. These records shall be permitted to be created by manual means.

4-4.6.4 All operator controls at the remote supervising station shall be operated at the beginning of each shift or change in personnel and the status of all off-normal conditions noted and recorded.

4-4.7 Testing and Maintenance. Testing and maintenance for remote supervising stations shall be performed in accordance with Chapter 7.

4-5 Communications Methods for Supervising Station Fire Alarm Systems.

NOTE: The requirements of Chapters 1 and 7 apply to continuously attended supervising station fire alarm systems, unless they conflict with the requirements of this section.

4-5.1 Scope. This section describes the requirements for the methods of communications between the protected premises and the supervising station. These include the transmitter located at the protected premises, the transmission channel between the protected premises and the supervising station or subsidiary station, and, where used, any subsidiary station and its communications channel, and the signal receiving, processing, display, and recording equipment at the supervising station. (*See Figure 4-5.1.*)

Exception: Transmission channels owned by and under the control of the protected premises owner that are not facilities leased from a supplier of communications service capabilities such as video cable, telephone, and similar services that are also offered to other customers.

4-5.2 General.

4-5.2.1 Applicable Requirements.

4-5.2.1.1 Where the protected premises master control unit is neither integral to nor collocated with the supervising station, the communications methods of Section 4-5 shall be used to connect the protected premises to either a subsidiary station (where used) or a supervising station providing central station service in accordance with Section 4-2, proprietary service in accordance with Section 4-3, or remote station service in accordance with Section 4-4. These

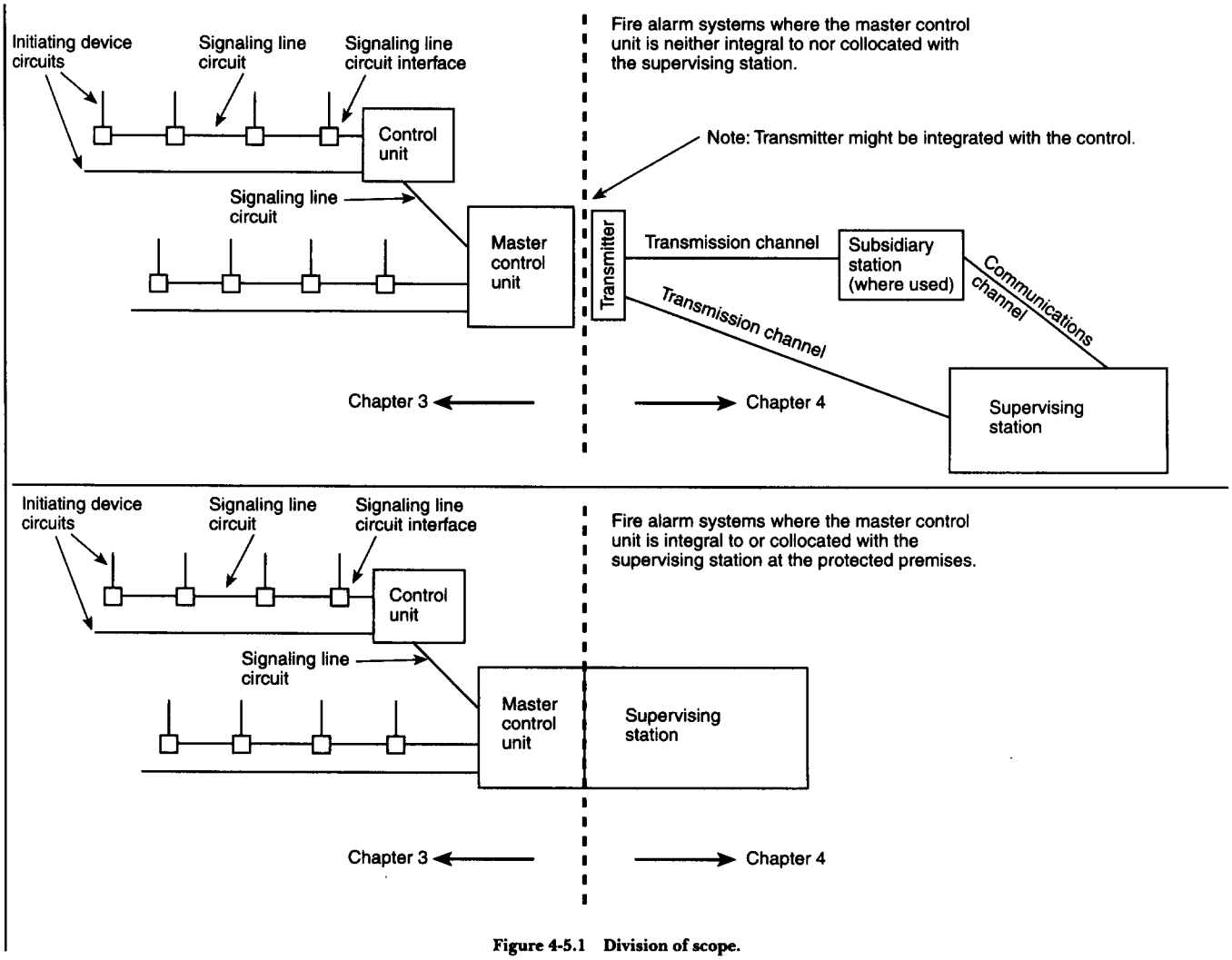


Figure 4-5.1 Division of scope.

communications methods shall be permitted to include active multiplex circuits that are part of a supervising station, including systems utilizing derived channels; digital alarm communicator systems, including digital alarm radio systems; McCulloh systems; two-way radio frequency (RF) multiplex systems; one-way radio alarm systems; or directly-connected noncoded systems.

4-5.2.1.2* Nothing in this chapter shall be interpreted as prohibiting the use of listed equipment using alternate communications methods that provide a level of reliability and supervision consistent with the requirements of Chapter 1 and the intended level of protection.

4-5.2.2 Equipment.

4-5.2.2.1 Fire alarm system equipment and installations shall comply with Federal Communication Commission (FCC) rules and regulations, as applicable, concerning electromagnetic radiation; use of radio frequencies; and connection to the public switched telephone network of telephone equipment, systems, and protection apparatus.

4-5.2.2.2 Radio receiving equipment shall be installed in compliance with NFPA 70, *National Electrical Code*, Article 810.

4-5.2.2.3 The external antennas of all radio transmitting and receiving equipment shall be protected in order to minimize the possibility of damage by static discharge or lightning.

4-5.2.3 Adverse Conditions.

4-5.2.3.1 For active and two-way RF multiplex systems, the occurrence of an adverse condition on the transmission channel between a protected premises and the supervising station that prevents the transmission of any status change signal shall be automatically indicated and recorded at the supervising station. This indication and record shall identify the affected portions of the system so that the supervising station operator can determine the location of the adverse condition by trunk or leg facility, or both.

4-5.2.3.2 For a one-way radio alarm system, the system shall be supervised to ensure that at least two independent radio alarm repeater station receivers (RARSR) are receiving signals for each radio alarm transmitter (RAT) during each 24-hour period. The occurrence of a failure to receive a signal by either RARSR shall be automatically indicated and recorded at the supervising station. The indication shall identify which RARSR has failed to receive such supervisory signals. It is not necessary for properly received test signals to be indicated at the supervising station.

4-5.2.3.3 For active and two-way RF multiplex systems that are part of a central station fire alarm system, restoration of normal service to the affected portions of the system shall be automatically recorded. When normal service is restored, the first status change of any initiating device circuit, or any initiating device directly connected to a signaling line circuit, or any combination thereof that occurred at any of the affected premises during the service interruption, also shall be recorded.

4-5.2.4 Dual Control.

4-5.2.4.1 Dual control, where required, shall provide for redundancy in the form of a standby circuit or a similar alternate means of transmitting signals over the primary trunk portion of a transmission channel. The same method of signal transmission shall be permitted to be used over separate routes, or alternate methods of signal transmission shall be permitted to be utilized. Public switched telephone network facilities shall be used only as an alternate method of transmitting signals.

4-5.2.4.2 Where utilizing facilities leased from a telephone company, that portion of the primary trunk facility between the supervising station and its serving wire center shall not be required to comply with the separate routing requirement of the primary trunk facility. Dual control, where used, shall require supervision as follows:

(a) Dedicated facilities that are available on a full-time basis, and whose use is limited to signaling purposes as defined in this code, shall be exercised at least once every hour.

(b) Public switched telephone network facilities shall be exercised at least once every 24 hours.

4-5.3 Communications Methods.

4-5.3.1 Active Multiplex Transmission Systems.

4-5.3.1.1 The multiplex transmission channel shall terminate in a transmitter at the protected premises and in a system unit at the supervising station. The derived channel shall terminate in a transmitter at the protected premises and in derived channel equipment at a subsidiary station location or a telephone company wire center. The derived channel equipment at the subsidiary station location or a telephone company wire center shall select or establish the communications with the supervising station.

4-5.3.1.2* Operation of the transmission channel shall conform to the requirements of this code whether channels are private facilities, such as microwave, or leased facilities furnished by a communications utility company. Where private signal transmission facilities are utilized, the equipment necessary to transmit signals shall also comply with the requirements for duplicate equipment or replacement of critical components, as described in 4-5.4.2. The trunk transmission channels shall be dedicated facilities for the main channel. For Type 1 multiplex systems, the public switched telephone network facilities shall be permitted to be used for the alternate channel.

Exception: Derived channel scanners with no more than 32 legs shall be permitted to use the public switched telephone network for the main channel.

4-5.3.1.2.1 Derived channel signals shall be permitted to be transmitted over the leg facility, which shall be permitted to be shared by the telephone equipment under all normal on-hook and off-hook operating conditions.

4-5.3.1.2.2 Where derived channel equipment uses the public switched telephone network to communicate with a supervising station, such equipment shall meet the requirements of 4-5.3.2.

4-5.3.1.2.3 The maximum end-to-end operating time parameters allowed for an active multiplex system are as follows:

(a) The maximum allowable time lapse from the initiation of a single fire alarm signal until it is recorded at the supervising station shall not exceed 90 seconds. When any number of subsequent fire alarm signals occur at any rate, they shall be recorded at a rate no slower than one every 10 additional seconds.

(b)* The maximum allowable time lapse from the occurrence of an adverse condition in any transmission channel until recording of the adverse condition is started shall not exceed 90 seconds for Type 1 and Type 2 systems, and 200 seconds for Type 3 systems. (*See 4-5.3.1.3.*)

(c) In addition to the maximum operating time allowed for fire alarm signals, the requirements of one of the following paragraphs shall be met:

1. A system unit having more than 500 initiating device circuits shall be able to record not less than 50 simultaneous status changes in 90 seconds.

2. A system unit having fewer than 500 initiating device circuits shall be able to record not less than 10 percent of the total number of simultaneous status changes within 90 seconds.

Exception: Proprietary supervising station systems.

NOTE: Operating time requirements for proprietary supervising station systems are specified in 4-3.4.7 through 4-3.4.9.

4-5.3.1.3 System Classification. Active multiplex systems are divided into three categories based upon their ability to perform under adverse conditions of their transmission channels. The system classifications are as follows:

(a) A Type 1 system shall have dual control as described in 4-5.2.4. An adverse condition on a trunk or leg facility shall not prevent the transmission of signals from any other trunk or leg facility, except those signals normally dependent on the portion of the transmission channel in which the adverse condition has occurred. An adverse condition limited to a leg facility shall not interrupt normal service on any trunk or other leg facility. The requirements of 4-5.2.1, 4-5.2.2, and 4-5.2.3 shall be met by Type 1 systems.

(b) A Type 2 system shall have the same requirements as a Type 1 system.

Exception: Dual control of the primary trunk facility shall not be required.

(c) A Type 3 system shall automatically indicate and record at the supervising station the occurrence of an adverse condition on the transmission channel between a protected premises and the supervising station. The requirements of 4-5.2 shall be met.

Exception: The requirements of 4-5.2.4 shall not apply.

4-5.3.1.4 System Loading Capacities. The capacities of active multiplex systems are based on the overall reliability of the signal receiving, processing, display, and recording equipment at the supervising and subsidiary stations, and the capability to transmit signals during adverse conditions of the signal transmission facilities. Table 4-5.3.1.4 establishes the allowable capacities.

4-5.3.1.5 Exceptions to Loading Capacities Listed in Table 4-5.3.1.4. Where the signal receiving, processing, display, and recording equipment are duplicated at the supervising station and a switchover can be accomplished in not more than 30 seconds with no loss of signals during this period, the capacity of a system unit shall be unlimited.

4-5.3.2 Digital Alarm Communicator Systems.

4-5.3.2.1 Digital Alarm Communicator Transmitter (DACT).

4-5.3.2.1.1 A DACT shall be connected to the public switched telephone network upstream of any private telephone system at the protected premises. In addition, the connections to the public switched telephone network shall be under the control of the subscriber for whom service is being provided by the supervising station fire alarm system, and special attention shall be required to ensure that this connection is made only to a loop start telephone circuit and not to a ground start telephone circuit.

Table 4-5.3.1.4 Loading Capacities for Active Multiplex Systems

	System Type		
	Type 1	**Type 2**	**Type 3**
A. Trunks			
Maximum number of fire alarm service initiating device circuits per primary trunk facility	5120	1280	256
Maximum number of leg facilities for fire alarm service per primary trunk facility	512	128	64
Maximum number of leg facilities for all types of fire alarm service per secondary trunk facility[1]	128	128	128
Maximum number of all types of initiating device circuits per primary trunk facility in any combination[1]	10,240	2560	512
Maximum number of leg facilities for all types of fire alarm service per primary trunk facility in any combination[1]	1024	256	128
B. System Units at the Supervising Station			
Maximum number of all types of initiating device circuits per system unit[1]	10,240[2]	10,240[2]	10,240[2]
Maximum number of fire protecting buildings and premises per system unit	512[2]	512[2]	512[2]
Maximum number of fire fire alarm service initiating device circuits per system unit	5120[2]	5120[2]	5120[2]
C. Systems Emitting from Subsidiary Station	Same as B	Same as B	Same as B

[1]Includes every initiating device circuit (e.g., waterflow, fire alarm, supervisory, guard, burglary, hold-up).
[2]Paragraph 4-5.3.1.5 applies.

Exception: Where public cellular telephone service is utilized as a secondary means of transmission, the requirements of this paragraph shall not apply to the cellular telephone service.

4-5.3.2.1.2 All information exchanged between the DACT at the protected premises and the digital alarm communicator receiver (DACR) at the supervising or subsidiary station shall be by digital code or equivalent. Signal repetition, digital parity check, or some equivalent means of signal verification shall be used.

4-5.3.2.1.3* A DACT shall be configured so that when it is required to transmit a signal to the supervising station, it shall seize the telephone line (going off-hook) at the protected premises, disconnect an outgoing or incoming telephone call, and prevent its use for outgoing telephone calls until signal transmission has been completed. A DACT shall not be connected to a party line telephone facility.

4-5.3.2.1.4 A DACT shall have the means to satisfactorily obtain an available dial tone, dial the number(s) of the DACR, obtain verification that the DACR is ready to receive signals, transmit the signal, and receive acknowledgment that the DACR has accepted that signal. In no event shall the time from going off-hook to on-hook exceed 90 seconds per attempt.

4-5.3.2.1.5* A DACT shall have suitable means to reset and retry where the first attempt to complete a signal transmission sequence is unsuccessful. A failure to complete connection shall not prevent subsequent attempts to transmit an alarm where such alarm is generated from any other initiating device circuit or signaling line circuit, or both. Additional attempts shall be made, until the signal transmission sequence has been completed, up to a minimum of five and a maximum of 10 attempts.

Where the maximum number of attempts to complete the sequence is reached, an indication of the failure shall be made at the premises.

4-5.3.2.1.6 DACT Transmission Channels.

4-5.3.2.1.6.1 A DACT shall employ one of the following combinations of transmission channels:

(a) Two telephone lines (numbers);

(b) One telephone line (number) and one cellular telephone connection;

(c) One telephone line (number) and a one-way radio system;

(d) One telephone line (number) equipped with a derived local channel;

(e) One telephone line (number) and a one-way private radio alarm system;

(f) One telephone line (number) and a private microwave radio system;

(g) One telephone line (number) and a two-way RF multiplex system.

4-5.3.2.1.6.2 The following requirements shall apply to all combinations in 4-5.3.2.1.6.1:

(a) Both channels shall be supervised in a manner appropriate for the means of transmission employed.

(b) Both channels shall be tested at intervals not exceeding 24 hours.

Exception No. 1: For public cellular telephone service, a verification (test) signal shall be transmitted at least monthly.

Exception No. 2: Where two telephone lines (numbers) are used, it shall be permitted, until June 1, 1998, to test the primary telephone line (number) at 24-hour intervals without testing the secondary line (number). After June 1, 1998, where two telephone lines (numbers) are used, it shall be permitted to test each telephone line (number) at alternating 24-hour intervals.

(c) The failure of either channel shall send a trouble signal on the other channel within 4 minutes.

(d) When one transmission channel has failed, all status change signals shall be sent over the other channel.

Exception: Where used in combination with a DACT, a derived local channel shall not be required to send status change signals other than those indicating that adverse conditions exist on the telephone line (number).

(e) The primary channel shall be capable of delivering an indication to the DACT that the message has been received by the supervising station.

(f) The first attempt to send a status change signal shall utilize the primary channel.

Exception: Where the primary channel is known to have failed.

(g) Simultaneous transmission over both channels shall be permitted.

(h) Failure of telephone lines (numbers) or cellular service shall be annunciated locally.

4-5.3.2.1.7 DACT Transmission Means.

4-5.3.2.1.7.1 A DACT shall be connected to two separate means of transmission at the protected premises. The DACT shall be capable of selecting the operable means of transmission in the event of failure of the other. The primary means of transmission shall be a telephone line (number) connected to the public switched network.

4-5.3.2.1.7.2 The first transmission attempt shall utilize the primary means of transmission.

4-5.3.2.1.8 Each DACT shall be programmed to call a second DACR line (number) where the signal transmission sequence to the first called line (number) is unsuccessful.

4-5.3.2.1.9* Where long distance telephone service (including WATS) is used, the second telephone number shall be provided by a different long distance service provider, where available.

4-5.3.2.1.10 Each DACT shall automatically initiate and complete a test signal transmission sequence to its associated DACR at least once every 24 hours. A successful signal transmission sequence of any other type within the same 24-hour period shall be considered sufficient to fulfill the requirement to verify the integrity of the reporting system, provided signal processing is automated so that 24-hour delinquencies are individually acknowledged by supervising station personnel.

4-5.3.2.1.11* Where a DACT is programmed to call a telephone line (number) that is call forwarded to the line (number) of the DACR, a means shall be implemented to verify the integrity of the call forwarding feature every 4 hours.

4-5.3.2.2 Digital Alarm Communicator Receiver (DACR).

4-5.3.2.2.1 Equipment.

4-5.3.2.2.1.1 Spare DACRs shall be provided in the supervising or subsidiary station and shall be able to be switched into the place of a failed unit within 30 seconds after detection of failure.

NOTE: One spare DACR may be permitted to serve as a backup for up to five DACRs in use.

4-5.3.2.2.1.2 The number of incoming telephone lines to a DACR shall be limited to eight lines.

Exception: Where the signal receiving, processing, display, and recording equipment at the supervising or subsidiary station is duplicated and a switchover can be accomplished in less than 30 seconds with no loss of signal during this period, the number of incoming lines to the unit shall be permitted to be unlimited.

4-5.3.2.2.2 Transmission Channel.

4-5.3.2.2.2.1* The DACR equipment at the supervising or subsidiary station shall be connected to a minimum of two separate incoming telephone lines (numbers). If the lines (numbers) are in a single hunt group, they shall be individually accessible; otherwise, separate hunt groups shall be required. These lines (numbers) shall be used for no other purpose than receiving signals from a DACT. These lines (numbers) shall be unlisted.

4-5.3.2.2.2.2 The failure of any telephone line (number) connected to a DACR due to loss of line voltage shall be annunciated visually and audibly in the supervising station.

4-5.3.2.2.2.3* The loading capacity for a hunt group shall be in accordance with Table 4-5.3.2.2.2.3 or be capable of demonstrating a 90 percent probability of immediately answering an incoming call.

(a) Each supervised burglar alarm (open/close) or each suppressed guard tour transmitter shall reduce the allowable DACTs as follows:

1. Up to a four-line hunt group, by 10;
2. Up to a five-line hunt group, by seven;
3. Up to a six-line hunt group, by six;
4. Up to a seven-line hunt group, by five;
5. Up to an eight-line hunt group, by four.

(b) Each guard tour transmitter shall reduce the allowable DACTs as follows:

1. Up to a four-line hunt group, by 30;
2. Up to a five-line hunt group, by 21;
3. Up to a six-line hunt group, by 18;
4. Up to a seven-line hunt group, by 15;
5. Up to an eight-line hunt group, by 12.

4-5.3.2.2.2.4* A signal shall be received on each individual incoming DACR line at least once every 24 hours.

4-5.3.2.2.2.5 The failure to receive a test signal from the protected premises shall be treated as a trouble signal. (*See 4-2.6.1.4.*)

4-5.3.2.3 Digital Alarm Radio System (DARS).

4-5.3.2.3.1 In the event that any DACT signal transmission is unsuccessful, the information shall be transmitted by means of the digital alarm radio transmitter (DART). The DACT shall continue its normal transmission sequence as required by 4-5.3.2.1.5.

4-5.3.2.3.2 The DARS shall be capable of demonstrating a minimum of 90 percent probability of successfully completing each transmission sequence.

4-5.3.2.3.3 Transmission sequences shall be repeated a minimum of five times. The digital alarm radio transmitter (DART) transmission shall be permitted to be terminated in less than five sequences where the DACT successfully communicates to the DACR.

4-5.3.2.3.4 Each DART shall automatically initiate and complete a test signal transmission sequence to its associated digital alarm radio receiver (DARR) at least once every 24 hours. A successful DART signal transmission sequence of any other type within the same 24-hour period shall be considered sufficient to fulfill the requirement to test the integrity of the reporting system, provided signal processing is automated so that 24-hour delinquencies are individually acknowledged by supervising station personnel.

4-5.3.2.4 Digital Alarm Radio Transmitter (DART). A DART shall transmit a digital code or equivalent by use of radio transmission to its associated digital alarm radio receiver (DARR). Signal repetition, digital parity check, or an equivalent means of signal verification shall be used. The DART shall comply with applicable FCC rules consistent with its operating frequency.

4-5.3.2.5 Digital Alarm Radio Receiver (DARR).

4-5.3.2.5.1 Equipment.

4-5.3.2.5.1.1 A spare DARR shall be provided in the supervising station and shall be able to be switched into the place of a failed unit within 30 seconds after detection of failure.

4-5.3.2.5.1.2 Facilities shall be provided at the supervising station for supervisory and control functions of subsidiary and repeater station radio receiving equipment. This shall be accomplished via a supervised circuit where the radio equipment is remotely located from the supervising or subsidiary station. The following conditions shall be supervised at the supervising station:

(a) Failure of ac power supplying the radio equipment;
(b) Receiver malfunction;
(c) Antenna and interconnecting cable malfunction;
(d) Indication of automatic switchover of the DARR;
(e) Data transmission line between the DARR and the supervising or subsidiary station.

4-5.3.3 McCulloh Systems.

4-5.3.3.1 Transmitters.

4-5.3.3.1.1 A coded alarm signal from a transmitter shall consist of not less than three complete rounds of the number or code transmitted.

4-5.3.3.1.2* A coded fire alarm box shall produce not less than three signal impulses for each revolution of the coded signal wheel or equivalent device.

4-5.3.3.1.3 Circuit-adjusting means for emergency operating shall be permitted to either be automatic or be provided through manual operation upon receipt of a trouble signal.

4-5.3.3.1.4 Equipment shall be provided at the supervising or subsidiary station on all circuits extending from the supervising or subsidiary station utilized for McCulloh systems for making the following tests:

Table 4-5.3.2.2.2.3 Loading Capacities for Hunt Groups

System Loading at the Supervising Station	Number of Lines in Hunt Group				
	1	2	3	4	5 to 8
With DACR lines processed in parallel					
Number of initiating circuits	N/A	5000	10,000	20,000	20,000
Number of DACTs[1]	N/A	500	1500	3000	3000
With DACR lines processed serially (put on hold, then answered one at a time)					
Number of initiating circuits	N/A	3000	5000	6000	6000
Number of DACTs[1]	N/A	300	800	1000	1000

N/A: Not acceptable.
[1]Table 4-5.3.2.2.2.3 is based on an average distribution of calls and an average connected time of 30 seconds for a message. The loading figures in the table presume that the lines are in a hunt group (i.e., DACT can access any available line). Note that a single-line DACR is NOT ACCEPTABLE (N/A) for any of the configurations shown.

(a) Current on each circuit under normal conditions;

(b) Current on each side of the circuit with the receiving equipment conditioned for an open circuit.

NOTE: The current readings in accordance with 4-5.3.3.1.4(a) should be compared with the normal readings to determine if a change in the circuit condition has occurred. A zero current reading in accordance with 4-5.3.3.1.4(b) indicates that the circuit is clear of a foreign ground.

4-5.3.3.2 Transmission Channels.

4-5.3.3.2.1 Circuits between the protected premises and the supervising or subsidiary station that are essential to the actuation or operation of devices initiating a signal indicative of fire shall be so arranged that the occurrence of a single break or single ground fault does not prevent transmission of an alarm.

Exception No. 1: Circuits wholly within the supervising or subsidiary station.

Exception No. 2: The carrier system portion of circuits.

4-5.3.3.2.2 The occurrence of a single break or a single ground fault on any circuit shall not of itself cause a false signal that could be interpreted as an alarm of fire. Where such single fault prevents the normal functioning of any circuit, its occurrence shall be indicated automatically at the supervising station by a trouble signal compelling attention and readily distinguishable from signals other than those indicative of an abnormal condition of supervised parts of a fire suppression system(s).

4-5.3.3.2.3 The circuits and devices shall be arranged to receive and record a signal readily identifiable as to location of origin, and provisions shall be made for equally identifiable transmission to the public fire service communications center.

4-5.3.3.2.4 Multipoint transmission channels between the protected premises and the supervising or subsidiary station and within the protected premises, consisting of one or more coded transmitters and an associated system unit(s), shall meet the requirements of either 4-5.3.3.2.5 or 4-5.3.3.2.6.

4-5.3.3.2.5 Where end-to-end metallic continuity is present, proper signals shall be received from other points under any one of the following transmission channel fault conditions at one point on the line:

(a) Open; or

(b) Ground; or

(c)* Wire-to-wire short; or

(d) Open and ground.

4-5.3.3.2.6 Where end-to-end metallic continuity is not present, the nonmetallic portion of transmission channels shall meet all of the following requirements:

(a) Two nonmetallic channels or one channel plus a means for immediate transfer to a standby channel shall be provided for each transmission channel, with a maximum of eight transmission channels being associated with each standby channel, or shall be provided over one channel, provided that service is limited to one plant.

(b) The two nonmetallic channels (or one channel with standby arrangement) for each transmission channel shall be provided by one of the following means, shown in descending order of preference:

1. Over separate facilities and separate routes; or
2. Over separate facilities in the same route; or
3. Over the same facilities in the same route.

(c) Failure of a nonmetallic channel or any portion thereof shall be indicated immediately and automatically in the supervising station.

(d) Proper signals shall be received from other points under any one of the following fault conditions at one point on the metallic portion of the transmission channel:

1. Open; or
2. Ground; or
3.* Wire-to-wire short.

4-5.3.3.3 Loading Capacity of McCulloh Circuits.

4-5.3.3.3.1 The number of transmitters connected to any transmission channel shall be limited to avoid interference. The total number of code wheels or equivalent connected to a single transmission channel shall not exceed 250. Alarm signal transmission channels shall be reserved exclusively for fire alarm signal transmitting service.

Exception: As provided in 4-5.3.3.3.4.

4-5.3.3.3.2 The number of waterflow switches permitted to be connected to actuate a single transmitter shall not exceed five switches.

4-5.3.3.3.3 The number of supervisory switches permitted to be connected to actuate a single transmitter shall not exceed 20.

4-5.3.3.3.4 Combined alarm and supervisory transmission channels shall comply with the following:

(a) Where both sprinkler supervisory signals and fire or waterflow alarm signals are transmitted over the same transmission channel, provision shall be made to obtain either alarm signal precedence or sufficient repetition of the alarm signal to prevent the loss of any alarm signal.

(b) Other signal transmitters (e.g., burglar, industrial processes) on an alarm transmission channel shall not exceed five.

4-5.3.3.3.5* Where signals from manual fire alarm boxes and waterflow alarm transmitters within a building are transmitted over the same transmission channel and are operating at the same time, there shall be no interference with the fire box signals. Provision of the shunt noninterfering method of operation shall be permitted for this performance.

4-5.3.3.3.6 One alarm transmission channel shall serve not more than 25 plants. A plant can consist of one or more buildings under the same ownership, and the circuit arrangement shall be such that an alarm signal cannot be received from more than one transmitter at a time within a plant. Where such noninterference is not provided, each building shall be considered a plant.

4-5.3.3.3.7 One sprinkler supervisory transmission channel circuit shall serve not more than 25 plants. A plant can consist of one or more buildings under the same ownership.

4-5.3.3.3.8 Connections to a guard supervisory transmission channel or to a combination manual fire alarm and guard transmission channel shall be limited so that not more than 60 scheduled guard report signals are transmitted in any 1-hour period. Patrol scheduling shall be such as to avoid interference between guard report signals.

4-5.3.4 Two-Way Radio Frequency (RF) Multiplex Systems.

4-5.3.4.1 The maximum end-to-end operating time parameters allowed for a two-way RF multiplex system are as follows:

(a) The maximum allowable time lapse from the initiation of a single fire alarm signal until it is recorded at the supervising station shall not exceed 90 seconds. When any number of subsequent fire alarm signals occur at any rate, they shall be recorded at a rate no slower than one every additional 10 seconds.

(b) The maximum allowable time lapse from the occurrence of an adverse condition in any transmission channel until recording of the adverse condition is started shall not exceed 90 seconds for Type 4 and Type 5 systems. (*See 4-5.3.4.4.*)

(c) In addition to the maximum operating time allowed for fire alarm signals, the requirements of one of the following paragraphs shall be met:

1. A system unit having more than 500 initiating device circuits shall be able to record not less than 50 simultaneous status changes in 90 seconds.

2. A system unit having fewer than 500 initiating device circuits shall be able to record not less than 10 percent of the total number of simultaneous status changes within 90 seconds.

4-5.3.4.2 Facilities shall be provided at the supervising station for the following supervisory and control functions of the supervising or subsidiary station and the repeater station radio transmitting and receiving equipment. This shall be accomplished via a supervised circuit where the radio equipment is remotely located from the system unit.

(a) The following conditions shall be supervised at the supervising station:

1. RF transmitter in use (radiating);
2. Failure of ac power supplying the radio equipment;
3. RF receiver malfunction;
4. Indication of automatic switchover.

(b) Independent deactivation of either RF transmitter shall be controlled from the supervising station.

4-5.3.4.3 Transmission Channel.

4-5.3.4.3.1 The RF multiplex transmission channel shall terminate in a RF transmitter/receiver at the protected premises and in a system unit at the supervising or subsidiary station.

4-5.3.4.3.2 Operation of the transmission channel shall conform to the requirements of this code whether channels are private facilities, such as microwave, or leased facilities furnished by a communications utility company. Where private signal transmission facilities are utilized, the equipment necessary to transmit signals shall also comply with requirements for duplicate equipment or replacement of critical components, as described in 4-5.4.2.

4-5.3.4.4* Two-way RF multiplex systems are divided into two categories based upon their ability to perform under adverse conditions. System classifications are of two types.

(a) A Type 4 system shall have two or more control sites configured as follows:

1. Each site shall have a RF receiver interconnected to the supervising or subsidiary station by a separate channel.

2. The RF transmitter/receiver located at the protected premises shall be within transmission range of at least two RF receiving sites.

3. The system shall contain two RF transmitters that are either:

a. Located at one site with the capability of interrogating all of the RF transmitters/receivers on the premises; or

b. Dispersed with all of the RF transmitters/receivers on the premises having the capability to be interrogated by two different RF transmitters.

4. Each RF transmitter shall maintain a status that allows immediate use at all times. Facilities shall be provided in the supervising or subsidiary station to operate any off-line RF transmitter at least once every 8 hours.

5. Any failure of one of the RF receivers shall in no way interfere with the operation of the system from the other RF receiver. Failure of any receiver shall be annunciated at the supervising station.

6. A physically separate channel shall be required between each RF transmitter or RF receiver site, or both, and the system unit.

(b) A Type 5 system shall have a single control site configured as follows:

1. A minimum of one RF receiving site;
2. A minimum of one RF transmitting site.

NOTE: The sites above can be collocated.

4-5.3.4.5 Loading Capacities.

4-5.3.4.5.1 The loading capacities of two-way RF multiplex systems are based on the overall reliability of the signal receiving, processing, display, and recording equipment at the supervising or subsidiary station and the capability to transmit signals during adverse conditions of the transmission channels. Table 4-5.3.4.5.1 establishes the allowable loading capacities.

4-5.3.4.5.2 Exceptions to Loading Capacities Listed in Table 4-5.3.4.5.1. Where the signal receiving, processing, display, and recording equipment are duplicated at the supervising station and a switchover can be accomplished in not more than 30 seconds with no loss of signals during this period, the capacity of a system unit shall be unlimited.

4-5.3.5 One-Way Private Radio Alarm Systems.

4-5.3.5.1 The requirements of 4-5.3.5 for a radio alarm repeater station receiver (RARSR) shall be satisfied where signals from each radio alarm transmitter (RAT) are received and supervised, in accordance with this chapter, by at least two independently powered, independently operating, and separately located RARSR.

4-5.3.5.2* The end-to-end operating time parameters allowed for a one-way radio alarm system shall be as follows:

(a) There shall be a 90 percent probability that the time between the initiation of a single fire alarm signal until it is recorded at the supervising station will not exceed 90 seconds.

(b) There shall be a 99 percent probability that the time between the initiation of a single fire alarm signal until it is recorded at the supervising station will not exceed 180 seconds.

(c) There shall be a 99.999 percent probability that the time between the initiation of a single fire alarm signal until it is recorded at the supervising station will not exceed 7.5 minutes (450 seconds), at which time the RAT shall cease transmitting.

When any number of subsequent fire alarm signals occur at any rate, they shall be recorded at an average rate no slower than one every additional 10 seconds.

(d) In addition to the maximum operating time allowed for fire signals, the system shall be able to record not less than 12 simultaneous status changes within 90 seconds at the supervising station.

Table 4-5.3.4.5.1 Loading Capacities for Two-Way RF Multiplex Systems

	System Type	
	Type 4	**Type 5**
A. Trunks		
Maximum number of fire alarm service initiating device circuits per primary trunk facility	5120	1280
Maximum number of leg facilities for fire alarm service per primary trunk facility	512	128
Maximum number of leg facilities for all types of fire alarm service per secondary trunk facility[1]	128	128
Maximum number of all types of initiating device circuits per primary trunk facility in any combination	10,240	2560
Maximum number of leg facilities for types of fire alarm service per primary trunk facility in any combination[1]	1024	256
B. System Units at the Supervising Station		
Maximum number of all types of initiating device circuits per system unit[1]	10,240[2]	10,240[2]
Maximum number of fire protected buildings and premises per system unit	512[2]	512[2]
Maximum number of fire alarm service initiating device circuits per system	5120[2]	5120[2]
C. Systems Emitting from Subsidiary Station	Same as B	Same as B

[1]Includes every initiating device circuit (e.g., waterflow, fire alarm supervisory, guard, burglary, hold-up).
[2]Paragraph 4-5.3.4.5.2 applies.

4-5.3.5.3 Supervision.

4-5.3.5.3.1 Equipment shall be provided at the supervising station for the supervisory and control functions of the supervising or subsidiary station and for the repeater station radio transmitting and receiving equipment. This shall be accomplished via a supervised circuit where the radio equipment is remotely located from the system unit. The following conditions shall be supervised at the supervising station:

(a) Failure of ac power supplying the radio equipment;

(b) RF receiver malfunction;

(c) Indication of automatic switchover (where applicable).

4-5.3.5.3.2 Protected Premises.

4-5.3.5.3.2.1 Interconnections between elements of transmitting equipment, including any antennas, shall be supervised either to cause an indication of failure at the protected premises or to transmit a trouble signal to the supervising station.

4-5.3.5.3.2.2 Where elements of transmitting equipment are physically separated, the wiring or cabling between them shall be protected by conduit.

4-5.3.5.4 Transmission Channels.

4-5.3.5.4.1 The one-way RF transmission channel shall originate with a one-way RF transmitting device at the protected premises and shall terminate at the RF receiving system of an RARSR capable of receiving transmissions from such transmitting devices.

4-5.3.5.4.2 A receiving network transmission channel shall terminate at an RARSR at one end and with either another RARSR or a radio alarm supervising station receiver (RASSR) at the other end.

4-5.3.5.4.3 Operation of receiving network transmission channels shall conform to the requirements of this code whether channels are private facilities, such as microwave, or leased facilities furnished by a communications utility company. Where private signal transmission facilities are utilized, the equipment necessary to transmit signals shall also comply with requirements for duplicate equipment or replacement of critical components as described in 4-5.4.2.

4-5.3.5.4.4 The system shall provide information indicating the quality of the received signal for each RARSR supervising each RAT in accordance with 4-5.3.5 and shall provide information at the supervising station when such signal quality falls below the minimum signal quality levels set forth in 4-5.3.5.

4-5.3.5.4.5 Each RAT shall be installed in such a manner so as to provide a signal quality over at least two independent one-way RF transmission channels, of the minimum quality level specified, that satisfies the performance requirements in 4-5.2.2 and 4-5.4.

4-5.3.5.5 Nonpublic one-way radio alarm systems shall be divided into two categories based upon the following number of RASSRs present in the system:

(a) A Type 6 system shall have one RASSR and at least two RARSRs.

(b) A Type 7 system shall have more than one RASSR and at least two RARSRs.

In a Type 7 system, when more than one RARSR is out of service and, as a result, any RATs are no longer being supervised, the affected supervising station shall be notified.

In a Type 6 system, when any RARSR is out of service, a trouble signal shall be annunciated at the supervising station.

4-5.3.5.6 The loading capacities of one-way radio alarm systems are based on the overall reliability of the signal receiving, processing, display, and recording equipment at the supervising or subsidiary station and the capability to transmit signals during adverse conditions of the transmission channels. Table 4-5.3.5.6 establishes the allowable loading capacities.

4-5.3.5.7 Exceptions to Loading Capacities Listed in Table 4-5.3.5.6. Where the signal receiving, processing, display, and recording equipment are duplicated at the supervising station and a switchover can be accomplished in not more than 30 seconds with no loss of signals during this period, the capacity of a system unit is unlimited.

4-5.3.6 Directly-Connected Noncoded Systems.

4-5.3.6.1 Circuits for transmission of alarm signals between the fire alarm control unit or the transmitter in the protected premises and the supervising station shall be arranged so as to comply with either of the following provisions:

(a) These circuits shall be arranged so that the occurrence of a single break or single ground fault does not prevent the transmission of an alarm signal. Circuits complying with this paragraph shall be automatically self-adjusting in the event of either a single break or a single ground fault and shall be automatically self-restoring in the event that the break or fault is corrected.

(b) These circuits shall be arranged so that they are normally isolated from ground (except for reference ground detection) and so that a single ground fault does not prevent the transmission of an alarm signal. Circuits complying with this paragraph shall be provided with a ground reference circuit so as to detect and indicate automatically the existence of a single ground fault, unless a multiple ground-fault condition that would prevent alarm operation is to be indicated by an alarm or by a trouble signal.

4-5.3.6.2 Circuits for transmission of supervisory signals shall be separate from alarm circuits. These circuits within the protected premises and between the protected premises and the supervising station shall be arranged as described in 4-5.3.6.1(a) or (b).

Exception: Where the reception of alarm signals and supervisory signals at the same supervising station is permitted by the authority having jurisdiction, the supervisory signals do not interfere with the alarm signals, and alarm signals have priority, the same circuit between the protected premises and the supervising station shall be permitted to be used for alarm and supervisory signals.

4-5.3.6.3 The occurrence of a single break or a single ground fault on any circuit shall not of itself cause a false signal that could be interpreted as an alarm of fire.

4-5.3.6.4 The requirements of 4-5.3.6.1 and 4-5.3.6.2 shall not apply to the following circuits:

(a) Circuits wholly within the supervising station;

(b) Circuits wholly within the protected premises extending from one or more automatic fire detectors or other noncoded initiating devices other than waterflow devices to a transmitter or control unit; or

(c) Power supply leads wholly within the building or buildings protected.

Table 4-5.3.5.6 Loading Capacities of One-Way Radio Alarm Systems

	System Type	
	Type 6	**Type 7**
A. Radio Alarm Repeater Station Receiver (RARSR)		
Maximum number of fire alarm service initiating device circuits per RARSR	5120	5120
Maximum number of RATs for fire	512	512
Maximum number of all types of initiating device circuits per RARSR in any combination[1]	10,240	10,240
Maximum number of RATs for all types of fire alarm service per RARSR in any combination[1]†	1024	1024
B. System Units at the Supervising Station		
Maximum number of all types of initiating device circuits per system unit[1]	10,240[2]	10,240[2]
Maximum number of fire protected buildings and premises per system unit	512[2]	512[2]
Maximum number of fire alarm service initiating device circuits per system unit	5120[2]	5120[2]

[1]Includes every initiating device circuit (e.g., waterflow, fire alarm, supervisory, guard, burglary, hold-up).
[2]Paragraph 4-5.3.5.7 applies.
†Each supervised BA (open/close) or each suppressed guard tour transmitter shall reduce the allowable RATs by five.
Each guard tour transmitter shall reduce the allowable RATs by 15.
Each two-way protected premises radio transmitter shall reduce the allowable RATs by two.

4-5.3.6.5 Loading Capacity of Circuits.

4-5.3.6.5.1 The number of initiating devices connected to any signaling circuit and the number of plants that shall be permitted to be served by a signal circuit shall be determined by the authority having jurisdiction and shall not exceed the limitations specified in 4-5.3.6.5.

NOTE: A plant can consist of one or more buildings under the same ownership.

4-5.3.6.5.2 A single circuit shall not serve more than one plant.

NOTE: Where a single plant involves more than one gate entrance or involves a number of buildings, separate circuits might be required so that the alarm to the supervising station indicates the area to which the fire department is to be dispatched.

4-5.3.7 Private Microwave Radio Systems.

4-5.3.7.1* Where a private microwave radio is used as the transmission channel and communications channel, appropriate supervised transmitting and receiving equipment shall be provided at supervising, subsidiary, and repeater stations.

4-5.3.7.2 Where more than five protected buildings or premises or 50 initiating devices or initiating device circuits are being serviced by a private radio carrier, the supervising, subsidiary, and repeater station radio facilities shall meet all of the following:

(a) Dual supervised transmitters, arranged for automatic switching from one to the other in case of trouble, shall be installed. Where the transmitters are located where someone is always on duty, switchboard facilities shall be permitted to be manually operated, provided the switching can be carried out within 30 seconds. Where the transmitters are located where no one is normally on duty, the circuit extending between the supervising station and the transmitters shall be a supervised circuit.

(b)* Transmitters shall be operated on a time ratio of 2:1 within each 24 hours.

(c) Dual receivers shall be installed with a means for selecting a usable output from one of the two receivers. The failure of one shall in no way interfere with the operation of the other. Failure of either receiver shall be annunciated.

4-5.3.7.3 Means shall be provided at the supervising station for the supervision and control of supervising, subsidiary, and repeater station radio transmitting and receiving equipment. This shall be accomplished via a supervised circuit where the radio equipment is remote from the supervising station.

(a) The following conditions shall be supervised at the supervising station:

1. Transmitter in use (radiating);
2. Failure of ac power supplying the radio equipment;
3. Receiver malfunction;
4. Indication of automatic switchover.

(b) It shall be possible to independently deactivate either transmitter from the supervising station.

4-5.4 Display and Recording.

4-5.4.1* Any status changes (including the initiation or restoration to normal of a trouble condition) that occur in an initiating device or in any interconnecting circuits or equipment, including the local protected premises controls from

the location of the initiating device(s) to the supervising station, shall be presented in a form to expedite prompt operator interpretation. Status change signals shall provide the following information:

(a) *Type of Signal.* Identification of the type of signal to show whether it is an alarm, supervisory, delinquency, or trouble signal;

(b) *Condition.* Identification of the signal to differentiate between an initiation of an alarm, supervisory, delinquency, or trouble signal and a restoration to normal from one or more of these conditions;

(c) *Location.* Identification of the point of origin of each status change signal.

4-5.4.2* Where duplicate equipment for signal receiving, processing, display, and recording is not provided, the installed equipment shall be so designed that any critical assembly can be replaced from on-premises spares and the system can be restored to service within 30 minutes. A critical assembly is an assembly in which a malfunction prevents the receipt and interpretation of signals by the supervising station operator.

Exception: Proprietary and remote station systems.

4-5.4.3* Any method of recording and display or indication of change of status signals shall be permitted, provided all of the following conditions are met:

(a) Each change of status signal requiring action to be taken by the operator shall result in an audible signal and not less than two independent methods of identifying the type, condition, and location of the status change.

(b) Each change of status signal shall be automatically recorded. The record shall provide the type of signal, condition, and location as required by 4-5.4.1 in addition to the time and date the signal was received.

(c) Failure of an operator to acknowledge or act upon a change of status signal shall not prevent subsequent alarm signals from being received, indicated or displayed, and recorded.

(d) Change of status signals requiring action to be taken by the operator shall be displayed or indicated in a manner that clearly differentiates them from those that have been acted upon and acknowledged.

(e) Each incoming signal to a DACR or DARR shall cause an audible signal that persists until manually acknowledged.

Exception: Test signals (see 4-5.3.2.1.10) received at a DACR or a DARR.

4-5.5 Testing and Maintenance. Testing and maintenance of communications methods shall be in accordance with the requirements of Chapter 7.

4-6 Public Fire Alarm Reporting Systems.

NOTE: The requirements of Chapters 1, 5, and 7 apply to public fire alarm reporting systems, unless they conflict with the requirements of this section.

4-6.1 Scope. This section covers the general requirements and use of public fire alarm reporting systems. These systems include the equipment necessary to effect the transmission and reception of fire alarms or other emergency calls from the public.

4-6.2 General Fundamentals.

4-6.2.1* Where implemented at the option of the authority having jurisdiction, a public fire alarm reporting system shall be designed, installed, operated, and maintained to provide the maximum practicable reliability for transmission and receipt of fire alarms.

4-6.2.2 It shall be permitted for a public fire alarm reporting system, as described herein, to be used for the transmission of other signals or calls of a public emergency nature, provided such transmission does not interfere with the transmission and receipt of fire alarms.

4-6.2.3 Alarm systems shall be Type A or Type B. A Type A system shall be provided where the number of all alarms required to be transmitted over the dispatch circuits exceeds 2500 per year.

NOTE: Where a Type A system is required, automatic transmission of alarms from boxes by use of electronic equipment is permitted, provided the following conditions are satisfied:

(a) Reliable facilities are provided for the automatic receipt, storage, retrieval, and transmission of alarms in the order received; and

(b) Override capability is provided to the operator(s) so that manual transmission and dispatch facilities are instantly available.

4-6.3 Management and Maintenance. See Chapter 7.

4-6.4 Equipment and Installation.

4-6.4.1 Means for actuation of alarms by the public shall be conspicuous and readily accessible for easy operation.

4-6.4.2 Public fire alarm reporting systems as defined in this chapter, shall, in their entirety, be subject to a complete operational acceptance test upon completion of system installation. This test(s) shall be made in accordance with the requirements of the authority having jurisdiction. However, in no case shall the operational functions tested be less than those stipulated in Chapter 7. Similar tests shall be performed on any alarm reporting devices as identified in this chapter that are added subsequent to the installation of the initial system.

4-6.4.3 Publicly accessible boxes shall be recognizable as such. Boxes shall have operating instructions plainly marked on the exterior surface.

4-6.4.4 The actuating device shall be readily available and of such design and so located as to make the method of its use apparent.

4-6.4.5 Publicly accessible boxes shall be as conspicuous as possible. Their color shall be distinctive.

4-6.4.6 All publicly accessible boxes mounted on support poles shall be identified by a wide band of distinctive colors or adequate signs placed 8 ft (2.44 m) above the ground and visible from all directions wherever possible.

4-6.4.7* Indicating lights of a distinctive color, visible for at least 1500 ft (460 m), shall be installed over publicly accessible boxes in mercantile and manufacturing areas. Equipping the street light nearest the box with a distinctively colored light shall be considered as meeting this requirement.

4-6.4.8 Boxes shall be securely mounted on poles, pedestals, or structural surfaces as directed by the authority having jurisdiction.

4-6.4.9 Concurrent operation of at least four boxes shall not result in the loss of an alarm.

4-6.5 Design of Boxes. See Chapter 5.

4-6.6* Location of Boxes. The location of publicly accessible boxes shall be designated by the authority having jurisdiction. Schools, hospitals, nursing homes, and places of public assembly shall have a box located at or near the main entrance, as directed by the authority having jurisdiction.

4-6.7 Power Supply.

4-6.7.1 General.

4-6.7.1.1 Batteries, motor-generators, or rectifiers shall be sufficient to supply all connected circuits without exceeding the capacity of any battery or overloading any generator or rectifier, so that circuits developing grounds or crosses with other circuits each can be supplied by an independent source to the extent required by 4-6.7.1.8(b).

4-6.7.1.2 Provision shall be made in the operating room for supplying any circuit from any battery, generator, or rectifier. Enclosed fuses shall be provided at points where supplies for individual circuits are taken from common leads. Necessary switches, testing, and signal-transmitting and receiving devices shall be provided to allow the isolation, control, and test of each circuit up to at least 10 percent of the total number of box and dispatch circuits, but never less than two circuits.

4-6.7.1.3 Where common-current source systems are grounded, the ground shall not exceed 10 percent of resistance of any connected circuit and shall be located at one side of the battery. Visual and audible indicating devices shall be provided for each box and dispatch circuit to give immediate warning of ground leakage endangering operability.

4-6.7.1.4 Local circuits at communications centers shall be supplied either in common with box circuits or coded radio-receiving system circuits or by a separate power source. The source of power for local circuits required to operate the essential features of the system shall be supervised.

4-6.7.1.5 Visual and audible means to indicate a 15 percent or greater reduction of normal power supply (rated voltage) shall be provided.

4-6.7.1.6 The forms and arrangements of power supply shall be classified as described in 4-6.7.1.7 through 4-6.7.1.9.

NOTE: Where the electrical service/capacity of the equipment required under NFPA 1221, *Standard for the Installation, Maintenance, and Use of Public Fire Service Communication Systems*, 2-1.6, is adequate to satisfy the needs of equipment in Section 4-6, such equipment is not required to be duplicated.

4-6.7.1.7 Form 2. Form 2 shall be permitted for Type A systems only. Box circuits shall be served in multiple by:

(a)* *Form 2A.* A rectifier or motor-generator powered from a single source of alternating current, with a floating storage battery having a 24-hour standby capacity.

(b)* *Form 2B.* A rectifier or motor-generator powered from two sources of alternating current, with a floating storage battery having a 4-hour standby capacity.

(c)* *Form 2C.* A duplicate rectifier or motor-generator powered from two sources of alternating current with transfer facilities to apply power from the secondary source to the system within 30 seconds (*see NFPA 1221, Standard for the Installation, Maintenance, and Use of Public Fire Service Communication Systems*). Each rectifier or motor-generator shall be capable of powering the entire system.

NOTE: For Forms 2A, 2B, and 2C, these arrangements are permitted but are not recommended where circuits are wholly or partly open-wire because of the possibility of trouble from multiple grounds.

4-6.7.1.8 Form 3. Each box circuit or coded radio receiving system shall be served by:

(a)* *Form 3A.* A rectifier or motor-generator powered from a single source of alternating current with a floating storage battery having a 60-hour standby capacity.

(b)* *Form 3B.* A rectifier or motor-generator powered from two sources of alternating current with a floating storage battery having a 24-hour standby capacity.

4-6.7.1.9 Form 4. Each box circuit or coded radio receiving system shall be served by:

(a)* *Form 4A.* An inverter powered from a common rectifier receiving power by a single source of alternating current with a floating storage battery having a 24-hour standby capacity.

(b)* *Form 4B.* An inverter powered from a common rectifier receiving power from two sources of alternating current with a floating storage battery having a 4-hour standby capacity.

NOTE: For Form 4A and Form 4B, it is permitted to distribute the system load between two or more common rectifiers and batteries.

(c)* *Form 4C.* A rectifier, converter, or motor-generator receiving power from two sources of alternating current with transfer facilities to apply power from the secondary source to the system within 30 seconds. (*See NFPA 1221, Standard for the Installation, Maintenance, and Use of Public Fire Service Communication Systems.*)

4-6.7.2 Rectifiers, Converters, Inverters, and Motor-Generators.

4-6.7.2.1 Rectifiers shall be supplied through an isolating transformer taking energy from a circuit not to exceed 250 volts.

4-6.7.2.2 Complete, ready-to-use spare units or spare parts shall be available in reserve.

4-6.7.2.3 One spare rectifier shall be provided for each 10 required for operation, but in no case shall less than one be available.

4-6.7.2.4 Leads from rectifiers or motor-generators, with storage battery floating, shall have fuses rated at not less than 1 ampere and not more than 200 percent of maximum connected load. Where not provided with battery floating, the fuse shall be not less than 3 amperes.

4-6.7.3 Engine-Driven Generator Sets.

4-6.7.3.1 The provisions of 4-6.7.3 shall apply to generators driven by internal combustion engines.

4-6.7.3.2 The installation of such units shall conform to the provisions of NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, and NFPA 110, *Standard for Emergency and Standby Power Systems*.

Exception: Where restricted by the provisions of 4-6.7.3.

4-6.7.3.3 The engine-driven generator shall be located in an adequately ventilated cutoff area of the building housing the communications center equipment. The area housing the unit shall be used for no other purpose other than for storage of spare parts or equipment. Exhaust fumes shall be discharged directly outside the building.

4-6.7.3.4 Liquid fuel shall be stored in outside underground tanks and gravity feed shall not be used. Sufficient fuel shall be available for 24 hours of operation at full load where a reliable source of fuel supply is available, at any time, on 2-hours' notice. Where a source of supply is not reliable or readily available, or where special arrangements need to be made for refueling as necessary, a supply sufficient for 48 hours of operation at full load shall be maintained.

4-6.7.3.5 Liquefied petroleum gas and natural gas installations shall meet the requirements of NFPA 54, *National Fuel Gas Code*, and NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*.

4-6.7.3.6 The unit, as a minimum, shall be of sufficient capacity to supply power to operate all fire alarm facilities and emergency lighting of the operating rooms or communications building.

4-6.7.3.7 A separate storage battery on automatic float charger shall be provided for starting the engine-driven generator.

4-6.7.3.8 Where more than one engine-driven generator is provided, each shall be provided with a separate fuel line and transfer pump.

4-6.7.4 Float-Charged Batteries.

4-6.7.4.1 Batteries shall be of the storage type; primary batteries (dry cells) shall not be used. All cells shall be of the sealed type. Lead-acid batteries shall be in jars of glass or other suitable transparent materials; other types of batteries shall be in containers suitable for the purpose.

4-6.7.4.2 Batteries shall be located in the same building as the operating equipment, preferably on the same floor, and readily accessible for maintenance and inspection. The battery room shall be aboveground and shall be ventilated to prevent accumulation of explosive gas mixtures; special ventilation shall be required only for unsealed cells.

Exception: Where permitted by NFPA 1221, Standard for the Installation, Maintenance, and Use of Public Fire Service Communication Systems, 2-11.2, the battery room shall not be required to be aboveground.

4-6.7.4.3 Batteries shall be mounted to provide effective insulation from the ground and from other batteries. The mounting shall be suitably protected against deterioration, and consideration shall be given to stability, especially in geographic areas subject to seismic disturbance.

4-6.8 Requirements for Metallic Systems and Metallic Interconnections.

4-6.8.1 Circuit Conductors.

4-6.8.1.1 Wires shall be terminated so as to provide good electrical conductivity and to prevent breaking from vibration or stress.

4-6.8.1.2 Circuit conductors on terminal racks shall be identified and isolated from conductors of other systems wherever possible and shall be suitably protected from mechanical injury.

4-6.8.1.3 Exterior cable and wire shall conform to International Municipal Signal Association specifications or their equivalent.

Exception: Where otherwise provided herein.

4-6.8.1.4 Where a public box is installed inside a building, it shall be placed as close as practical to the point of entrance of the circuit. The circuit from the point of entrance to the public box shall be installed in conduit or electrical metallic tubing in accordance with Chapter 3 of NFPA 70, *National Electrical Code*.

Exception: This requirement shall not apply to coded radio box systems.

4-6.8.2 Cables.

4-6.8.2.1 General.

4-6.8.2.1.1 Cables that meet the requirements of NFPA 70, *National Electrical Code*, Article 310, for installation in wet locations shall be satisfactory for overhead or underground installation.

Exception: Direct-burial cable shall be specifically approved for this purpose.

4-6.8.2.1.2 Paper or pressed pulp insulation shall not be considered satisfactory for an emergency service such as a fire alarm system, except that cables containing conductors with such insulation shall be permitted where pressurized with dry air or nitrogen. Loss of pressure in cables shall be indicated by a visual or audible warning system located where an individual who can interpret the pressure readings and who has authority to have the indicated abnormal condition corrected is in constant attendance.

4-6.8.2.1.3 Natural rubber-sheathed cable shall not be used where it could be exposed to oil, grease, or other substances or conditions that tend to deteriorate the cable sheath. Braided-sheathed cable shall be used only inside of buildings where run in conduit or metal raceways.

4-6.8.2.1.4 Other municipally controlled signal wires shall be permitted to be installed in the same cable with fire alarm wires. Cables controlled by or containing wires of private signaling organizations shall be permitted to be used for fire alarm purposes only by permission of the authority having jurisdiction.

4-6.8.2.1.5 Signaling wires that, because of the source of current supply, might introduce a hazard shall be protected and supplied as required for lighting circuits.

4-6.8.2.1.6 All cables with all taps and splices made shall be tested for insulation resistance when installed, but before connection to terminals. Such tests shall indicate an insulation resistance of at least 200 megohms per mile between any one conductor and all other conductors, the sheath, and the ground.

4-6.8.2.2 Underground Cables.

4-6.8.2.2.1 Underground cables in duct or direct burial shall be brought aboveground only at points where liability of mechanical injury or of disablement from heat incident to fires in adjacent buildings is minimized.

4-6.8.2.2.2 Cables shall be permitted in duct systems and manholes containing low-tension fire alarm system conductors only, except low-tension secondary power cables shall be permitted. Where in duct systems or manholes containing power circuit conductors in excess of 250 volts to ground, fire alarm cables shall be located as far as possible from such power cables and shall be separated from them by a noncombustible barrier or by such other means as is practicable to protect the fire alarm cables from injury.

4-6.8.2.2.3 All cables installed in manholes shall be properly racked and marked for identification.

4-6.8.2.2.4 All conduits or ducts entering buildings from underground duct systems shall be effectively sealed against moisture or gases entering the building.

4-6.8.2.2.5 Cable joints shall be located only in manholes, fire stations, and other locations where proper accessibility is provided and where there is little liability of injury to the cable due to either falling walls or operations in the buildings. Cable joints shall be made to provide and maintain conductivity, insulation, and protection at least equal to that afforded by the cables that are joined. Cable ends shall be sealed against moisture.

4-6.8.2.2.6 Direct-burial cable, without enclosure in ducts, shall be laid in grass plots, under sidewalks, or in other places where the ground is not likely to be opened for other underground construction. If splices are made, such splices shall, where practicable, be accessible for inspection and tests. Such cables shall be buried at least 18 in. (0.5 m) deep and, where crossing streets or other areas likely to be opened for other underground construction, shall be in duct or conduit or be covered by creosoted planking of at least 2 in. × 4 in. (50 mm × 100 mm) with half-round grooves, spiked or banded together after the cable is installed.

4-6.8.2.3 Aerial Construction.

4-6.8.2.3.1 Fire alarm wires shall be run under all other wires except communications wires. Suitable precautions shall be provided where passing through trees, under bridges, over railroads, and at other places where injury or deterioration is possible. Wires and cables shall not be attached to a crossarm carrying electric light and power wires, except circuits carrying up to 220 volts for municipal communications use. Such 220-volt circuits shall be tagged or otherwise identified.

4-6.8.2.3.2 Aerial cable shall be supported by messenger wire of adequate tensile strength.

Exception: Where permitted in 4-6.8.2.3.3.

4-6.8.2.3.3 Two-conductor cable shall be messenger-supported.

Exception: Where two-conductor cable has conductors of No. 20 AWG or larger size and has mechanical strength equivalent to No. 10 AWG hard-drawn copper.

4-6.8.2.3.4 Single wire shall meet International Municipal Signal Association specifications and shall not be smaller than No. 10 Roebling gauge where of galvanized iron or steel, No. 10 AWG where of hard-drawn copper, No. 12 AWG where of approved copper-covered steel, or No. 6 AWG where of aluminum. Span lengths shall not exceed manufacturers' recommendations.

4-6.8.2.3.5 Wires to buildings shall contact only intended supports and shall enter through an approved weatherhead or suitable sleeves slanting upward and inward. Drip loops shall be formed on wires outside of buildings.

4-6.8.2.4 Leads Down Poles.

4-6.8.2.4.1 Leads down poles shall be protected against mechanical injury. Any metallic covering shall form a continuous conducting path to ground. Installation, in all cases, shall prevent water from entering the conduit or box.

4-6.8.2.4.2 Leads to boxes shall have 600-volt insulation approved for wet locations, as defined in NFPA 70, *National Electrical Code*.

4-6.8.2.5 Wiring Inside Buildings.

4-6.8.2.5.1 At the communications center, conductors shall extend as directly as possible to the operating room in conduits, ducts, shafts, raceways, or overhead racks and troughs of a type of construction affording protection against fire and mechanical injury.

4-6.8.2.5.2 All conductors inside buildings shall be in conduit, electrical tubing, metal molding, or raceways. Installation shall be in accordance with NFPA 70, *National Electrical Code*.

4-6.8.2.5.3 Conductors shall have an approved insulation; the insulation or other outer covering shall be flame-retardant and moisture-resistant.

4-6.8.2.5.4 Conductors shall be installed as far as possible without joints. Splices shall be permitted only in junction or terminal boxes. Wire terminals, splices, and joints shall conform to NFPA 70, *National Electrical Code*.

4-6.8.2.5.5 Conductors bunched together in a vertical run connecting two or more floors shall have a flame-retardant covering sufficient to prevent the carrying of fire from floor to floor.

Exception: This requirement shall not apply where the conductors are encased in a metallic conduit or located in a fire-resistive shaft having fire stops at each floor.

4-6.8.2.5.6 Where cable or wiring is exposed to unusual fire hazards, it shall be properly protected.

4-6.8.2.5.7 Cable terminals and cross-connecting facilities shall be located in or adjacent to the operations room.

4-6.8.2.5.8 Where signal conductors and electric light and power wires are run in the same shaft, they shall be separated by at least 2.0 in. (51 mm), or either system shall be encased in a noncombustible enclosure.

4-6.9 Facilities for Signal Transmission.

4-6.9.1 Circuits.

4-6.9.1.1 General.

4-6.9.1.1.1 ANSI/IEEE C2, *National Electrical Safety Code*, shall be used as a guide for the installation of outdoor circuitry.

4-6.9.1.1.2 In all installations, first consideration shall be given to continuity of service. Particular attention shall be given to liability of mechanical injury; disablement from heat that is incident to a fire; injury by falling walls; and damage by floods, corrosive vapors, or other causes.

4-6.9.1.1.3 Open local circuits within single buildings shall be permitted in accordance with Chapter 3.

4-6.9.1.1.4 All circuits shall be so routed as to allow ready tracing of circuits for trouble.

4-6.9.1.1.5 Circuits shall not pass over, under, through, or be attached to buildings or property not owned by or under the control of the authority having jurisdiction or the agency responsible for maintaining the system.

Exception: Where the circuit is terminated in a box on the premises.

4-6.9.1.2 Box Circuits. Accessible and reliable means, available only to the authority having jurisdiction or the agency responsible for maintaining the public fire alarm reporting system, shall be provided for disconnecting the auxiliary loop to the box inside the building, and definite notification shall be given to occupants of the building when the interior box is not in service.

4-6.9.1.3 Tie Circuits.

4-6.9.1.3.1 A separate tie circuit shall be provided from the communications center to each subsidiary communications center.

4-6.9.1.3.2 The tie circuit between the communications center and the subsidiary communications center shall not be used for any other purpose.

4-6.9.1.3.3 In a Type B wire system, where all boxes in the system are of the succession type, it shall be permitted to use the tie circuit as a dispatch circuit to the extent permitted by NFPA 1221, *Standard for the Installation, Maintenance, and Use of Public Fire Service Communication Systems.*

4-6.9.1.4* Circuit Protection.

4-6.9.1.4.1 General.

4-6.9.1.4.1.1 The protective devices shall be located close to or be combined with the cable terminals.

4-6.9.1.4.1.2 Lightning arresters suitable for the purpose shall be provided. Lightning arresters shall be marked with the name of the manufacturer and model designation.

4-6.9.1.4.1.3 All lightning arresters shall be connected to a suitable ground in accordance with NFPA 70, *National Electrical Code.*

4-6.9.1.4.1.4 All fuses shall be plainly marked with their rated ampere capacity. All fuses rated over 2 amperes shall be of the enclosed type.

4-6.9.1.4.1.5 Circuit protection required at the communications center shall be provided in every building housing communications center equipment.

4-6.9.1.4.1.6 Each conductor entering a fire station from partially or entirely aerial lines shall be protected by a lightning arrester.

4-6.9.1.4.2 Communications Center.

4-6.9.1.4.2.1 All conductors entering the communications center shall be protected by the following devices, in the order named, starting from the exterior circuit:

(a) A fuse rated at 3 amperes minimum to 7 amperes maximum, and not less than 2000 volts;

(b) A lightning arrester;

(c) A fuse or circuit breaker, rated at 1/2 ampere.

4-6.9.1.4.2.2 The 1/2-ampere protection on the tie circuits shall be omitted at subsidiary communications centers.

4-6.9.1.4.3 Protection on Aerial Construction.

4-6.9.1.4.3.1 At junction points of open aerial conductors and cable, each conductor shall be protected by a lightning arrester of the weatherproof type. There also shall be a connection between the lightning arrester ground, any metallic sheath, and messenger wire.

4-6.9.1.4.3.2 Aerial open-wire and non-messenger-supported two-conductor cable circuits shall be protected by a lightning arrester at intervals of approximately 2000 ft (610 m).

4-6.9.1.4.3.3 Lightning arresters, other than of the air-gap or self-restoring type, shall not be installed in fire alarm circuits.

4-6.9.1.4.3.4 All protective devices shall be accessible for maintenance and inspection.

4-6.10 Power.

4-6.10.1 Requirements for Constant-Current Systems.

4-6.10.1.1 Means shall be provided for manually regulating the current in box circuits so that the operating current is maintained within 10 percent of normal throughout changes in external circuit resistance from 20 percent above to 50 percent below normal.

4-6.10.1.2 The voltage supplied to maintain normal line current on box circuits shall not exceed 150 volts, measured under no-load conditions, and shall be such that the line current cannot be reduced below safe operating value by the simultaneous operation of four boxes.

4-6.10.1.3 Visual and audible means to indicate a 20 percent or greater reduction in the normal current in any alarm circuit shall be provided. All devices connected in series with any alarm circuit shall function properly when the alarm circuit current is reduced to 70 percent of normal.

4-6.10.1.4 Sufficient meters shall be provided to indicate the current in any box circuit and the voltage of any power source. Meters used in common for several circuits shall be provided with cut-in devices designed to reduce the probability of cross-connecting circuits.

4-6.11 Receiving Equipment — Facilities for Receipt of Box Alarms.

4-6.11.1 General.

4-6.11.1.1 Alarms from boxes shall be automatically received and recorded at the communications center.

4-6.11.1.2 A permanent visual record and an audible signal shall be required to indicate the receipt of an alarm. The permanent record shall indicate the exact location from which the alarm is being transmitted.

NOTE: The audible signal device can be common to several box circuits and arranged so that the fire alarm operator can manually silence the signal temporarily by a self-restoring switch.

4-6.11.1.3 Facilities shall be provided that automatically record the date and time of receipt of each alarm.

Exception: Only the time shall be required to be automatically recorded for voice recordings.

4-6.11.2 Visual Recording Devices.

4-6.11.2.1 A device for producing a permanent graphic recording of all alarm, supervisory, trouble, and test signals received or retransmitted, or both, shall be provided at each communications center for each alarm circuit and tie circuit. Where each circuit is served by a dedicated recording device, the number of reserve recording devices required on site shall be equal to at least 5 percent of the circuits in service and in no case less than 1 percent. Where two or more circuits are served by a common recording device, a reserve recording device shall be available on site for each circuit connected to a common recorder.

4-6.11.2.2 In a Type B wire system, one such recording device shall be installed in each fire station and at least one shall be installed in the communications center.

4-6.12 Supervision.

4-6.12.1 To ensure reliability, wired circuits upon which transmission and receipt of alarms depend shall be under constant electrical supervision to give prompt warning of conditions adversely affecting reliability.

4-6.12.2 The power supplied to all required circuits and devices of the system shall be supervised.

4-6.12.3 Trouble signals shall actuate a sounding device located where there is a responsible person on duty at all times.

4-6.12.4 Trouble signals shall be distinct from alarm signals and shall be indicated by both a visual light and an audible signal.

NOTE 1: The audible signal can be common to several supervised circuits.

NOTE 2: A switch for silencing the audible trouble signal is permitted, provided the visual signal remains operating until the silencing switch is restored to its normal position.

4-6.12.5 The audible signal shall be responsive to faults on any other circuits that occur prior to restoration of the silencing switch to normal.

4-6.13 Coded Wired Reporting Systems.

4-6.13.1 For a Type B system, the effectiveness of noninterference and succession functions between box circuits shall be no less than between boxes in any one circuit. The disablement of any metallic box circuit shall cause a warning signal in all other circuits, and, thereafter, the circuit or circuits not otherwise broken shall be automatically restored to operative condition.

4-6.13.2 Box circuits shall be sufficient in number and so laid out that the areas that would be left without box protection in case of disruption of a circuit do not exceed those covered by 20 properly spaced boxes where all or any part of the circuit is of aerial open-wire, or 30 properly spaced boxes where the circuit is entirely in underground or messenger-supported cable.

4-6.13.3 Where all boxes on any individual circuit and associated equipment are designed and installed to provide for receipt of alarms through the ground in the event of a break in the circuit, the circuit shall be permitted to serve twice the number of aerial open-wire and cable circuits, respectively, as are specified in 4-6.13.2.

4-6.13.4 The installation of additional boxes in an area served by the number of properly spaced boxes indicated above shall not constitute geographical overloading of a circuit.

4-6.13.5 Sounding devices for signals shall be provided for box circuits.

NOTE 1: In a Type A system, it is satisfactory to use a common sounding device for more than one circuit, and it should be installed at the communications center.

NOTE 2: In a Type B system, a sounding device is to be installed in each fire station at the same location as the recording device for that circuit, unless installed at the communications center, where a common sounding device is permitted.

4-6.14 Coded Radio Reporting Systems.

4-6.14.1 Radio Box Channel (Frequency).

4-6.14.1.1 The number of boxes permitted on a single frequency shall be governed by the following:

(a) For systems utilizing one-way transmission in which the individual box automatically initiates the required message (*see 4-6.14.6.3*) using circuitry integral to the boxes, not more than 500 boxes shall be permitted on a single frequency.

(b) For systems utilizing a two-way concept in which interrogation signals (*see 4-6.14.6.3*) are transmitted to the individual boxes from the communications center on the same frequency used for receipt of alarms, not more than 250 boxes shall be permitted on a single frequency. Where interrogation signals are transmitted on a frequency that differs from that used for receipt of alarms, not more than 500 boxes shall be permitted on a single frequency.

(c) A specific frequency shall be designated for both fire and other fire-related or public safety alarm signals, and supervisory signals (test and tamper). All acknowledgment and other signals shall utilize a separate frequency.

4-6.14.1.2 Where box message signals to the communications center or acknowledgment of message receipt signals from the communications center to the box are repeated, associated repeating facilities shall conform to the requirements indicated in NFPA 1221, *Standard for the Installation, Maintenance, and Use of Public Fire Service Communication Systems*, 3-4.1.2.

4-6.14.2 Metallic Interconnections. Accessible and reliable means, available only to the agency responsible for maintaining the public fire alarm reporting system, shall be provided for disconnecting the auxiliary loop to the box inside the building, and definite notification shall be given to occupants of the building when the interior box is not in service.

4-6.14.3 Receiving Equipment — Facilities for Receipt of Box Alarms.

4-6.14.3.1 Type A System.

4-6.14.3.1.1* For each frequency used, two separate receiving networks, each including an antenna, an audible alerting device, a receiver, a power supply, signal processing equipment, a means of providing a permanent graphic recording of the incoming message that is both timed and dated, and other associated equipment shall be provided

and shall be installed at the communications center. Facilities shall be so arranged that a failure of either receiving network cannot affect the receipt of messages from boxes.

4-6.14.3.1.2 Where the system configuration is such that a polling device is incorporated into the receiving network to allow remote/selective initiation of box tests (*see Chapter 7*), a separate such device shall be included in each of the two required receiving networks. Furthermore, the polling devices shall be configured for automatic cycle initiation in their primary operating mode, capable of continuous self-monitoring, and integrated into the network(s) to provide automatic switchover and operational continuity in the event of failure of either device.

4-6.14.3.1.3 Test signals from boxes shall not be required to include the date as part of their permanent recording, provided that the date is automatically printed on the recording tape at the beginning of each calendar day.

4-6.14.3.2 Type B System.

4-6.14.3.2.1 For each frequency used, a single, complete receiving network shall be permitted in each fire station, provided the communications center conforms to 4-6.14.3.1.1. Where the jurisdiction maintains two or more alarm reception points in operation, one receiving network shall be permitted to be at each alarm reception point.

4-6.14.3.2.2 Where alarm signals are transmitted to a fire station from the communications center using the coded radio-type receiving equipment in the fire station to receive and record the alarm message, a second receiving network conforming to 4-6.14.3.2.1 shall be provided at each fire station, and that receiving network shall employ a frequency other than that used for the receipt of box messages.

4-6.14.4 Power. Power shall be provided in accordance with 4-6.7.

4-6.14.5 Testing. See Chapter 7.

4-6.14.6 Supervision.

4-6.14.6.1 All coded radio box systems shall provide constant monitoring of the frequency in use. Both an audible and a visual indication of any sustained carrier signal, where in excess of 15 seconds' duration, shall be provided for each receiving system at the communications center.

4-6.14.6.2 The power supplied to all required circuits and devices of the system shall be supervised.

4-6.14.6.3 Each coded radio box shall automatically transmit a test message at least once in each 24-hour period.

4-6.14.6.4 Receiving equipment associated with coded radio-type systems, including any related repeater(s), shall be tested at least hourly. The receipt of test messages shall be considered sufficient to comply with this requirement, provided at least one such message is received each hour.

4-6.14.6.5 Radio repeaters upon which receipt of alarms depend shall be provided with dual receivers and transmitters. Failure of the primary transmitter or receiver shall cause an automatic switchover to the secondary receiver and transmitter.

Exception: Where the repeater controls are located where an individual is always on duty, manual switchover shall be permitted, provided it can be completed within 30 seconds.

4-6.14.6.6 Trouble signals shall actuate a sounding device located where there is always a responsible person on duty.

4-6.14.6.7 Trouble signals shall be distinct from alarm signals and shall be indicated by both a visual light and an audible signal.

NOTE 1: The audible signal may be permitted to be common to several supervised circuits.

NOTE 2: A switch for silencing the audible trouble signal may be permitted where the visual signal remains operating until the silencing switch is restored to its normal position.

4-6.14.6.8 The audible signal shall be responsive to faults on any other circuits that might occur prior to restoration of the silencing switch to normal.

4-6.15 Telephone (Series) Reporting Systems.

4-6.15.1 A permanent visual recording device installed in the communications center shall be provided to record all incoming box signals. A spare recording device shall be provided for five or more box circuits.

4-6.15.2 A second visual means of identifying the calling box shall be provided.

4-6.15.3 Audible signals shall indicate all incoming calls from box circuits.

4-6.15.4 All voice transmissions from boxes for emergencies shall be recorded with the capability of instant playback.

4-6.15.5 A voice recording facility shall be provided for each operator handling incoming alarms to eliminate the possibility of interference.

4-6.15.6 Box circuits shall be sufficient in number and so laid out that the areas that would be left without box protection in case of disruption of a circuit do not exceed those covered by 20 properly spaced boxes where all or any part of the circuit is of aerial open-wire, or 30 properly spaced boxes where the circuit is entirely in underground or messenger-supported cable.

4-6.15.7 Where all boxes on any individual circuit and associated equipment are designed and installed to provide for receipt of alarms through the ground in the event of a break in the circuit, the circuit shall be permitted to serve twice the number of aerial open-wire and cable circuits, respectively, as are specified in 4-6.15.6.

4-6.15.8 The installation of additional boxes in an area served by the number of properly spaced boxes indicated above shall not constitute geographical overloading of a circuit.

4-6.16 Telephone (Parallel) Reporting Systems.

4-6.16.1 Box Circuits.

4-6.16.1.1 Where a municipal box is installed inside a building, it shall be placed as close as practical to the point of entrance of the circuit, and the exterior wire shall be installed in conduit or electrical metallic tubing, in accordance with Chapter 3 of NFPA 70, *National Electrical Code*.

4-6.16.1.2 Accessible and reliable means, available only to the authority having jurisdiction or the agency responsible for maintaining the public fire alarm reporting system, shall be provided for disconnecting the box inside the building, and definite notification shall be given to occupants of the building when the interior box is not in service.

4-6.16.1.3 A separate circuit shall be provided for each box.

4-6.16.1.4 Where a concentrator-identifier or similar device is employed, at least two tie circuits for the first 40 boxes connected shall be provided to the communications center. A tie circuit shall be provided for each 40 additional boxes, or fraction thereof, connected to the concentrator-identifier.

NOTE: These tie circuits are not to be used for any other purpose or function.

4-6.16.1.5 Power shall be provided in accordance with Section 4-6.7.

4-6.16.2 Receiving Equipment — Facilities for Receipt of Box Alarms.

4-6.16.2.1 The box circuits shall be terminated:

(a) Directly on a console or switchboard located in the communications center; or

(b) In concentrator-identifier equipment located in a subsidiary communications center.

NOTE: The audible signal device can be common to several box circuits and arranged so that the operator can manually silence the signal temporarily with a self-restoring switch.

4-6.16.2.2 All voice transmissions from boxes for emergencies shall be recorded with the capability of instant playback.

4-6.16.2.3 A means of voice recording shall be provided for each operator handling incoming alarms to eliminate the possibility of interference.

4-6.16.2.4 Either a continuous line test or periodic (up to 6 minutes) automatic line tests shall detect an open, short, ground, or leakage condition. When one of these conditions occurs, a visual and audible trouble signal shall be actuated where there is an operator on duty.

4-7 Auxiliary Fire Alarm Systems.

NOTE: The requirements of Chapters 1 and 7 apply to auxiliary fire alarm systems, unless they conflict with the requirements of this section.

4-7.1 Scope. This section describes the equipment and circuits necessary to connect a protected premises (*see Chapter 3*) to a public fire alarm reporting system (*see Section 4-6*).

4-7.2 General.

4-7.2.1 An auxiliary fire alarm system shall be used only in connection with a public fire alarm reporting system that is suitable for the service. A system satisfactory to the authority having jurisdiction shall be considered as meeting this requirement.

4-7.2.2 Permission for the connection of an auxiliary fire alarm system to a public fire alarm reporting system, and acceptance of the type of auxiliary transmitter and its actuating mechanism, circuits, and components connected thereto, shall be obtained from the authority having jurisdiction.

4-7.2.3 An auxiliary fire alarm system shall be maintained and supervised by a responsible person or corporation.

4-7.2.4 Section 4-7 does not require the use of audible alarm signals other than those necessary to operate the auxiliary fire alarm system. Where it is desired to provide fire alarm evacuation signals in the protected property, the alarms, circuits, and controls shall comply with the provisions of Chapter 3, in addition to the provisions of Section 4-7.

4-7.3 Communications Center Facilities. The communications center facilities shall be in accordance with the requirements of Section 4-6.

4-7.4 Equipment.

4-7.4.1 Types of Systems. There are three types of auxiliary fire alarm systems as follows:

(a)* *Local Energy Type.*

1. Local energy systems shall be permitted to be of the coded or noncoded type.

2. Power supply sources for local energy systems shall conform to Chapter 1.

(b)* *Shunt Type.*

1. Shunt systems shall be noncoded with respect to any remote electrical tripping or actuating devices.

2. All conductors of the shunt circuit shall be installed in accordance with NFPA 70, *National Electrical Code*, Article 346, for rigid conduit, or Article 348, for electrical metallic tubing.

3. Both sides of the shunt circuit shall be in the same conduit.

4. Where an auxiliary transmitter is located within a private premises, it shall be installed in accordance with 4-6.9.1.

5. Where a shunt loop is used, it shall not exceed a length of 750 ft (230 m) and shall be in conduit.

6. Conductors of the shunt circuits shall not be smaller than No. 14 AWG and shall be insulated as prescribed in NFPA 70, *National Electrical Code*, Article 310.

7. The power for shunt-type systems shall be provided by the public fire alarm reporting system.

8.* A local system made to an auxiliary system by the addition of a relay whose coil is energized by a local power supply and whose normally closed contacts trip a shunt-type master box shall not be permitted. [*See Figure A-4-7.4.1(b)8.*]

(c)* *Parallel Telephone Type.*

1. Parallel telephone systems shall be noncoded with respect to any remote electrical tripping or actuating devices.

2. Two methods of parallel telephone systems shall be permitted to be used as follows:

a. The circuits are extended beyond the entrance termination point to actuating devices, with the supervisory device beyond the last actuating device in the circuit; or

b. The supervisory device for the circuit is located at the entrance termination point. The tripping relay shall be located immediately adjacent to the supervisory device and shall be connected thereto with conductors not smaller than No. 14 AWG in conduit.

3. Nonvoice circuits connected to a parallel telephone system shall be indicated with a color that is both distinctive

Table 4-7.4.2 Application of Public Fire Alarm Reporting Systems with Auxiliary Fire Alarm Systems

Reporting Systems	Local Energy Type	Shunt Type	Parallel Type
Coded wired	Yes	Yes	No
Coded radio	Yes	No	No
Telephone series	Yes	No	No
Telephone parallel	No	No	Yes

Table 4-7.4.3 Application of Initiating Device with Auxiliary Fire Alarm Systems

Initiating Devices	Local Energy Type	Shunt Type	Parallel Type
Manual fire alarm	Yes	Yes	Yes
Waterflow or actuation of the fire extinguishing system(s) or suppression system(s)	Yes	Yes	Yes
Automatic detection devices	Yes	No	Yes

and different from that of voice circuits and shall be grouped in a reserved separate section of the receiving equipment with adequate written warning that no voice is to be expected on these alarms and that the fire department is to be dispatched on alarm light indications.

4-7.4.2 The interface of the three types of auxiliary fire alarm systems with the four types of public fire alarm reporting systems shall be in accordance with Table 4-7.4.2.

4-7.4.3 The application of the three types of auxiliary fire alarm systems shall be limited to the initiating devices specified in Table 4-7.4.3.

4-7.4.4 Location of Transmitting Devices.

4-7.4.4.1 Shunt-type auxiliary systems shall be arranged so that one auxiliary transmitter does not serve more than 100,000 ft^2 (9290 m^2) total area.

Exception: Where otherwise permitted by the authority having jurisdiction.

4-7.4.4.2 A separate auxiliary transmitter shall be provided for each building or where permitted by the authority having jurisdiction for each group of buildings of single ownership or occupancy.

4-7.4.4.3 The same box shall be permitted to be used as a public fire alarm reporting system box and as a transmitting device for an auxiliary system where permitted by the authority having jurisdiction, provided that the box is located at the outside of the entrance to the protected property.

NOTE: The fire department might require the box to be equipped with a signal light to differentiate between automatic and manual operation, unless local outside alarms at the protected property serve the same purpose.

4-7.4.4.4 The transmitting device shall be located as required by the authority having jurisdiction.

4-7.4.4.5 The system shall be so designed and arranged that a single fault on the auxiliary system shall not jeopardize operation of the public fire alarm reporting system and shall not, in case of a single fault on either the auxiliary or public fire alarm reporting system, transmit a false alarm on either system.

Exception: Shunt systems. [*See 4-7.4.1(b).*]

4-7.5 Personnel. Personnel necessary to receive and act on signals from auxiliary fire alarm systems shall be in accordance with the requirements of Section 4-6 and NFPA 1221, *Standard for the Installation, Maintenance, and Use of Public Fire Service Communication Systems.*

4-7.6 Operations. Operations for auxiliary fire alarm systems shall be in accordance with the requirements of Section 4-6 and NFPA 1221, *Standard for the Installation, Maintenance, and Use of Public Fire Service Communication Systems.*

4-7.7 Testing and Maintenance. Testing and maintenance of auxiliary fire alarm systems shall be in accordance with the requirements of Chapter 7.

Chapter 5 Initiating Devices

5-1 Introduction.

5-1.1 Scope. This chapter covers minimum requirements for performance, selection, use, and location of automatic fire detection devices, sprinkler waterflow detectors, manually activated fire alarm stations, and supervisory signal initiating devices, including guard tour reporting used to ensure timely warning for the purposes of life safety and the protection of a building, space, structure, area, or object.

NOTE: For detector requirements in a household system, refer to Chapter 2.

5-1.2 Purpose.

5-1.2.1 The material in this chapter is intended for use by persons knowledgeable in the application of fire detection and fire alarm systems/services.

5-1.2.2 Automatic and manual initiating devices contribute to life safety, fire protection, and property conservation only where used in conjunction with other equipment. The interconnection of these devices with control equipment configurations and power supplies, or with output systems responding to external actuation, is detailed elsewhere in this code or other appropriate NFPA codes and standards.

5-1.3 Installation and Required Location of Initiating Devices.

5-1.3.1 Where subject to mechanical damage, an initiating device shall be protected. A mechanical guard used to protect a smoke or heat detector shall be listed for use with the detector being used.

5-1.3.2 In all cases, initiating devices shall be supported independently of their attachment to the circuit conductors.

5-1.3.3 Initiating devices shall be installed in all areas where required by the appropriate NFPA standard or the authority having jurisdiction. Each installed initiating device shall be accessible for periodic maintenance and testing.

5-1.3.4* Connection to the Fire Alarm System. Duplicate terminals or leads, or their equivalent, shall be provided on each initiating device for the express purpose of connecting into the fire alarm system to provide supervision of the connections. Such terminals or leads are necessary to ensure that the wire run is broken and that the individual connections are made to the incoming and outgoing leads or other terminals for signaling and power.

Exception: Initiating devices that provide equivalent supervision.

5-1.4 Requirements for Smoke and Heat Detectors.

5-1.4.1 Detectors shall not be recessed into the mounting surface in any manner.

Exception: Where tested and listed for such recessed mounting.

5-1.4.2 Where required, total coverage shall include all rooms, halls, storage areas, basements, attics, lofts, spaces above suspended ceilings, and other subdivisions and accessible spaces; and the inside of all closets, elevator shafts, enclosed stairways, dumbwaiter shafts, and chutes. Inaccessible areas shall not be required to be protected by detectors.

Exception No. 1: Where inaccessible areas contain combustible material, they shall be made accessible and shall be protected by a detector(s).

Exception No. 2: Detectors shall not be required in combustible blind spaces where any of the following conditions exist:

(a) Where the ceiling is attached directly to the underside of the supporting beams of a combustible roof or floor deck;

(b) Where the concealed space is entirely filled with a noncombustible insulation. In solid joist construction, the insulation shall be required to fill only the space from the ceiling to the bottom edge of the joist of the roof or floor deck;

(c) Where there are small, concealed spaces over rooms, provided any space in question does not exceed 50 ft² (4.6 m²) in area ;

(d) In spaces formed by sets of facing studs or solid joists in walls, floors, or ceilings where the distance between the facing studs or solid joists is less than 6 in. (150 mm).

Exception No. 3: Detectors shall not be required below open grid ceilings where all of the following conditions exist:

(a) The openings of the grid are 1/4 in. (6.4 mm) or larger in the least dimension.

(b) The thickness of the material does not exceed the least dimension.

(c) The openings constitute at least 70 percent of the area of the ceiling material.

Exception No. 4: Concealed, accessible spaces above suspended ceilings, used as a return air plenum meeting the requirements of NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems, where equipped with smoke detection at each connection from the plenum to the central air-handling system.

5-1.4.3* Detectors shall be required underneath open loading docks or platforms and their covers and for accessible underfloor spaces.

Exception: Where permitted by the authority having jurisdiction, detectors shall not be required where all of the following conditions exist:

(a) The space is not accessible for storage purposes or entrance of unauthorized persons and is protected against the accumulation of windborne debris.

(b) The space contains no equipment such as steam pipes, electric wiring, shafting, or conveyors.

(c) The floor over the space is tight.

(d) No flammable liquids are processed, handled, or stored on the floor above.

5-1.4.4* Where codes, standards, laws, or authorities having jurisdiction require the protection of selected areas only, the specified areas shall be protected in accordance with this code.

5-1.4.5* Stratification. The possible effect of stratification below the ceiling shall be considered. (*Also see Appendix B for additional guidance.*)

5-2 Heat-Sensing Fire Detectors. Heat detectors shall be installed in all areas where required either by the appropriate NFPA standard or the authority having jurisdiction.

5-2.1 Temperature Classification.

5-2.1.1 Color Coding.

5-2.1.1.1 Heat detectors of the fixed-temperature or rate-compensated, spot-pattern type shall be classified as to the temperature of operation and marked with the appropriate color code. (*See Table 5-2.1.1.1.*)

Exception: Heat detectors where the alarm threshold is field adjustable and that are marked with the temperature range.

5-2.1.1.2 Where the overall color of a detector is the same as the color code marking required for that detector, one of the following arrangements, applied in a contrasting color and visible after installation, shall be employed:

(a) A ring on the surface of the detector; or

(b) The temperature rating in numerals at least 3/8 in. (9.5 mm) high.

5-2.1.2* A heat detector integrally mounted on a smoke detector shall be listed or approved for not less than 50-ft (15-m) spacing.

5-2.2 Location.

5-2.2.1* Spot-type heat detectors shall be located on the ceiling not less than 4 in. (100 mm) from the sidewall or on the sidewalls between 4 in. and 12 in. (100 mm and 300 mm) from the ceiling. (*See Figure A-5-2.2.1.*)

Exception No. 1: In the case of solid open joist construction, detectors shall be mounted at the bottom of the joists.

Exception No. 2: In the case of beam construction where beams are less than 12 in. (300 mm) in depth and less than 8 ft (2.4 m) on center, detectors shall be permitted to be installed on the bottom of beams.

Table 5-2.1.1.1 Temperature Classification for Heat Detectors

Temperature Classification	Temp. Rating Range (°F)	Temp. Rating Range (°C)	Max. Ceiling Temp. (°F)	Max. Ceiling Temp. (°C)	Color Code
Low[1]	100 to 134	39 to 57	20 below[2]	11 below[2]	Uncolored
Ordinary	135 to 174	58 to 79	100	38	Uncolored
Intermediate	175 to 249	80 to 121	150	66	White
High	250 to 324	122 to 162	225	107	Blue
Extra high	325 to 399	163 to 204	300	149	Red
Very extra high	400 to 499	205 to 259	375	191	Green
Ultra high	500 to 575	260 to 302	475	246	Orange

[1]Intended only for installation in controlled ambient areas. Units shall be marked to indicate maximum ambient installation temperature.
[2]Maximum ceiling temperature has to be 20°F (11°C) or more below detector rated temperature.
NOTE: The difference between the rated temperature and the maximum ambient should be as small as possible to minimize the response time.

5-2.2.2 Line-type heat detectors shall be located on the ceiling or on the sidewalls not more than 20 in. (500 mm) from the ceiling.

Exception No. 1: In the case of solid open joist construction, detectors shall be mounted at the bottom of the joists.

Exception No. 2: In the case of beam construction where beams are less than 12 in. (300 mm) in depth and less than 8 ft (2.4 m) on center, detectors shall be permitted to be installed on the bottom of beams.

Exception No. 3: Where a line-type detector is used in an application other than open area protection, the manufacturer's installation instructions shall be followed.

5-2.3* Temperature. Detectors having fixed-temperature or rate-compensated elements shall be selected in accordance with Table 5-2.1.1.1 for the maximum ceiling temperature that can be expected.

5-2.4* Spacing.

5-2.4.1* Smooth Ceiling Spacing. One of the following requirements shall apply:

(a) The distance between detectors shall not exceed their listed spacing, and there shall be detectors within a distance of ½ the listed spacing, measured at a right angle, from all walls or partitions extending to within 18 in. (460 mm) of the ceiling; or

(b) All points on the ceiling shall have a detector within a distance equal to 0.7 times the listed spacing (0.7S). This is useful in calculating locations in corridors or irregular areas.

5-2.4.1.1* Irregular Areas. For irregularly shaped areas, the spacing between detectors shall be permitted to be greater than the listed spacing, provided the maximum spacing from a detector to the farthest point of a sidewall or corner within its zone of protection is not greater than 0.7 times the listed spacing. (*See Figure A-5-2.4.1.1.*)

5-2.4.1.2* High Ceilings. On ceilings 10 ft to 30 ft (3 m to 9.1 m) high, heat detector linear spacing shall be reduced in accordance with Table 5-2.4.1.2.

Exception: Table 5-2.4.1.2 shall not apply to the following detectors, which rely on the integration effect:

(a) Line-type electrical conductivity detectors [see A-1-4, "Fixed Temperature Detector," (b), "Electrical Conductivity"];

(b) Pneumatic rate-of-rise tubing [see A-1-4, "Rate-of-Rise Detector," (a), "Pneumatic Rate-of-Rise Tubing"];

(c) Series connected thermoelectric effect detectors [see A-1-4, "Rate-of-Rise Detector," (c), "Thermoelectric Effect Detector"].

In these cases, the manufacturer's recommendations shall be followed for appropriate alarm point and spacing.

NOTE: Table 5-2.4.1.2 provides for spacing modifications to take into account different ceiling heights for generalized fire conditions. An alternative design method that allows a designer to take into account ceiling height, fire size, and ambient temperature is provided in Appendix B.

5-2.4.2* Solid Joist Construction. The spacing of heat detectors, where measured at right angles to the solid joists, shall not exceed 50 percent of the smooth ceiling spacing permitted under 5-2.4.1 and 5-2.4.1.1. (*See Figure A-5-2.4.2.*)

5-2.4.3* Beam Construction. A ceiling shall be treated as a smooth ceiling where the beams project no more than 4 in. (100 mm) below the ceiling. Where the beams project more than 4 in. (100 mm) below the ceiling, the spacing of spot-type heat detectors at right angles to the direction of beam travel shall be not more than 2/3 of the smooth ceiling spacing permitted under 5-2.4.1 and 5-2.4.1.1. Where the beams project more than 18 in. (460 mm) below the ceiling and are more than 8 ft (2.4 m) on center, each bay formed by the beams shall be treated as a separate area.

5-2.4.4 Sloped Ceilings.

5-2.4.4.1* Peaked. A row of detectors shall first be spaced and located at or within 3 ft (0.9 m) of the peak of the ceiling, measured horizontally. The number and spacing of additional detectors, if any, shall be based on the horizontal projection of the ceiling in accordance with the type of ceiling construction. (*See Figure A-5-2.4.4.1.*)

5-2.4.4.2* Shed. Sloped ceilings having a rise greater than 1 ft in 8 ft (1 m in 8 m) horizontally shall have a row of detectors located on the ceiling within 3 ft (0.9 m) of the high side of the ceiling measured horizontally, spaced in accordance with the type of construction. The remaining detectors, if any, shall be located in the remaining area on the basis of the horizontal projection of the ceiling. (*See Figure A-5-2.4.4.2.*)

5-2.4.4.3 For a roof slope of less than 30 degrees, all detectors shall be spaced utilizing the height at the peak. For a roof slope of greater than 30 degrees, the average slope height shall be used for all detectors other than those located in the peak.

5-3 Smoke-Sensing Fire Detectors.

5-3.1 General.

5-3.1.1* The purpose of Section 5-3 is to provide information to assist in design and installation of reliable early warning smoke detection systems for protection of life and property.

Table 5-2.4.1.2 Heat Detector Spacing Reduction Based on Ceiling Height

Ceiling Height Above (ft)	Ceiling Height Above (m)	Up to (ft)	Up to (m)	Percent of Listed Spacing
0	0	10	3.05	100
10	3.05	12	3.66	91
12	3.66	14	4.27	84
14	4.27	16	4.88	77
16	4.88	18	5.49	71
18	5.49	20	6.10	64
20	6.10	22	6.71	58
22	6.71	24	7.32	52
24	7.32	26	7.93	46
26	7.93	28	8.54	40
28	8.54	30	9.14	34

5-3.1.2 Section 5-3 covers general area application of smoke detectors in ordinary indoor locations.

5-3.1.3 For information on use of smoke detectors for control of smoke spread, refer to Section 5-10.

5-3.1.4 For additional guidance in the application of smoke detectors for flaming fires of various sizes and growth rates in areas of various ceiling heights, refer to Appendix B.

5-3.2* Smoke detectors shall be installed in all areas where required either by the appropriate NFPA standard or by the authority having jurisdiction.

5-3.3 Sensitivity.

5-3.3.1 Smoke detectors shall be marked with their nominal production sensitivity (percent per foot obscuration), as required by the listing. The production tolerance around the nominal sensitivity also shall be indicated.

5-3.3.2 Smoke detectors that have provision for field adjustment of sensitivity shall have an adjustment range of not less than 0.6 percent per foot obscuration. Where the means of adjustment is on the detector, a method shall be available to restore the detector to its factory calibration. Detectors that have provision for program controlled adjustment of sensitivity shall be permitted to be marked with their programmable sensitivity range only.

5-3.4 Location and Spacing.

5-3.4.1* General.

5-3.4.1.1 The location and spacing of smoke detectors shall result from an evaluation based on the guidelines detailed in this code and on engineering judgment. Some of the conditions that shall be considered include:

(a) Ceiling shape and surface.
(b) Ceiling height.
(c) Configuration of contents in the area to be protected.
(d) Burning characteristics of the combustible materials present.
(e) Ventilation.
(f) Ambient environment.

5-3.4.1.2 Where the intent is to protect against a specific hazard, the detector(s) shall be permitted to be installed closer to the hazard in a position where the detector can readily intercept the smoke.

5-3.4.2 Air Sampling-Type Smoke Detector. Each sampling port of an air sampling-type smoke detector shall be treated as a spot-type detector for the purpose of location and spacing. Maximum air sample transport time from the farthest sampling point shall not exceed 120 seconds.

5-3.4.3* Spot-Type Smoke Detectors.

5-3.4.3.1 Spot-type smoke detectors shall be located on the ceiling not less than 4 in. (100 mm) from a sidewall to the near edge or, where on a sidewall, between 4 in. and 12 in. (100 mm and 300 mm) down from the ceiling to the top of the detector. (*See Figure A-5-2.2.1.*)

Exception No. 1: *See 5-1.4.5.*

Exception No. 2: *See 5-3.4.6.*

5-3.4.3.2* To minimize dust contamination of smoke detectors where installed under raised room floors and similar spaces, they shall be mounted only in an orientation for which they have been listed. (*See Figure A-5-3.4.3.2.*)

5-3.4.4 Projected Beam-Type Smoke Detectors. Projected beam-type smoke detectors (*see A-1-4, "Photoelectric Light Obscuration Smoke Detection"*) normally shall be located with their projected beams parallel to the ceiling and in accordance with the manufacturer's documented instructions.

Exception No. 1: *See 5-1.4.5.*

Exception No. 2: *Beams shall be permitted to be installed vertically or at any angle needed to afford protection of the hazard involved (e.g., vertical beams through the open shaft area of a stairwell where there is a clear vertical space inside the handrails).*

5-3.4.4.1 The beam length shall not exceed the maximum permitted by the equipment listing.

5-3.4.4.2 Where mirrors are used with projected beams, they shall be installed in accordance with the manufacturer's documented instructions.

5-3.4.5 Smooth Ceiling Spacing.

5-3.4.5.1 Spot-Type Detectors.

5-3.4.5.1.1 On smooth ceilings, spacing of 30 ft (9.1 m) shall be permitted to be used as a guide. In all cases, the manufacturer's documented instructions shall be followed. Other spacing shall be permitted to be used depending on ceiling height, different conditions, or response requirements. (*See Appendix B for detection of flaming fires.*)

5-3.4.5.1.2* For smooth ceilings, all points on the ceiling shall have a detector within a distance equal to 0.7 times the selected spacing.

5-3.4.5.2* Projected Beam-Type Detectors. For location and spacing of projected beam-type detectors, the manufacturer's documented installation instructions shall be followed. (*See Figure A-5-3.4.5.2.*)

5-3.4.6* Solid Joist and Beam Construction. Solid joists shall be considered equivalent to beams for smoke detector spacing guidelines.

5-3.4.6.1* Flat Ceilings.

(a) For ceiling heights of 12 ft (3.66 m) or lower and beam depths of 1 ft (0.3 m) or less, smooth ceiling spacings running in the direction parallel to the run of the beams shall be used and ½ the smooth ceiling spacing shall be in the direction perpendicular to the run of the beams. Spot-type detectors shall be permitted to be located either on the ceiling or on the bottom of the beams.

(b) For beam depths exceeding 1 ft (0.3 m) or for ceiling heights exceeding 12 ft (3.66 m), spot-type detectors shall be located on the ceiling in every beam pocket.

5-3.4.6.2* Sloped Ceilings.

(a) For beamed ceilings with beams running parallel to (up) the slope, the spacing for flat beamed ceilings shall be used. The ceiling height shall be taken as the average height over the slope. For slopes greater than 10 degrees, the detectors located at ½ the spacing from the low end shall not be required. Spacings shall be measured along a horizontal projection of the ceilings.

(b) For beamed ceilings with beams running perpendicular to (across) the slope, the spacing for flat beamed ceilings shall be used. The ceiling height shall be taken as the average height over the slope.

5-3.4.6.3 A projected beam-type smoke detector shall be considered equivalent to a row of spot-type smoke detectors for flat and sloped ceiling applications.

5-3.4.7 Peaked. Detectors shall first be spaced and located within 3 ft (0.9 m) of the peak, measured horizontally. The number and spacing of additional detectors, if any, shall be based on the horizontal projection of the ceiling. (*See Figure A-5-2.4.4.1.*)

5-3.4.8 Shed. Detectors shall first be spaced and located within 3 ft (0.9 m) of the high side of the ceiling, measured horizontally. The number and spacing of additional detectors, if any, shall be based on the horizontal projection of the ceiling. (*See Figure A-5-2.4.4.2.*)

5-3.4.9 Raised Floors and Suspended Ceilings. Spaces beneath raised floors and above suspended ceilings shall be considered separate rooms for smoke detector spacing. Detectors installed beneath raised floors or above suspended ceilings, or both, including raised floors and suspended ceilings used for environmental air, shall not be used in lieu of providing detection within the room.

5-3.4.9.1 Raised Floors. Detectors installed beneath raised floors shall be spaced in accordance with 5-3.4.1, 5-3.4.1.2, and 5-3.4.3.2. Where the area beneath the raised floor is also used for environmental air, detector spacing shall also conform to 5-3.5.1 and 5-3.5.2.

5-3.4.9.2 Suspended Ceilings. Detector spacing above suspended ceilings shall conform to the requirements of 5-3.4, as appropriate for the ceiling configuration. Where detectors are installed in ceilings used for environmental air, detector spacing shall also conform to 5-3.5.1 and 5-3.5.2.

5-3.4.10 Partitions. Where partitions extend upward to within 18 in. (460 mm) of the ceiling, they shall not influence the spacing. Where the partition extends to within less than 18 in. (460 mm) of the ceiling, the effect of smoke travel shall be considered in the reduction of spacing.

5-3.5 Heating, Ventilating, and Air Conditioning (HVAC).

5-3.5.1* In spaces served by air-handling systems, detectors shall not be located where air from supply diffusers could dilute smoke before it reaches the detectors. Detectors shall be located to intercept the airflow toward the return air opening(s) where the opening(s) is not adjacent to the supply. Any detectors needed to meet this requirement shall be in addition to, and not a substitute for, detectors required by 5-3.4 to protect the balance of the area when the air-handling system is shut down.

Exception: Where detector rearrangement complies with the requirements for protection under both airflow and static conditions.

5-3.5.2 Plenums.

5-3.5.2.1 In under-floor spaces and above-ceiling spaces that are used as HVAC plenums, detectors shall be listed for the anticipated environment (*see 5-3.6.1.1*). Detector spacings and locations shall be selected based upon anticipated airflow patterns and fire type.

5-3.5.2.2* Detectors placed in environmental air ducts or plenums shall not be used as a substitute for open area detectors (*see Section 5-10, Table A-5-3.6.1.1, A-5-10.1, and A-5-10.2*). Where open area protection is required, 5-3.4 shall apply.

5-3.6 Special Considerations.

5-3.6.1 The selection and placement of smoke detectors shall take into consideration both the performance characteristics of the detector and the areas into which the detectors are to be installed to prevent nuisance alarms or improper operation after installation. Some of the considerations are provided in 5-3.6.1.1 through 5-3.6.1.3.

5-3.6.1.1* Smoke detectors shall be installed in areas where the normal ambient conditions are not likely to exceed the following range of environmental conditions:

(a) A temperature of 100°F (38°C), or a temperature 32°F (0°C); or

(b) A relative humidity of 93 percent; or

(c) An air velocity of 300 fpm (1.5 mps).

Exception: Detectors specifically designed for use in ambients exceeding the limits of 5-3.6.1.1(a) through (c) and listed for the temperature, humidity, and air velocity conditions expected.

5-3.6.1.2* To avoid nuisance alarms, the location of smoke detectors shall take into consideration normal sources of smoke, moisture, dust or fumes, and electrical or mechanical influences.

5-3.6.1.3 Detectors shall not be installed until after the construction clean-up of all trades is complete and final.

Table 5-3.6.6.3 Smoke Detector Spacing Based on Air Movement

Min/Air Change	Air Changes/hr	ft² (m²)/Detector
1	60	125 (11.61)
2	30	250 (23.23)
3	20	375 (34.84)
4	15	500 (46.45)
5	12	625 (58.06)
6	10	750 (69.68)
7	8.6	875 (81.29)
8	7.5	900 (83.61)
9	6.7	900 (83.61)
10	6	900 (83.61)

Exception: Where required by the authority having jurisdiction for protection during construction.

Detectors that have been installed prior to final clean-up by all trades shall be cleaned or replaced in accordance with Chapter 7.

5-3.6.2 Spot-Type Detectors.

5-3.6.2.1 Smoke detectors having a fixed temperature element as part of the unit shall be selected in accordance with Table 5-2.1.1.1 for the maximum ceiling temperature that can be expected in service.

5-3.6.2.2* Holes in the back of a detector shall be covered by a gasket, sealant, or equivalent, and the detector shall be mounted so that airflow from inside or around the housing does not prevent the entry of smoke during a fire or test condition.

5-3.6.3 Projected Beam-Type Detectors.

5-3.6.3.1 Projected beam-type detectors and mirrors shall be firmly mounted on stable surfaces so as to prevent false or erratic operation due to movement. The beam shall be so designed that small angular movements of the light source or receiver do not prevent operation due to smoke and do not cause nuisance alarms.

5-3.6.3.2* The light path of projected beam-type detectors shall be kept clear of opaque obstacles at all times.

5-3.6.4 Air Sampling-Type Detectors.

5-3.6.4.1* Sampling pipe networks shall be designed on the basis of and shall be supported by sound fluid dynamic principles to ensure proper performance. Network design details shall include calculations showing the flow characteristics of the pipe network and for each sample port.

5-3.6.4.2* Air sampling detectors shall give a trouble signal where the airflow is outside the manufacturer's specified range. The sampling ports and in-line filter (where used) shall be kept clear in accordance with the manufacturer's documented instructions.

5-3.6.4.3 Air sampling network piping and fittings shall be airtight and permanently fixed. Sampling system piping shall be conspicuously identified as "SMOKE DETECTOR SAMPLING TUBE. DO NOT DISTURB," as follows:

(a) At changes in direction or branches of piping;

(b) At each side of penetrations of walls, floors, or similar barriers;

(c) At intervals on piping sufficient to provide ready visibility within the space, but no greater than 20 ft (6 m).

5-3.6.5* High Rack Storage. Where smoke detectors are installed in high rack storage areas, consideration shall be given to installing detectors at several levels in the racks [*see Figures A-5-3.6.5(a) and (b).*] Where detectors are installed to actuate a suppression system, see NFPA 231C, *Standard for Rack Storage of Materials.*

5-3.6.6 High Air Movement Areas.

5-3.6.6.1 General. The purpose and scope of 5-3.6.6 are to provide location and spacing guidance for smoke detectors intended for early warning of fire in high air movement areas.

Exception: Detectors provided for the control of smoke spread are covered by the requirements of Section 5-10.

5-3.6.6.2 Location. Smoke detectors shall not be located directly in the airstream of supply registers.

5-3.6.6.3 Spacing. Smoke detector spacing depends upon the movement of air within the room (including both supplied and recirculated air), which can be designated as minutes per air change or air changes per hour. Spacing shall be in accordance with Table 5-3.6.6.3 and Figure 5-3.6.6.3.

Exception: Air sampling or projected beam smoke detectors installed in accordance with the manufacturer's documented instructions.

5-4 Radiant Energy-Sensing Fire Detectors.

5-4.1 General.

5-4.1.1 The purpose and scope of Section 5-4 are to provide standards for the selection, location, and spacing of fire detectors that sense the radiant energy produced by burning substances. These detectors are categorized as flame detectors and spark/ember detectors.

5-4.1.1.1 Flame Detectors. See Section 1-4, definition of Flame Detector.

5-4.1.1.2 Spark/Ember Detectors. See Section 1-4, definition of Spark/Ember Detector.

5-4.1.2 Radiant Energy. For the purpose of this code, radiant energy includes the electromagnetic radiation emitted as a by-product of the combustion reaction, which obeys the laws of optics. This includes radiation in the ultraviolet, visible, and infrared portions of the spectrum emitted by flames or glowing embers. These portions of the spectrum are distinguished by wavelengths as shown in Table 5-4.1.2.

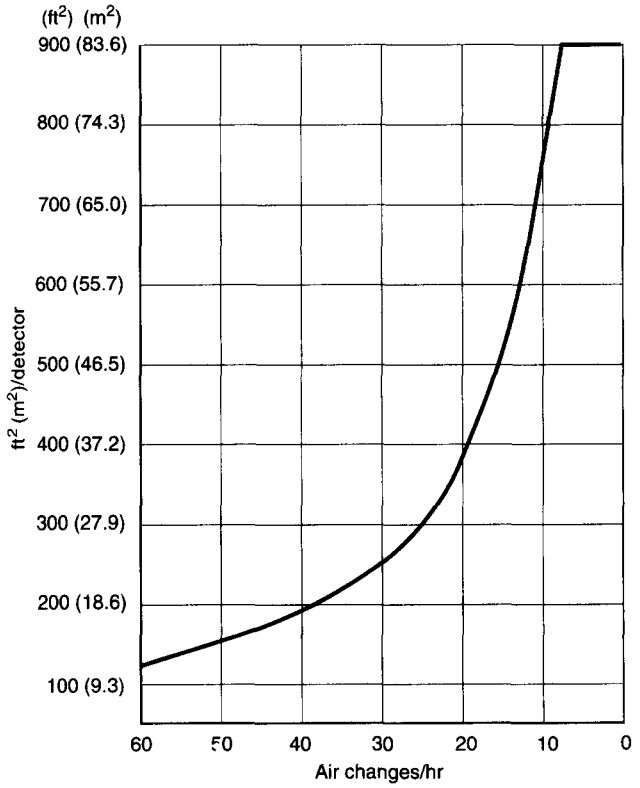


Figure 5-3.6.6.3 High air movement areas (not to be used for under-floor or above-ceiling spaces).

Table 5-4.1.2 Spectrum Wavelength Ranges (μm)

Ultraviolet	0.1 to 0.35
Visible	0.36 to 0.75
Infrared	0.76 to 220

NOTE: 1.0 μm = 1000 nM = 10,000 Å.

5-4.2* Fire Characteristics and Detector Selection.

5-4.2.1* The type and quantity of radiant energy-sensing fire detectors shall be determined based upon the performance characteristics of the detector and an analysis of the hazard, including the burning characteristics of the fuel, the fire growth rate, the environment, the ambient conditions, and the capabilities of the extinguishing media and equipment.

5-4.2.2 The selection of the radiant energy-sensing detectors shall be based upon:

(a) The matching of the spectral response of the detector to the spectral emissions of the fire or fires to be detected; and

(b) Minimizing the possibility of spurious nuisance alarms from nonfire sources inherent to the hazard area. (*See A-5-4.2.1.*)

5-4.3 Spacing Considerations.

5-4.3.1 General Rules.

5-4.3.1.1* Radiant energy-sensing fire detectors shall be employed consistent with the listing or approval and the inverse square law, which defines the fire size versus distance curve for the detector.

5-4.3.1.2 Detectors shall be used in sufficient quantity and positioned so that no point requiring detection in the hazard area is obstructed or outside the field of view of at least one detector.

5-4.3.2 Spacing Considerations for Flame Detectors.

5-4.3.2.1* The location and spacing of detectors shall be the result of an engineering evaluation that takes into consideration:

(a) The size of the fire that is to be detected.
(b) The fuel involved.
(c) The sensitivity of the detector.
(d) The field of view of the detector.
(e) The distance between the fire and the detector.
(f) The radiant energy absorption of the atmosphere.
(g) The presence of extraneous sources of radiant emissions.
(h) The purpose of the detection system.
(i) The response time required.

5-4.3.2.2 The system design shall specify the size of the flaming fire of given fuel that is to be detected.

5-4.3.2.3* In applications where the fire to be detected could occur in an area not on the optical axis of the detector, the distance shall be reduced or detectors added to compensate for the angular displacement of the fire in accordance with the manufacturer's documented instructions.

5-4.3.2.4* In applications in which the fire to be detected is of a fuel that differs from the test fuel used in the process of listing or approval, the distance between the detector and the fire shall be adjusted consistent with the fuel specificity of the detector as established by the manufacturer.

5-4.3.2.5 Since flame detectors are essentially line of sight devices, special care shall be taken to ensure that their ability to respond to the required area of fire in the zone that is to be protected is not compromised by the presence of intervening structural members or other opaque objects or materials.

5-4.3.2.6* Provisions shall be made to sustain detector window clarity in applications where airborne particulates and aerosols coat the detector window between maintenance intervals and affect sensitivity.

5-4.3.3 Spacing Considerations for Spark/Ember Detectors.

5-4.3.3.1* The location and spacing of detectors shall be the result of an engineering evaluation that takes into consideration:

(a) The size of the spark or ember that is to be detected. z
(b) The fuel involved.
(c) The sensitivity of the detector.
(d) The field of view of the detector.
(e) The distance between the fire and the detector.
(f) The radiant energy absorption of the atmosphere.
(g) The presence of extraneous sources of radiant emissions.
(h) The purpose of the detection systems.
(i) The response time required.

5-4.3.3.2* The system design shall specify the size of the spark or ember of the given fuel that the detection system is to detect.

5-4.3.3.3 Spark detectors shall be positioned so that all points within the cross section of the conveyance duct, conveyor, or chute where the detectors are located are within the field of view (as as defined in Section 1-4) of at least one detector.

5-4.3.3.4 The location and spacing of the detectors shall be adjusted using the inverse square law, modified for the atmospheric absorption and the absorption of nonburning fuel suspended in the air in accordance with the manufacturer's documented instructions. (*See A-5-4.3.1.1.*)

5-4.3.3.5* In applications where the sparks to be detected could occur in an area not on the optical axis of the detector, the distance shall be reduced or detectors added to compensate for the angular displacement of the fire in accordance with the manufacturer's documented instructions.

5-4.3.3.6* Provisions shall be made to sustain the detector window clarity in applications where airborne particulates and aerosols coat the detector window and affect sensitivity.

5-4.4 Other Considerations.

5-4.4.1 Radiant energy-sensing detectors shall be protected either by way of design or installation to ensure that optical performance is not compromised.

5-4.4.2 Where necessary, radiant energy-sensing detectors shall be shielded or otherwise arranged to prevent action from unwanted radiant energy.

5-4.4.3 Where used in outdoor applications, radiant energy-sensing detectors shall be shielded or otherwise arranged in a fashion to prevent diminishing sensitivity by conditions such as rain or snow and yet allow a clear field of vision of the hazard area.

5-4.4.4 A radiant energy-sensing fire detector shall not be installed in a location where the ambient conditions are known to exceed the extremes for which the detector has been listed.

5-5 Other Fire Detectors.

5-5.1 Detectors in the classification of "other fire detectors" are those that operate on principles different from detectors covered by Sections 5-2, 5-3, and 5-4. Such detectors shall be installed in all areas where they are required either by the appropriate NFPA standard or by the authority having jurisdiction.

5-5.2 Facilities for testing or metering or instrumentation to ensure adequate initial sensitivity and adequate retention thereof, relative to the protected hazard, shall be provided. These facilities shall be employed at regular intervals.

5-5.3 These detectors shall operate where subjected to the abnormal concentration of combustion effects that occur during a fire, such as water vapor, ionized molecules, or other phenomena for which they are designed. Detection is dependent upon the size and intensity of fire to provide the necessary quantity of required products and related thermal lift, circulation, or diffusion for adequate operation.

5-5.4 Room sizes and contours, airflow patterns, obstructions, and other characteristics of the protected hazard shall be taken into account.

5-5.5 Location and Spacing.

5-5.5.1 The location and spacing of detectors shall be based on the principle of operation and an engineering survey of the conditions anticipated in service. The manufacturer's technical bulletin shall be consulted for recommended detector uses and locations.

5-5.5.2 Detectors shall not be spaced beyond their listed or approved maximums. Closer spacing shall be utilized where the structural or other characteristics of the protected hazard warrant.

5-5.5.3 Consideration shall be given to all factors that could affect the location and sensitivity of the detectors, including structural features such as the sizes and shapes of rooms and bays and their occupancies and uses, ceiling heights, ceiling and other obstructions, ventilation, ambient environment, stock piles, files, and fire hazard locations.

5-5.5.4 The overall situation shall be reviewed frequently to ensure that changes in structural or usage conditions that could interfere with fire detection are remedied.

5-5.6 Special Considerations. The selection and placement of detectors shall take into consideration both the performance characteristics of the detector and the areas into which the detectors are to be installed to prevent nuisance alarms or nonoperation after installation.

5-6 Sprinkler Waterflow Alarm-Initiating Devices.

5-6.1 The provisions of this section shall apply to devices that initiate an alarm indicating a flow of water in a sprinkler system.

5-6.2* Initiation of the alarm signal shall occur within 90 seconds of waterflow at the alarm-initiating device when flow equal to or greater than that from a single sprinkler of the smallest orifice size installed in the system occurs. Movement of water due to waste, surges, or variable pressure shall not be indicated.

5-6.3 Piping between the sprinkler system and a pressure actuated alarm-initiating device shall be galvanized or of nonferrous metal or other approved corrosion-resistant material of not less than $\frac{3}{8}$ in. (9.5 mm) nominal pipe size.

5-7* Detection of the Operation of Other Automatic Extinguishing Systems. The operation of other fire extinguishing system(s) or suppression system(s) shall initiate an alarm signal by means appropriate to the system, such as agent flow or agent pressure, by alarm-initiating devices installed in accordance with their individual listings.

5-8 Manually Actuated Alarm-Initiating Devices.

5-8.1 Manual fire alarm boxes shall be used only for fire alarm-initiating purposes. However, combination manual fire alarm boxes and guard's signaling stations shall be permitted.

5-8.1.1 Mounting. Each manual fire alarm box shall be securely mounted. The operable part of each manual fire alarm box shall be not less than $3\frac{1}{2}$ ft (1.1 m) and not more than $4\frac{1}{2}$ ft (1.37 m) above floor level.

5-8.1.2 Distribution. Manual fire alarm boxes shall be distributed throughout the protected area so that they are unobstructed and readily accessible. They shall be located in the normal path of exit from the area with a manual fire alarm box at each exit on each floor. Additional manual fire alarm boxes shall be provided so that travel distance to the nearest fire alarm box will not be in excess of 200 ft (61 m) measured horizontally on the same floor.

5-8.1.3* A coded manual fire alarm box shall produce at least three repetitions of the coded signal, with each repetition to consist of at least three impulses.

5-8.2 Publicly Accessible Fire Service Boxes (Street Boxes).

5-8.2.1 Street boxes, when in an abnormal condition, shall leave the circuit usable.

5-8.2.2 Street boxes shall be designed so that recycling does not occur if a box actuating device is held in the actuating position and so that they are ready to accept a new signal as soon as the actuating device is released.

5-8.2.3 Street boxes, when actuated, shall give a visible or audible indication to the user that the box is operating or that the signal has been transmitted to the communications center.

NOTE: Where the operating mechanism of a box creates sufficient sound to be heard by the user, the requirements are satisfied.

5-8.2.4 The street box housing shall protect the internal components from the weather.

5-8.2.5 Doors on street boxes shall remain operable under adverse climatic conditions, including icing and salt spray.

5-8.2.6 Street boxes shall be recognizable as such. Street boxes shall have instructions for use plainly marked on their exterior surfaces.

5-8.2.7 Street boxes shall be securely mounted on poles, pedestals, or structural surfaces as directed by the authority having jurisdiction.

5-8.2.8 Street boxes shall be as conspicuous as possible. Their color shall be distinctive, and they shall be visible from as many directions as possible. A wide band of distinctive colors visible over the tops of parked cars or adequate signs completely visible from all directions shall be applied to supporting poles.

5-8.2.9* Location-designating lights of distinctive color, visible for at least 1500 ft (460 m) in all directions, shall be installed over street boxes. The street light nearest the street box, where equipped with a distinctively colored light, shall be considered as meeting this requirement.

5-8.2.10 Street box cases and parts that are, at any time, accessible to users shall be of insulating materials or permanently and effectively grounded. All ground connections to street boxes shall comply with the requirements of NFPA 70, *National Electrical Code*, Article 250.

5-8.2.11 Where a street box is installed inside a structure, it shall be placed as close as is practicable to the point of entrance of the circuit, and the exterior wire shall be installed in conduit or electrical metallic tubing in accordance with Chapter 3 of NFPA 70, *National Electrical Code*.

5-8.2.12 Coded Radio Street Boxes.

5-8.2.12.1 Coded radio street boxes shall be designed and operated in compliance with all applicable rules and regulations of the FCC, as well as with the requirements established herein.

5-8.2.12.2 Coded radio street boxes shall provide no less than three specific and individually identifiable functions to the communications center, in addition to the street box number, as follows:

(a) Test;
(b) Tamper; and
(c) Fire.

5-8.2.12.3* Coded radio street boxes shall transmit to the communications center no less than one repetition for "test," no less than one repetition for "tamper," and no less than three repetitions for "fire."

5-8.2.12.4 Where multifunction coded radio street boxes are used to transmit to the communications center a request(s) for emergency service or assistance in addition to those stipulated in 5-8.2.12.2, each such additional message function shall be individually identifiable.

5-8.2.12.5 Multifunction coded radio street boxes shall be so designed as to prevent the loss of supplemental or concurrently actuated messages.

5-8.2.12.6 An actuating device held or locked in the activating position shall not prevent the activation and transmission of other messages.

5-8.2.13 Power Source.

5-8.2.13.1 Box primary power shall be permitted to be from a utility distribution system, a photovoltaic power system, or user power, or shall be self-powered using either an integral battery or other stored energy source, as approved by the authority having jurisdiction.

5-8.2.13.2 Self-powered boxes shall have sufficient power for uninterrupted operation for a period of not less than 6 months. Self-powered boxes shall transmit a low power warning message to the communications center for at least 15 days prior to the time the power source will fail to operate the box. This message shall be part of all subsequent transmissions.

Use of a charger to extend the life of a self-powered box shall be permitted where the charger does not interfere with box operation. The box shall be capable of operation for not less than 6 months with the charger disconnected.

5-8.2.13.3 Boxes powered by a utility distribution system shall have an integral standby, sealed, rechargeable battery capable of powering box functions for at least 60 hours in the event of primary power failure. Transfer to standby battery power shall be automatic and without interruption to box operation. Where operating from primary power, the box shall be capable of operation with a dead or disconnected battery. A local trouble indication shall activate upon primary power failure. A battery charger shall be provided in compliance with 1-5.2.9.2, except as modified herein.

Where the primary power has failed, boxes shall transmit a power failure message to the communications center as part of subsequent test messages until primary power is restored. A low battery message shall be transmitted to the

communications center where the remaining battery standby time is less than 54 hours.

5-8.2.13.4 Photovoltaic power systems shall provide box operation for not less than 6 months.

Photovoltaic power systems shall be supervised. The battery shall have power to sustain operation for a minimum period of 15 days without recharging. The box shall transmit a trouble message to the communications center when the charger has failed for more than 24 hours. This message shall be part of all subsequent transmissions. Where the remaining battery standby duration is less than 10 days, a low battery message shall be transmitted to the communications center.

5-8.2.13.5 User-powered boxes shall have an automatic self-test feature.

5-8.2.14 Design of Telephone Street Boxes (Series or Parallel).

5-8.2.14.1 If a handset is used, the caps on the transmitter and receiver shall be secured to reduce the probability of the telephone street box being disabled due to vandalism.

5-8.2.14.2 Telephone street boxes shall be designed to allow the communications center operator to determine whether or not the telephone street box has been restored to normal condition after use.

5-9 Supervisory Signal-Initiating Devices.

5-9.1 Control Valve Supervisory Signal-Initiating Device. Two separate and distinct signals shall be initiated: one indicating movement of the valve from its normal position, and the other indicating restoration of the valve to its normal position. The off-normal signal shall be initiated during the first two revolutions of the hand wheel or during 1/5 of the travel distance of the valve control apparatus from its normal position. The off-normal signal shall not be restored at any valve position except normal.

5-9.2 Pressure Supervisory Signal-Initiating Device. Two separate and distinct signals shall be initiated: one indicating that the required pressure has increased or decreased, and the other indicating restoration of the pressure to its normal value.

(a) A pressure tank supervisory signal-initiating device for a pressurized limited water supply, such as a pressure tank, shall indicate both high and low pressure conditions. A signal shall be initiated when the required pressure increases or decreases 10 psi (70 kPa) from the normal pressure.

(b) A pressure supervisory signal-initiating device for a dry-pipe sprinkler system shall indicate both high and low pressure conditions. A signal shall be initiated when the pressure increases or decreases 10 psi (70 kPa) from the normal pressure.

(c) A steam pressure supervisory signal-initiating device shall indicate a low pressure condition. A signal shall be initiated when the pressure reaches or exceeds 110 percent of the minimum operating pressure of the steam-operated equipment supplied.

(d) An initiating device for supervising the pressure of sources other than those specified in 5-9.2(a) through (c) shall be provided as required by the authority having jurisdiction.

5-9.3 Water Level Supervisory Signal-Initiating Device. Two separate and distinct signals shall be initiated: one indicating that the required water level has been lowered or raised, and the other indicating restoration to the normal level.

(a) A pressure tank signal-initiating device shall indicate both high and low level conditions. A signal shall be obtained when the water level falls 3 in. (76 mm) below or rises 3 in. (76 mm) above the normal level.

(b) A supervisory signal-initiating device for other than pressure tanks shall initiate a low level signal when the water level falls 12 in. (300 mm) below the normal level.

5-9.4 Water Temperature Supervisory Signal-Initiating Device. A temperature supervisory device for a water storage container exposed to freezing conditions shall initiate two separate and distinctive signals. One signal shall indicate that the temperature of the water has dropped to 40°F (4.4°C), and the other shall indicate restoration to a proper temperature.

5-9.5 Room Temperature Supervisory Signal-Initiating Device. A room temperature supervisory device shall indicate a decrease in room temperature to 40°F (4.4°C) and its restoration to above 40°F (4.4°C).

5-10* Smoke Detectors for Control of Smoke Spread.

5-10.1* Smoke detectors installed and used to prevent smoke spread by initiating control of fans, dampers, doors, and other equipment shall be classified as:

(a) Area detectors that are installed in the related smoke compartments.

(b) Detectors that are installed in the air duct systems.

5-10.2* Detectors that are installed in the air duct system per 5-10.1(b) shall not be used as a substitute for open area protection. Where open area protection is required, 5-3.4 shall apply.

5-10.3 Smoke detectors in the related smoke compartment for open area protection shall be the preferred means to initiate control of smoke spread.

5-10.4* Purposes.

5-10.4.1 To prevent the recirculation of dangerous quantities of smoke, a detector approved for air duct use shall be installed on the supply side of air-handling systems as required by NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*, and 5-10.5.2.1.

5-10.4.2 Where smoke detectors are used to initiate selectively the operation of equipment to control smoke spread, the requirements of 5-10.5.2.2 shall apply.

5-10.4.3 Where detectors are used to initiate the operation of smoke doors, the requirements of 5-10.7 shall apply.

5-10.4.4 Where duct detectors are used to initiate the operation of smoke dampers within ducts, the requirements of 5-10.6 shall apply.

5-10.5 Application.

5-10.5.1 Area Detectors within Smoke Compartments. Area smoke detectors shall be permitted to be used to control the spread of smoke by initiating appropriate operation of doors, dampers, and other equipment.

5-10.5.2 Smoke Detection for the Air Duct System.

5-10.5.2.1 Supply Air System. Where the detection of smoke in the supply air system is required by other NFPA standards, a detector(s) listed for the air velocity present and located in the supply air duct downstream of both the fan and the filters shall be installed.

Exception: Additional smoke detectors shall not be required to be installed in ducts where the air duct system passes through other smoke compartments not served by the duct.

5-10.5.2.2* Return Air System. Where the detection of smoke in the return air system is required by other NFPA standards, a detector(s) listed for the air velocity present shall be located at every return air opening within the smoke compartment, where the air leaves each smoke compartment, or in the duct system before the air enters the return air system common to more than one smoke compartment. [*See Figures A-5-10.5.2.2(a), (b), and (c).*]

Exception No. 1: Where complete smoke detection is installed in the smoke compartment, installation of air duct detectors in the return air system shall not be required, provided their function can be accomplished by the design of the area detection system.

Exception No. 2: Additional smoke detectors shall not be required to be installed in ducts where the air duct system passes through other smoke compartments not served by the duct.

5-10.6 Location and Installation of Detectors in Air Duct Systems.

5-10.6.1 Detectors shall be listed for the purpose.

5-10.6.2* Air duct detectors shall be securely installed in such a way as to obtain a representative sample of the airstream. This shall be permitted to be achieved by any of the following methods:

(a) Rigid mounting within the duct;

(b) Rigid mounting to the wall of the duct with the sensing element protruding into the duct;

(c) Installation outside the duct with rigidly mounted sampling tubes protruding into the duct;

(d) Installation through the duct with projected light beam.

5-10.6.3 Detectors shall be accessible for cleaning and shall be mounted in accordance with the manufacturer's instructions. Access doors or panels shall be provided in accordance with NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*.

5-10.6.4 The location of all detectors in air duct systems shall be permanently and clearly identified and recorded.

5-10.6.5 Detectors mounted outside of a duct employing sampling tubes for transporting smoke from inside the duct to the detector shall be designed and installed to allow verification of airflow from the duct to the detector.

5-10.6.6 Detectors shall be listed for proper operation over the complete range of air velocities, temperature, and humidity expected at the detector when the air-handling system is operating.

5-10.6.7 All penetrations of a return air duct in the vicinity of detectors installed on or in an air duct shall be sealed to prevent entrance of outside air and possible dilution or redirection of smoke within the duct.

5-10.6.8 Where in-duct smoke detectors are installed in concealed locations, more than 10 ft (3 m) above the finished floor, or in arrangements where the detector's alarm indicator is not readily visible to responding personnel, the detectors shall be provided with remote alarm indicators. Remote alarm indicators shall be installed in a readily accessible location and shall be clearly labeled to indicate both their function (e.g., "In-Duct Smoke Detector Alarm") and the air-handling unit(s) associated with each detector.

Exception: Where the specific detector in alarm is indicated at the control unit.

5-10.7 Smoke Detectors for Door Release Service.

5-10.7.1 Smoke door release not initiated by a fire alarm system that includes smoke detectors protecting the areas on both sides of the door affected shall be accomplished by smoke detectors applied as specified in 5-10.7.

5-10.7.2 Smoke detectors listed exclusively for door release service shall not be used for open area protection.

A smoke detector used concurrently for door release service and open area protection shall be permitted where listed for open area protection and installed in accordance with 5-3.4.

5-10.7.3 Smoke detectors shall be of the photoelectric, ionization, or other approved type.

5-10.7.4 Number of Detectors Required.

5-10.7.4.1 Where doors are to be closed in response to smoke flowing in either direction, the requirements of 5-10.7.4.1.1 through 5-10.7.4.1.3 shall apply.

5-10.7.4.1.1 Where the depth of wall section above the door is 24 in. (610 mm) or less, one ceiling-mounted detector shall be required on one side of the doorway only. (*See Figure 5-10.7.4.1.1, parts B and D.*)

5-10.7.4.1.2* Where the depth of wall section above the door is greater than 24 in. (610 mm), two ceiling-mounted detectors shall be required, one on each side of the doorway. (*See Figure 5-10.7.4.1.1, part F.*)

5-10.7.4.1.3 Where a detector is specifically listed for door frame mounting or where a listed combination or integral detector-door closer assembly is used, only one detector shall be required where installed in the manner recommended by the manufacturer.

5-10.7.4.2 Where door release is intended to prevent smoke transmission from one space to another in one direction only, one detector located in the space to which smoke is to be confined shall be required, regardless of the depth of wall section above the door. Alternatively, a smoke detector conforming with 5-10.7.4.1.3 shall be permitted to be used.

5-10.7.4.3 Where there are multiple doorways, additional ceiling-mounted detectors shall be required as specified in 5-10.7.4.3.1 through 5-10.7.4.3.3.

5-10.7.4.3.1 Where the separation between doorways exceeds 24 in. (610 mm), each doorway shall be treated separately. (*See Figure 5-10.7.4.3.1, part E.*)

5-10.7.4.3.2 Each group of three doorway openings shall be treated separately. (*See Figure 5-10.7.4.3.2.*)

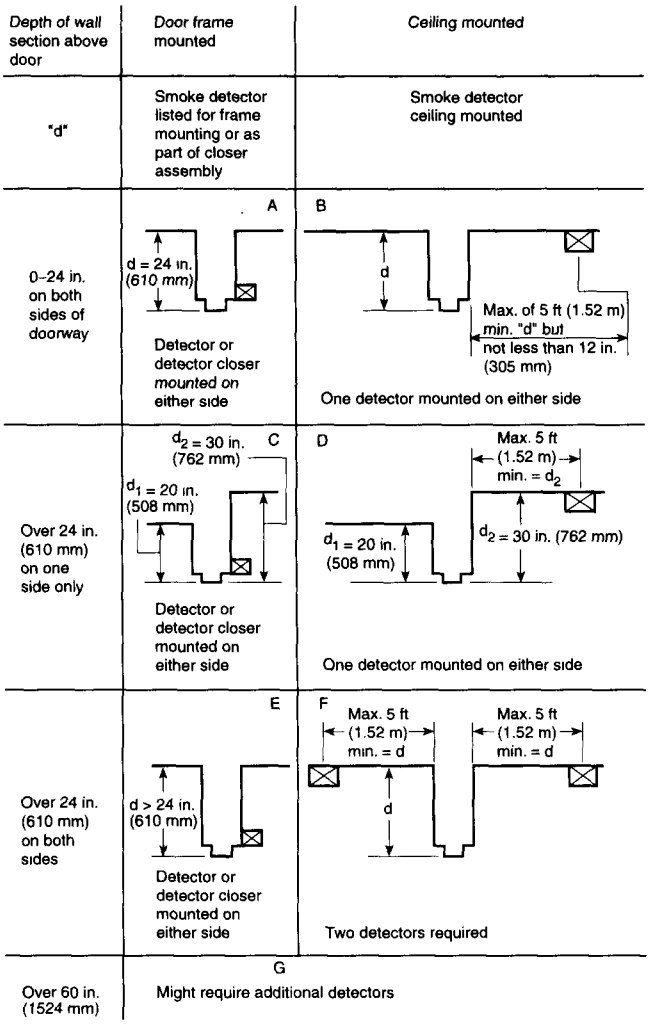


Figure 5-10.7.4.1.1 Detector location requirements for wall sections.

5-10.7.4.3.3 Each group of doorway openings that exceeds 20 ft (6.1 m) in width measured at its overall extremes shall be treated separately. (*See Figure 5-10.7.4.3.3.*)

5-10.7.4.4 Where there are multiple doorways and listed door frame-mounted detectors or where listed combination or integral detector-door closer assemblies are used, there shall be one detector for each single or double doorway.

5-10.7.5 Location.

5-10.7.5.1 Where ceiling-mounted smoke detectors are to be installed on a smooth ceiling for a single or double doorway, they shall be located as follows (*see Figure 5-10.7.4.3.1*):

(a) On the centerline of the doorway; and

(b) No more than 5 ft (1.5 m), measured along the ceiling and perpendicular to the doorway (*see Figure 5-10.7.4.1.1*); and

(c) No closer than shown in Figure 5-10.7.4.1.1, parts B, D, and F.

5-10.7.5.2 Where ceiling-mounted detectors are to be installed in conditions other than those outlined in 5-10.7.5.1, an engineering evaluation shall be made.

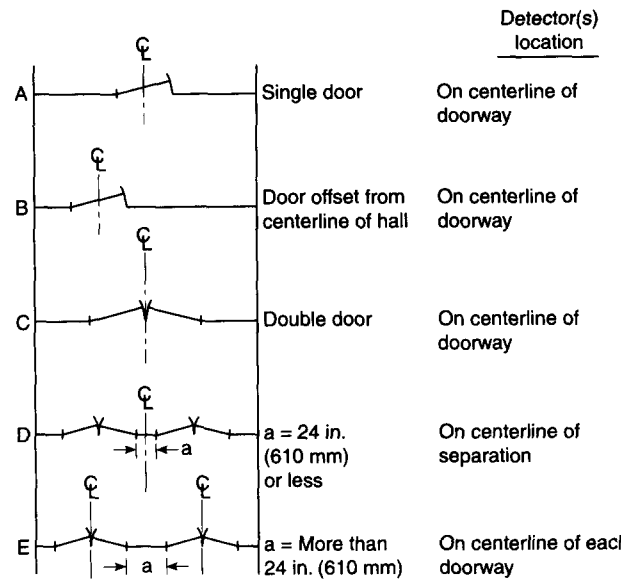


Figure 5-10.7.4.3.1 Detector location requirements for single and double doors.

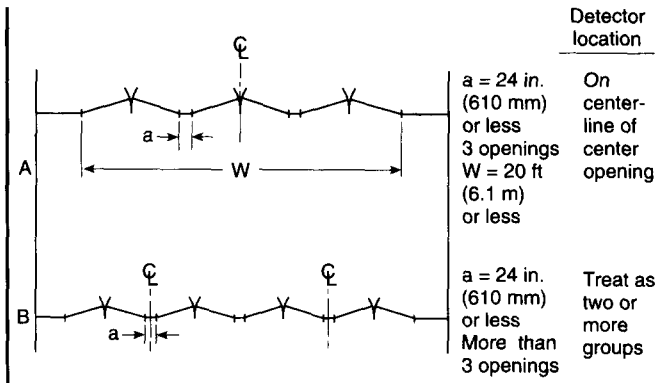


Figure 5-10.7.4.3.2 Detector location requirements for group doorways.

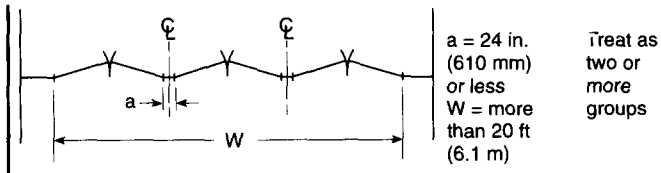


Figure 5-10.7.4.3.3 Detector location requirements for group doorways over 20 ft (6.1 m) in width.

Chapter 6 Notification Appliances for Fire Alarm Systems

6-1 Scope.

6-1.1 Minimum Requirements. This chapter covers minimum requirements for the performance, location, and mounting of notification appliances for fire alarm systems for the purpose of evacuation or relocation of the occupants.

6-1.2 Intended Use. These requirements are intended to be used with other NFPA standards that deal specifically with fire alarm, extinguishment, or control systems. Notification appliances for fire alarm systems add to fire protection by providing stimuli for initiating emergency action.

6-1.3 All notification appliances or combinations thereof installed in conformity with this chapter shall be listed for the purpose for which they are used.

6-1.4 These requirements are intended to address the reception of a notification signal and not its information content.

6-1.5 Interconnection of Appliances. The interconnection of appliances, the control configurations, the power supplies, and the use of the information provided by notification appliances for fire alarm systems are described in Chapter 1 and Chapter 3.

6-2 General.

6-2.1 Nameplates.

6-2.1.1 Notification appliances shall include on their nameplates reference to electrical requirements and rated audible or visible performance, or both, as defined by the listing authority.

6-2.1.2 The audible appliances shall include on their nameplates reference to their parameters or reference to installation documents (supplied with the appliance) that include the parameters in accordance with 6-3.2. The visible appliances shall include on their nameplates reference to their parameters or reference to installation documents (supplied with the appliance) that include the parameters in accordance with 6-4.2.1.

6-2.2 Physical Construction. Appliances intended for use in special environments (e.g., outdoors versus indoors, high or low temperatures, high humidity, dusty conditions, hazardous locations) or where subject to tampering shall be listed for the intended application.

6-2.3* Where subject to obvious mechanical damage, appliances shall be suitably protected. Where guards or covers are employed, they shall be listed for use with the appliance. Their effect on the appliance's field performance shall be considered in accordance with the listing requirements.

6-2.4 In all cases, appliances shall be supported independently of their attachments to the circuit conductors.

6-3 Audible Characteristics.

6-3.1 General Requirements.

6-3.1.1 Audibility. The sound level of an installed audible signal shall be adequate to perform its intended function and shall meet the requirements of the authority having jurisdiction or other applicable standards.

6-3.1.2 An average sound level greater than 105 dBA shall require the use of a visible signal appliance(s) in accordance with Section 6-4.

6-3.1.3 The total sound pressure level produced by combining the ambient sound pressure level with all audible signaling appliances operating shall not exceed 120 dBA anywhere in the occupied area.

6-3.1.4 Sound sources not normally found continuously in the occupied area shall not be required to be considered in measuring maximum ambient sound level.

6-3.1.5 Mechanical Equipment Rooms. Where audible appliances are installed in mechanical equipment rooms, the average ambient sound level used for design guidance shall be at least 85 dBA for all occupancies.

6-3.2* Public Mode Audible Requirements.

6-3.2.1 Audible signal appliances intended for operation in the public mode shall have a sound level of not less than 75 dBA at 10 ft (3 m) or more than 120 dBA at the minimum hearing distance from the audible appliance.

6-3.2.2* To ensure that audible public mode signals are clearly heard, they shall have a sound level at least 15 dBA above the average ambient sound level or 5 dBA above the maximum sound level having a duration of at least 60 seconds, whichever is greater, measured 5 ft (1.5 m) above the floor in the occupiable area.

6-3.3 Private Mode Audible Requirements.

6-3.3.1 Private Mode. Audible signals intended for operation in the private mode shall have a sound level of not less than 45 dBA at 10 ft (3 m) or more than 120 dBA at the minimum hearing distance from the audible appliance.

6-3.3.2 To ensure that audible private mode signals are clearly heard, they shall have a sound level at least 10 dBA above the average ambient sound level or 5 dBA above the maximum sound level having a duration of at least 60 seconds, whichever is greater, measured 5 ft (1.5 m) above the floor in the occupiable area.

6-3.4 Sleeping Areas. Where audible appliances are installed to signal sleeping areas, they shall have a sound level of at least 15 dBA above the average ambient sound level or 5 dBA above the maximum sound level having a duration of at least 60 seconds or a sound level of at least 70 dBA, whichever is greater, measured at the pillow level in the occupiable area.

6-3.5 Location of Audible Signal Appliances.

6-3.5.1 Where ceiling heights allow, wall-mounted appliances shall have their tops at heights above the finished floors of not less than 90 in. (2.30 m) and below the finished ceilings of not less than 6 in. (152 mm). This requirement shall not preclude ceiling-mounted or recessed appliances.

Exception: Combination audible/visible appliances installed in sleeping areas shall comply with 6-4.4.3.

6-3.5.2 Where combination audible/visible appliances are installed, the location of the installed appliance shall be determined by the requirements of 6-4.4.

Exception: Where the combination audible/visible appliance serves as an integral part of a smoke detector, the mounting location shall be in accordance with Chapter 2.

6-4 Visible Characteristics, Public Mode.

6-4.1 There are two methods of visible signaling. These are methods in which the message of notification of an emergency condition is conveyed by direct viewing of the illuminating appliance or by means of illumination of the surrounding area.

NOTE: One method of determining compliance with Section 6-4 is that the product be listed in accordance with UL 1971, *Standard for Safety Signaling Devices for the Hearing Impaired.*

6-4.2 Light Pulse Characteristics. The flash rate shall not exceed two flashes per second (2 Hz) nor be less than one flash every second (1 Hz) throughout the listed voltage range of the appliance.

6-4.2.1 A maximum pulse duration shall be 0.2 second with a maximum duty cycle of 40 percent. The pulse duration is defined as the time interval between initial and final points of 10 percent of maximum signal.

6-4.2.2 The light source color shall be clear or nominal white and shall not exceed 1000 candela (cd) (effective intensity).

6-4.3 Appliance Photometrics. Visible notification appliances used in the public mode shall be located so that the operating effect of the appliance can be seen by the intended viewers and shall be of a type, size, intensity, and number so that the viewer can discern when they have been illuminated, regardless of the viewer's orientation.

6-4.4 Appliance Location. Wall-mounted appliances shall have their bottoms at heights above the finished floor of not less than 80 in. (2 m) and no greater than 96 in. (2.4 m). Ceiling-mounted appliances shall be installed per Table 6-4.4.1(b).

Exception: Appliances installed in sleeping areas shall comply with 6-4.4.3.

6-4.4.1* Spacing in Rooms.

6-4.4.1.1 Spacing shall be in accordance with Figure 6-4.4.1.1 and Tables 6-4.4.1.1(a) and (b). The separation between appliances shall not exceed 100 ft (30 m).

Visible notification appliances shall be installed in accordance with Table 6-4.4.1.1(a), using one of the following:

(a)* A single visible notification appliance; or

(b) Two visible notification appliances located on opposite walls; or

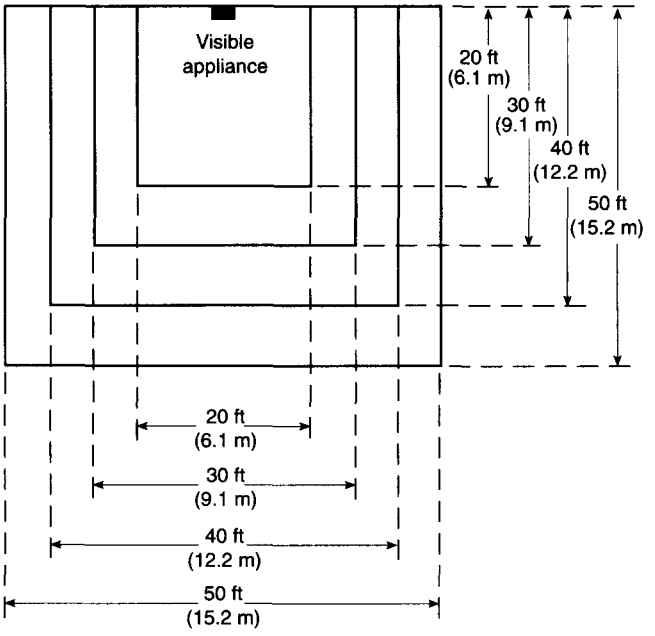
(c)* In rooms 80 ft × 80 ft (24.4 m × 24.4 m) or greater, where there are more than two appliances in any field of view, they shall be spaced a minimum of 55 ft (16.76 m) from each other; or

(d) More than two visible notification appliances that flash in synchronization.

6-4.4.1.2 Where a room configuration is not square, the square room size that entirely encompasses the room or subdivides the room into multiple squares shall be used.

6-4.4.2* Spacing in Corridors.

6-4.4.2.1 Table 6-4.4.2.1 shall apply to corridors not exceeding 20 ft (6.1 m) in width. For corridors greater than 20 ft (6.1 m) wide, refer to Figure 6-4.4.1.1 and Tables 6-4.4.1.1(a) and (b). In a corridor application, visible appliances shall be rated not less than 15 cd.



Note: Figure 6-4.4.1.1 is based on locating the visible signaling appliance at the halfway distance of the longest wall. In square rooms with appliances not centered or nonsquare rooms, the effective intensity (cd) from one visible signaling appliance shall be determined by maximum room size dimensions obtained either by measuring the distance to the farthest wall or by doubling the distance to the farthest adjacent wall, whichever is greater, as shown in Table 6-4.4.1.1(a).

Figure 6-4.4.1.1 Room spacing for wall-mounted visible appliances.

6-4.4.2.2 The visible appliances shall be located no more than 15 ft (4.57 m) from the end of the corridor with a separation no greater than 100 ft (30.4 m) between appliances. Where there is an interruption of the concentrated viewing path, such as a fire door, an elevation change, or any other obstruction, the area shall be considered as a separate corridor.

6-4.4.3* Sleeping Areas.

6-4.4.3.1 Combination smoke detectors and visible appliances shall be installed in accordance with the applicable requirements of Chapter 6, Chapter 2, and Chapter 5.

6-4.4.3.2 Table 6-4.4.3.2 shall apply to sleeping areas having no linear dimension greater than 16 ft (4.87 m). For larger rooms, the visible notification appliance shall be located within 16 ft (4.87 m) of the pillow.

6-4.4.4 Where visible appliances are required, a minimum of one appliance shall be installed in the concentrated viewing path such as might be experienced in such areas as classrooms or theater stages.

6-5 Visible Characteristics, Private Mode. Visible signals used in the private mode shall be adequate for their intended purpose.

6-6 Supplementary Visible Signaling Method. A supplementary visible appliance is intended to augment an audible or visible signal.

6-6.1 A supplementary visible appliance shall comply with its marked rated performance.

6-6.2 Supplementary visible notification appliances shall be permitted to be located less than 80 in. (2 m) above the floor.

Table 6-4.4.1.1(a) Room Spacing for Wall-Mounted Visible Appliances

Maximum Room Size (ft)	Maximum Room Size (m)	Minimum Required Light Output, Candela (cd) (Effective Intensity): One Light Per Room (cd)	Two Lights per Room (Located on Opposite Walls) (cd)	Four Lights per Room One Light per Wall) (cd)
20 × 20	6.1 × 6.1	15	N/A	N/A
30 × 30	9.14 × 9.14	30	15	N/A
40 × 40	12.2 × 12.2	60	30	N/A
50 × 50	15.2 × 15.2	95	60	N/A
60 × 60	18.3 × 18.3	135	95	N/A
70 × 70	21.3 × 21.3	185	95	N/A
80 × 80	24.4 × 24.4	240	135	60
90 × 90	27.4 × 27.4	305	185	95
100 × 100	30.5 × 30.5	375	240	95
110 × 110	33.5 × 33.5	455	240	135
120 × 120	36.6 × 36.6	540	305	135
130 × 130	39.6 × 39.6	635	375	185

N/A: Not allowable.

Table 6-4.4.1.1(b) Room Spacing for Ceiling-Mounted Visible Appliances

Maximum Room Size (ft)	Maximum Room Size (m)	Minimum Required Light Output, Candela (cd) (Effective Intensity): Maximum Ceiling Height (ft)	Maximum Ceiling Height (m)	One Light (cd)
20 × 20	6.1 × 6.1	10	3.05	15
30 × 30	9.14 × 9.14	10	3.05	30
40 × 40	12.2 × 12.2	10	3.05	60
50 × 50	15.2 × 15.2	10	3.05	95
20 × 20	6.1 × 6.1	20	6.1	30
30 × 30	9.14 × 9.14	20	6.1	45
40 × 40	12.2 × 12.2	20	6.1	80
50 × 50	15.2 × 15.2	20	6.1	115
20 × 20	6.1 × 6.1	30	9.14	55
30 × 30	9.14 × 9.14	30	9.14	75
40 × 40	12.2 × 12.2	30	9.14	115
50 × 50	15.2 × 15.2	30	9.14	150

NOTE 1: Where ceiling heights exceed 30 ft (9.14 m), visible signaling appliances shall be suspended at or below 30 ft (9.14 m) or wall-mounted in accordance with Table 6-4.4.1.1(a).

NOTE 2: Table 6-4.4.1.1(b) is based on locating the visible signaling appliance at the center of the room. Where it is not located at the center of the room, the effective intensity (cd) shall be determined by doubling the distance from the appliance to the farthest wall to obtain the maximum room size.

Table 6-4.4.2.1 Corridor Spacing for Visible Appliances

Corridor Length (ft)	Corridor Length (m)	Minimum Number of 15-cd Visible Appliances Required
0–30	0–9.14	1
31–130	9.45–39.6	2
131–230	39.93–70	3
231–330	70.4–100.6	4
331–430	100.9–131.1	5
431–530	131.4–161.5	6

Table 6-4.4.3.2 Effective Intensity Requirements for Sleeping Area

Visible Notification Appliance: Distance from Ceiling to Top of Lens	Intensity
Greater than or equal to 24 in. (610 mm)	110 cd
Less than 24 in. (610 mm)	177 cd

6-7 Textual Audible Appliances.

6-7.1 Performance. The textual appliance shall reproduce normal voice frequencies.

6-7.2 Loudspeaker Appliance. The sound level in dBA of the loudspeaker appliance evacuation tone signals of the particular mode installed shall comply with all the requirements in 6-3.2.

6-7.3 Location of Loudspeaker Appliances.

6-7.3.1 Where ceiling heights allow, wall-mounted loudspeaker appliances shall have their tops at heights above the finished floors of not less than 90 in. (2.30 m) and below the finished ceilings of not less than 6 in. (152 mm). This requirement shall not preclude ceiling-mounted or recessed appliances.

6-7.3.2 Where loudspeaker/visible appliances are installed, the height of the installed appliance shall comply with 6-4.4.

Exception: Combination loudspeaker/visible appliances installed in sleeping areas shall comply with 6-4.4.3.

6-7.4 Telephone Appliance. The telephone appliance shall be in accordance with EIA Tr 41.3, *Telephones*.

6-7.5 Location of Telephone Appliances. Wall-mounted telephone appliances or related jacks shall be of convenient heights not to exceed 66 in. (1.7 m).

Exception: Where accessible to the general public, one telephone appliance per location shall be no higher than 54 in. (1.37 m) with clear access to the wall of at least 30 in. (0.76 m) wide.

6-8* Textual Visible Appliances.

6-8.1 The temporary textual visible appliance shall be a nonstorage display that produces either visible alphanumerics subtending a character angle to the observing eye of not less than 10 minutes of arc or visible pictorial images.

6-8.1.1 The alphanumeric display shall have an equivalent minimum 7 × 5 matrix character definition, a minimum grey scale contrast as defined by 10 shades of grey, and a character retentivity from 1/2 minute to 5 minutes.

6-8.1.2 The pictorial display shall have a minimum 250-line scan per frame and a minimum of 250 points per line scan, each arranged on a scale of 10 shades of grey, and shall have 30 frames per second. The display shall have an aspect ratio of 1:1.33.

6-8.2 Location. All textual visible appliances in the private mode shall be located in rooms accessible only to those persons directly concerned with the implementation and direction of emergency action initiation and procedure in the areas protected by the fire alarm system.

Exception: In the lobby of a building where required by the authority having jurisdiction.

Chapter 7 Inspection, Testing, and Maintenance

7-1 General.

7-1.1 Scope. This chapter covers the minimum requirements for the inspection, testing, and maintenance of the fire alarm systems described in Chapters 1, 3, and 4 and for their initiation and notification components described in Chapters 5 and 6. The testing and maintenance requirements for one- and two-family dwelling units are located in Chapter 2. Single station detectors used for other than one- and two-family dwelling units shall be tested and maintained in accordance with this chapter. More stringent inspection, testing, or maintenance procedures that are required by other parties shall be permitted.

7-1.1.1 Inspection, testing, and maintenance programs shall satisfy the requirements of this code, conform to the equipment manufacturer's recommendations, and verify proper operation of the fire alarm system.

7-1.1.2 Nothing in this chapter is intended to prevent the use of alternate test methods or testing devices, provided such methods or devices are equivalent in effectiveness and safety and meet the intent of the requirements of this chapter.

7-1.2 The owner or owner's designated representative shall be responsible for inspection, testing, and maintenance of the system and alterations or additions to this system. The delegation of responsibility shall be in writing, with a copy of such delegation made available to the authority having jurisdiction.

7-1.2.1 Inspection, testing, or maintenance shall be permitted to be done by a person or organization other than the owner where conducted under a written contract. Testing and maintenance of central station service systems shall be performed under the contractual arrangements specified in 4-2.2.2.

7-1.2.2 Service personnel shall be qualified and experienced in the inspection, testing, and maintenance of fire alarm systems. Examples of qualified personnel shall be permitted to include, but shall not be limited to, individuals who are:

(a) Factory trained and certified.

(b) National Institute for Certification in Engineering Technologies fire alarm certified.

(c) International Municipal Signal Association fire alarm certified.

(d) Certified by a state or local authority.

(e) Trained and qualified personnel employed by an organization listed by a national testing laboratory for the servicing of fire alarm systems.

7-1.3* Notification.

7-1.3.1 Before proceeding with any testing, all persons who receive and facilities that receive alarm, supervisory, or trouble signals, and all building occupants, shall be notified to prevent unnecessary response. At the conclusion of testing, those previously notified (and others, as necessary) shall be notified that testing has been concluded.

7-1.3.2 The owner or owner's designated representative and service personnel shall coordinate system testing to prevent interruption of critical building systems or equipment.

7-1.4 Prior to system maintenance or testing, the system certificate and the information regarding the system and system alterations, including specifications, wiring diagrams,

and floor plans, shall be made available by the owner or a designated representative to the service personnel.

7-1.5 Releasing Systems. This subsection covers requirements pertinent to testing fire alarm systems initiating fire suppression system releasing functions.

7-1.5.1 Testing personnel shall be familiar with the specific arrangement and operation of the suppression system(s) and releasing function(s) and cognizant of the hazards associated with inadvertent system discharge.

7-1.5.2 Occupant notification shall be required whenever a fire alarm system configured for releasing service is being serviced or tested.

7-1.5.3 Discharge testing of suppression systems shall not be required by this code. Suppression systems shall be secured from inadvertent actuation, including disconnection of releasing solenoids/electric actuators, closing of valves, other actions, or combinations thereof, as appropriate for the specific system, for the duration of the fire alarm system testing.

7-1.5.4 Testing shall include verification that the releasing circuits and components energized or actuated by the fire alarm system are electrically supervised and operate as intended on alarm.

7-1.5.5 Suppression systems and releasing components shall be returned to their normal condition upon completion of system testing.

7-1.6 System Testing.

7-1.6.1 Initial Acceptance Testing. All new systems shall be inspected and tested in accordance with the requirements of this chapter.

7-1.6.2* Reacceptance Testing.

7-1.6.2.1 Reacceptance testing shall be performed after system components are added or deleted; after any modification, repair, or adjustment to system hardware or wiring; or after any change to software. All components, circuits, systems operations, or site-specific software functions known to be affected by the change or identified by a means that indicates the system operational changes shall be 100 percent tested. In addition, 10 percent of initiating devices that are not directly affected by the change, up to a maximum of 50 devices, also shall be tested and proper system operation shall be verified. A revised record of completion in accordance with 1-7.2.1 shall be prepared to reflect any changes.

7-1.6.2.2 Changes to all control units connected or controlled by the system executive software shall require a 10-percent functional test of the system, including a test of at least one device on each input and output circuit to verify critical system functions such as notification appliances, control functions, and off-premises reporting.

7-2 Test Methods.

7-2.1* Central Stations. The installation shall be inspected at the request of the authority having jurisdiction for complete information regarding the system, including specifications, wiring diagrams, and floor plans that have been submitted for approval prior to installation of equipment and wiring.

7-2.2* Fire alarm systems and other systems and equipment that are associated with fire alarm systems and accessory equipment shall be tested according to Table 7-2.2.

7-3 Inspection and Testing Frequency.

7-3.1* Visual Inspection. Visual inspection shall be performed in accordance with the schedules in this chapter or more frequently where required by the authority having jurisdiction. The visual inspection shall be made to ensure that there are no changes that can affect equipment performance.

Exception No. 1: Devices or equipment that is inaccessible for safety considerations (e.g., continuous process operations, energized electrical equipment, radiation, excessive height) shall be inspected during scheduled shutdowns where approved by the authority having jurisdiction. Extended intervals shall not exceed 18 months.

Exception No. 2: Where automatic inspection is performed at a frequency of not less than weekly by a remotely monitored fire alarm control unit specifically listed for such application, the visual inspection frequency shall be permitted to be annual. (See Table 7-3.1.)

7-3.2* Testing. Testing shall be performed in accordance with the schedules in this chapter or more frequently where required by the authority having jurisdiction. Where automatic testing is performed at least weekly by a remotely monitored fire alarm control unit specifically listed for the application, the manual testing frequency shall be permitted to be extended to annual. (*See Table 7-3.2.*)

Exception: Devices or equipment that is inaccessible for safety considerations (e.g., continuous process operations, energized electrical equipment, radiation, excessive height) shall be tested during scheduled shutdowns where approved by the authority having jurisdiction but not more than every 18 months.

Table 7-2.2 Test Methods

Device	Method
1. Control Equipment	
a. Functions	At a minimum, control equipment shall be tested to verify proper receipt of alarm, supervisory, and trouble signals (inputs), operation of evacuation signals and auxiliary functions (outputs), circuit supervision including detection of open circuits and ground faults, and power supply supervision for detection of loss of ac power and disconnection of secondary batteries.
b. Fuses	Remove fuse and verify rating and supervision.
c. Interfaced Equipment	Integrity of single or multiple circuits providing interface between two or more control panels shall be verified. Interfaced equipment connections shall be tested by operating or simulating operation of the equipment being supervised. Signals required to be transmitted shall be verified at the control panel.
d. Lamps and LEDs	Lamps and LEDs shall be illuminated.
e. Primary (Main) Power Supply	All secondary (standby) power shall be disconnected and tested under maximum load, including all alarm appliances requiring simultaneous operation. All secondary (standby) power shall be reconnected at end of test. For redundant power supplies, each shall be tested separately.
2. Engine-Driven Generator	Where an engine-driven generator dedicated to the fire alarm system is used as a required power source, operation of the generator shall be verified in accordance with NFPA 110, *Standard for Emergency and Standby Power Systems*, by the building owner.
3. Secondary (Standby) Power Supply	Disconnect all primary (main) power supplies and verify that required trouble indication for loss of primary power occurs. Measure or verify system's standby and alarm current demand and, using manufacturer's data, verify whether batteries are adequate to meet standby and alarm requirements. Operate general alarm systems for a minimum of 5 minutes and emergency voice communications systems for a minimum of 15 minutes. Reconnect primary (main) power supply at end of test.
4. Uninterrupted Power Supply (UPS)	Where a UPS system dedicated to the fire alarm system is used as a required power source, operation of the UPS system shall be verified by the building owner in accordance with NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems*.
5. Batteries — General Tests	
a. Visual Inspection	Inspect batteries for corrosion or leakage. Check and ensure tightness of connections. Where necessary, clean and coat the battery terminals or connections. Visually inspect electrolyte level in lead-acid batteries.
b. Battery Replacement	Batteries shall be replaced in accordance with the recommendations of the alarm equipment manufacturer, or when the recharged battery voltage or current falls below the manufacturer's recommendations.
c. Charger Test	Check operation of battery charger in accordance with charger test for the specific type of battery.
d. Discharge Test	With the battery charger disconnected, load test the batteries following the manufacturer's recommendations. The voltage level shall not fall below the levels specified. *Exception: An artificial load equal to the full fire alarm load connected to the battery shall be permitted to be utilized in conducting this test.*
e. Load Voltage Test	With the battery charger disconnected, measure the terminal voltage while supplying the maximum load required by its application. The voltage level shall not fall below the levels specified for the specific type of battery. Where the voltage falls below the level specified, corrective action shall be taken and the batteries shall be retested. *Exception: An artificial load equal to the full fire alarm load connected to the battery shall be permitted to be utilized in conducting this test.*
f. Open Circuit Voltage	With the battery charger disconnected, measure the open circuit voltage of the battery.

Table 7-2.2 Test Methods *(continued)*

Device	Method
6. Battery Tests (Specific Types)	
a. Primary Battery Load Voltage Test	The maximum load for a No. 6 primary battery shall not be more than 2 amperes per cell. An individual (1.5-volt) cell shall be replaced when a load of 1 ohm reduces the voltage below 1 volt. A 6-volt assembly shall be replaced where a test load of 4 ohms reduces the voltage below 4 volts.
b. Lead-Acid Type:	
1. Charger Test	With the batteries fully charged and connected to the charger, measure the voltage across the batteries with a voltmeter. The voltage shall be 2.30 volts per cell ± 0.02 volt at 25°C (77°F) or as specified by the equipment manufacturer.
2. Load Voltage Test	Under load, the battery shall not fall below 2.05 volts per cell.
3. Specific Gravity	The specific gravity of the liquid in the pilot cell or all of the cells shall be measured as required. The specific gravity shall be within the range specified by the manufacturer. Although the specified specific gravity can vary from manufacturer to manufacturer, a range of 1.205 – 1.220 is typical for regular lead-acid batteries, while 1.240 – 1.260 is typical for high performance batteries. A hydrometer that shows only a pass or fail condition of the battery and does not indicate the specific gravity shall not be used, since such a reading does not give a true indication of the battery condition.
c. Nickel-Cadmium Type:	
1. Charger Test	With the batteries fully charged and connected to the charger, place an amp meter in series with the battery under charge. The charging current shall be in accordance with the manufacturer's recommendations for the type of battery used. In the absence of specific information, this usually is $1/30$ to $1/25$ of the battery rating. [Example: 4000 mAh × $1/25$ = 160 mA charging current at 25°C (77°F).]
2. Load Voltage Test	Under load, the float voltage for the entire battery shall be 1.42 volts per cell, nominal. If possible, cells shall be measured individually.
d. Sealed Lead-Acid Type:	
1. Charger Test	With the batteries fully charged and connected to the charger, measure the voltage across the batteries with a voltmeter. The voltage should be 2.30 volts per cell ± 0.02 volt at 25°C (77°F) or as specified by the equipment manufacturer.
2. Load Voltage Test	Under load, the battery shall perform in accordance with the battery manufacturers' specifications.
7. Public Reporting System Tests	In addition to the tests and inspection required above, the following requirements shall apply. Manual tests of the power supply for public reporting circuits shall be made and recorded at least once during each 24-hour period. Such tests shall include: (a) Current strength of each circuit. Changes in current of any circuit, amounting to 10 percent of normal current, shall be investigated immediately. (b) Voltage across terminals of each circuit, inside of terminals of protective devices. Changes in voltage of any circuit, amounting to 10 percent of normal voltage, shall be investigated immediately. (c) Voltage between ground and circuits. Where this test shows a reading in excess of 50 percent of that shown in the test specified in (b) above, the trouble shall be immediately located and cleared; readings in excess of 25 percent shall be given early attention. These readings shall be taken with a voltmeter of not more than 100-ohms resistance per volt. NOTE 1: The voltmeter sensitivity has been changed from 1000 ohms per volt to 100 ohms per volt so that false ground readings (caused by induced voltages) are minimized. NOTE 2: Systems in which each circuit is supplied by an independent current source (Forms 3 and 4) require tests between ground and each side of each circuit. Common current source systems (Form 2) require voltage tests between ground and each terminal of each battery and other current source. (d) A ground current reading shall be permitted in lieu of (c) above. Where this method of testing is used, all grounds showing a current reading in excess of 5 percent of the normal line current shall be given immediate attention.

Table 7-2.2 Test Methods *(continued)*

Device	Method
	(e) Voltage across terminals of common battery, on switchboard side of fuses. (f) Voltage between common battery terminals and ground. Abnormal ground readings shall be investigated immediately. NOTE: Tests specified in (e) and (f) above apply only to those systems using a common battery. Where more than one common battery is used, each common battery is to be tested.
8. Transient Suppressors	Lightning protection equipment shall be inspected and maintained per manufacturer's specifications. Additional inspections shall be required after any lightning strikes. Equipment located in moderate to severe areas outlined in NFPA 780, *Standard for the Installation of Lightning Protection Systems*, Appendix I, shall be inspected semi-annually and after any lightning strikes.
9. Control Panel Trouble Signals	
a. Audible and Visual	Verify operation of panel trouble signals and ring-back feature for systems using a trouble-silencing switch that requires resetting.
b. Disconnect Switches	Where control unit (panel) has disconnect or isolating switches, verify that each switch performs its intended function and a trouble signal is received when a supervised function is disconnected.
c. Ground-Fault Monitoring Circuit	Where system has ground detection feature, verify that a ground-fault indication is given whenever any installation conductor is grounded.
d. Transmission of Signals to Off-Premises Location	Actuate an appropriate initiating device and verify that alarm signal is received at the off-premises location. Create a trouble condition and verify that a trouble signal is received at the off-premises location. Actuate a supervisory device and verify that a supervisory signal is received at the off-premises location. Where a transmission carrier is capable of operation under a single or multiple fault condition, activate an initiating device during such fault condition and verify that a trouble signal is received at the off-premises location in addition to the alarm signal.
10. Remote Annunciators	Verify for proper operation and confirm proper identification. Where provided, verify proper operation under a fault condition.
11. Conductors/Metallic	
a. Stray Voltage	All installation conductors shall be tested with a volt/ohm meter to verify that there are no stray (unwanted) voltages between installation conductors or between installation conductors and ground. Unless a different threshold is specified in the system installed equipment manufacturer's specifications, the maximum allowable stray voltage shall not exceed 1 volt ac/dc.
b. Ground Faults	All installation conductors other than those intentionally and permanently grounded shall be tested for isolation from ground per the installed equipment manufacturer's specifications.
c. Short Circuit Faults	All installation conductors other than those intentionally connected together shall be tested for conductor-to-conductor isolation per the installed equipment manufacturer's specifications. These same circuits also shall be tested conductor-to-ground.
d. Loop Resistance	With each initiating and indicating circuit installation conductor pair short-circuited at the far end, measure and record the resistance of each circuit. Verify that the loop resistance does not exceed the installed equipment manufacturer's specified limits.
12. Conductors/Nonmetallic	
a. Circuit Integrity	Test each initiating device, indicating appliance, and signaling line circuit to confirm that the integrity of installation conductors is being properly supervised.

Table 7-2.2 Test Methods *(continued)*

Device	Method
b. Fiber Optics	The fiber-optic transmission line shall be tested in accordance with the manufacturer's instructions, by the use of an optical power meter, or by an optical time domain reflectometer to measure the relative power loss of the line. This relative figure for each fiber-optic line shall be recorded in the fire alarm control panel. Where the power level drops 2 percent or more from the value recorded during the initial acceptance test, the transmission line, section thereof, or connectors shall be repaired or replaced by a qualified technician to bring the line back into compliance with the accepted transmission level per manufacturer's recommendations.
c. Supervision	Introduction of a fault in any supervised circuit shall result in a suitable trouble indication at the control unit. One connection shall be opened at not less than 10 percent of the initiating device, indicating appliance, and signaling line circuits. Test each initiating device, indicating appliance, and signaling line circuit for proper alarm response. NOTE: See Table 3-6 for description of circuit performance and capacity.
13. Initiating Devices	
a. Electromechanical Releasing Device:	
1. Nonrestorable-Type Link	Remove the fusible link and operate the associated device to ensure proper operation. Lubricate any moving parts as necessary.
2. Restorable-Type Link	Remove the fusible link and operate the associated device to ensure proper operation. Lubricate any moving parts as necessary. NOTE: Fusible thermal link detectors are commonly used to close fire doors and fire dampers. They can be actuated by the presence of external heat, which causes a solder element in the link to fuse, or by an electric thermal device, which, when energized, generates heat within the body of the link, causing the link to fuse and separate.
b. Fire Extinguishing System(s) or Suppression System(s) Alarm Switch	Mechanically or electrically operate the switch and verify receipt of signal by the control panel.
c. Fire-Gas and Other Detectors	Fire-gas detectors and other fire detectors shall be tested as prescribed by the manufacturer and as necessary for the application.
d. Heat Detectors:	
1. Fixed-Temperature, Rate-of-Rise, Rate-of-Compensation, Restorable Line, Spot Type (excluding Pneumatic Tube Type)	Heat test with a heat source per manufacturer's recommendations for response within 1 minute. Precaution should be taken to avoid damage to the nonrestorable fixed-temperature element of a combination rate-of-rise/fixed-temperature element.
2. Fixed-Temperature, Nonrestorable Line Type	Do not heat test. Test mechanically and electrically for function. Measure and record loop resistance. Investigate changes from acceptance test.
3. Fixed-Temperature, Nonrestorable Spot Type	After 15 years, replace all devices or laboratory test two detectors per 100. Replace the two detectors with new devices. Where a failure occurs on any of the detectors removed, additional detectors shall be removed and tested to determine either a general problem involving faulty detectors or a localized problem involving one or two defective detectors.
4. Nonrestorable (General)	Do not heat test. Test mechanically and electrically for function.
5. Restorable Line Type, Pneumatic Tube Only	Heat source (where test chambers are in circuit) or pressure pump.
e. Fire Alarm Boxes	Operate per manufacturer's instruction. For key-operated presignal fire alarm boxes, test both presignal and general alarm circuits.
f. Radiant Energy Fire Detectors	Flame detectors and spark/ember detectors shall be tested in accordance with the manufacturer's instructions to determine that each detector is operative. Flame detector and spark/ember detector sensitivity shall be determined using either:

Table 7-2.2 Test Methods *(continued)*

Device	Method
	(a) A calibrated test method; or (b) The manufacturer's calibrated sensitivity test instrument; or (c) Listed control panel arranged for the purpose; or (d) Other calibrated sensitivity test method acceptable to the authority having jurisdiction that is directly proportional to the input signal from a fire consistent with the detector listing or approval. Detectors found to be outside of the approved range of sensitivity shall be replaced or adjusted to bring them into the approved range where designed to be field adjustable. Flame detector and spark/ember detector sensitivity shall not be determined using a light source that administers an unmeasured quantity of radiation at an undefined distance from the detector.
g. Smoke Detectors: 1. Systems Detectors	The detectors shall be tested in place to ensure smoke entry into the sensing chamber and an alarm response. Testing with smoke or listed aerosol acceptable to the manufacturer, or other means acceptable to the detector manufacturer, shall be permitted as one acceptable test method. Ensure that each smoke detector is within its listed and marked sensitivity range by testing using either: (a) A calibrated test method; or (b) The manufacturer's calibrated sensitivity test instrument; or (c) Listed control equipment arranged for the purpose; or (d) A smoke detector/control unit arrangement whereby the detector causes a signal at the control unit when its sensitivity is outside its acceptable sensitivity range; or (e) Other calibrated sensitivity test method acceptable to the authority having jurisdiction. NOTE: The detector sensitivity cannot be tested or measured using any spray device that administers an unmeasured concentration of aerosol into the detector.
2. Single Station Detectors	The detectors shall be tested in place to ensure smoke entry into the sensing chamber and an alarm response. Testing with smoke or listed aerosol acceptable to the manufacturer, or other means acceptable to the detector manufacturer, shall be permitted as one acceptable test method.
3. Air Sampling	Per manufacturer's recommended test methods, and verify detector alarm response through the end sampling port on each pipe run, as well as verifying airflow through all other ports.
4. Duct Type	Air duct detectors shall be tested or inspected to ensure that the device will sample the airstream. The test shall be made in accordance with the manufacturer's instructions.
5. Projected Beam Type	The detector shall be tested by introducing smoke, other aerosol, or an optical filter into the beam path.
6. Smoke Detector with Built-in Thermal Element	Operate both portions of the detector independently as described for the respective devices.
7. Smoke Detectors with Control Output Functions	Where individual fire detectors are used to control the operation of equipment as permitted by 3-7.1, the control capability shall remain operable even where all of the initiating devices connected to the same initiating circuit are in an alarm state.
h. Initiating Devices, Supervisory: 1. Control Valve Switch	Operate valve and verify signal receipt within the first two revolutions of the hand wheel or within $\frac{1}{5}$ of the travel distance, or per the manufacturer's specifications.
2. High- or Low-Air Pressure Switch	Operate switch and verify that receipt of signal is obtained where the required pressure is increased or decreased 10 psi (70 kPa) from the required pressure level.
3. Room Temperature Switch	Operate switch and verify receipt of signal to indicate the decrease in room temperature to 40°F (4.4°C) and its restoration to above 40°F (4.4°C).

Table 7-2.2 Test Methods (*continued*)

Device	Method
4. Water Level Switch	Operate switch and verify the receipt of signal indicating the water level raised or lowered 3 in. (76.2 mm) from the required level within a pressure tank, or 12 in. (305 mm) from the required level of a nonpressure tank, and its restoral to required level.
5. Water Temperature Switch	Operate switch and verify receipt of signal to indicate the decrease in water temperature to 40°F (4.4°C) and its restoration to above 40°F (4.4°C).
i. Mechanical, Electrosonic, or Pressure-Type Waterflow Device	Flow water through an inspector's test connection indicating the flow of water equal to that from a single sprinkler of the smallest orifice size installed in the system for wet-pipe systems, or an alarm test bypass connection for dry-pipe, pre-action, or deluge systems in accordance with NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*.
14. Alarm Notification Appliances	
a. Audible	Measure sound pressure level with sound level meter meeting ANSI S-1.4a, *Specifications for Sound Level Meters*, Type 2 requirements. Measure and record levels throughout protected area.
b. Speakers	Measure sound pressure level with sound level meter meeting ANSI S-1.4a, *Specifications for Sound Level Meters*, Type 2 requirements. Measure and record levels throughout protected area. Verify voice clarity.
c. Visible	Test in accordance with manufacturer's instructions. Verify device locations are per approved layout and confirm that no floor plan changes affect the approved layout.
15. Special Hazard Equipment	
a. Abort Switch (IRI Type)	Operate abort switch. Verify correct sequence and operation.
b. Abort Switch (Recycle Type)	Operate abort switch. Verify correct matrix develops with each sensor operated.
c. Abort Switch (Special Type)	Operate abort switch. Verify correct sequence and operation in accordance with authority having jurisdiction. Note sequence on as-built drawings or in owner's manual.
d. Cross Zone Detection Circuit	Operate one sensor or detector on each zone. Verify that correct sequence occurs with operation of first zone and then with operation of second zone.
e. Matrix-Type Circuit	Operate all sensors in system. Verify correct matrix develops with each sensor operated.
f. Release Solenoid Circuit	Use solenoid with equal current requirements. Verify operation of solenoid.
g. Squibb Release Circuit	Use AGI flashbulb or other test light acceptable to the manufacturer. Verify operation of flashbulb or light.
h. Verified, Sequential, or Counting Zone Circuit	Operate required sensors at a minimum of four locations in circuit. Verify correct sequence with both the first and second detector in alarm.
i. All Above Devices or Circuits or Combinations Thereof	Verify supervision of circuits by creating an open circuit. Note specific trouble indications.
16. Supervising Station Fire Alarm Systems — Transmission Equipment	
a. All Equipment	Test all system functions and features in accordance with the equipment manufacturer's instructions for proper operation in conformance with the applicable sections of Chapter 4. Actuate an initiating device; and verify that the appropriate initiating device signal is received at the supervising station within 90 seconds. Upon completion of the test, restore the system to its normal condition. Where test jacks are used, the first and last tests shall be made without the use of the test jack.

Table 7-2.2 Test Methods *(continued)*

Device	Method
b. Digital Alarm Communicator Transmitter (DACT)	Ensure that the DACT is connected to two separate means of transmission. *Exception: DACTs that are connected to a telephone line (number) that is also supervised for adverse conditions by a derived local channel.* Test the DACT for line seizure capability by initiating a signal while utilizing the primary line for a telephone call. Verify that the appropriate signal is received at the supervising station. Verify that completion of the transmission attempt was completed within 90 seconds from going off-hook to on-hook. Disconnect the primary line from the DACT. Verify that the DACT trouble signal is indicated at the premises and is transmitted to the supervising station within 4 minutes of detection of the fault. Disconnect the secondary means of transmission from the DACT. Verify that the DACT trouble signal is indicated at the premises and is transmitted to the supervising station within 4 minutes of detection of the fault. Cause the DACT to transmit a signal to the DACR while a fault in the primary telephone number is simulated. Verify that the DACT utilized the secondary telephone number to complete the transmission to the DACR.
c. Digital Alarm Radio Transmitter (DART)	Disconnect the primary telephone line. Verify that the DART transmits a trouble signal to the supervising station within 4 minutes.
d. McCulloh Transmitter	Actuate an initiating device. Verify that the McCulloh transmitter produces not less than three complete rounds of not less than three signal impulses each. Where end-to-end metallic continuity is present and with a properly balanced circuit, cause each of the following four transmission channel fault conditions in turn and verify receipt of proper signals at the supervising station: (a) Open; (b) Ground; (c) Wire-to-wire short; (d) Open and ground. Where end-to-end metallic continuity is not present and with a properly balanced circuit, cause each of the following three transmission channel fault conditions in turn and verify receipt of proper signals at the supervising station: (a) Open; (b) Ground; (c) Wire-to-wire short.
e. Radio Alarm Transmitter (RAT)	Cause a fault between elements of the transmitting equipment. Verify that an indication of the fault is indicated at the protected premises or that a trouble signal is transmitted to the supervising station.
17. Supervising Station Fire Alarm Systems — Receiving Equipment	
a. All Equipment	Test all system functions and features in accordance with the equipment manufacturer's instructions for proper operation in conformance with the applicable sections of Chapter 4. Actuate an initiating device, and verify that the appropriate initiating device signal is received at the supervising station within 90 seconds. Upon completion of the test, restore the system to its normal condition. Where test jacks are used, the first and last tests shall be made without the use of the test jack.
b. Digital Alarm Communicator Receiver (DACR)	Disconnect in turn each telephone line (number) from the DACR and verify that a signal of trouble is audibly and visually annunciated in the supervising station. Cause a signal to be transmitted on each individual incoming DACR line at least once every 24 hours. Verify receipt of these signals.

Table 7-2.2 Test Methods *(continued)*

Device	Method
c. Digital Alarm Radio Receiver (DARR)	Cause the following conditions of all DARRs on all subsidiary and repeater station receiving equipment. Verify that the supervising station receives appropriate signals for each of the following conditions: (a) AC power failure of the radio equipment; (b) Receiver malfunction; (c) Antenna and interconnecting cable failure; (d) Indication of automatic switchover of the DARR; (e) Data transmission line failure between the DARR and the supervising or subsidiary station.
d. McCulloh Systems	Test and record the current on each circuit at each supervising and subsidiary station under the following conditions: (a) Normal; (b) On each side of the circuit with the receiving equipment conditioned for an open circuit. Cause a single break or ground condition on each transmission channel. Where such a fault prevents the normal functioning of the circuit, verify that a trouble signal has been received. Cause each of the following conditions at each of the supervising or subsidiary stations and all repeater station radio transmitting and receiving equipment. Verify receipt of appropriate signals at the supervising station: (a) RF transmitter in use (radiating); (b) AC power failure supplying the radio equipment; (c) RF receiver malfunction; (d) Indication of automatic switchover.
e. Radio Alarm Supervising Station Receiver (RASSR) and Radio Alarm Repeater Station Receiver (RARSR)	Cause each of the following conditions at each of the supervising or subsidiary stations and all repeater station radio transmitting and receiving equipment. Verify receipt of appropriate signals at the supervising station: (a) AC power failure supplying the radio equipment; (b) RF receiver malfunction; (c) Indication of automatic switchover (where applicable).
f. Private Microwave Radio Systems	Cause each of the following conditions at each of the supervising or subsidiary stations and all repeater station radio transmitting and receiving equipment. Verify receipt of appropriate signals at the supervising station: (a) RF transmitter in use (radiating); (b) AC power failure supplying the radio equipment; (c) RF receiver malfunction; (d) Indication of automatic switchover.
18. Emergency Communications Equipment	
a. Amplifier/Tone Generators	Verification of proper switching and operation of backup equipment.
b. Call-in Signal Silence	Operate function and verify receipt of proper visual and audible signals at control panel.
c. Off-hook Indicator (Ring Down)	Install phone set or remove phone from hook and verify receipt of signal at control panel.
d. Phone Jacks	Visual inspection and initiate communications path through jack.
e. Phone Set	Activate each phone set and verify proper operation.
f. System Performance	Operate system with a minimum of any five handsets simultaneously. Verify acceptable voice quality and clarity.
19. Interface Equipment	Interface equipment connections shall be tested by operating or simulating the equipment being supervised. Signals required to be transmitted shall be verified at the control panel. Test frequency for interface equipment shall be the same as the frequency required by the applicable NFPA standard(s) for the equipment being supervised.

Table 7-2.2 Test Methods *(continued)*

Device	Method
20. Guard's Tour Equipment	Test the device in accordance with manufacturer's specifications.
21. Special Procedures	
a. Alarm Verification	Verify time delay and alarm response for smoke detector circuits identified as having alarm verification.
b. Multiplex Systems	Verify communications between sending and receiving units under both normal and standby power.
	Verify communications between sending and receiving units under open circuit and short circuit trouble conditions.
	Verify communications between sending and receiving units in all directions where multiple communications pathways are provided.
	Where redundant central control equipment is provided, verify switchover and all required functions and operations of secondary control equipment.
	Verify all system functions and features in accordance with manufacturer's instructions.
22. Low Power Radio (Wireless Systems)	The following procedures describe additional acceptance and reacceptance test methods to verify wireless protection system operation:
	(a) The manufacturer's manual and the as-built drawings provided by the system supplier shall be used to verify proper operation after the initial testing phase has been performed by the supplier or by the supplier's designated representative.
	(b) Starting from the normal condition, initialize the system in accordance with the manufacturer's manual. A test shall be conducted to verify the alternative path, or paths, by turning off or disconnecting the primary wireless repeater. The alternative communications path shall exist between the wireless control panel and peripheral devices used to establish initiation, indicating, control, and annunciation. The system shall be tested for both alarm and trouble conditions.
	(c) Batteries for all components in the system shall be checked monthly. Where the control panel checks all batteries and all components daily, the system shall not require monthly testing of the batteries.

7-3.2.1* Detector sensitivity shall be checked within 1 year after installation and every alternate year thereafter. After the second required calibration test, where sensitivity tests indicate that the detector has remained within its listed and marked sensitivity range (or 4 percent obscuration light grey smoke, if not marked), the length of time between calibration tests shall be permitted to be extended to a maximum of 5 years. Where the frequency is extended, records of detector-caused nuisance alarms and subsequent trends of these alarms shall be maintained. In zones or in areas where nuisance alarms show any increase over the previous year, calibration tests shall be performed.

To ensure that each smoke detector is within its listed and marked sensitivity range, it shall be tested using either:

(a) A calibrated test method; or

(b) The manufacturer's calibrated sensitivity test instrument; or

(c) Listed control equipment arranged for the purpose; or

(d) A smoke detector/control unit arrangement whereby the detector causes a signal at the control unit where its sensitivity is outside its acceptable sensitivity range; or

(e) Other calibrated sensitivity test method acceptable to the authority having jurisdiction.

Detectors found to have a sensitivity outside the listed and marked sensitivity range shall be cleaned and recalibrated or replaced.

Exception No. 1: Detectors listed as field adjustable shall be permitted to be either adjusted within the listed and marked sensitivity range and cleaned and recalibrated, or they shall be replaced.

Exception No. 2: This requirement shall not apply to single station detectors referenced in 7-3.3 and Table 7-2.2.

The detector sensitivity shall not be tested or measured using any device that administers an unmeasured concentration of smoke or other aerosol into the detector.

7-3.2.2 Test frequency of interfaced equipment shall be the same as specified by the applicable NFPA standards for the equipment being supervised.

7-3.2.3 For restorable fixed-temperature spot-type heat detectors, two or more detectors shall be tested on each initiating circuit annually. Different detectors shall be tested each year, with records kept by the building owner specifying which detectors have been tested. Within 5 years, each detector shall have been tested.

Table 7-3.1 Visual Inspection Frequencies

	Component	Init./Reaccpt.	Monthly	Quarterly	Semiann.	Ann.
1.	**Control Equipment: Fire Alarm Systems Monitored for Alarm, Supervisory, Trouble Signals**					
	a. Fuses	X				X
	b. Interfaced Equipment	X				X
	c. Lamps and LEDs	X				X
	d. Primary (Main) Power Supply	X				X
2.	**Control Equipment: Fire Alarm Systems Unmonitored for Alarm, Supervisory, Trouble Signals**					
	a. Fuses	X (weekly)				
	b. Interfaced Equipment	X (weekly)				
	c. Lamps and LEDs	X (weekly)				
	d. Primary (Main) Power Supply	X (weekly)				
3.	**Batteries**					
	a. Lead-Acid	X	X			
	b. Nickel-Cadmium	X			X	
	c. Primary (Dry Cell)	X	X			
	d. Sealed Lead-Acid	X			X	
4.	**Transient Suppressors**	X			X	
5.	**Control Panel Trouble Signals**	X			X	
6.	**Fiber-Optic Cable Connections**	X				X
7.	**Emergency Voice/Alarm Communications Equipment**	X			X	
8.	**Remote Annunciators**	X			X	
9.	**Initiating Devices**					
	a. Air Sampling	X			X	
	b. Duct Detectors	X			X	
	c. Electromechanical Releasing Devices	X			X	
	d. Fire Extinguishing System(s) or Suppression System(s) Switches	X			X	
	e. Fire Alarm Boxes	X			X	
	f. Heat Detectors	X			X	
	g. Radiant Energy Fire Detectors	X		X		
	h. Smoke Detectors	X			X	
	i. Supervisory Signal Devices	X		X		
	j. Waterflow Devices	X		X		
10.	**Guard's Tour Equipment**	X			X	
11.	**Interface Equipment**	X			X	
12.	**Alarm Notification Appliances — Supervised**	X			X	
13.	**Supervising Station Fire Alarm Systems — Transmitters**					
	a. DACT	X			X	
	b. DART	X			X	
	c. McCulloh	X			X	
	d. RAT	X			X	
14.	**Special Procedures**	X			X	
15.	**Supervising Station Fire Alarm Systems — Receivers**					
	a. DACR[1]	X	X			
	b. DARR[1]	X			X	
	c. McCulloh Systems[1]	X			X	
	d. Two-Way RF Multiplex[1]	X			X	
	e. RASSR[1]	X			X	
	f. RARS[1]	X			X	
	g. Private Microwave[1]	X			X	

[1]Reports of automatic signal receipt shall be verified daily.

Table 7-3.2 Testing Frequencies

Component	Init./Reaccpt.	Monthly	Quarterly	Semiann.	Ann.	Table 7-2.2 Reference
1. Control Equipment: Fire Alarm Systems Monitored for Alarm, Supervisory, Trouble Signals						1, 7, 16, 17
a. Functions	X				X	
b. Fuses	X				X	
c. Interfaced Equipment	X				X	
d. Lamps and LEDs	X				X	
e. Primary (Main) Power Supply	X				X	
f. Transponders	X				X	
2. Control Equipment: Fire Alarm Systems Unmonitored for Alarm, Supervisory, Trouble Signals						1
a. Functions	X		X			
b. Fuses	X		X			
c. Interfaced Equipment	X		X			
d. Lamps and LEDs	X		X			
e. Primary (Main) Power Supply	X		X			
f. Transponders	X		X			
3. Engine-Driven Generator	X (weekly)					
4. Batteries — Central Station Facilities						
a. Lead-Acid Type						6b
1. Charger Test (Replace battery as needed.)	X				X	
2. Discharge Test (30 min)	X	X				
3. Load Voltage Test	X	X				
4. Specific Gravity	X			X		
b. Nickel-Cadmium Type						6c
1. Charger Test (Replace battery as needed.)	X		X			
2. Discharge Test (30 min)	X				X	
3. Load Voltage Test	X				X	
c. Sealed Lead-Acid Type	X	X				6d
1. Charger Test (Replace battery as needed.)		X	X			
2. Discharge Test (30 min)	X	X				
3. Load Voltage Test	X	X				
5. Batteries — Fire Alarm Systems						
a. Lead-Acid Type						6b
1. Charger Test (Replace battery as needed.)	X				X	
2. Discharge Test (30 min)	X			X		
3. Load Voltage Test	X			X		
4. Specific Gravity	X			X		
b. Nickel-Cadmium Type						6c
1. Charger Test (Replace battery as needed.)	X				X	
2. Discharge Test (30 min)	X				X	
3. Load Voltage Test	X			X		
c. Primary Type (Dry Cell)						6a
1. Load Voltage Test	X	X				
d. Sealed Lead-Acid Type						6d
1. Charger Test (Replace battery every 4 years.)	X				X	
2. Discharge Test (30 min)	X				X	
3. Load Voltage Test	X			X		
6. Batteries — Public Fire Alarm Reporting Systems	X (daily)					
Voltage tests in accordance with Table 7-2.2 , item 7, Public Reporting System Tests, paragraphs (a) through (f).						
a. Lead-Acid Type						6b
1. Charger Test (Replace battery as needed.)	X				X	

Table 7-3.2 Testing Frequencies *(continued)*

	Component	Init./Reaccpt.	Monthly	Quarterly	Semiann.	Ann.	Table 7-2.2 Reference
	2. Discharge Test (2 hr)	X		X			
	3. Load Voltage Test	X		X			
	4. Specific Gravity	X			X		
	b. Nickel-Cadmium Type						6c
	1. Charger Test	X				X	
	(Replace battery as needed.)						
	2. Discharge Test (2 hr)	X				X	
	3. Load Voltage Test	X		X			
	c. Sealed Lead-Acid Type						6d
	1. Charger Test	X				X	
	(Replace battery as needed.)						
	2. Discharge Test (2 hr)	X				X	
	3. Load Voltage Test	X		X			
| 7.	**Fiber-Optic Cable Power**	X				X	12b
| 8.	**Control Unit Trouble Signals**	X				X	9
| 9.	**Conductors/Metallic**	X					11
| 10.	**Conductors/Nonmetallic**	X					12
| 11.	**Emergency Voice/Alarm Communications Equipment**	X				X	18
| 12.	**Retransmission Equipment**	X (*See 7-3.4.*)					
| 13.	**Remote Annunciators**	X				X	10
14.	**Initiating Devices**						13
	a. Duct Detectors	X				X	
	b. Electromechanical Releasing Device	X				X	
	c. Fire Extinguishing System(s) or Suppression System(s) Switches	X				X	
	d. Fire-Gas and Other Detectors	X				X	
	e. Heat Detectors	X				X	
	f. Fire Alarm Boxes	X				X	
|	g. Radiant Energy Fire Detectors	X			X		
	h. All Smoke Detectors — Functional	X				X	
	i. Smoke Detectors — Sensitivity (*See 7-3.2.1.*)						
|	j. Supervisory Signal Devices	X		X			
	k. Waterflow Devices (except valve tamper switches)	X			X		
	l. Valve Tamper Switches				X		
| 15.	**Guard's Tour Equipment**	X					
| 16.	**Interface Equipment**	X				X	19
| 17.	**Special Hazard Equipment**	X				X	15
| 18.	**Alarm Notification Appliances**						14
	a. Audible Devices	X				X	
	b. Speakers	X				X	
	c. Visible Devices	X				X	
| 19.	**Off-Premises Transmission Equipment**	X		X			
20.	**Supervising Station Fire Alarm Systems — Transmitters**						16
	a. DACT	X				X	
	b. DART	X				X	
	c. McCulloh	X				X	
	d. RAT	X				X	
| 21.	**Special Procedures**	X				X	21

Table 7-3.2 Testing Frequencies *(continued)*

Component	Init./Reaccpt.	Monthly	Quarterly	Semiann.	Ann.	Table 7-2.2 Reference
22. Supervising Station Fire Alarm Systems — Receivers						17
a. DACR	X	X				
b. DARR	X	X				
c. McCulloh Systems	X	X				
d. Two-Way RF Multiplex	X	X				
e. RASSR	X	X				
f. RARSR	X	X				
g. Private Microwave	X	X				

NOTE: For testing addressable and analog-described devices, which are normally affixed to either a single, molded assembly or are a twist-lock type affixed to a base, TESTING SHALL BE DONE UTILIZING THE SIGNALING STYLE CIRCUITS (Styles 0.5 through 7). The addressable term was determined by the Technical Committee in Formal Interpretation 79-8 on NFPA 72D and Formal Interpretation 87-1 on NFPA 72A.
Analog-type detectors shall be tested with the same criteria.

7-3.3 Single station smoke detectors installed in one- and two-family living units shall be inspected, tested, and maintained as specified in Chapter 2. Single station detectors installed in other than one- and two-family dwelling units shall be tested and maintained in accordance with this chapter.

7-3.4 Test of all circuits extending from the central station shall be made at intervals of not more than 24 hours.

7-4 Maintenance.

7-4.1 Fire alarm system equipment shall be periodically maintained in accordance with the manufacturer's instructions. The frequency of maintenance depends on the type of equipment and the local ambient conditions.

7-4.2 Any accumulation of dust and dirt can adversely affect device and appliance performance. The frequency of cleaning depends on the type of equipment and the local ambient conditions.

7-4.3 All apparatus requiring rewinding or resetting to maintain normal operation shall be restored to normal as promptly as possible after each test and alarm and kept in normal condition for operation. All test signals received shall be recorded to indicate date, time, and type.

7-4.4 The retransmission means as defined in Section 4-2 shall be tested at intervals of not more than 12 hours. The retransmission signal and the time and date of the retransmission shall be recorded in the central station.

Exception: Where the retransmission means is the public switched telephone network, it shall be permitted to be tested weekly to confirm its operation to each public fire service communications center.

7-5 Records.

7-5.1* Permanent Records. After successful completion of acceptance tests satisfactory to the authority having jurisdiction, a set of reproducible as-built installation drawings, operation and maintenance manuals, and a written sequence of operation shall be provided to the building owner or the owner's designated representative. It shall be the responsibility of the owner to maintain these records for the life of system and to keep them available for examination by any authority having jurisdiction. Paper or electronic media shall be permitted.

7-5.2 Maintenance, Inspection, and Testing Records.

7-5.2.1 Records shall be retained until the next test and for 1 year thereafter.

7-5.2.2 A permanent record of all inspections, testing, and maintenance shall be provided that includes the following information of periodic tests and all the applicable information requested in Figure 7-5.2.2.

(a) Date;
(b) Test frequency;
(c) Name of property;
(d) Address;
(e) Name of person performing inspection, maintenance, tests, or combination thereof, and affiliation, business address, and telephone number;
(f) Name, address, and representative of approving agency(ies);
(g) Designation of the detector(s) tested ("Tests performed in accordance with Section _____.");
(h) Functional test of detectors;
(i)* Functional test of required sequence of operations;
(j) Check of all smoke detectors;
(k) Loop resistance for all fixed-temperature line-type heat detectors;
(l) Other tests as required by equipment manufacturers;
(m) Other tests as required by the authority having jurisdiction;
(n) Signatures of tester and approved authority representative;
(o) Disposition of problems identified during test (e.g., owner notified, problem corrected/successfully retested, device abandoned in place).

7-5.3 Where off-premises monitoring is provided, records of signals, tests, and operations recorded at the monitoring center shall be maintained for not less than 12 months. Upon request, a hard copy record shall be available for examination by the authority having jurisdiction. Paper or electronic media shall be permitted.

7-5.4 Where the operation of a device, circuit, control panel function, or special hazard system interface is simulated, it shall be noted on the certificate that the operation was simulated, and the certificate shall indicate by whom it was simulated.

INSPECTION AND TESTING FORM

DATE: _____

TIME: _____

SERVICE ORGANIZATION
NAME: _____

ADDRESS: _____

REPRESENTATIVE: _____

LICENSE NO.: _____

TELEPHONE: _____

PROPERTY NAME (USER)
NAME: _____

ADDRESS: _____

OWNER CONTACT: _____

TELEPHONE: _____

MONITORING ENTITY
CONTACT: _____

TELEPHONE: _____

MONITORING ACCOUNT REF. NO.: _____

APPROVING AGENCY
CONTACT: _____

TELEPHONE: _____

TYPE TRANSMISSION
[ ]- McCulloh
[ ]- Multiplex
[ ]- Digital
[ ]- Reverse Priority
[ ]- RF
[ ]- Other (Specify)

_____

_____

SERVICE
[ ]- Weekly
[ ]- Monthly
[ ]- Quarterly
[ ]- Semiannually
[ ]- Annually
[ ]- Other (Specify)

PANEL MANUFACTURER: _____

MODEL NO.: _____

CIRCUIT STYLES: _____

NO. OF CIRCUITS: _____

SOFTWARE REV.: _____

LAST DATE SYSTEM HAD ANY SERVICE PERFORMED: _____

LAST DATE THAT ANY SOFTWARE OR CONFIGURATION WAS REVISED: _____

ALARM-INITIATING DEVICES AND CIRCUIT INFORMATION

QTY OF	CIRCUIT STYLE	
_____	_____	MANUAL STATIONS
_____	_____	ION DETECTORS
_____	_____	PHOTO DETECTORS
_____	_____	DUCT DETECTORS
_____	_____	HEAT DETECTORS
_____	_____	WATERFLOW SWITCHES
_____	_____	SUPERVISORY SWITCHES
_____	_____	OTHER (SPECIFY): _____

_____

Figure 7-5.2.2 Inspection and Testing Form.

ALARM NOTIFICATION APPLIANCES AND CIRCUIT INFORMATION

QTY OF	CIRCUIT STYLE	
_____	_____	BELLS
_____	_____	HORNS
_____	_____	CHIMES
_____	_____	STROBES
_____	_____	SPEAKERS
_____	_____	OTHER (SPECIFY): _____

NO. OF ALARM INDICATING CIRCUITS: _____

ARE CIRCUITS SUPERVISED? [ ] YES [ ] NO

SUPERVISORY SIGNAL-INITIATING DEVICES AND CIRCUIT INFORMATION

QTY OF	CIRCUIT STYLE	
_____	_____	BUILDING TEMP.
_____	_____	SITE WATER TEMP.
_____	_____	SITE WATER LEVEL
_____	_____	FIRE PUMP POWER
_____	_____	FIRE PUMP RUNNING
_____	_____	FIRE PUMP AUTO POSITION
_____	_____	FIRE PUMP OR PUMP CONTROLLER TROUBLE
_____	_____	FIRE PUMP RUNNING
_____	_____	GENERATOR IN AUTO POSITION
_____	_____	GENERATOR OR CONTROLLER TROUBLE
_____	_____	SWITCH TRANSFER
_____	_____	GENERATOR ENGINE RUNNING
_____	_____	OTHER: _____

SIGNALING LINE CIRCUITS

Quantity and style (See NFPA 72, Table 3-6) of signaling line circuits connected to system:

Quantity_____ Style(s) _____

SYSTEM POWER SUPPLIES

a. Primary (Main): Nominal Voltage _____, Amps _____
Overcurrent Protection: Type _____, Amps _____
Location (Panel Number): _____
Disconnecting Means Location: _____

b. Secondary (Standby):
_____ Storage Battery: Amp-Hr. Rating _____
Calculated capacity to operate system, in hours: _____ 24 _____ 60 _____
_____ Engine-driven generator dedicated to fire alarm system:
Location of fuel storage: _____

TYPE BATTERY

[ ] Dry Cell
[ ] Nickel-Cadmium
[ ] Sealed Lead-Acid
[ ] Lead-Acid
[ ] Other (Specify) _____

c. Emergency or standby system used as a backup to primary power supply, instead of using a secondary power supply:
_____ Emergency system described in NFPA 70, Article 700
_____ Legally required standby described in NFPA 70, Article 701
_____ Optional standby system described in NFPA 70, Article 702, which also meets the performance requirements of Article 700 or 701.

Figure 7-5.2.2 Inspection and Testing Form (*continued*).

PRIOR TO ANY TESTING

NOTIFICATIONS ARE MADE:	YES	NO	WHO	TIME
MONITORING ENTITY	[ ]	[ ]	_____	_____
BUILDING OCCUPANTS	[ ]	[ ]	_____	_____
BUILDING MANAGEMENT	[ ]	[ ]	_____	_____
OTHER (SPECIFY)	[ ]	[ ]	_____	_____
AHJ (NOTIFIED) OF ANY IMPAIRMENTS	[ ]	[ ]	_____	_____

SYSTEM TESTS AND INSPECTIONS

TYPE	VISUAL	FUNCTIONAL	COMMENTS
CONTROL PANEL	[ ]	[ ]	_____
INTERFACE EQ.	[ ]	[ ]	_____
LAMPS/LEDS	[ ]	[ ]	_____
FUSES	[ ]	[ ]	_____
PRIMARY POWER SUPPLY	[ ]	[ ]	_____
TROUBLE SIGNALS	[ ]	[ ]	_____
DISCONNECT SWITCHES	[ ]	[ ]	_____
GROUND FAULT MONITORING	[ ]	[ ]	_____

SECONDARY POWER

TYPE	VISUAL	FUNCTIONAL	COMMENTS
BATTERY CONDITION	[ ]		_____
LOAD VOLTAGE		[ ]	_____
DISCHARGE TEST		[ ]	_____
CHARGER TEST		[ ]	_____
SPECIFIC GRAVITY		[ ]	_____
TRANSIENT SUPPRESSORS	[ ]		_____
REMOTE ANNUNCIATORS	[ ]	[ ]	_____
NOTIFICATION APPLIANCES			
AUDIBLE	[ ]	[ ]	_____
VISUAL	[ ]	[ ]	_____
SPEAKERS	[ ]	[ ]	_____
VOICE CLARITY	[ ]		_____

INITIATING AND SUPERVISORY DEVICE TESTS AND INSPECTIONS

LOC. & S/N	DEVICE TYPE	VISUAL CHECK	FUNC-TIONAL TEST	FACTORY SETTING	MEAS. SETTING	PASS	FAIL
_____	_____	[ ]	[ ]	_____	_____	[ ]	[ ]
_____	_____	[ ]	[ ]	_____	_____	[ ]	[ ]
_____	_____	[ ]	[ ]	_____	_____	[ ]	[ ]
_____	_____	[ ]	[ ]	_____	_____	[ ]	[ ]
_____	_____	[ ]	[ ]	_____	_____	[ ]	[ ]
_____	_____	[ ]	[ ]	_____	_____	[ ]	[ ]

COMMENTS: _____

_____

_____

_____

Figure 7-5.2.2 Inspection and Testing Form (*continued*).

EMERGENCY COMMUNICATIONS EQUIPMENT	VISUAL	FUNCTIONAL	COMMENTS
PHONE SET	[ ]	[ ]	_____
PHONE JACKS	[ ]	[ ]	_____
OFF-HOOK INDICATOR	[ ]	[ ]	_____
AMPLIFIER(S)	[ ]	[ ]	_____
TONE GENERATOR(S)	[ ]	[ ]	_____
CALL-IN SIGNAL	[ ]	[ ]	_____
SYSTEM PERFORMANCE	[ ]	[ ]	_____

	VISUAL	DEVICE OPERATION	SIMULATED OPERATION
INTERFACE EQUIPMENT			
(SPECIFY) _____	[ ]	[ ]	[ ]
(SPECIFY) _____	[ ]	[ ]	[ ]
(SPECIFY) _____	[ ]	[ ]	[ ]
SPECIAL HAZARD SYSTEMS			
(SPECIFY) _____	[ ]	[ ]	[ ]
(SPECIFY) _____	[ ]	[ ]	[ ]
(SPECIFY) _____	[ ]	[ ]	[ ]

SPECIAL PROCEDURES: _____

_____

_____

_____

COMMENTS: _____

_____

_____

_____

_____

ON/OFF PREMISES MONITORING:	YES	NO	TIME	COMMENTS
ALARM SIGNAL	[ ]	[ ]	_____	_____
ALARM RESTORAL	[ ]	[ ]	_____	_____
TROUBLE SIGNAL	[ ]	[ ]	_____	_____
SUPERVISORY SIGNAL	[ ]	[ ]	_____	_____
SUPERVISORY RESTORAL	[ ]	[ ]	_____	_____

NOTIFICATIONS THAT TESTING IS COMPLETE:	YES	NO	WHO	TIME
BUILDING MANAGEMENT	[ ]	[ ]	_____	_____
MONITORING AGENCY	[ ]	[ ]	_____	_____
BUILDING OCCUPANTS	[ ]	[ ]	_____	_____
OTHER (SPECIFY)	[ ]	[ ]	_____	_____

THE FOLLOWING DID NOT OPERATE CORRECTLY: _____

_____

_____

_____

SYSTEM RESTORED TO NORMAL OPERATION: DATE _____ TIME _____

THIS TESTING WAS PERFORMED IN ACCORDANCE WITH APPLICABLE NFPA STANDARDS.

NAME OF INSPECTOR: _____ DATE: _____ TIME: _____

SIGNATURE: _____

NAME OF OWNER OR REPRESENTATIVE: _____

DATE: _____ TIME: _____

SIGNATURE: _____

Figure 7-5.2.2 Inspection and Testing Form (*continued*).

Chapter 8 Referenced Publications

8-1 The following documents or portions thereof are referenced within this code and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

8-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers*, 1990 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1996 edition.

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, 1996 edition.

NFPA 13R, *Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height*, 1996 edition.

NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps*, 1996 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 1995 edition.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 1994 edition.

NFPA 54, *National Fuel Gas Code*, 1996 edition.

NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*, 1995 edition.

NFPA 70, *National Electrical Code*, 1996 edition.

NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*, 1996 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems*, 1993 edition.

NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems*, 1996 edition.

NFPA 601, *Standard for Security Services in Fire Loss Prevention*, 1996 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 1995 edition.

NFPA 1221, *Standard for the Installation, Maintenance, and Use of Public Fire Service Communication Systems*, 1994 edition.

8-1.2 Other Publications.

8-1.2.1 ANSI Publications. American National Standards Institute, 1430 Broadway, New York, NY 10036.

ANSI A-58.1, *Building Code Requirements for Minimum Design Loads in Buildings and Other Structures*, 1982.

ANSI S-1.4a, *Specifications for Sound Level Meters*, 1985.

ANSI S3.41, *Audible Emergency Evacuation Signal*, 1990.

ANSI/ASME A17.1, *Safety Code for Elevators and Escalators*, 1993.

ANSI/IEEE C2, *National Electrical Safety Code*, 1993.

ANSI/UL 217, *Standard for Safety Single and Multiple Station Smoke Detectors*, 1993.

ANSI/UL 268, *Standard for Safety Smoke Detectors for Fire Protective Signaling Systems*, 1989.

ANSI/UL 827, *Standard for Safety Central-Station for Watchman, Fire-Alarm and Supervisory Services*, 1993.

8-1.2.2 EIA Publication. Electronic Industries Association, 2500 Wilson Boulevard, Arlington, VA 22201-3834.

EIA Tr 41.3, *Telephones.*

8-1.3 Additional References.

International Municipal Signal Association, P.O. Box 539, Newark, NY 14513.

National Institute for Certification in Engineering Technologies, 1420 King Street, Alexandria, VA 22314-2794.

Appendix A Explanatory Material

This Appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

A-1-2.1 In determining the performance criteria of circuits, the performance and capacity tables in Chapters 3 and 4 should be consulted. Where modifying an existing system, the system should be tested to determine the style of each circuit for the proper description and understanding of the system.

A-1-4 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations that is in a position to determine compliance with appropriate standards for the current production of listed items.

A-1-4 Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A-1-4 Ember. Class A and Class D combustibles burn as embers under conditions where the flame typically associated with fire does not necessarily exist. This glowing combustion yields radiant emissions in parts of the radiant energy spectrum that are radically different from those parts affected by flaming combustion. Specialized detectors, specifically designed to detect those emissions, should be used

in applications where this type of combustion is expected. In general, flame detectors are not intended for the detection of embers.

A-1-4 Fixed Temperature Detector. The difference between the operating temperature of a fixed temperature device and the surrounding air temperature is proportional to the rate at which the temperature is rising and is commonly referred to as "thermal lag." The air temperature is always higher than the operating temperature of the device.

Typical examples of fixed temperature-sensing elements follow.

(a) *Bimetallic.* A sensing element comprised of two metals having different coefficients of thermal expansion arranged so that the effect is deflection in one direction when heated and in the opposite direction when cooled.

(b) *Electrical Conductivity.* A line-type or spot-type sensing element whose resistance varies as a function of temperature.

(c) *Fusible Alloy.* A sensing element of a special composition (eutectic) metal that melts rapidly at the rated temperature.

(d) *Heat-Sensitive Cable.* A line-type device whose sensing element comprises, in one type, two current-carrying wires separated by heat-sensitive insulation that softens at the rated temperature, thus allowing the wires to make electrical contact. In another type, a single wire is centered in a metallic tube, and the intervening space is filled with a substance that, at a critical temperature, becomes conductive, thus establishing electrical contact between the tube and the wire.

(e) *Liquid Expansion.* A sensing element comprising a liquid capable of marked expansion in volume in response to temperature increase.

A-1-4 Ionization Smoke Detection. Ionization smoke detection is more responsive to invisible particles (smaller than 1 micron in size) produced by most flaming fires. It is somewhat less responsive to the larger particles typical of most smoldering fires. Smoke detectors utilizing the ionization principle are usually of the spot type.

A-1-4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A-1-4 Photoelectric Light Obscuration Smoke Detection. The response of photoelectric light obscuration smoke detectors is usually not affected by the color of smoke.

Smoke detectors utilizing the light obscuration principle are usually of the line type. These detectors are commonly referred to as "projected beam smoke detectors."

A-1-4 Photoelectric Light-Scattering Smoke Detection. Photoelectric light-scattering smoke detection is more responsive to visible particles (larger than 1 micron in size) produced by most smoldering fires. It is somewhat less responsive to the smaller particles typical of most flaming fires. It is also less responsive to black smoke than to lighter colored smoke. Smoke detectors utilizing the light-scattering principle are usually of the spot type.

A-1-4 Rate Compensation Detector. A typical example is a spot-type detector with a tubular casing of a metal that tends to expand lengthwise as it is heated and an associated contact mechanism that closes at a certain point in the elongation. A second metallic element inside the tube exerts an opposing force on the contacts, tending to hold them open. The forces are balanced in such a way that, on a slow rate-of-temperature rise, there is more time for heat to penetrate to the inner element, which inhibits contact closure until the total device has been heated to its rated temperature level. However, on a fast rate-of-temperature rise, there is not as much time for heat to penetrate to the inner element, which exerts less of an inhibiting effect so that contact closure is achieved when the total device has been heated to a lower temperature. This, in effect, compensates for thermal lag.

A-1-4 Rate-of-Rise Detector. Typical examples of rate-of-rise detectors follow.

(a) *Pneumatic Rate-of-Rise Tubing.* A line-type detector comprising small-diameter tubing, usually copper, that is installed on the ceiling or high on the walls throughout the protected area. The tubing is terminated in a detector unit containing diaphragms and associated contacts set to actuate at a predetermined pressure. The system is sealed except for calibrated vents that compensate for normal changes in temperature.

(b) *Spot-Type Pneumatic Rate-of-Rise Detector.* A device consisting of an air chamber, a diaphragm, contacts, and a compensating vent in a single enclosure. The principle of operation is the same as that described for pneumatic rate-of-rise tubing.

(c) *Thermoelectric Effect Detector.* A device whose sensing element comprises a thermocouple or thermopile unit that produces an increase in electric potential in response to an increase in temperature. This potential is monitored by associated control equipment, and an alarm is initiated when the potential increases at an abnormal rate.

(d) *Electrical Conductivity-Type Rate-of-Rise Detector.* A line-type or spot-type sensing element whose resistance changes due to a change in temperature. The rate of change of resistance is monitored by associated control equipment, and an alarm is initiated when the rate of temperature increase exceeds a preset value.

A-1-4 Spark. The overwhelming majority of applications involving the detection of Class A and Class D combustibles with radiant energy-sensing detectors involve the transport of particulate solid materials through pneumatic conveyor ducts or mechanical conveyors. It is common in the industries that include such hazards to refer to a moving piece of burning material as a "spark" and to systems for the detection of such fires as "spark detection systems."

A-1-4 Wavelength. The concept of wavelength is extremely important in selecting the proper detector for a particular application. There is a precise interrelation between the wavelength of light being emitted from a flame and the combustion chemistry producing the flame. Specific subatomic, atomic, and molecular events yield radiant energy of specific wavelengths. For example, ultraviolet photons are emitted as the result of the complete loss of electrons or very large changes in electron energy levels. During combustion, molecules are violently torn apart by the chemical reactivity of oxygen, and electrons are released in the process, recombining at drastically lower energy levels, thus giving rise to ultraviolet radiation. Visible radiation is generally the result of smaller changes in electron energy levels

within the molecules of fuel, flame intermediates, and products of combustion. Infrared radiation comes from the vibration of molecules or parts of molecules when they are in the superheated state associated with combustion. Each chemical compound exhibits a group of wavelengths at which it is resonant. These wavelengths constitute the chemical's infrared spectrum, which is usually unique to that chemical.

This interrelationship between wavelength and combustion chemistry affects the relative performance of various types of detectors with respect to various fires.

A-1-5.2.7(c) An engine-driven generator without standby battery supplement should not be assumed to be capable of a reliable power transfer within 30 seconds of a primary power loss.

A-1-5.2.7(d) UPS equipment often contains an internal bypass arrangement to supply the load directly from the line. These internal bypass arrangements are a potential source of failure. UPS equipment also requires periodic maintenance. It is, therefore, necessary to provide a means of promptly and safely bypassing and isolating the UPS equipment from all power sources while maintaining continuity of power supply to the equipment normally supplied by the UPS.

A-1-5.2.9 Rechargeable-(Storage-)Type Batteries. The following newer types of rechargeable batteries are normally used in protected premises applications:

(a) *Vented Lead-Acid, Gelled, or Starved Electrolyte Battery.* This rechargeable-type battery is generally used in place of primary batteries in applications having a relatively high current drain or requiring the extended standby capability of much lower currents. The nominal voltage of a single cell is 2 volts, and the battery is available in multiples of 2 volts (e.g., 2, 4, 6, 12). Batteries should be stored according to the manufacturer's recommendations.

(b) *Nickel-Cadmium Battery.* The sealed-type nickel-cadmium battery generally used in applications where the battery current drain during a power outage is low to moderate (typically up to a few hundred milliamperes) and is fairly constant. Nickel-cadmium batteries are also available in much larger capacities for other applications. The nominal voltage per cell is 1.42 volts, with batteries available in multiples of 1.42 (e.g., 12.78, 25.56). Batteries in storage can be stored in any state of charge for indefinite periods. However, a battery in storage will lose capacity (will self-discharge), depending on storage time and temperature. Typically, batteries stored for more than 1 month require an 8-hour to 14-hour charge period to restore capacity. In service, the battery should receive a continuous constant charging current sufficient to keep it fully charged (typically, the charge rate equals $1/10$ to $1/20$ of the ampere-hour rating of the battery). Because batteries are made up of individual cells connected in series, the possibility exists that, during deep discharge, one or more cells that are low in capacity will reach complete discharge prior to other cells. The cells with remaining life tend to charge the depleted cells, causing a polarity reversal resulting in permanent battery damage. This condition can be determined by measuring the open cell voltage of a fully charged battery (voltage should be a minimum of 1.28 volts per cell multiplied by the number of cells). Voltage depression effect is a minor change in discharge voltage level caused by constant current charging below the system discharge rate.

In some applications of nickel-cadmium batteries (e.g., battery-powered shavers), a memory characteristic also exists. Specifically, where the battery is discharged daily for 1 minute, followed by a recharge, operation for 5 minutes will not result in the rated ampere-hour output. The reason for this is that the battery has developed a 1-minute discharge memory.

(c) *Sealed Lead-Acid Battery.* In a sealed lead-acid battery, the electrolyte is totally absorbed by the separators, and no venting normally occurs. Gas evolved during recharge is internally recombined, resulting in minimal loss of capacity life. A high pressure vent, however, is provided to avoid damage under abnormal conditions.

A-1-5.2.9.2(c) Batteries are trickle-charged where they are off-line and waiting to be put under load in the event of a loss of power.

Float-charged batteries are fully charged and connected across the output of the rectifiers to smooth the output and serve as a standby source of power in the event of a loss of line power.

A-1-5.4.2.1 Coded Alarm Signal Designations. The following recommended coded signal designations for buildings having four floors and multiple basements are provided in Table A-1-5.4.2.1:

Table A-1-5.4.2.1 Recommended Coded Signal Designations

Location	Coded Signal
4th floor	2-4
3rd floor	2-3
2nd floor	2-2
1st floor	2-1
Basement	3-1
Subasement	3-2

A-1-5.4.5 The operability of controlled mechanical equipment (e.g., smoke and fire dampers, elevator recall arrangements, door holders) should be verified by periodic testing. Failure to test and properly maintain controlled mechanical equipment can result in operational failure during an emergency, with potential consequences up to and including loss of life.

A-1-5.4.7(b) A tamper switch, low pressure switch, or other device intended to cause a supervisory signal when actuated should not be connected in series with the end-of-line supervisory device of initiating device circuits, unless a distinctive signal, different from a trouble signal, is indicated.

A-1-5.4.11.4 The bypass means is intended to enable automatic or manual day/night/weekend operation.

A-1-5.5.1(a) This requirement does not preclude transfer to secondary supply at less than 85 percent of nominal primary voltage, provided the requirements of 1-5.2.6 are met.

A-1-5.5.2.1 Specifications. Fire alarm specifications can include some or all of the following:

(a) The address of the protected premises;
(b) The owner of the protected premises;

(c) The authority having jurisdiction;

(d) The applicable codes, standards, and other design criteria to which the system is required to comply;

(e) The type of building construction and occupancy;

(f) The fire department response point(s) and annunciator location(s);

(g) The type of fire alarm system to be provided;

(h) Calculations (e.g., secondary supply and voltage drop calculations);

(i) The type(s) of fire alarm-initiating devices, supervisory alarm-initiating devices, and evacuation notification appliances to be provided;

(j) The intended area(s) of coverage;

(k) A complete list of detection, evacuation signaling, and annunciator zones;

(l) A complete list of fire safety control functions;

(m) A complete sequence of operations detailing all inputs and outputs.

A-1-5.5.4 Wiring and Equipment. The installation of all fire alarm system wiring should take into account the fire alarm system manufacturer's published installation instructions and the limitations of the applicable product listings or approvals.

A-1-5.7.1.2 System Zoning. Fire alarm system annunciation should, as a minimum, be sufficiently specific to identify the origin of a fire alarm signal in accordance with the following:

(a) Where a floor exceeds 20,000 ft^2 (1860 m^2) in area, the floor should be subdivided into detection zones of 20,000 ft^2 (1860 m^2) or less, consistent with the existing smoke and fire barriers on the floor.

(b) Where a floor exceeds 20,000 ft^2 (1860 m^2) in area and is undivided by smoke or fire barriers, detection zoning should be determined on a case-by-case basis in consultation with the authority having jurisdiction.

(c) Waterflow switches on sprinkler systems that serve multiple floors, areas exceeding 20,000 ft^2 (1860 m^2), or areas inconsistent with the established detection system zoning should be annunciated individually.

(d) In-duct smoke detectors on air-handling systems that serve multiple floors, areas exceeding 20,000 ft^2 (1860 m^2), or areas inconsistent with the established detection system zoning should be annunciated individually.

(e) Where a floor area exceeds 20,000 ft^2 (1860 m^2), additional zoning should be provided. The length of any zone should not exceed 300 ft (91 m) in any direction Where the building is provided with automatic sprinklers throughout, the area of the alarm zone should be permitted to coincide with the allowable area of the sprinkler zone.

A-1-5.8.5.1 Backup amplifying and evacuation signal-generating equipment is recommended with automatic transfer upon primary equipment failure to ensure prompt restoration of service in the event of equipment failure.

A-1-7.2.1 The requirements of Chapter 7 should be used to perform the installation wiring and operational acceptance tests required when completing the record of completion.

A-1-7.2.2(a) The owner's manual should include:

(a) A detailed narrative description of the system inputs, evacuation signaling, ancillary functions, annunciation, intended sequence of operations, expansion capability, application considerations, and limitations.

(b) Operator instructions for basic system operations, including alarm acknowledgment, system reset, interpretation of system output (LEDs, CRT display, and printout), operation of manual evacuation signaling and ancillary function controls, and change of printer paper.

(c) A detailed description of routine maintenance and testing as required and recommended and as would be provided under a maintenance contract, including testing and maintenance instructions for each type of device installed. This information should include the following:

1. A listing of the individual system components that require periodic testing and maintenance;
2. Step-by-step instructions detailing the requisite testing and maintenance procedures, and the intervals at which these procedures shall be performed, for each type of device installed;
3. A schedule that correlates the testing and maintenance procedures recommended by A-1-7.2.2(c)2 with the listing recommended by A-1-7.2.2(c)1.

(d) Detailed troubleshooting instructions for each trouble condition generated from the monitored field wiring, including opens, grounds, and loop failures. These instructions should include a list of all trouble signals annunciated by the system, a description of the condition(s) that causes such trouble signals, and step-by-step instructions describing how to isolate such problems and correct them (or how to call for service, as appropriate).

(e) A service directory, including a list of names and telephone numbers of those who provide service for the system.

A-2 Household Fire Warning Protection.

(a) *Fire Danger in the Home.* Fire is the third leading cause of accidental death. Residential occupancies account for most fire fatalities, and most of these deaths occur at night during the sleeping hours.

Most fire injuries also occur in the home. It is estimated that 1.5 million Americans are injured by fire each year. Many never resume normal lives.

It is estimated that each household will experience three (usually unreported) fires per decade and two fires serious enough to report to a fire department per lifetime.

(b) *Fire Safety in the Home.* This code is intended to provide reasonable fire safety for persons in family living units. Reasonable fire safety can be produced through a three-point program:

1. Minimizing fire hazards;
2. Providing a fire warning system;
3. Having and practicing an escape plan.

(c) *Minimizing Life Safety Hazards.* This code cannot protect all persons at all times. For instance, the application of this code might not provide protection against the three traditional fatal fire scenarios:

1. Smoking in bed;
2. Leaving children home alone;
3. Cleaning with flammable liquids such as gasoline.

However, Chapter 2 can lead to reasonable safety from fire where the three points under A-2(b) are observed.

(d) *Fire Warning System.* There are two types of fire to which household fire warning equipment needs to respond. One is a rapidly developing, high heat fire. The other is a slow, smoldering fire. Either can produce smoke and toxic gases.

Household fires are especially dangerous at night when the occupants are asleep. Fires produce smoke and deadly gases that can overcome occupants while they are asleep. Furthermore, dense smoke reduces visibility. Most fire casualties are victims of smoke and gas inhalation rather than burns. To warn against a fire, Chapter 2 requires smoke detectors in accordance with 2-2.1.1.1 and recommends heat or smoke detectors in all other major areas. (*See 2-2.1.1.1.*)

(e) *Family Escape Plan.* There often is very little time between the detection of a fire and the time it becomes deadly. This interval can be as little as 1 minute or 2 minutes. Thus, this code requires detection means to give a family some advance warning of the development of conditions that become dangerous to life within a short period of time. Such warning, however, could be wasted unless the family has planned in advance for rapid exit from their residence. Therefore, in addition to the fire warning system, this code requires exit plan information to be furnished.

Planning and practicing for fire conditions with a focus on rapid exit from the residence are important. Drills should be held so that all family members know the action to be taken. Each person should plan for the possibility that exit out of a bedroom window could be necessary. An exit out of the residence without the need to open a bedroom door is essential.

(f) *Special Provisions for the Disabled.* For special circumstances where life safety of an occupant(s) depends upon prompt rescue by others, the fire warning system should include means of prompt, automatic notification to those who are to be depended upon for rescue.

A-2-1.1 Chapter 2 does not attempt to cover all equipment, methods, and requirements that might be necessary or advantageous for the protection of lives and property from fire.

NFPA 72 is a "minimum code," and it provides a number of requirements related to household fire warning equipment that are deemed to be the practical and necessary minimum for average conditions at the present state of the art.

A-2-2.1.1 Experience has shown that all hostile fires in family living units generate smoke to some degree. This is also true with respect to heat buildup from fires. However, the results of full-scale experiments conducted over the past several years in the U.S., using typical fires in family living units, indicate that detectable quantities of smoke precede detectable levels of heat in nearly all cases. In addition, slowly developing, smoldering fires can produce smoke and toxic gases without a significant increase in the room's temperature. Again, the results of experiments indicate that detectable quantities of smoke precede the development of hazardous atmospheres in nearly all cases.

For the above reasons, the required protection in this code utilizes smoke detectors as the primary life safety equipment for providing a reasonable level of protection against fire.

Of course, it is possible to install fewer detectors than required in this code. It could be argued that the installation of only one fire detector, whether a smoke or heat detector, offers some life-saving potential. While this is true, it is the opinion of the committee that developed Chapter 2 that the smoke detector requirements as stated in 2-2.1.1 are the minimum that should be considered.

The installation of additional detectors of either the smoke or heat type should result in a higher degree of protection. Adding detectors to rooms that are normally closed off from the required detectors increases the escape time because the fire does not need to build to the higher level necessary to force smoke out of the closed room to the required detector. As a consequence, it is recommended that the householder consider the installation of additional fire protection devices. However, it should be understood that Chapter 2 does not require additional detectors over and above those called for in 2-2.1.1.

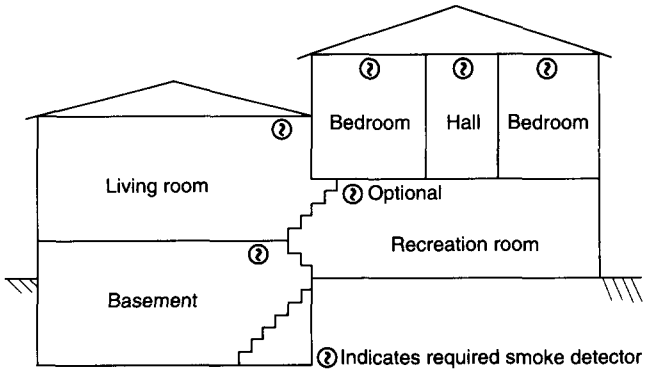


Figure A-2-2.1.1.2 Split level arrangement. Smoke detectors are required where shown. Smoke detectors are optional where a door is not provided between living room and recreation room.

A-2-2.2 At times, depending upon conditions, the audibility of detection devices could be seriously impaired where occupants are within the bedroom area. For instance, there might be a noisy window air conditioner or room humidifier generating an ambient noise level of 55 dBA or higher. The detection devices' alarms need to penetrate through the closed doors and be heard over the bedroom's noise levels with sufficient intensity to awaken sleeping occupants therein. Test data indicate that detection devices having sound pressure ratings of 85 dBA of 10 ft (3 m) and installed outside the bedrooms can produce about 15 dBA over ambient noise levels of 55 dBA in the bedrooms. This is likely to be sufficient to awaken the average sleeping person.

Detectors located remote from the bedroom area might not be loud enough to awaken the average person. In such cases, it is recommended that detectors be interconnected in such a way that the operation of the remote detector causes an alarm of sufficient intensity to penetrate the bedrooms. The interconnection can be accomplished by the installation of a fire detection system, by the wiring together of multiple station alarm devices, or by the use of line carrier or radio frequency transmitters/receivers.

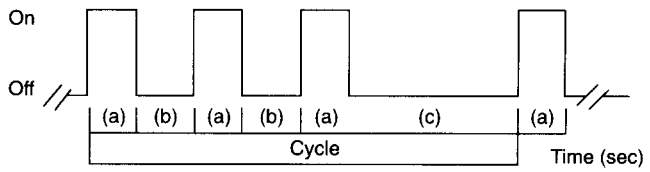
A-2-2.2.2 The use of the distinctive three-pulse temporal pattern fire alarm evacuation signal required by 3-7.2(a) had previously been recommended for this purpose by this code since 1979. It has since been adopted as both an American

National Standard (ANSI S3.41, *Audible Emergency Evacuation Signal*) and an International Standard (ISO 8201, *Audible Emergency Evacuation Signal*).

Copies of both of these standards are available from the Standards Secretariat, Acoustical Society of America, 335 East 45th Street, New York, NY 10017-3483. Telephone 212-661-9404, ext. 562.

The standard fire alarm evacuation signal is a three-pulse temporal pattern using any appropriate sound. The pattern consists of an "on" phase (a) lasting 0.5 second ± 10 percent followed by an "off" phase (b) lasting 0.5 second ± 10 percent, for three successive "on" periods, which are followed by an "off" phase (c) lasting 1.5 seconds ± 10 percent [*see Figures A-2-2.2.2(a) and (b)*]. The signal should be repeated for a period appropriate for the purposes of evacuation of the building, but for not less than 180 seconds. A single-stroke bell or chime sounded at "on" intervals lasting 1 second ± 10 percent, with a 2-second ± 10 percent "off" interval after each third "on" stroke, may be permitted [*see Figure A-2-2.2.2(c)*].

The minimum repetition time may be permitted to be manually interrupted.



Key:
Phase (a) signal is "on" for 0.5 sec ± 10%
Phase (b) signal is "off" for 0.5 sec ± 10%
Phase (c) signal is "off" for 1.5 sec ± 10% [(c) = (a) + 2(b)]
Total cycle lasts for 4 sec ± 10%

Figure A-2-2.2.2(a) Temporal pattern parameters.

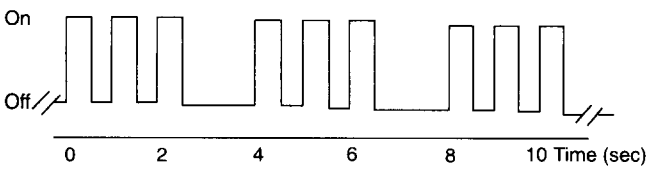


Figure A-2-2.2.2(b) Temporal pattern imposed on signaling appliances that emit a continuous signal while energized.

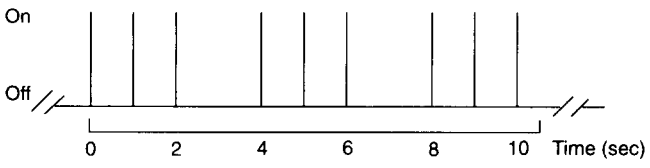


Figure A-2-2.2.2(c) Temporal pattern imposed on a single-stroke bell or chime.

A-2-4.3 The linear space rating is the maximum allowable distance between heat detectors. The linear space rating is also a measure of detector response time to a standard test fire when tested at the same distance. The higher the rating, the faster the response time. This code recognizes only those heat detectors with ratings of 50 ft (15 m) or more.

A-2-4.3.2 A heat detector with a temperature rating somewhat in excess of the highest normally expected ambient temperature is specified in order to avoid the possibility of premature response of the heat detector to nonfire conditions.

Some areas or rooms of the family living unit can experience ambient temperatures considerably higher than those in the normally occupied living spaces. Examples are unfinished attics, the space near hot air registers, and some furnace rooms. This fact should be considered in the selection of the appropriate temperature rating for fixed-temperature heat detectors to be installed in these areas or rooms.

A-2-4.9.2 Where the exception to 2-4.9.2, which provides for screening alarm signals to minimize response to false alarms, is to be implemented, the following should be considered:

(a) Was the verification call answered at the protected premises?

(b) Did the respondent provide proper identification?

(c) Is it necessary for the respondent to identify the cause of the alarm signal?

(d) Should the public service fire communications center be notified and advised that an alarm signal was received, including the response to the verification call, when an authorized respondent states that fire service response is not desired?

(e) Should the public service fire communications center be notified and advised that an alarm signal was received, including the response to the verification call, for all other situations, including both a hostile fire and no answer to the verification call?

(f) What other actions should be required by a standard operating procedure?

A-2-5.1.1.1 Where homeowner inspection, testing, and maintenance are required or assumed, the equipment should be installed in an accessible manner.

A-2-5.1.2.1 One of the common problems associated with residential smoke detectors is the nuisance alarms that are usually triggered by products of combustion from cooking, smoking, or other household particulates. While an alarm for such a condition is anticipated and tolerated by the occupant of a family living unit through routine living experience, the alarm is not permitted where it also sounds alarms in other family living units or in common use spaces. Nuisance alarms caused by cooking are a very common occurrence, and inspection authorities should be aware of the possible ramifications where the coverage is extended beyond the limits of the family living unit.

A-2-5.2 One of the most critical factors of any fire alarm system is the location of the fire detecting devices. This appendix is not a technical study. It is an attempt to provide some fundamentals on detector location. For simplicity, only those types of detectors recognized by Chapter 2 (i.e., smoke and heat detectors) are discussed. In addition, special problems requiring engineering judgment, such as locations in attics and in rooms with high ceilings, are not covered.

A-2-5.2.1 Smoke Detection.

(a) *Where to Locate the Required Smoke Detectors in Existing Construction.* The major threat from fire in a family living unit occurs at night when everyone is asleep. The principal threat to persons in sleeping areas comes from fires in the remainder of the unit; therefore, a smoke detector(s) is best located between the bedroom areas and the rest of the unit.

In units with only one bedroom area on one floor, the smoke detector(s) should be located as shown in Figure A-2-5.2.1(a).

In family living units with more than one bedroom area or with bedrooms on more than one floor, more than one smoke detector is required, as shown in Figure A-2.5.2.1(b).

In addition to smoke detectors outside of the sleeping areas, Chapter 2 requires the installation of a smoke detector on each additional story of the family living unit, including the basement. These installations are shown in Figure A-2-5.2.1(c). The living area smoke detector should be installed in the living room or near the stairway to the upper level, or in both locations. The basement smoke detector should be installed in close proximity to the stairway leading to the floor above. Where installed on an open-joisted ceiling, the detector should be placed on the bottom of the joists. The detector should be positioned relative to the stairway so as to intercept smoke coming from a fire in the basement before the smoke enters the stairway.

(b) *Where to Locate the Required Smoke Detectors in New Construction.* All of the smoke detectors specified in A-2-5.2.1(a) for existing construction are required, and, in addition, a smoke detector is required in each bedroom.

(c) *Are More Smoke Detectors Desirable?* The required number of smoke detectors might not provide reliable early warning protection for those areas separated by a door from the areas protected by the required smoke detectors. For this reason, it is recommended that the householder consider the use of additional smoke detectors for those areas for increased protection. The additional areas include the basement, bedrooms, dining room, furnace room, utility room, and hallways not protected by the required smoke detectors. The installation of smoke detectors in kitchens, attics (finished or unfinished), or garages is not normally recommended, as these locations occasionally experience conditions that can result in improper operation.

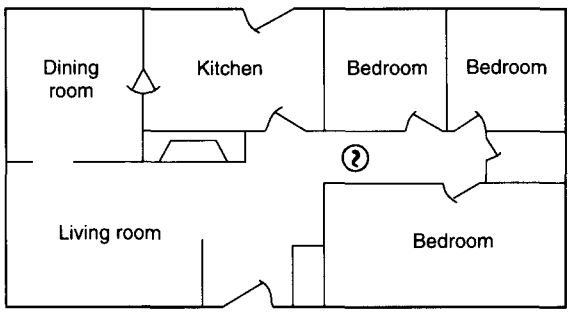


Figure A-2-5.2.1(a) A smoke detector should be located between the sleeping area and the rest of the family living unit.

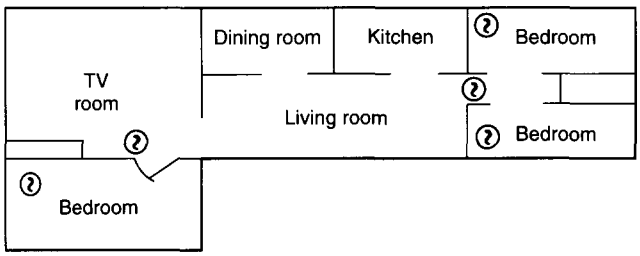


Figure A-2-5.2.1(b) In family living units with more than one sleeping area, a smoke detector should be provided to protect each sleeping area in addition to detectors required in bedrooms.

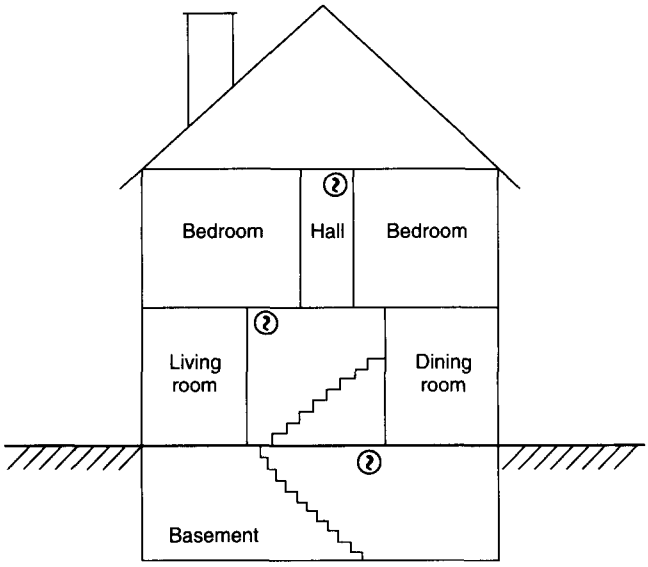


Figure A-2-5.2.1(c) A smoke detector should be located on each story.

A-2-5.2.1.5 Smoke Detector Mounting — Dead Air Space. The smoke from a fire generally rises to the ceiling, spreads out across the ceiling surface, and begins to bank down from the ceiling. The corner where the ceiling and wall meet is an air space into which the smoke could have difficulty penetrating. In most fires, this dead air space measures about 4 in. (0.1 m) along the ceiling from the corner and about 4 in. (0.1 m) down the wall, as shown in Figure A-2-5.2.2(b). Detectors should not be placed in this dead air space.

Smoke and heat detectors should be installed in those locations recommended by the manufacturer, except in those cases where the space above the ceiling is open to the outside and little or no insulation is present over the ceiling. Such cases result in the ceiling being excessively cold in the winter or excessively hot in the summer. Where the ceiling is significantly different in temperature from the air space below, smoke and heat have difficulty reaching the ceiling and a detector that is located on that ceiling. In this situation, placement of the detector on a sidewall, with the top 4 in. to 12 in. (0.1 m to 0.3 m) from the ceiling, is recommended.

The situation described above for uninsulated or poorly insulated ceilings can also exist, to a lesser extent, in the case of outside walls. The recommendation is to place the smoke detector on a sidewall. However, where the sidewall is an exterior wall with little or no insulation, an interior wall should be selected. It should be recognized that the condition of inadequately insulated ceilings and walls can exist in multifamily housing (apartments), single-family housing, and mobile homes.

In those family living units employing radiant heating in the ceiling, the wall location is the recommended location. Radiant heating in the ceiling can create a hot-air, boundary layer along the ceiling surface, which can seriously restrict the movement of smoke and heat to a ceiling-mounted detector.

A-2-5.2.2 Heat Detection.

(a) *General.* While Chapter 2 does not require heat detectors as part of the basic protection scheme, it is recommended that the householder consider the use of additional

heat detectors for the same reasons presented under A-2-5.2.1(c). The additional areas lending themselves to protection with heat detectors are the kitchen, dining room, attic (finished or unfinished), furnace room, utility room, basement, and integral or attached garage. For bedrooms, the installation of a smoke detector is recommended over the installation of a heat detector for protection of the occupants from fires in their bedrooms.

(b) *Heat Detector Mounting — Dead Air Space.* Heat from a fire rises to the ceiling, spreads out across the ceiling surface, and begins to bank down from the ceiling. The corner where the ceiling and the wall meet is an air space into which heat has difficulty penetrating. In most fires, this dead air space measures about 4 in. (0.1 m) along the ceiling from the corner and 4 in. (0.1 m) down the wall as shown in Figure A-2-5.2.2(b). Heat detectors should not be placed in this dead air space.

The placement of the detector is critical where maximum speed of fire detection is desired. Thus, a logical location for a detector is the center of the ceiling. At this location, the detector is closest to all areas of the room.

If the detector cannot be located in the center of the ceiling, an off-center location on the ceiling may be permitted to be used.

The next logical location for mounting detectors is on the sidewall. Any detector mounted on the sidewall should be located as near as possible to the ceiling. A detector mounted on the sidewall should have the top of the detector between 4 in. and 12 in. (0.1 m and 0.3 m) from the ceiling.

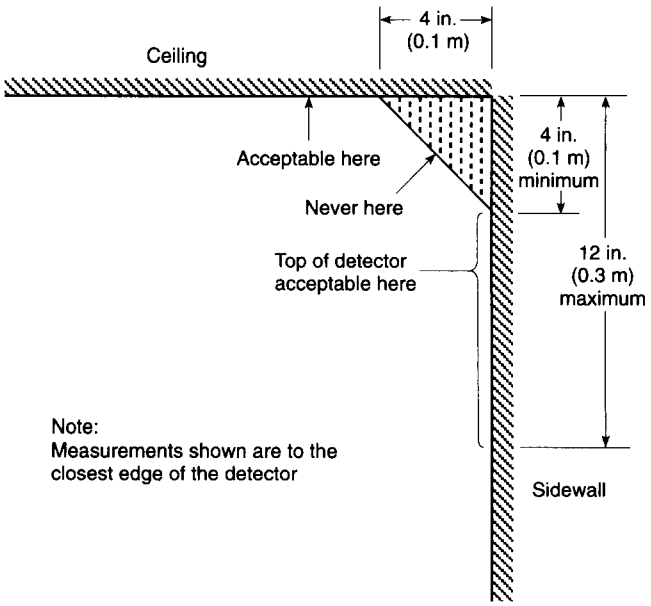


Figure A-2-5.2.2(b) Example of proper mounting for detectors.

(c) *The Spacing of Detectors.* Where a room is too large for protection by a single detector, several detectors should be used. It is important that they be properly located so all parts of the room are covered. (*For further information on the spacing of detectors, see Chapter 5.*)

(d) *Where the Distance Between Detectors Should Be Further Reduced.* The distance between detectors is based on data obtained from the spread of heat across a smooth ceiling. Where the ceiling is not smooth, the placement of the detector should be tailored to the situation.

For instance, with open wood joists, heat travels freely down the joist channels so that the maximum distance between detectors [50 ft (15 m)] may be permitted to be used. However, heat has trouble spreading across the joists, so the distance in this direction should be ½ the distance allowed between detectors, as shown in Figure A-2-5.2.2(d), and the distance to the wall is reduced to 12½ ft (3.8 m). Since ½ × 50 ft (15 m) is 25 ft (7.6 m), the distance between detectors across open wood joists should not exceed 25 ft (7.6 m), as shown in Figure A-2-5.2.2(d), and the distance to the wall is reduced [½ × 25 ft (7.6 m)] to 12.5 ft (3.8 m). Paragraph 2-5.2.2.4 requires that detectors be mounted on the bottom of the joists and not up in joist channels.

Walls, partitions, doorways, ceiling beams, and open joists interrupt the normal flow of heat, thus creating new areas to be protected.

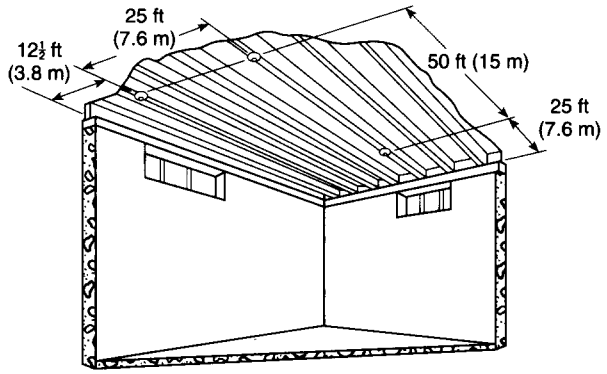


Figure A-2-5.2.2(d) Open joists, attics, and extra high ceilings are some of the areas that require special knowledge for installation.

A-2-5.2.2.3 See A-2-5.2.1.5.

A-2-5.2.2.5 In addition to the special requirements for heat detectors installed on ceilings with exposed joists, reduced spacing also might be required due to other structural characteristics of the protected area, possible drafts, or other conditions that could affect detector operation.

A-2-6.1 Good fire protection requires that the equipment be periodically maintained. If the householder is unable to perform the required maintenance, a maintenance agreement should be considered.

A-2-6.2 It is a good practice to establish a specific schedule for these tests.

A-3-2.4 This requirement is intended to limit damage to a fire alarm system, resulting from a fire, to the area in which the fire occurs. The concern is maintaining the operability of the system in areas beyond, but threatened by, the fire.

Conformance to this requirement could entail that:

(a) Where common risers or trunk circuits are used:

1. Separately routed, redundant risers or trunk circuits be provided, arranged so that one or more circuit faults on one riser or trunk circuit cause the system to switch over automatically to its associated, alternate circuit without loss of function. This capability should allow full system operation with a damaged or severed riser or trunk circuit.

2. Primary and alternate conductors for redundant circuits be separated by 2-hour fire-resistive construction.

(b) Where multiple individual circuits are routed in a common riser, conduit, raceway, cable, bundle of conductors, or other arrangement resulting in close physical proximity and resultant susceptibility to common misfortune, such circuits be Class A, capable of full operation over a single open or single ground fault.

(c) Where Class A circuits are required, they be installed so that the supply and return conductors are routed separately. Supply and return risers should be separated by at least 2-hour rated fire construction.

A-3-4.3 Class A circuits are considered to be more reliable than Class B circuits because they remain fully operational during the occurrence of a single open or a single ground fault, while Class B circuits remain operational only up to the location of an open fault. However, neither Class A nor Class B circuits remain operational during a wire-to-wire short.

For both Class A and Class B initiating device circuits, a wire-to-wire short is permitted to cause an alarm on the system based on the rationale that a wire-to-wire short is the result of a double fault (e.g., both circuit conductors have become grounded), while the code only considers the consequences of single faults. For many applications, an alarm caused by a wire-to-wire short is not permitted, and limitation to a simple Class A designation is not adequate. Introducing the style designation has made it possible to specify the exact performance required during a variety of possible fault conditions.

Limitation to Class A and Class B circuits only poses a more serious problem for signaling line circuits. Though a Class A signaling line circuit remains fully operational during the occurrence of a single open or single ground fault, a wire-to-wire short disables the entire circuit. The risk of such a catastrophic failure is unacceptable to many system designers, users, and authorities having jurisdiction. Once again, using the style designation makes it possible to specify either full system operation during a wire-to-wire short (Style 7) or a level of performance in between that of a Style 7 and a minimum function Class A circuit (Style 2).

A specifier can specify a circuit as either Class A or Class B where system performance during wire-to-wire shorts is of no concern, or it can specify, by the appropriate style designation, where the system performance during a wire-to-wire short and other multiple fault conditions *is* of concern.

A-3-4.4 A goal of 3-4.4 is to provide adequate separation between the outgoing and return cables. This separation is required to help ensure protection of the cables from physical damage. The recommended minimum separation to prevent physical damage is 1 ft (305 mm) where the cable is installed vertically and 4 ft (1.22 m) where the cable is installed horizontally.

A-3-5 Tables 3-5 and 3-6 should be used as follows:

(a) It should be determined whether the initiating devices are:

1. Directly connected to the initiating device circuit.
2. Directly connected to a signaling line circuit interface on a signaling line circuit.
3. Directly connected to an initiating device circuit, which in turn is connected to a signaling line circuit interface on a signaling line circuit.

(b) The style of signaling performance required should be determined. The columns marked A through Eα in Table 3-5, and 0.5 through 7α in Table 3-6 are arranged in ascending order of performance and capacities.

(c) Upon determining the style of the system, the charts, singularly or together, specify the maximum number of devices, equipment, premises, and buildings permitted to be incorporated into an actual protected premises installation.

(d) In contrast, where the number of devices, equipment, premises, and buildings (in addition to signaling ability) in an installation is known, a required system style can be determined.

(e) The prime purpose of the tables is to enable identification of minimum performance for styles of initiating device circuits and signaling line circuits. It is not the intention that the styles be construed as grades. That is, a Style 3 system is not superior to a Style 2 system, or vice versa. In fact, a particular style might better provide adequate and reliable signaling for an installation than a more complex style. The quantities tabulated under each style do, unfortunately, tend to imply that a given style is superior to the style to its left. The increased quantities for the higher style numbers are based on the ability to signal an alarm during an abnormal condition in addition to signaling the same abnormal condition.

(f) The tables allow users, designers, manufacturers, and the authority having jurisdiction to identify minimum performance of present and future systems by determining the trouble and alarm signals received at the control unit for the specified abnormal conditions.

(g) The overall system reliability is considered to be equal from style to style where the capacities are at the maximum allowed.

(h) Upon determining the style of the system, the tables indicate specifics such as the maximum number of devices, equipment, and protected buildings permitted to be incorporated into an actual installation for a protected premises fire alarm system.

(i) The number of automatic fire detectors connected to an initiating device circuit is limited by good engineering practice. Where a large number of detectors are connected to one initiating device circuit covering a widespread area, pinpointing the source of alarm becomes difficult and time consuming.

On certain types of detectors, a trouble signal results from faults in the detector. When this occurs where there are large numbers of detectors on an initiating device circuit, locating the faulty detector also becomes difficult and time consuming.

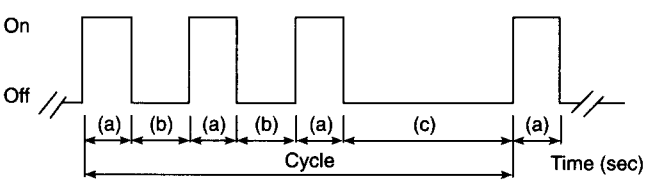
A-3-6 See A-3-5.

A-3-7.2(a) The use of the distinctive three-pulse temporal pattern fire alarm evacuation signal required by 3-7.2(a) became effective July 1, 1996, for new systems installed after that date. It had previously been recommended for this purpose by this code since 1979. It has since been adopted as both an American National Standard (ANSI S3.41, *Audible Emergency Evacuation Signal*) and an International Standard (ISO 8201, *Audible Emergency Evacuation Signal*).

Copies of both of these standards are available from the Standards Secretariat, Acoustical Society of America, 335 East 45th Street, New York, NY 10017-3483. Telephone 212-661-9404, ext. 562.

The standard fire alarm evacuation signal is a three-pulse temporal pattern using any appropriate sound. The pattern consists of an "on" phase (a) lasting 0.5 second ± 10 percent followed by an "off" phase (b) lasting 0.5 second ± 10 percent, for three successive "on" periods, which are then followed by an "off" phase (c) lasting 1.5 seconds ± 10 percent [*see Figures A-3-7.2(a)(1) and (2)*]. The signal should be repeated for a period appropriate for the purposes of evacuation of the building, but for not less than 180 seconds. A single-stroke bell or chime sounded at "on" intervals lasting 1 second ± 10 percent, with a 2-second ± 10 percent "off" interval after each third "on" stroke, may be permitted [*see Figure A-3-7.2(a)(3)*].

The minimum repetition time shall be permitted to be manually interrupted.



Key:
Phase (a) signal is "on" for 0.5 sec ± 10%
Phase (b) signal is "off" for 0.5 sec ± 10%
Phase (c) signal is "off" for 1.5 sec ± 10% [(c) = (a) + 2(b)]
Total cycle lasts for 4 sec ± 10%

Figure A-3-7.2(a)(1) Temporal pattern parameters.

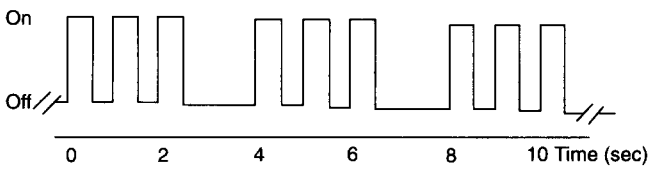


Figure A-3-7.2(a)(2) Temporal pattern imposed on signaling appliances that emit a continuous signal while energized.

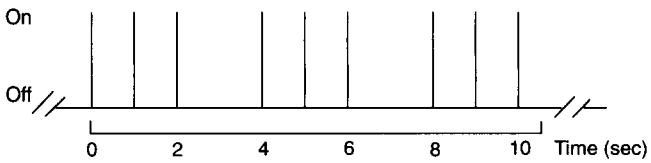


Figure A-3-7.2(a)(3) Temporal pattern imposed on a single-stroke bell or chime.

A-3-8.2.3 The alarm verification feature should not be used as a substitute for proper detector location/applications or regular system maintenance. Alarm verification features are intended to reduce the frequency of false alarms caused by transient conditions. They are not intended to compensate for design errors or lack of maintenance.

A-3-8.2.5 See A-3-8.2.5(c).

A-3-8.2.5(c) Alarm response, as identified, is intended to be the activation of the building evacuation (notification) alarms.

Example:

Given: Area to be protected: 30 ft × 60 ft (9.14 m × 18.28 m). No air movement.

Detectors listed to cover 900 ft^2 (83.6 m^2).

Solution: Per 3-8.2.5(c), area is required to be reduced by 1/2, or 900 ft^2 ÷ 2 = 450 ft^2 (83.6 m^2 ÷ 2 = 41.8 m^2) per detector. Number of devices required per Chapter 5.

30 ft × 60 ft = 1800 ft^2 (9.14 m × 18.28 m = 167.2 m^2)

1800 ft^2 ÷ 450 ft^2 (167.2 m^2 ÷ 41.8 m^2) per detector = 4 detectors.

Therefore, four detectors are required.

Where the system requires the operation of two detection devices to initiate an automatic suppression system and the first automatic detection device causes the activation of notification appliances within the protected space, the maximum area per detector is not intended to be reduced by 1/2.

Example (for fire extinguishing and suppression systems):

Given: Area to be protected: 30 ft × 60 ft (9.14 m × 18.28 m). No air movement.

Detectors listed to cover 900 ft^2 (83.6 m^2). Number of detectors required per Chapter 5.

Solution: 30 ft × 60 ft = 1800 ft^2 (9.14 m × 18.28 m = 167.2 m^2)

1800 ft^2 ÷ 900 ft^2 (167.2 m^2 ÷ 83.6 m^2) per detector = 2 detectors.

Therefore, two detectors are required.

A-3-8.3 Embossed plastic tape, pencil, ink, or crayon should not be considered to be a permanently attached placard.

A-3-8.6.2 Supervisory systems are not intended to provide indication of design, installation, or functional defects in the supervised systems or system components and are not a substitute for regular testing of those systems in accordance with the applicable standard.

Supervised conditions should include, but should not be limited to:

(a) Control valves 1 1/2 in. (38.1 mm) or larger.

(b) Pressure:
- Dry-pipe system air
- Pressure tank air
- Pre-action system supervisory air
- Steam for flooding systems
- Public water.

(c) Water tanks:
- Level
- Temperature.

(d) Building temperature (including areas such as valve closet and fire pump house).

(e) Fire pumps:
- Electric:
  - Running (alarm or supervisory)
  - Power failure
  - Phase reversal.
- Engine-driven:
  - Running (alarm or supervisory)
  - Failure to start
  - Controller off "automatic"
  - Trouble (e.g., low oil, high temperature, overspeed).
- Steam turbine:
  - Running (alarm or supervisory)
  - Steam pressure
  - Steam control valves.

(f) Fire suppression systems appropriate to the system employed.

A-3-8.10.2 Sealing or locking such a valve in the open position or removing the handle from the valve does not meet the intent of this requirement.

A-3-8.13.1 The provisions of this paragraph apply to the types of equipment used in common for fire alarm systems (such as fire alarm, sprinkler supervisory, or guard's tour service) and for other systems (such as burglar alarm or coded paging systems) and to methods of circuit wiring common to both types of systems.

A-3-8.14.1 Dedicated fire alarm system control units are required for elevator recall by 3-8.14.1 in order that the elevator recall systems be monitored for integrity and have primary and secondary power meeting the requirements of this code.

The control unit used for this purpose should be located in an area that is normally occupied and should have audible and visible indicators to annunciate supervisory (elevator recall) and trouble conditions; however, no form of general occupant notification or evacuation signal is required or intended by 3-8.14.1.

A-3-8.14.6 It is recommended that the installation be in accordance with Figures A-3-8.14.6(a) and (b). Figure A-3-8.14.6(a) should be used where the elevator is installed at the same time as the building fire alarm system. Figure A-3-8.14.6(b) should be used where the elevator is installed after the building fire alarm system.

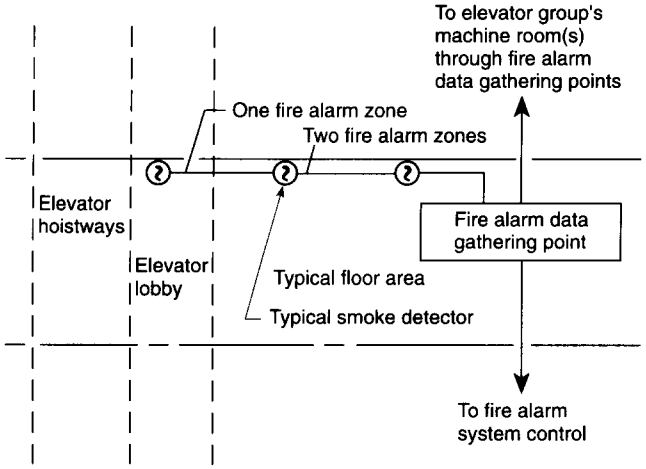


Figure A-3-8.14.6(a) Elevator zone — elevator and fire alarm system installed at same time.

A-3-8.15.1 A lower response time index is intended to provide detector response prior to the sprinkler response, since a lower temperature rating alone might not provide earlier response. The listed spacing rating of the heat detector should be 25 ft (7.6 m) or greater.

A-3-8.15.3 Care should be taken to ensure that elevator power cannot be interrupted due to water pressure surges in the sprinkler system.

A-3-10.6 Automatic fire suppression systems referred to in 3-10.6 include, but are not limited to, preaction and deluge sprinkler systems, carbon dioxide systems, halon systems, and dry chemical systems.

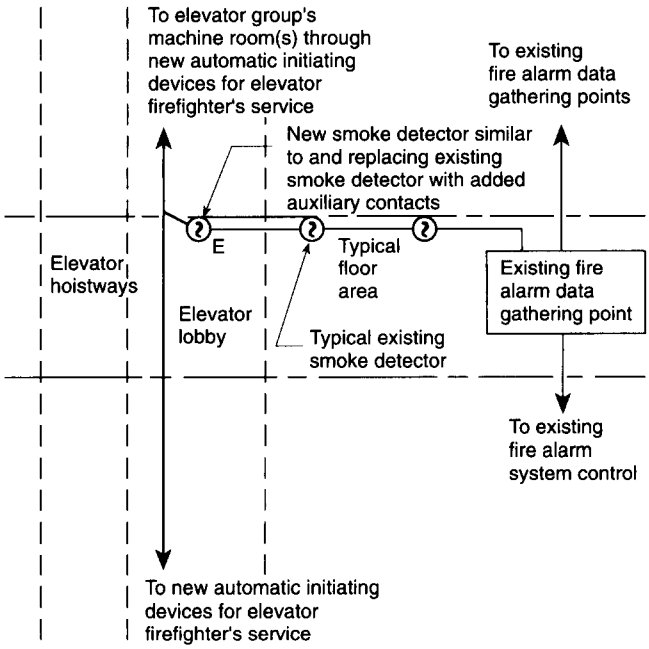


Figure A-3-8.14.6(b) Elevator zone — elevator installed after fire alarm system.

A-3-11 This code contemplates field installations interconnecting two or more listed control units, possibly from different manufacturers, that together fulfill the requirements of this code.

Such an arrangement should preserve the reliability, adequacy, and integrity of all alarm, supervisory, and trouble signals and interconnecting circuits intended to be in accordance with the provisions of this code.

Where interconnected control units are in separate buildings, consideration should be given to protecting the interconnecting wiring from electrical and radio frequency interference.

A-3-12.6.1 It is not the intention that emergency voice/alarm communications service be limited to English-speaking populations. Emergency messages should be provided in the language of the predominant building population. Where there is a possibility of isolated groups that do not speak the predominant language, multilingual messages should be provided. It is expected that small groups of transients unfamiliar with the predominant language will be picked up in the traffic flow in the event of emergency and are not likely to be in an isolated situation.

A-3-12.6.5.1 The choice of the location(s) for the fire command center should also consider the ability of the fire alarm system to operate and function during any probable single event.

A-3-12.6.6.2 The design and layout of the loudspeaker audible notification appliances should be arranged such that they do not interfere with the operations of the emergency response personnel. Speakers located in the vicinity of the fire command center should be arranged so they do not cause audio feedback when the system microphone is used. Speakers installed in the area of two-way telephone stations should be arranged so that the sound pressure level emitted does not preclude the effective use of the two-way telephone system. Circuits for paging zones and telephone zones

should be separated, shielded, or otherwise arranged to prevent audio cross talk between circuits.

A-3-12.8.3 Consideration should be given to the type of fire fighters' telephone handset used in areas where high ambient noise levels exist or areas where high noise levels could exist during a fire condition. Push-to-talk handsets, handsets containing directional microphones, or handsets containing other suitable noise-canceling features can be used.

A-3-13 Special Requirements for Low Power Radio (Wireless) Systems.

(a) The term "wireless" has been replaced with "low power radio" to eliminate potential confusion with other transmission media such as optical fiber cables.

(b) Low power radio devices are required to comply with the applicable low power requirements of Title 47, *Code of Federal Regulations*, Part 15.

A-4-2.2.2 There are related types of contract service that often are provided from, or controlled by, a central station but that are neither anticipated by, nor consistent with, the provisions of 4-2.2.2. Although 4-2.2.2 does not preclude such arrangements, a central station company is expected to recognize, provide for, and preserve the reliability, adequacy, and integrity of those supervisory and alarm services intended to be in accordance with the provisions of 4-2.2.2.

A-4-2.2.4 It is the responsibility of the prime contractor to remove all compliance markings (certification markings or placards) when a service contract goes into effect that conflicts in any way with the requirements of 4-2.2.4.

A-4-2.2.5 The prime contractor should be aware of statutes, public agency regulations, or certifications regarding fire alarm systems that might be binding on the subscriber. The prime contractor should identify for the subscriber which agencies could be an authority having jurisdiction and, where possible, advise the subscriber of any requirements or approvals being mandated by these agencies.

The subscriber has the responsibility for notifying the prime contractor of those private organizations that are being designated as an authority having jurisdiction. The subscriber also has the responsibility to notify the prime contractor of changes in the authority having jurisdiction, such as where there is a change in insurance companies. Although the responsibility is primarily the subscriber's, the prime contractor should also take the responsibility to seek out these private authorities having jurisdiction through the subscriber. The prime contractor has the responsibility for maintaining current records on the authority(ies) having jurisdiction for each protected premises.

The most prevalent public agency involved as an authority having jurisdiction with regard to fire alarm systems is the local fire department or fire prevention bureau. These are normally city or county agencies with statutory authority, and their approval of fire alarm system installations might be required. At the state level, the fire marshal's office is most likely to serve as the public regulatory agency.

The most prevalent private organizations involved as authorities having jurisdiction are insurance companies. Others include insurance rating bureaus, insurance brokers and agents, and private consultants. It is important to note that these organizations have no statutory authority and become authorities having jurisdiction only when designated by the subscriber.

With both public and private concerns to satisfy, it is not uncommon to find multiple authorities having jurisdiction involved with a particular protected premises. It is necessary to identify all authorities having jurisdiction in order to obtain all the necessary approvals for a central station fire alarm system installation.

A-4-2.4.4 Two telephone lines (numbers) at the central station connected to the public switched telephone network, each having its own telephone instrument connected, and two telephone lines (numbers) available at the public fire service communications center to which a central station operator can retransmit an alarm meet the intent of this requirement.

A-4-2.4.4.2 The following methods have been used successfully for supervising retransmission circuits (channels):

(a) An electrically supervised circuit (channel) provided with suitable code sending and automatic recording equipment.

(b) A supervised circuit (channel) providing suitable voice transmitting, receiving, and automatic recording equipment. The circuit may be permitted to be a telephone circuit that:

1. Cannot be used for any other purpose;
2. Is provided with a two-way ring down feature for supervision between the fire department communications center and the central station;
3. Is provided with terminal equipment located on the premises at each end; and
4. Is provided with 24-hour standby power.

NOTE: Local on-premises circuits are not required to be supervised.

(c) Radio facilities using transmissions over a supervised channel with supervised transmitting and receiving equipment. Circuit continuity ensured by any means at intervals not exceeding 8 hours is satisfactory.

A-4-2.6.1.1(a) The term "immediately" in this context is intended to mean "without unreasonable delay." Routine handling should take a maximum of 90 seconds from receipt of an alarm signal by the central station until the initiation of retransmission to the public fire service communications center.

A-4-2.6.1.3 It is anticipated that the central station will first attempt to notify designated personnel at the protected premises. When such notification cannot be made, it might be appropriate to notify law enforcement or the fire department, or both. For example, if a valve supervisory signal is received where protected premises are not occupied, it is appropriate to notify the police.

A-4-2.6.1.3(a) The term "immediately" in this context is intended to mean "without unreasonable delay." Routine handling should take a maximum of 4 minutes from receipt of a supervisory signal by the central station until the initiation of communications with a person(s) designated by the subscriber.

A-4-2.6.1.4(a) The term "immediately" in this context is intended to mean "without unreasonable delay." Routine handling should take a maximum of 4 minutes from receipt of a trouble signal by the central station until initiation of the investigation by telephone.

A-4-2.6.1.5(b) The term "immediately" in this context is intended to mean "without unreasonable delay." Routine handling should take a maximum of 4 minutes from receipt of a trouble signal by the central station until initiation of the investigation by telephone.

A-4-3.2.4 The following functions are included in Appendix A to provide guidelines for utilizing building systems and equipment in addition to proprietary fire alarm equipment in order to provide life safety and property protection.

Building functions that should be initiated or controlled during a fire alarm condition include, but should not be limited to, the following:

(a) Elevator operation consistent with ANSI A17.1, *Safety Code for Elevators and Escalators.*

(b) Unlocking of stairwell and exit doors. (*See NFPA 80, Standard for Fire Doors and Fire Windows, and NFPA 101, Life Safety Code.*)

(c) Release of fire and smoke dampers. (*See NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems, and NFPA 90B, Standard for the Installation of Warm Air Heating and Air Conditioning Systems.*)

(d) Monitoring and initiating of self-contained automatic fire extinguishing system(s) or suppression system(s) and equipment. (*See NFPA 11, Standard for Low-Expansion Foam; NFPA 11A, Standard for Medium- and High-Expansion Foam Systems; NFPA 12, Standard on Carbon Dioxide Extinguishing Systems; NFPA 12A, Standard on Halon 1301 Fire Extinguishing Systems; NFPA 13, Standard for the Installation of Sprinkler Systems; NFPA 14, Standard for the Installation of Standpipe and Hose Systems; NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection; and NFPA 17, Standard for Dry Chemical Extinguishing Systems.*)

(e) Lighting control necessary to provide essential illumination during fire alarm conditions. (*See NFPA 70, National Electrical Code, and NFPA 101, Life Safety Code.*)

(f) Emergency shutoff of hazardous gas.

(g) Control of building environmental heating, ventilating, and air conditioning equipment to provide smoke control. (*See NFPA 90A , Standard for the Installation of Air Conditioning and Ventilating Systems.*)

(h) Control of process, data processing, and similar equipment as necessary during fire alarm conditions.

A-4-3.6.5 It is the intent of this code that the operator within the proprietary supervising station should have a secure means of immediately retransmitting any signal indicative of a fire to the public fire department communications center. Automatic retransmission using an approved method installed in accordance with Sections 4-2, 4-3, 4-4, 4-6, and 4-7 is the best method for proper retransmission. However, a manual means may be permitted to be used, consisting of either a manual connection following the requirements of Sections 4-2, 4-4, and 4-7, or, for proprietary supervising stations serving only contiguous properties, a means in the form of a municipal fire alarm box installed within 50 ft (15 m) of the proprietary supervising station in accordance with Section 4-6 may be permitted.

A-4-3.6.6 Regardless of the type of retransmission facility used, telephone communications between the proprietary supervising station and the fire department should be available at all times and should not depend on a switchboard operator.

A-4-4.3 As a minimum, the room or rooms containing the remote supervising station equipment should have a 1-hour fire rating, and the entire structure should be protected by an alarm system complying with Chapter 3.

A-4-5.2.1.2 It is not the intent of the requirements of Section 4-5 to limit the use of listed equipment using alternate communications methods, provided these methods demonstrate performance characteristics that are equal to or superior to those technologies described in Section 4-5. Such demonstration of equivalency is to be evidenced by the equipment using the alternate communications methods meeting all the requirements of Chapter 1, including those that deal with such factors as reliability, monitoring for integrity, and listing. It is further expected that suitable proposals stating the requirements for such technology will be submitted for inclusion in subsequent editions of this code.

A-4-5.3.1.2 Where derived channels are used, normal operating conditions of the telephone equipment are not to inhibit or impair the successful transmission of signals. These normal conditions include, but are not limited to:

(a) Intraoffice calls with a transponder on the originating end.

(b) Intraoffice calls with a transponder on the terminating end.

(c) Intraoffice calls with transponders on both ends.

(d) Receipt and origination of long distance calls.

(e) Calls to announcement circuits.

(f) Permanent signal receiver off-hook tone.

(g) Ringing with no answer, with transponder on either the originating or the receiving end.

(h) Calls to tone circuits (i.e., service tone, test tone, busy, or reorder).

(i) Simultaneous with voice source.

(j) Simultaneous with data source.

(k) Tip and ring reversal.

(l) Cable identification equipment.

A-4-5.3.1.2.3(b) Derived channel systems comprise Type 1 and Type 2 systems only.

A-4-5.3.2.1.3 In order to give the DACT the ability to disconnect an incoming call to the protected premises, telephone service should be of the type that provides for timed-release disconnect. In some telephone systems (step-by-step offices), timed-release disconnect is not provided.

A-4-5.3.2.1.5 A DACT can be programmed to originate calls to the DACR telephone lines (numbers) in any alternating sequence. The sequence can consist of single or multiple calls to one DACR telephone line (number), followed by single or multiple calls to a second DACR telephone line (number), or any combination thereof that is consistent with the minimum/maximum attempt requirements in 4-5.3.2.1.5.

A-4-5.3.2.1.9 The requirement for use of two different long distance providers is to prevent a lost signal due to a fault in one long distance provider's network. This requirement is not meant to apply in local situations where signal traffic is strictly within the area covered by one local telephone company.

Since it is never certain whether a subscriber has changed long distance providers, it is recommended that, where direct dialer service is used, a telephone call should be forced onto a specific long distance provider's network by using the dialing prefix carrier identification code (CIC) specific to each long distance provider.

A-4-5.3.2.1.11 Since call forwarding requires equipment at a telephone company central office that might occasionally interrupt the call forwarding feature, a signal should be initiated whereby the integrity of the forwarded telephone line (number) that is being called by DACTs is verified every 4 hours. This can be accomplished by a single DACT, either in service or used solely for verification, that automatically initiates and completes a transmission sequence to its associated DACR every 4 hours. A successful signal transmission sequence of any other type within the same 4-hour period should be considered sufficient to fulfill this requirement.

Call forwarding should not be confused with WATS or 800 service. The latter, differentiated from the former by dialing the 800 prefix, is a dedicated service used mainly for its toll-free feature; all calls are preprogrammed to terminate at a fixed telephone line (number) or to a dedicated line.

A-4-5.3.2.2.2.1 The timed-release disconnect considerations as outlined in A-4-5.3.2.1.3 apply to the telephone lines (numbers) connected to a DACR at the supervising station.

It might be necessary to consult with appropriate telephone service personnel to ensure that numbers assigned to the DACR can be individually accessed even where they are connected in rotary (a hunt group).

A-4-5.3.2.2.2.3 In determining system loading, Table 4-5.3.2.2.2.3 can be used, or it should be demonstrated that there is a 90 percent probability of incoming line availability. Table 4-5.3.2.2.2.3 is based on an average distribution of calls and an average connected time of 30 seconds per message. Therefore, where it is proposed to use Table 4-5.3.2.2.2.3 to determine system loading, if any factors are disclosed that could extend DACR connect time so as to increase the average connect time, the alternate method of determining system loading should be used. Higher (or possibly lower) loadings might be appropriate in some applications.

(a) Some factors that could increase (or decrease) the capacity of a hunt group follow.

1. Shorter (or longer) average message transmission time can influence hunt group capacity.

2. The use of audio monitoring (listen-in) slow scan video or other similar equipment can significantly increase the connected time for a signal and reduce effective hunt group capacity.

3. The clustering of active burglar alarm signals can generate high peak loads at certain hours.

4. Inappropriate scheduling of 24-hour test signals can generate excessive peak loads.

(b) Demonstration of a 90 percent probability of incoming line availability can be accomplished by the following in-service monitoring of line activity:

1. Incoming lines are assigned to telephone hunt groups. When a DACT calls the main number of a hunt group, it can connect to any currently available line in that hunt group.

2. The receiver continuously monitors the "available" status of each line. A line is available when it is waiting for an incoming call. A line is unavailable for any of the following reasons:

a. Currently processing a call

b. Line in trouble

c. Audio monitoring (listen-in) in progress

d. Any other condition that makes the line input unable to accept calls.

3. The receiver monitors the "available" status of the hunt group. A hunt group is available when any line in it is available.

4. A message is emitted by the receiver when a hunt group is unavailable for more than 1 minute out of 10 minutes. This message references the hunt group and the degree of overload.

A-4-5.3.2.2.2.4 The verification of the 24-hour DACR line test should be done early enough in the day to allow repairs to be made by the telephone company.

A-4-5.3.3.1.2 The following recommended coded signal designations for a building having four floors and basements are provided in Table A-4-5.3.3.1.2:

Table A-4-5.3.3.1.2 Recommended Coded Signal Designations

Location	Coded Signal
4th floor	2-4
3rd floor	2-3
2nd floor	2-2
1st floor	2-1
Basement	3-1
Subbasement	3-2

A-4-5.3.3.2.5(c) Though rare, it is understood that the occurrence of a wire-to-wire short on the primary trunk facility near the supervising station could disable the transmission system without immediate detection.

A-4-5.3.3.2.6(d)3 Though rare, it is understood that the occurrence of a wire-to-wire short on the primary trunk facility near the supervising station could disable the transmission system without immediate detection.

A-4-5.3.3.3.5 At the time of system acceptance, verification should be made that manual fire alarm box signals are free of transmission channel interference.

A-4-5.3.4.4 The intent of the plurality of control sites is to safeguard against damage caused by lightning and to minimize the effect of interference on the receipt of signals.

A-4-5.3.5.2 It is intended that each RAT communicate with two or more independently located RARSRs. The location of such RARSRs should be such that they do not share common facilities.

NOTE: All probability calculations required for the purposes of Chapter 4 should be made in accordance with established communications procedures, should assume the maximum channel loading parameters specified, and should further assume that 25 RATs are actively in alarm and are being received by each RARSR.

A-4-5.3.7.1 A private microwave radio can be used either as a transmission channel, to connect a transmitter to a supervising station or subsidiary station, or as a communications channel to connect a subsidiary station(s) to a supervising station(s). This can be done independently or in conjunction with wireline facilities.

A-4-5.3.7.2(b) Transmitters should be operated alternately, 16 hours on and 16 hours off.

A-4-5.4.1 The signal information may be permitted to be provided in coded form. Records may be permitted to be used to interpret these codes.

A-4-5.4.2 In order to expedite repairs, it is recommended that spare modules, such as printed circuit boards, CRT displays, or printers, be stocked at the supervising station.

A-4-5.4.3 For all forms of transmission, the maximum time to process an alarm signal should be 90 seconds. The maximum time to process a supervisory signal should be 4 minutes. The time to process an alarm or supervisory signal is defined as that time measured from receipt of a signal until retransmission or subscriber contact is initiated.

When the level of traffic in a supervising station system reaches a magnitude such that delayed response is possible, even where the loading tables or loading formulas of this code are not exceeded, it is envisioned that it will be necessary to employ an enhanced method of processing.

For example, in a system where a single DACR instrument provided with fire and burglar alarm service is connected to multiple telephone lines, it is conceivable that, during certain periods of the day, fire alarm signals could be delayed by the security signaling traffic, such as opening and closing signals. Such an enhanced system would, upon receipt of a signal:

(a) Automatically process the signals, differentiating between those that require immediate response by supervising station personnel and those that need only be logged.

(b) Automatically provide relevant subscriber information to assist supervising station personnel in their response.

(c) Maintain a timed, unalterable log of the signals received and the response of supervising station personnel to such signals.

A-4-6.2.1 Where choosing from available options to implement a public fire alarm reporting system, the operating agency should consider which of the choices would facilitate the maximum reliability of the system where such a choice is not cost prohibitive.

A-4-6.4.7 Indicating Lights.

(a) The current supply for designating lamps at street boxes should be secured at lamp locations from the local electric utility company.

(b) Alternating current power may be permitted to be superimposed on metallic fire alarm circuits for supplying designating lamps or for control or actuation of equipment devices for fire alarm or other emergency signals, provided the following conditions exist:

1. Voltages between any wire and ground or between one wire and any other wire of the system should not exceed 150 volts; the total resultant current in any line circuit should not exceed 1/4 ampere.

2. Components such as coupling capacitors, transformers, chokes, or coils should be rated for 600-volt working voltage and have a breakdown voltage of at least twice the working voltage plus 1000 volts.

3. There is no interference with fire alarm service under any conditions.

A-4-6.6 Where the intent is for complete coverage, it should not be necessary to travel in excess of one block or 500 ft (150 m) to reach a box. In residential areas, it should not be necessary to travel in excess of two blocks or 800 ft (240 m) to reach a box.

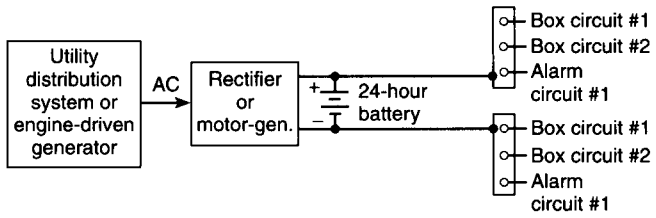


Figure A-4-6.7.1.7(a) Form 2A.

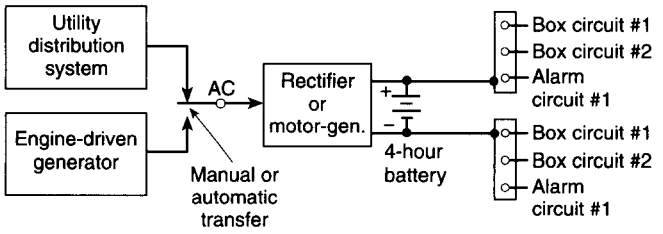


Figure A-4-6.7.1.7(b)(1) Form 2B-1.

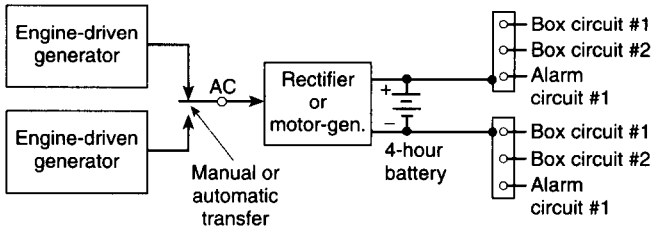


Figure A-4-6.7.1.7(b)(2) Form 2B-2.

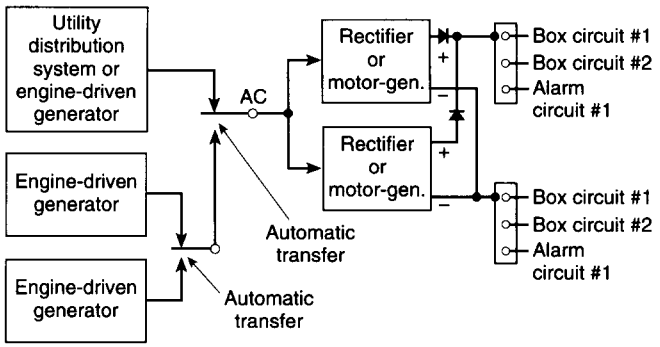


Figure A-4-6.7.1.7(c) Form 2C.

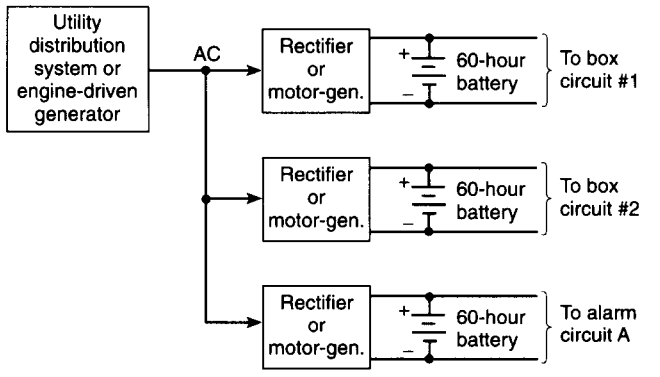
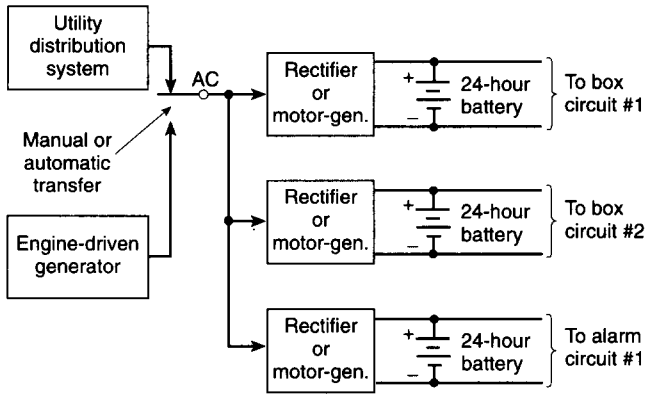


Figure A-4-6.7.1.8(a) Form 3A.



FigureA-4-6.7.1.8(b)(1) Form 3B-1.

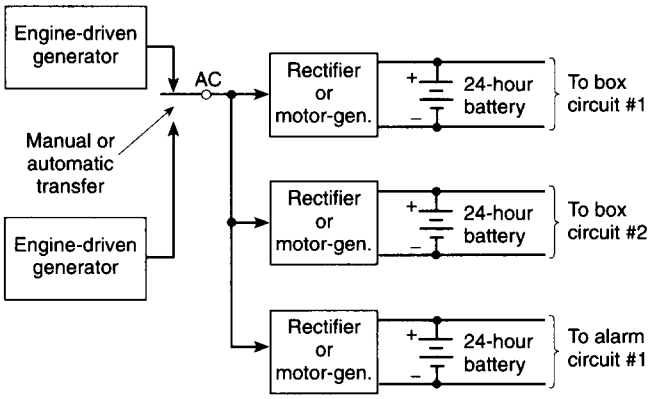


Figure A-4-6.7.1.8(b)(2) Form 3B-2.

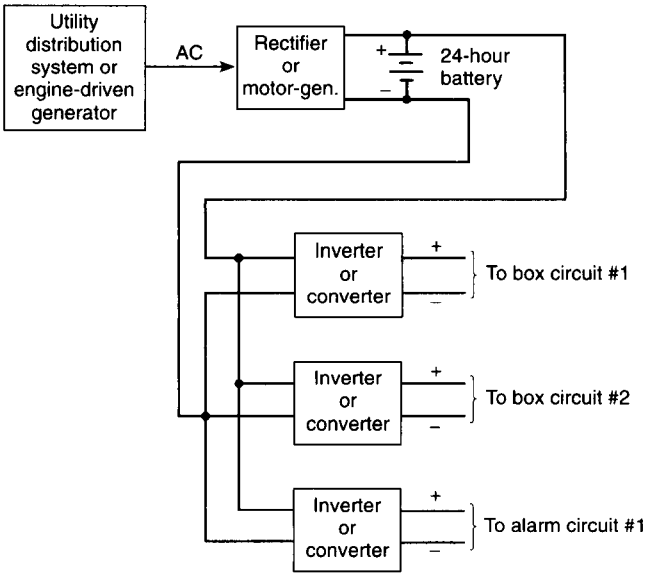


Figure A-4-6.7.1.9(a) Form 4A.

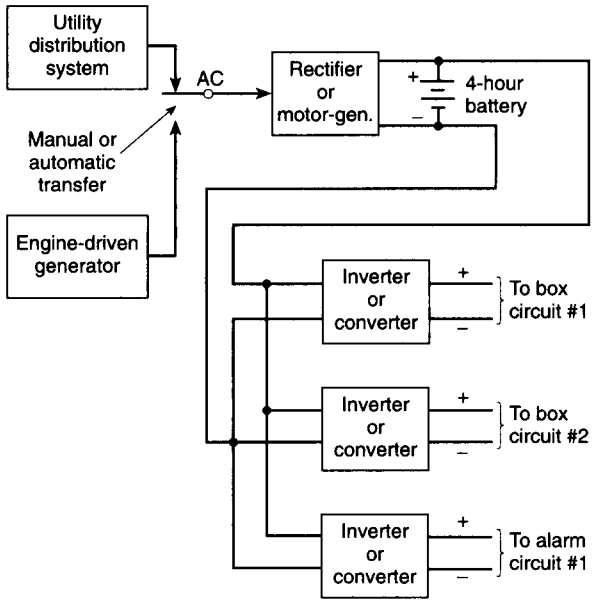


Figure A-4-6.7.1.9(b)(1) Form 4B-1.

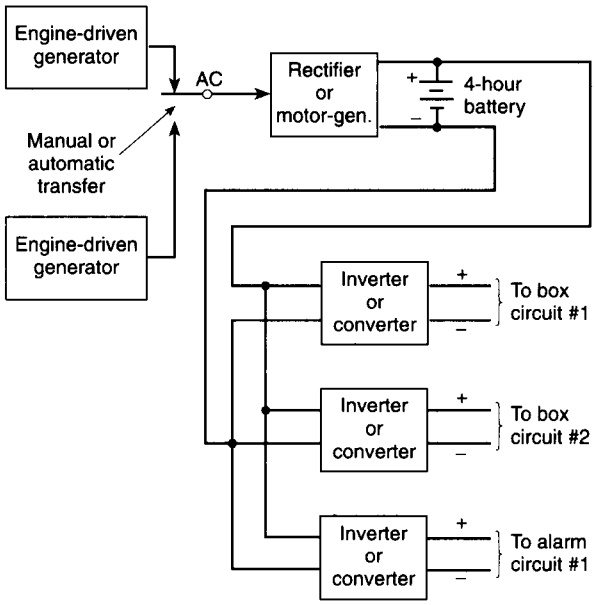


Figure A-4-6.7.1.9(b)(2) Form 4B-2.

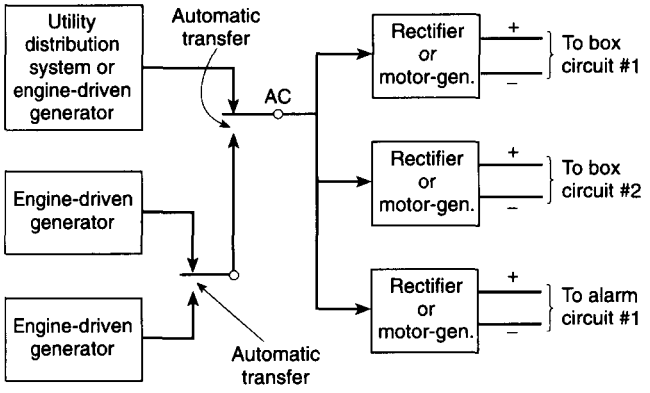


Figure A-4-6.7.1.9(c) Form 4C.

A-4-6.9.1.4 All requirements for circuit protection do not apply to coded radio reporting systems. These systems do not use metallic circuits.

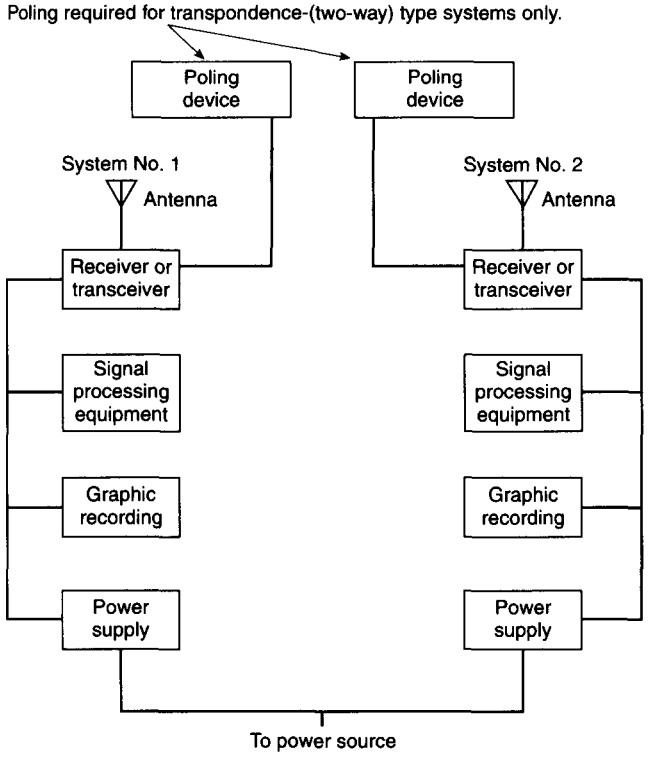


Figure A-4-6.14.3.1.1 Type A system receiving networks.

A-4-7.4.1(a) The local energy-type system [*see Figures A-4-7.4.1(a)(1) and A-4-7.4.1(a)(2)*] is electrically isolated from the public fire alarm reporting system and has its own power supply. The tripping of the transmitting device does not depend on the current in the system. In a wired circuit, receipt of the alarm by the communications center when the circuit is accidentally opened depends on the design of the transmitting device and the associated communications center equipment (i.e., whether or not the system is designed to receive alarms through manual or automatic ground operational facilities). In a radio box-type system, receipt of the alarm by the communications center depends on the proper operation of the radio transmitting and receiving equipment.

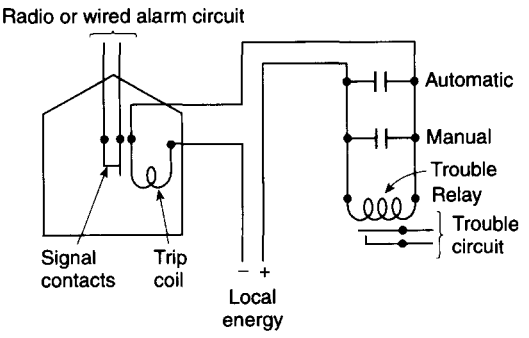


Figure A-4-7.4.1(a)(1) Local energy-type auxiliary fire alarm system.

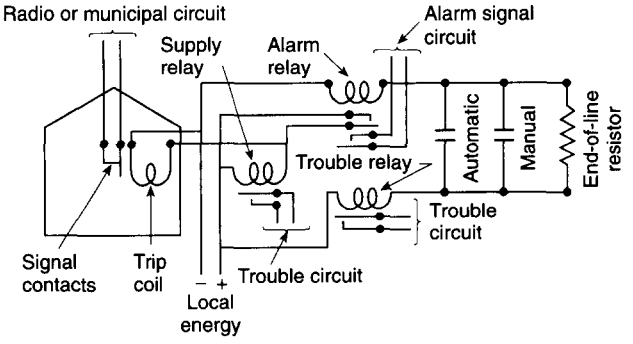


Figure A-4-7.4.1(a)(2) Local energy-type auxiliary fire alarm system.

A-4-7.4.1(b) The shunt-type [*see Figures A-4-7.4.1(b) and A-4-7.4.1(b)8*] is electrically connected to, and is an integral part of, the public fire alarm reporting system. A ground fault on the auxiliary circuit is a fault on the public fire alarm reporting system circuit, and an accidental opening of the auxiliary circuit sends a needless (or false) alarm to the communications center. An open circuit in the transmitting device trip coil is not indicated either at the protected property or at the communications center; also, if an initiating device is operated, an alarm is not transmitted, but an open circuit indication is given at the communications center. If a public fire alarm reporting system circuit is open when a connected shunt-type system is operated, the transmitting device does not trip until the public fire alarm reporting system circuit returns to normal, at which time the alarm is transmitted, unless the auxiliary circuit is first returned to a normal condition.

Additional design restrictions for shunt systems are found in laws or ordinances.

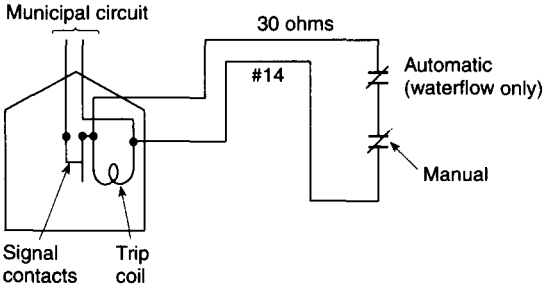


Figure A-4-7.4.1(b) Shunt-type auxiliary fire alarm system.

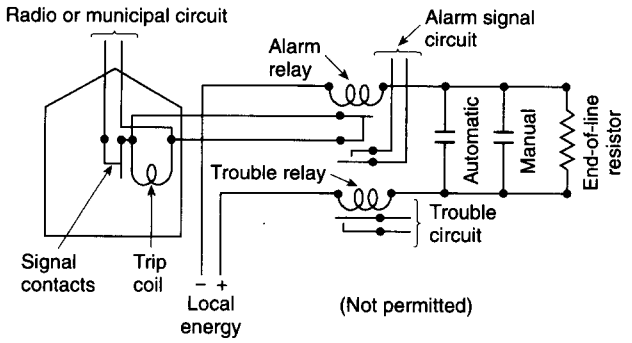


Figure A-4-7.4.1(b)8 Shunt-type auxiliary fire alarm system.

A-4-7.4.1(c) A parallel telephone-type system [*see Figure A-4-7.4.1(c)*] is a system in which alarms are transmitted over a circuit directly connected to the annunciating switchboard at the public fire service communications center and terminated at the protected property by an end-of-line device.

Such auxiliary systems are for connection to public fire alarm reporting systems of the type in which each alarm box annunciates at the communications center by individual circuit.

NOTE: The essential difference between the local energy or parallel telephone types and the shunt-type system is that accidental opening of the alarm-initiating circuits causes an alarm on the shunt-type system only.

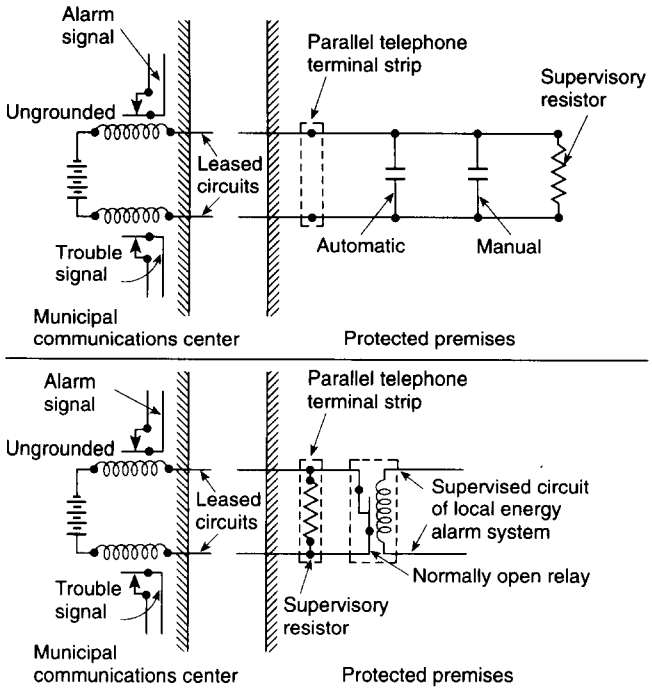


Figure A-4-7.4.1(c) Parallel telephone-type auxiliary fire alarm system.

A-5-1.3.4 Refer to Figures A-5-1.3.4(a) and (b) on pages 119–120 for proper connections of automatic fire detectors to fire alarm system initiating device circuits and power supply circuits.

A-5-1.4.3 Detectors might be required under large benches, shelves, or table, and inside cupboards or other enclosures.

A-5-1.4.4 If there are no detectors in the room or area of origin, the fire could be too large to control where detected by remotely located detectors.

A-5-1.4.5 Stratification. Stratification of air in a room can hinder air containing smoke particles or gaseous combustion products from reaching ceiling-mounted smoke or fire-gas detectors.

Stratification occurs when air containing smoke particles or gaseous combustion products is heated by smoldering or burning material and, becoming less dense than the surrounding cooler air, rises until it reaches a level at which there is no longer a difference in temperature between it and the surrounding air.

Stratification also can occur when evaporative coolers are used, because moisture introduced by these devices can condense on smoke, causing it to fall toward the floor. Therefore, to ensure rapid response, it might be necessary to install smoke detectors on sidewalls or at locations below the ceiling.

In installations where detection of smoldering or small fires is desired and where the possibility of stratification exists, consideration should be given to mounting a portion of the detectors below the ceiling. In high ceiling areas, projected beam-type or air sampling-type detectors at different levels also should be considered. (*See Figure A-5-1.4.5.*)

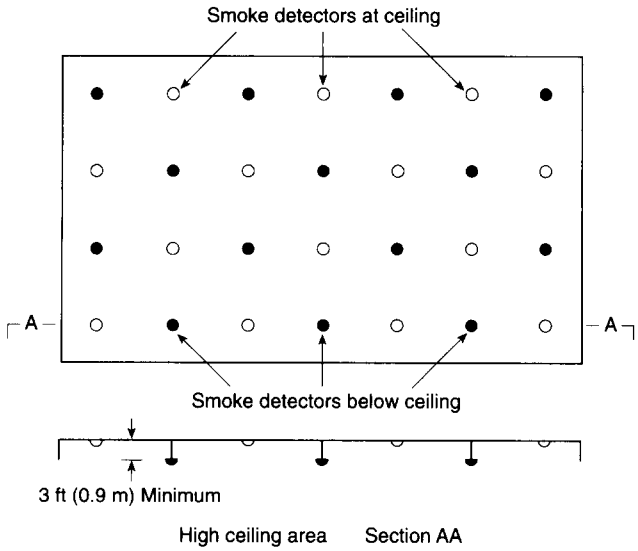
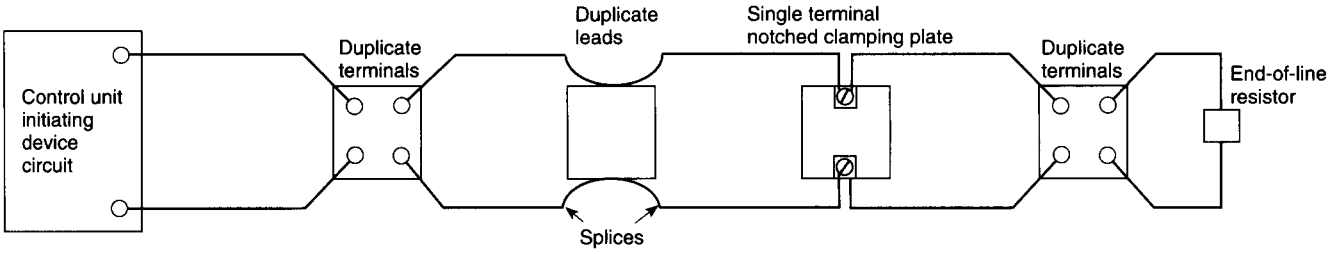
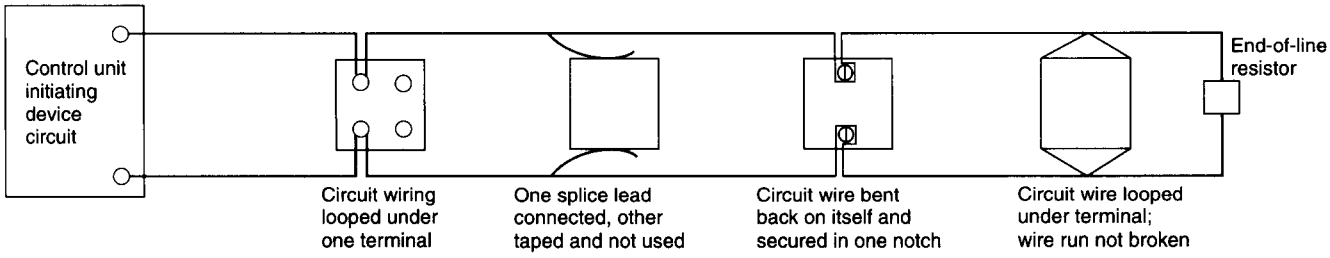


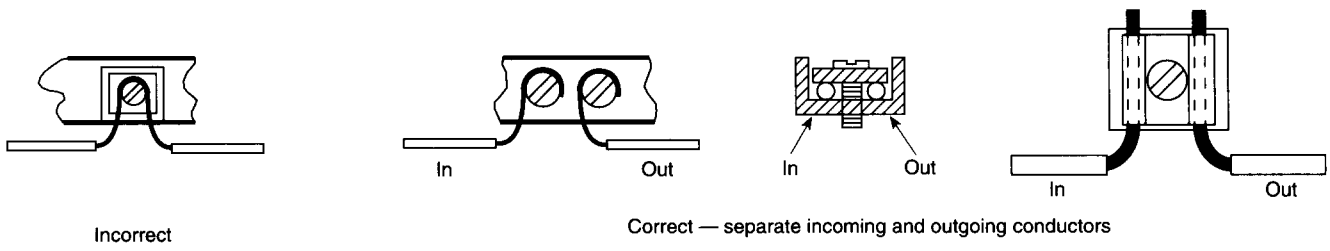
Figure A-5-1.4.5 Smoke detector layout accounting for stratification.



Correct wiring method — two-wire detectors



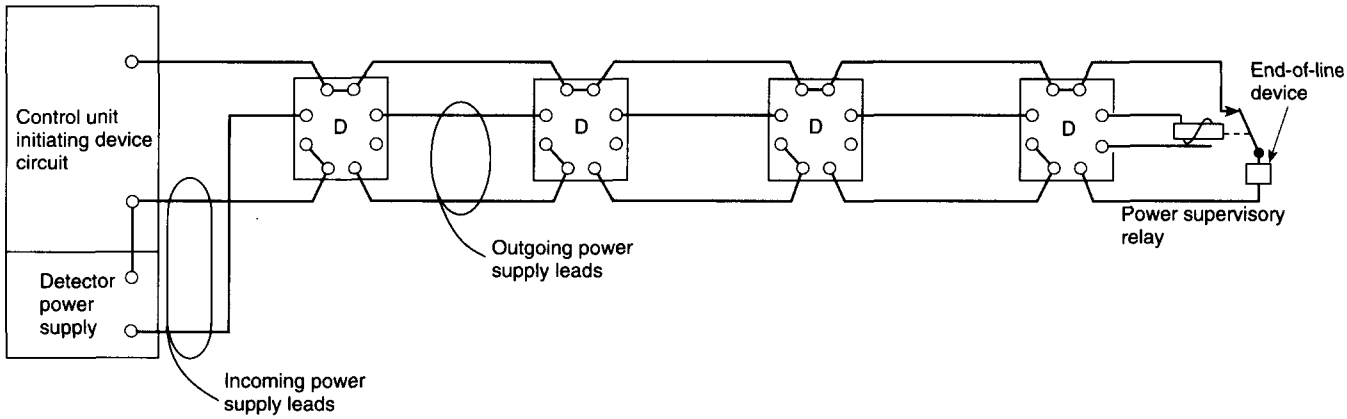
Incorrect wiring method — two-wire detectors



Incorrect

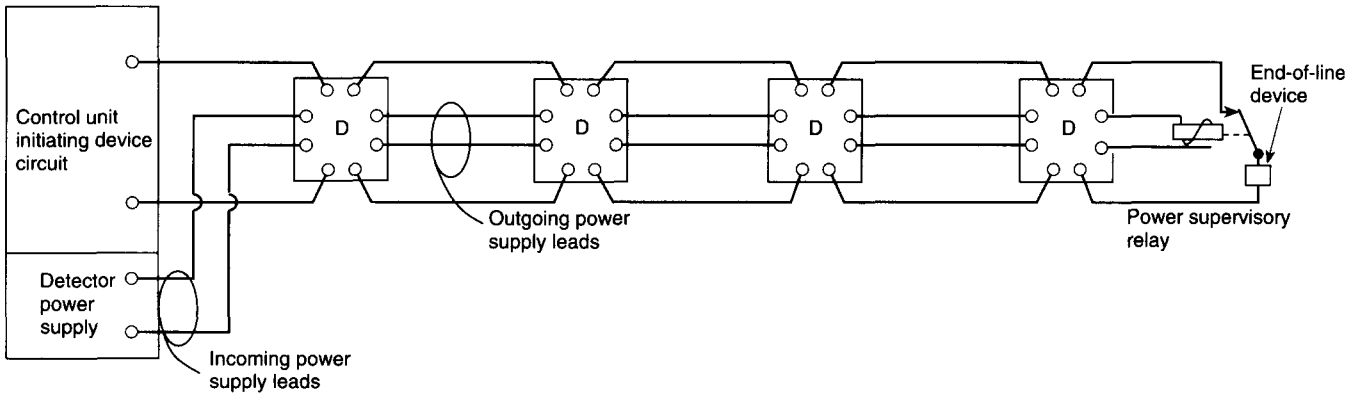
Correct — separate incoming and outgoing conductors

Figure A-5-1.3.4(a) Correct wiring methods—four-wire detectors with separate power supply.



D = Detector

Illustrates four-wire smoke detector employing a three-wire connecting arrangement. One side of power supply is connected to one side of initiating device circuit. Wire run broken at each connection to smoke detector to provide supervision.



D = Detector

Illustrates four-wire smoke detector employing a four-wire connecting arrangement. Incoming and outgoing leads or terminals for both initiating device and power supply connections. Wire run broken at each connection to provide supervision.

Figure A-5-1.3.4(b) Wiring arrangements for three- and four-wire detectors.

A-5-2.1.2 The linear space rating is the maximum allowable distance between heat detectors. The linear space rating is also a measure of the heat detector response time to a standard test fire where tested at the same distance. The higher the rating, the faster the response time. This code recognizes only those heat detectors with ratings of 50 ft (15 m) or more.

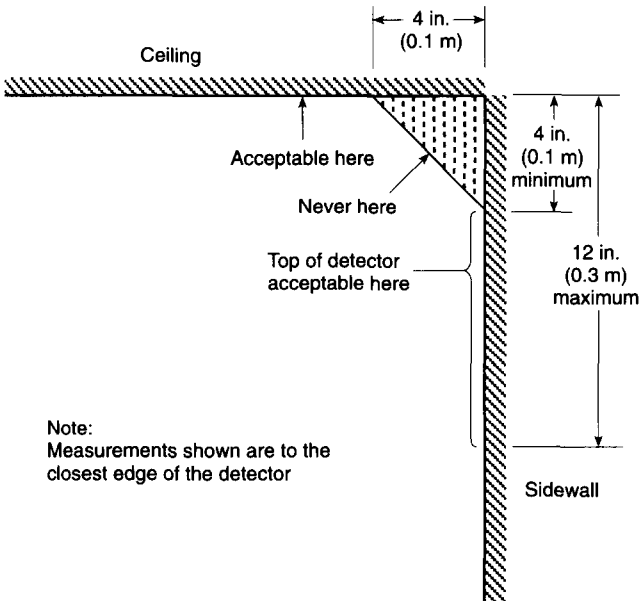


Figure A-5-2.2.1 Example of proper mounting for detectors.

A-5-2.3 A heat detector with a temperature rating somewhat in excess of the highest normally expected ambient temperature is specified in order to avoid the possibility of premature operation of the heat detector to nonfire conditions.

A-5-2.4 In addition to the special requirements for heat detectors installed on ceilings with exposed joists, reduced spacing also might be required due to other structural characteristics of the protected area, possible drafts, or other conditions that could affect detector operation.

A-5-2.4.1 Maximum linear spacings on smooth ceilings for spot-type heat detectors are determined by full-scale fire tests. These tests assume that the detectors are to be installed in a pattern of one or more squares, each side of which equals the maximum spacing as determined in the test. This is illustrated in Figure A-5-2.4.1(a). The detector to be tested is placed at a corner of the square so that it is positioned at the farthest possible distance from the fire while remaining within the square. Thus, the distance from the detector ("D") to the fire ("F") is always the test spacing multiplied by 0.7 and can be set up as shown in Table A-5-2.4.1.

Once the correct maximum test distance has been determined, it is valid to interchange the positions of the fire ("F") and the detector ("D"). The detector is now in the middle of the square, and the listing specifies that the detector is adequate to detect a fire that occurs anywhere within that square — even out to the farthest corner.

In laying out detector installations, designers work in terms of rectangles, as building areas are generally rectangular in shape. The pattern of heat spread from a fire source, however, is not rectangular in shape. On a smooth ceiling,

Table A-5-2.4.1 Test Spacing for Spot-Type Heat Detectors

Test Spacing	Maximum Test Distance from Fire to Detector (0.7 × D)		
(ft)	(m)	(ft)	(m)
50 × 50	15.24 × 15.24	35	10.67
40 × 40	12.19 × 12.19	28	8.53
30 × 30	9.1 × 9.1	21	6.40
25 × 25	7.62 × 7.62	17.5	5.33
20 × 20	6.10 × 6.10	14	4.27
15 × 15	4.57 × 4.57	10.5	3.20

heat spreads out in all directions in an ever-expanding circle. Thus, the coverage of a detector is not, in fact, a square, but rather a circle whose radius is the linear spacing multiplied by 0.7.

This is graphically illustrated in Figure A-5-2.4.1(b). With the detector as the center, by rotating the square, an infinite number of squares can be laid out, the corners of which create the plot of a circle whose radius is 0.7 times the listed spacing. The detector will cover any of these squares and, consequently, any point within the confines of the circle.

So far this explanation has considered squares and circles. In practical applications, very few areas turn out to be exactly square, and circular areas are extremely rare. Designers deal generally with rectangles of odd dimensions and corners of rooms or areas formed by wall intercepts, where spacing to one wall is less than $\frac{1}{2}$ the listed spacing. To simplify the rest of this explanation, the use of a detector with a listed spacing of 30 ft × 30 ft (9.1 m × 9.1 m) should be considered. The principles derived are equally applicable to other types.

Figure A-5-2.4.1(c) illustrates the derivation of this concept. A detector is placed in the center of a circle with a radius of 21 ft (0.7 × 30 ft) [6.4 m (0.7 × 9.1 m)]. A series of rectangles with one dimension less than the permitted maximum of 30 ft (9.1 m) is constructed within the circle. The following conclusions can be drawn:

(a) As the smaller dimension decreases, the longer dimension can be increased beyond the linear maximum spacing of the detector with no loss in detection efficiency.

(b) A single detector covers any area that fits within the circle. For a rectangle, a single, properly located detector may be permitted, provided the diagonal of the rectangle does not exceed the diameter of the circle.

(c) Relative detector efficiency actually is increased, because the area coverage in square feet is always less than the 900 ft^2 (83.6 m^2) permitted if the full 30 ft × 30 ft (9.1 m × 9.1 m) square were to be utilized. The principle illustrated here allows equal linear spacing between the detector and the fire, with no recognition for the effect of reflection from walls or partitions, which in narrow rooms or corridors is of additional benefit. For detectors that are not centered, the longer dimension should always be used in laying out the radius of coverage.

Areas so large that they exceed the rectangular dimensions given in Figure A-5-2.4.1(c) require additional detectors. Often proper placement of detectors can be facilitated by breaking down the area into multiple rectangles of the dimensions that fit most appropriately [*see Figure A-5-2.4.1(d)*]. For example, see Figure A-5-2.4.1(c). A corridor 10 ft (3 m) wide and up to 82 ft (25 m) long can be covered with two 30-ft (9.1-m) detectors. An area 40 ft (12.2 m) wide and up to 74 ft (22.6 m) long can be

covered with four detectors. Irregular areas need more careful planning to make certain that no spot on the ceiling is more than 21 ft (6.4 m) away from a detector. These points can be determined by striking arcs from the remote corner.

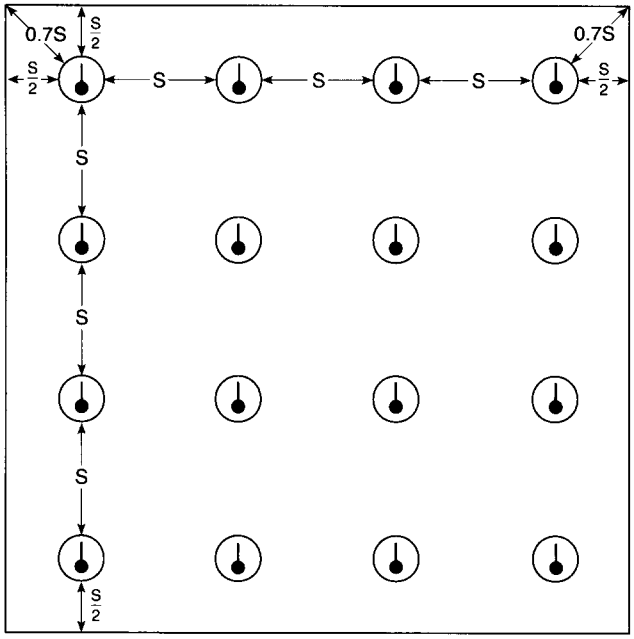


Figure A-5-2.4.1(a) Spot-type heat detectors.

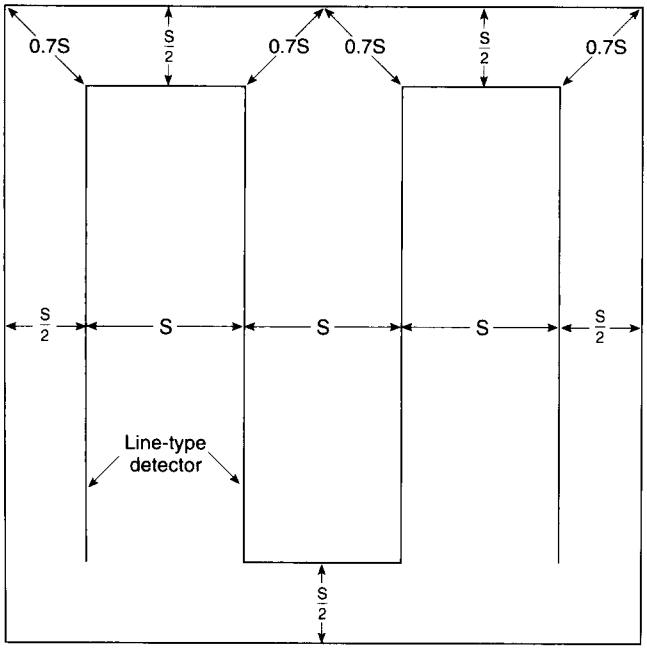


Figure A-5-2.4.1(b) Line-type detectors — spacing layouts, smooth ceiling.

Where any part of the area lies beyond the circle with a radius of 0.7 times the listed spacings, additional detectors are required.

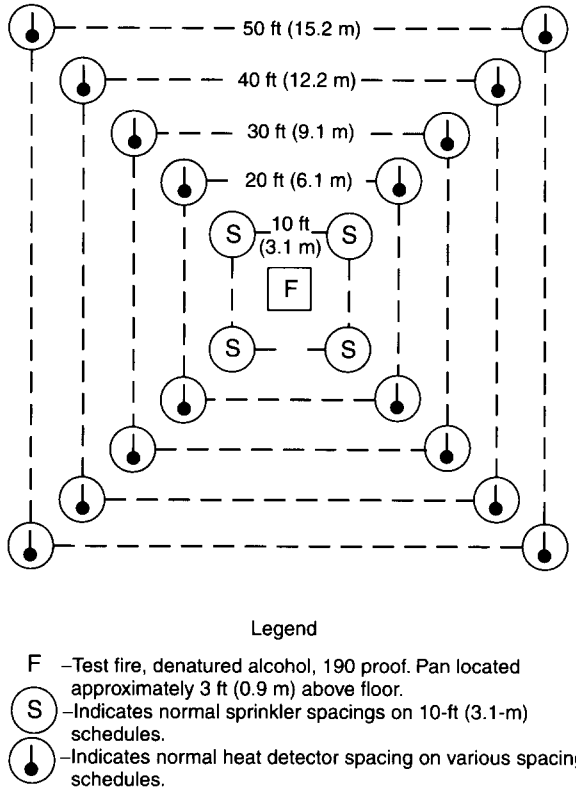


Figure A-5-2.4.1(c) Fire test layout.

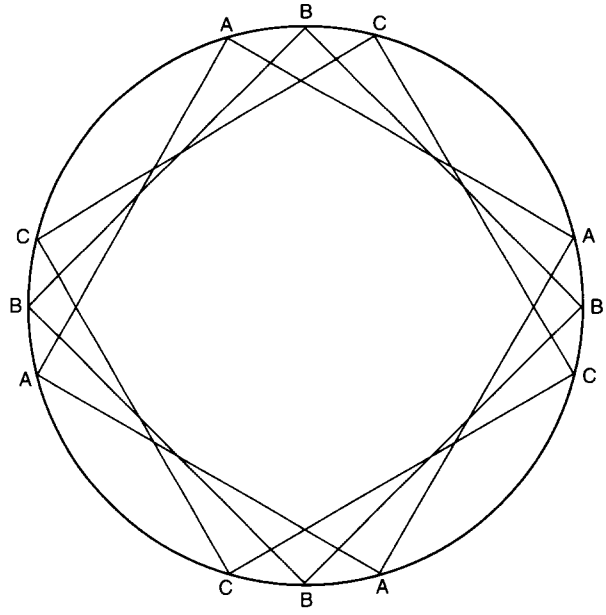


Figure A-5-2.4.1(d) A detector will cover any square laid out in the confines of a circle whose radius is 0.7 times the listed spacing.

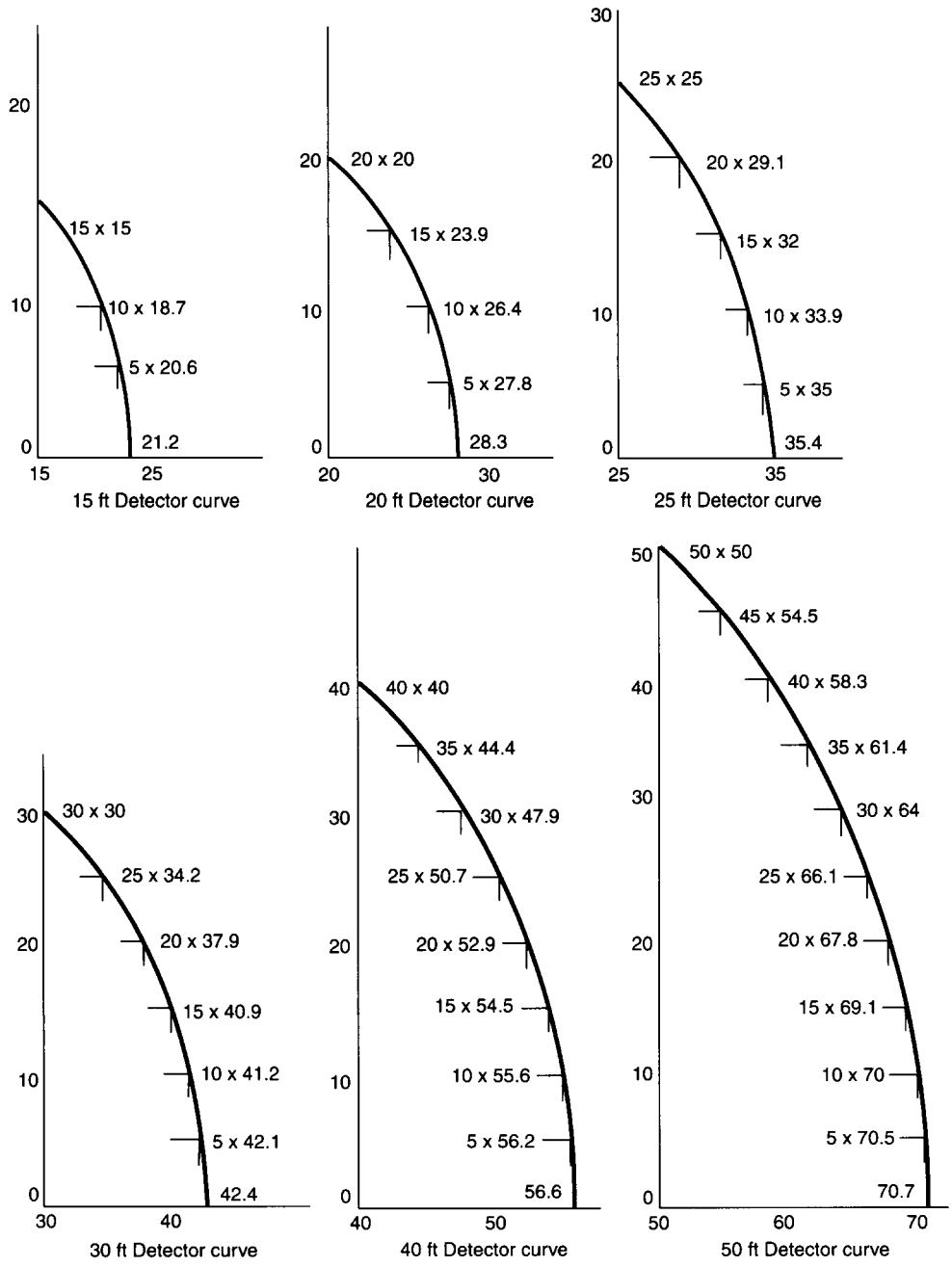
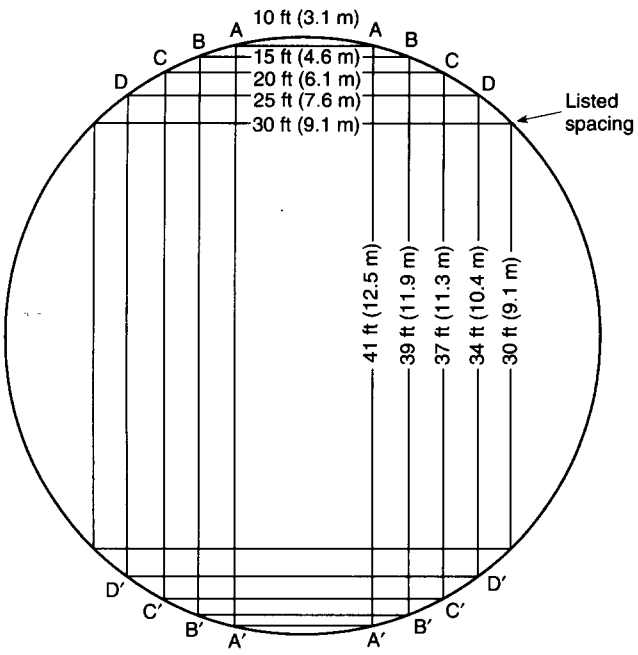


Figure A-5-2.4.1(e) Typical rectangles for detector curves of 15 ft to 50 ft (4.57 m to 15.24 m).



Rectangle A = 10 ft x 41 ft = 410 ft^2 (3.1 m x 12.5 m = 38.1 m^2)
B = 15 ft x 39 ft = 585 ft^2 (4.6 m x 11.9 m = 54.3 m^2)
C = 20 ft x 37 ft = 740 ft^2 (6.1 m x 11.3 m = 68.8 m^2)
D = 25 ft x 34 ft = 850 ft^2 (7.6 m x 10.4 m = 78.9 m^2)
Listed spacing = 30 ft x 30 ft = 900 ft^2 (9.1 m x 9.1 m = 83.6 m^2)

Figure A-5-2.4.1(f) Detector spacing, rectangular areas.

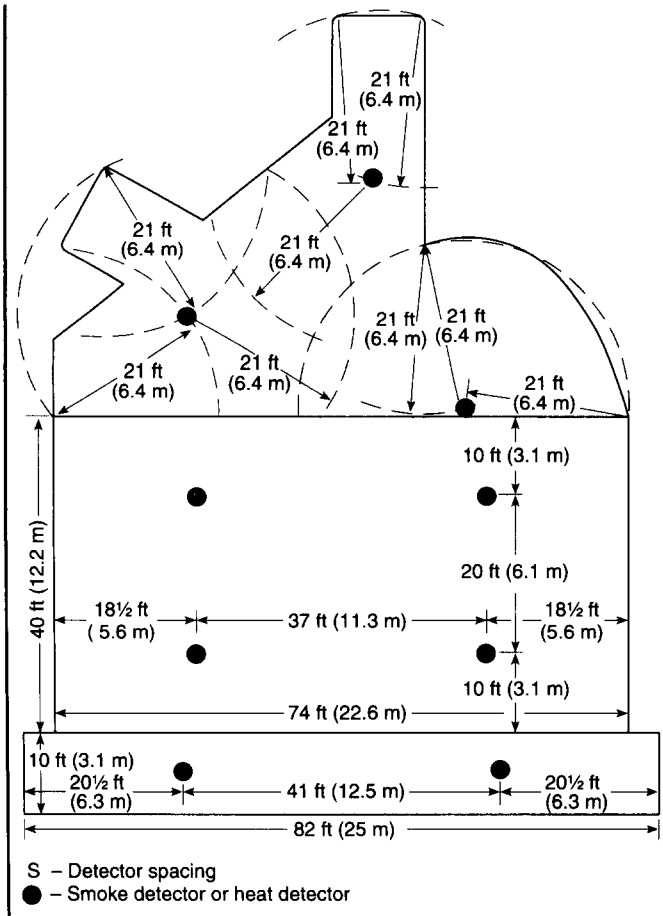


Figure A-5-2.4.1.1 Smoke or heat detector spacing layout, irregular areas.

A-5-2.4.1.2 Both 5-2.4.1.2 and Table 5-2.4.1.2 are constructed to provide detector performance on higher ceilings [to 30 ft (9.1 m) high)] that is essentially equivalent to that which would exist with detectors on a 10-ft (3-m) ceiling.

The Fire Detection Institute Fire Test Report (*see references in Appendix C*), used as a basis for Table 5-2.4.1.2, does not include data on integration-type detectors. Pending development of such data, the manufacturer's recommendations provide guidance.

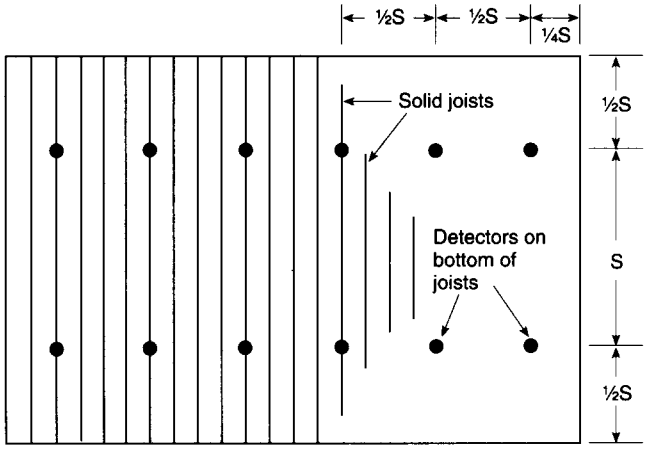


Figure A-5-2.4.2 Detector spacing layout, solid joist construction.

A-5-2.4.3 Location and spacing of heat detectors should consider beam depth, ceiling height, beam spacing, and fire size.

(a) If the ratio of beam depth (D) to ceiling height (H) (D/H) is greater than 0.10 and the ratio of beam spacing (W) to ceiling height (H) (W/H) is greater than 0.40, heat detectors should be located in each beam pocket.

(b) If either the ratio of beam depth to ceiling height (D/H) is less than 0.10 or the ratio of beam spacing to ceiling height (W/H) is less than 0.40, heat detectors should be installed on the bottom of the beams.

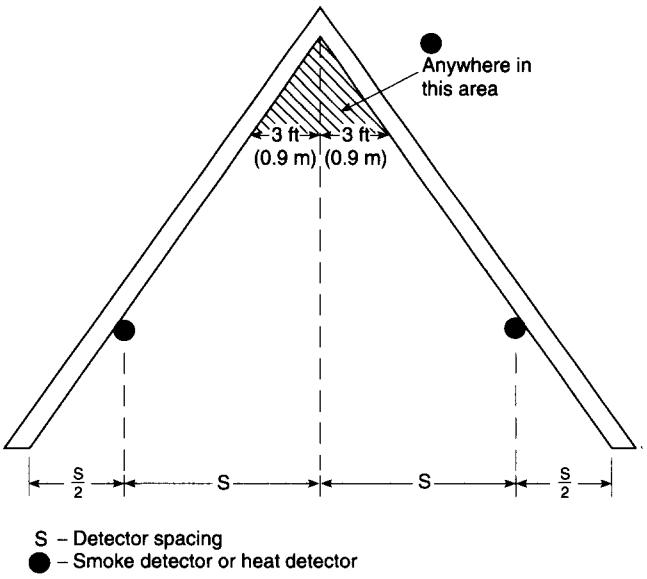


Figure A-5-2.4.4.1 Smoke or heat detector spacing layout, sloped ceilings (peaked type).

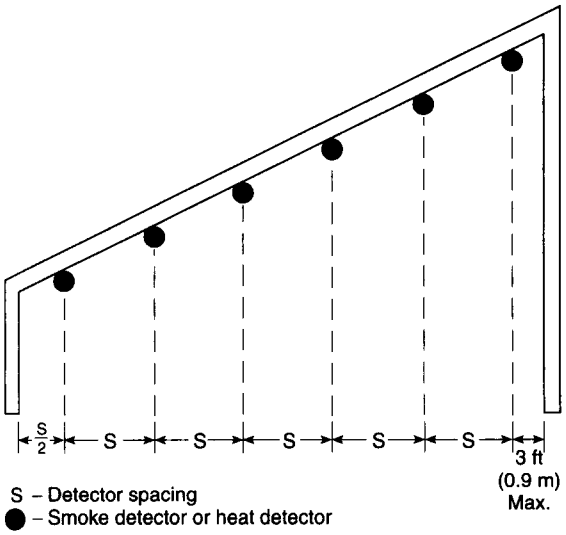


Figure A-5-2.4.4.2 Smoke or heat detector spacing layout, sloped ceilings (shed type).

A-5-3.1.1 The addition of a heat detector to a smoke detector does not enhance its performance as an early warning device.

A-5-3.2 The person designing an installation should keep in mind that, in order for a smoke detector to respond, the smoke has to travel from the point of origin to the detector. In evaluating any particular building or location, likely fire locations should be determined first. From each of these points of origin, paths of smoke travel should be determined. Wherever practical, actual field tests should be conducted. The most desired locations for smoke detectors are the common points of intersection of smoke travel from fire locations throughout the building.

NOTE: This is one of the reasons that specific spacing is not assigned to smoke detectors by the testing laboratories.

A-5-3.4.1 For operation, all types of smoke detectors depend on smoke entering the sensing chamber or light beam. Where sufficient concentration is present, operation is obtained. Since the detectors are usually mounted on the ceiling, response time depends on the nature of the fire. A hot fire rapidly drives the smoke up to the ceiling. A smoldering fire, such as in a sofa, produces little heat; therefore, the time for smoke to reach the detector is increased.

A-5-3.4.3 In high ceiling areas, such as atriums, where spot-type smoke detectors are not accessible for periodic maintenance and testing, projected beam-type or air sampling-type detectors should be considered where access can be provided.

A-5-3.4.3.2 See Figure A-5-3.4.3.2

A-5-3.4.5.1.2 This is useful in calculating locations in corridors or irregular areas (*see A-5-2.4.1 and Figure A-5-2.4.1.1*). For irregularly shaped areas, the spacing between detectors may be permitted to be greater than the selected spacing, provided the maximum spacing from a detector to the farthest point of a sidewall or corner within its zone of protection is not greater than 0.7 times the selected spacing (0.7S). (*See Figure A-5-2.4.1.1.*)

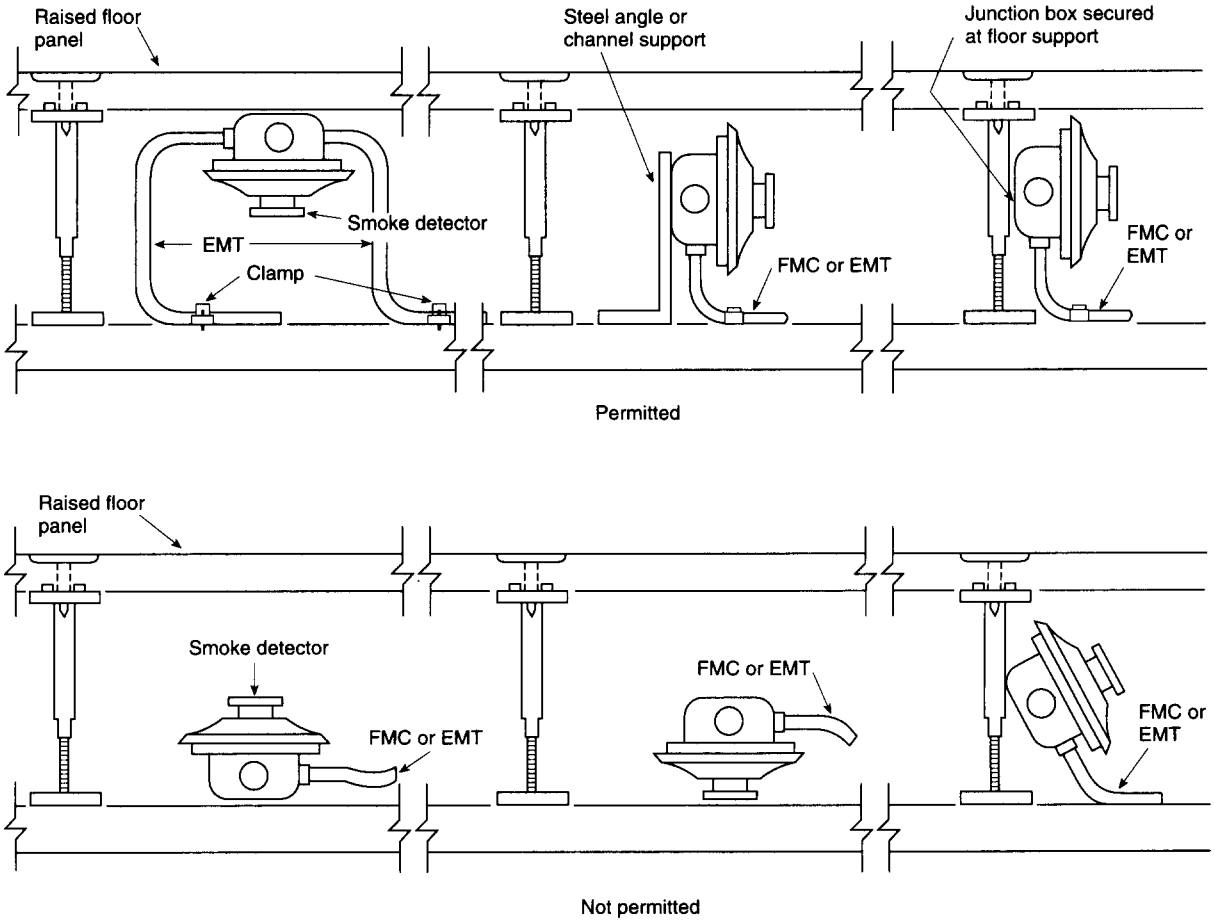


Figure A-5-3.4.3.2 Mounting installations, permitted (top) and not permitted (bottom).

A-5-3.4.5.2 On smooth ceilings, a spacing of not more than 60 ft (18.3 m) between projected beams and not more than ½ that spacing between a projected beam and a sidewall (wall parallel to the beam travel) should be used as a guide. Other spacing should be determined based on ceiling height, airflow characteristics, and response requirements.

In some cases, the light beam projector is mounted on one end wall, with the light beam receiver mounted on the opposite wall. However, it is also permitted to suspend the projector and receiver from the ceiling at a distance from the end walls not exceeding ¼ the selected spacing. (*See Figure A-5-3.4.5.2.*)

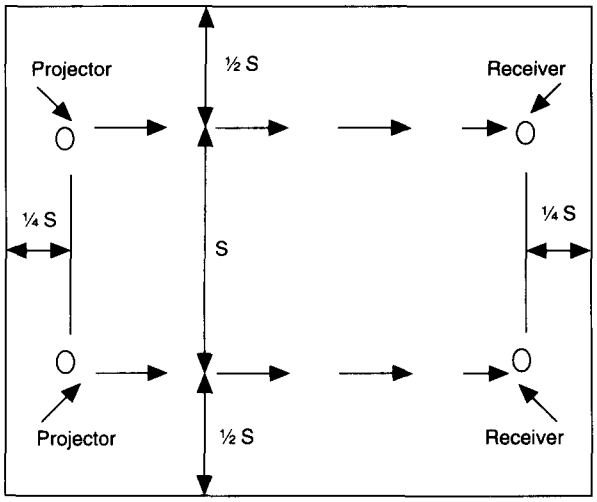


Figure A-5-3.4.5.2 Maximum distance at which ceiling-suspended light projector and receiver may be permitted to be positioned from end wall is ¼ selected spacing (S).

A-5-3.4.6 Detectors are placed at reduced spacings at right angles to joists or beams in an attempt to ensure that detection time is equivalent to that which would be experienced on a flat ceiling. It takes longer for the combustion products (smoke or heat) to travel at right angles to beams or joists because of the phenomenon wherein a plume from a relatively hot fire with significant thermal lift tends to fill the pocket between each beam or joist before moving to the next beam or joist.

Though it is true that this phenomenon might not be significant in a small smoldering fire where there is only enough thermal lift to cause stratification at the bottom of the joists, reduced spacing is still recommended to ensure that detection time is equivalent to that which would exist on a flat ceiling, even in the case of a hotter type of fire.

A-5-3.4.6.1 The spacing guidelines in 5-3.4.6.1 are based on a detection design fire of 100 kW. For detection at a larger 1-MW fire and ceiling heights of 28 ft (8.53 m) or less, smooth ceiling spacings should be used and the detectors may be permitted to be located on the ceiling or the bottom of the beams.

A-5-3.4.6.2 The spacing guidelines in 5-3.4.6.2 are based on a detection design fire of 100 kW. For detection at a larger 1-MW fire, the following spacings should be used:

(a) For beamed ceilings with beams running parallel to (up) the slope, with slopes 10 degrees or less, spacing for flat-beamed ceilings should be used. For ceilings with slopes greater that 10 degrees, twice the smooth ceiling spacing should be used in the direction parallel to (up) the slopes, and ½ the spacing should be used in the direction perpendicular to (across) the slope. For slopes greater than 10 degrees, the detectors located at a distance of ½ the spacing from the low end are not required. Spacing should be measured along the horizontal projection of the ceiling.

(b) For beamed ceilings with beams running perpendicular to (across) the slope for any slope, smooth ceiling spacing should be used in the direction parallel to the beams (across the slope), and ½ the smooth ceiling spacing should be used in the direction perpendicular to the beams (up the slope).

A-5-3.5.1 Detectors should not be located in a direct airflow nor closer than 3 ft (1 m) from an air supply diffuser.

A-5-3.5.2.2 Smoke might not be drawn into the duct or plenums when the ventilating system is shut down. Furthermore, when the ventilating system is operating, the detector(s) can be less responsive to a fire condition in the room of fire origin due to dilution by clean air.

A-5-3.6.1.1 Product-listing standards include tests for temporary excursions beyond normal limits. In addition to temperature, humidity, and velocity variations, smoke detectors should operate reliably under such common environmental conditions as mechanical vibration, electrical interference, and other environmental influences. Tests for these conditions are also conducted by the testing laboratories in their listing program. In those cases in which environmental conditions approach the limits shown in Table A-5-3.6.1.1, the detector manufacturer should be consulted for additional information and recommendations.

A-5-3.6.1.2 Smoke detectors can be affected by electrical and mechanical influences and by aerosols and particulate matter found in protected spaces. The location of detectors should be such that the influences of aerosols and particulate matter from sources such as those in Table A-5-3.6.1.2(a) are minimized. Similarly, the influences of electrical and mechanical factors shown in Table A-5-3.6.1.2(b) should be minimized. While it might not be possible to isolate environmental factors totally, an awareness of these factors during system layout and design favorably affects detector performance.

Table A-5-3.6.1.1 Environmental Conditions that Influence Detector Response

Detection Protection	Air Velocity >300 ft (>91.44 m)/min	Altitude >3000 ft (>914.4 m)	Humidity >93% RH	Temp. <32°F >100°F (<0°C >37.8°C)	Color of Smoke
Ion	X	X	X	X	O
Photo	O	O	X	X	X
Beam	O	O	X	X	O
Air Sampling	O	O	X	X	O

X = Can affect detector response.
O = Generally does not affect detector response.

Table A-5-3.6.1.2(a) Common Sources of Aerosols and Particulate Matter Moisture

Moisture	Combustion Products and Fumes (*continued*)
Live steam	Excessive tobacco smoke
Steam tables	Heat treating
Showers	Corrosive atmospheres
Humidifiers	Dust or lint
Slop sink	Linen/bedding handling
Humid outside air	Sawing, drilling, and grinding
Water spray	Pneumatic transport
	Textile and agricultural processing
Combustion Products and Fumes	
Cooking equipment	**Engine Exhaust**
Ovens	Gasoline forklift trucks
Dryers	Diesel trucks and locomotives
Fireplaces	Engines not vented to the outside
Exhaust hoods	
Cutting, welding, and brazing	**Heating Element with Abnormal Conditions**
Machining	Dust accumulations
Paint spray	Improper exhaust
Curing	Incomplete combustion
Chemical fumes	
Cleaning fluids	

Table A-5-3.6.1.2(b) Sources of Electrical and Mechanical Influences on Smoke Detectors

Electrical Noise and Transients	Airflow
Vibration or shock	Gusts
Radiation	Excessive velocity
Radio frequency	
Intense light	
Lightning	
Electrostatic discharge	
Power supply	

A-5-3.6.2.2 Airflow through holes in the rear of a smoke detector can interfere with smoke entry to the sensing chamber. Similarly, air from the conduit system can flow around the outside edges of the detector and interfere with smoke reaching the sensing chamber. Additionally, holes in the rear of a detector provide a means for entry of dust, dirt, and insects, each of which can adversely affect the detector's performance.

A-5-3.6.3.2 Where the light path of a projected beam-type detector is abruptly interrupted or obscured, the unit should not initiate an alarm. It should give a trouble signal after verification of blockage.

A-5-3.6.4.1 Air Sampling-Type Detectors. A single-pipe network has a shorter transport time than a multiple-pipe network of similar length pipe; however, a multiple-pipe system provides a faster smoke transport time than a single-pipe system of the same total length. As the number of sampling holes in a pipe increases, the smoke transport time increases. Where practical, pipe run lengths in a multiple-pipe system should be nearly equal, or the system should be otherwise pneumatically balanced.

A-5-3.6.4.2 The air sampling-type detector system should be able to withstand dusty environments by either air filtering or electronic discrimination of particle size. The detector should be capable of providing optimal time delays of alarm outputs to eliminate nuisance alarms due to transient smoke conditions. The detector should also provide facilities for the connection of monitoring equipment for the recording of background smoke level information necessary in setting alert and alarm levels and delays.

A-5-3.6.5 High Rack Storage. For the most effective detection of fire in high rack storage areas, detectors should be located on the ceiling above each aisle and at intermediate levels in the racks. This is necessary to detect smoke that is trapped in the racks at an early stage of fire development, when insufficient thermal energy is released to carry the smoke to the ceiling. Earliest detection of smoke is achieved by locating the intermediate level detectors adjacent to alternate pallet sections as shown in Figures A-5-3.6 .5(a) and (b). The detector manufacturer's recommendations and engineering judgment should be followed for specific installations.

A projected beam-type detector may be permitted to be used in lieu of a single row of individual spot-type smoke detectors.

Sampling ports of an air sampling-type detector may be permitted to be located above each aisle to provide coverage equivalent to the location of spot-type detectors. The manufacturer's recommendations and engineering judgment should be followed for the specific installation.

A-5-4.2 Operating Principles of Detectors.

(a) **Flame Detectors.** Ultraviolet flame detectors typically use a vacuum photodiode Geiger-Muller tube to detect the ultraviolet radiation that is produced by a flame. The photodiode allows a burst of current to flow for each ultraviolet photon that hits the active area of the tube. When the number of current bursts per unit time reaches a predetermined level, the detector initiates an alarm.

A single wavelength infrared flame detector uses one of several different photocell types to detect the infrared emissions in a single wavelength band that are produced by a flame. These detectors generally include provisions to minimize alarms from commonly occurring infrared sources such as incandescent lighting or sunlight.

An ultraviolet/infrared (UV/IR) flame detector senses ultraviolet radiation with a vacuum photodiode tube and a selected wavelength of infrared radiation with a photocell

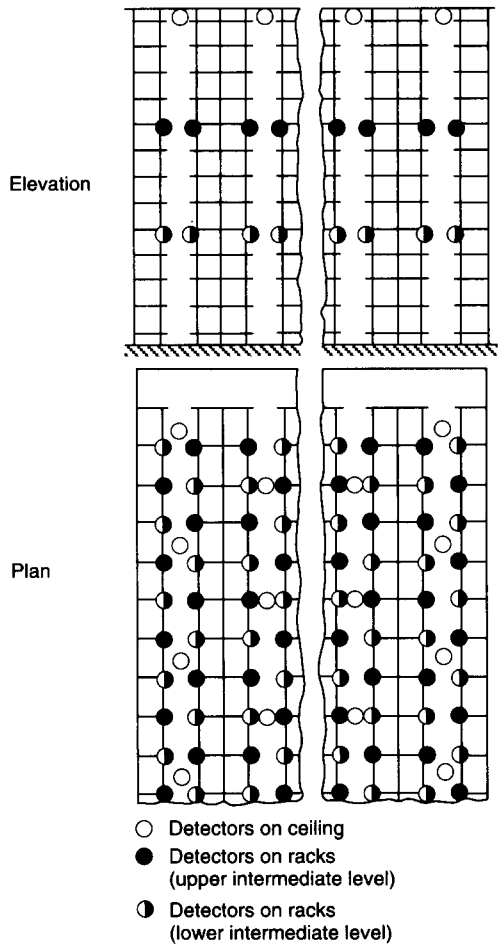


Figure A-5-3.6.5(a) Detector location for solid storage (closed rack) in which transverse and longitudinal flue spaces are irregular or nonexistent, as for slatted or solid shelved storage.

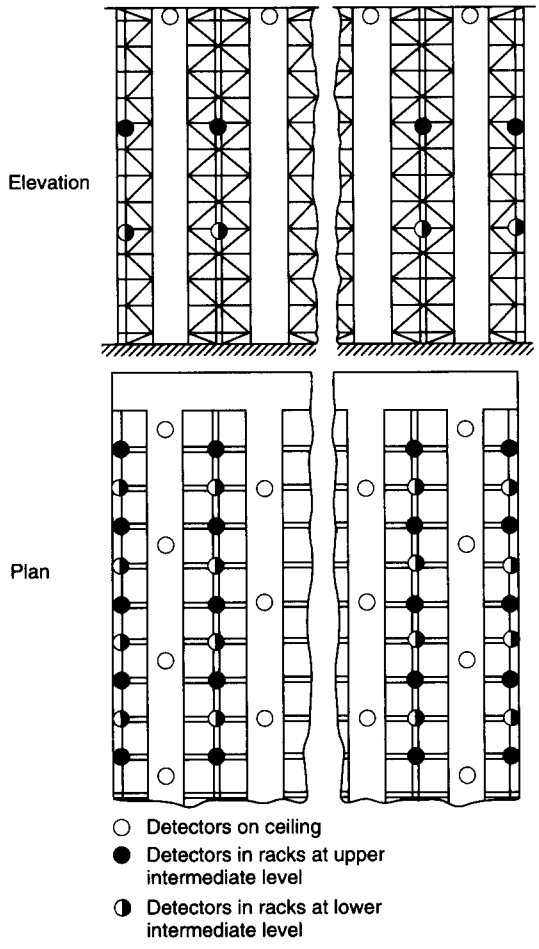


Figure A-5-3.6.5(b) Detector location for palletized storage (open rack) or no shelved storage in which regular transverse and longitudinal flue spaces are maintained.

and uses the combined signal to indicate a fire. These detectors need exposure to both types of radiation before an alarm signal can be initiated.

A multiple wavelength infrared (IR/IR) flame detector senses radiation at two or more narrow bands of wavelengths in the infrared spectrum. These detectors electronically compare the emissions between the band and initiate a signal where the relationship between the two bands indicates a fire.

(b) **Spark/Ember Detectors.** A spark/ember-sensing detector usually uses a solid state photodiode or phototransistor to sense the radiant energy emitted by embers, typically between 0.5 microns and 2.0 microns in normally dark environments. These detectors can be made extremely sensitive (microwatts), and their response times can be made very short (microseconds).

A-5-4.2.1 The radiant energy from a flame or spark/ember is comprised of emissions in various bands of the ultraviolet, visible, and infrared portions of the spectrum. The relative quantities of radiation emitted in each part of the spectrum are determined by the fuel chemistry, the temperature, and the rate of combustion. The detector should be matched to the characteristics of the fire.

Almost all materials that participate in flaming combustion emit ultraviolet radiation to some degree during flaming combustion, whereas only carbon-containing fuels emit significant radiation at the 4.35 micron (carbon dioxide) band used by many detector types to detect a flame. (*See Figure A-5-4.2.1.*)

The radiant energy emitted from an ember is determined primarily by the fuel temperature (Planck's Law Emissions) and the emissivity of the fuel. Radiant energy from an ember is primarily infrared and, to a lesser degree, visible in wavelength. In general, embers do not emit ultraviolet energy in significant quantities (0.1 percent of total emissions) until the ember achieves temperatures of 2000°K (1727°C or 3240°F). In most cases, the emissions are included in the band of 0.8 microns to 2.0 microns, corresponding to temperatures of approximately 750°F to 1830°F (398°C to 1000°C).

Most radiant energy detectors have some form of qualification circuitry within them that uses time to help distinguish between spurious, transient signals and legitimate fire alarms. These circuits become very important where the anticipated fire scenario and the ability of the detector to

respond to that anticipated fire are considered. For example, a detector that utilizes an integration circuit or a timing circuit to respond to the flickering light from a fire might not respond well to a deflagration resulting from the ignition of accumulated combustible vapors and gases, or where the fire is a spark that is traveling up to 328 ft/sec (100 m/sec) past the detector. Under these circumstances, a detector that has a high speed response capability is most appropriate. On the other hand, in applications where the development of the fire is slower, a detector that utilizes time for the confirmation of repetitive signals is appropriate. Consequently, the fire growth rate should be considered in selecting the detector. The detector performance should be selected to respond to the anticipated fire.

The radiant emissions are not the only criteria to be considered. The medium between the anticipated fire and the detector is also very important. Different wavelengths of radiant energy are absorbed with varying degrees of efficiency by materials that are suspended in the air or that accumulate on the optical surfaces of the detector. Generally, aerosols and surface deposits reduce the sensitivity of the detector. The detection technology utilized should take into account those normally occurring aerosols and surface deposits to minimize the reduction of system response between maintenance intervals. It should be noted that the smoke evolved from the combustion of middle and heavy fraction petroleum distillates is highly absorptive in the ultraviolet end of the spectrum. Where using this type of detection, the system should be designed to minimize the effect of smoke interference on the response of the detection system.

The environment and ambient conditions anticipated in the area to be protected impact the choice of detector. All detectors have limitations on the range of ambient temperatures over which they will respond, consistent with their tested or approved sensitivities. The designer should make certain that the detector is compatible with the range of ambient temperatures anticipated in the area in which it is installed. In addition, rain, snow, and ice attenuate both ultraviolet and infrared radiation to varying degrees. Where anticipated, provisions should be made to protect the detector from accumulations of these materials on its optical surfaces.

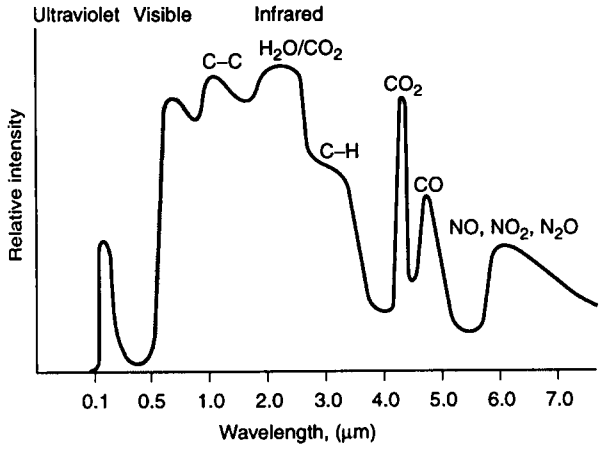


Figure A-5-4.2.1 Spectrum of a "typical" flame (free-burning gasoline).

A-5-4.3.1.1 All optical detectors respond according to the following theoretical equation:

$$S = \frac{kpe^{\zeta}d}{d^2}$$

where:

k = proportionality constant for the detector
p = radiant power emitted by the fire
e = Naperian logarithm base (2.7183)
ζ = extinction coefficient of air
d = distance between the fire and the detector
S = radiant power reaching the detector.

The sensitivity (S) typically is measured in nanowatts. This equation yields a family of curves similar to the one shown in Figure A-5-4.3.1.1.

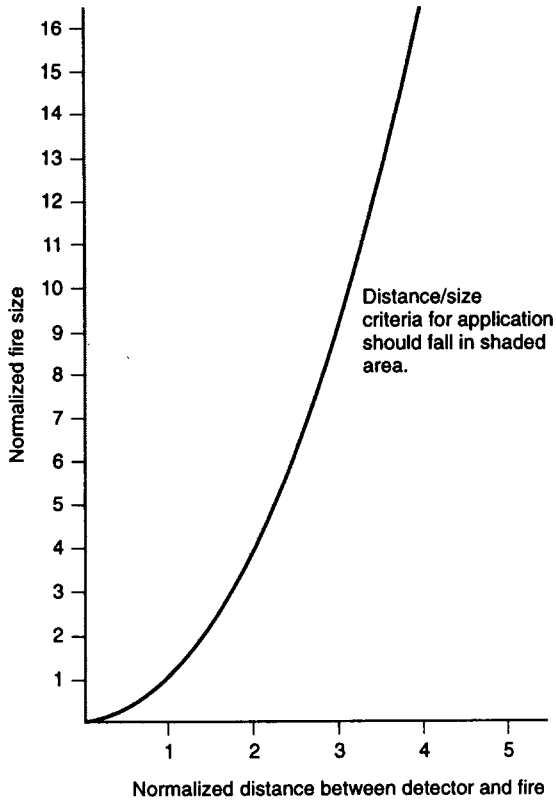


Figure A-5-4.3.1.1 Generalized fire size vs. distance.

The curve defines the maximum distance at which the detector consistently detects a fire of defined size and fuel. Detectors should be employed only in the shaded area beneath the curve.

Under the best of conditions, with no atmospheric absorption, the radiant power reaching the detector is reduced by a factor of 4 if the distance between the detector and the fire is doubled. For the consumption of the atmospheric extinction, the exponential term Zeta (ζ) is added to the equation. Zeta is a measure of the clarity of the air at the wavelength under consideration. Zeta is affected by humidity, dust, and any other contaminants in the air that are absorbent at the wavelength in question. Zeta generally has values between – 0.001 and – 0.1 for normal ambient air.

A-5-4.3.2.1 Flame Detector Applications and Stability.

(a) The types of application for which flame detectors are suitable are:

1. High-ceiling, open-spaced buildings such as warehouses and aircraft hangers.
2. Outdoor or semioutdoor areas where winds or draughts can prevent smoke from reaching a heat or smoke detector.
3. Areas where rapidly developing flaming fires can occur, such as aircraft hangers, petrochemical production, storage and transfer areas, natural gas installations, paint shops, or solvent areas.
4. Areas needing high fire risk machinery or installations, often coupled with an automatic gas extinguishing system.
5. Environments that are unsuitable for other types of detectors.

(b) Some extraneous sources of radiant emissions that have been identified as interfering with the stability of flame detectors include:

1. Sunlight
2. Lightning
3. X-rays
4. Gamma rays
5. Cosmic rays
6. Ultraviolet radiation from arc welding
7. Electromagnetic interference (EMI, RFI)
8. Hot objects
9. Artificial lighting.

A-5-4.3.2.3 The greater the angular displacement of the fire from the optical axis of the detector, the larger the fire must become before it is detected. This phenomenon establishes the field of view of the detector. Figure A-5-4.3.2.3 shows an example of the effective sensitivity versus angular displacement of a flame detector.

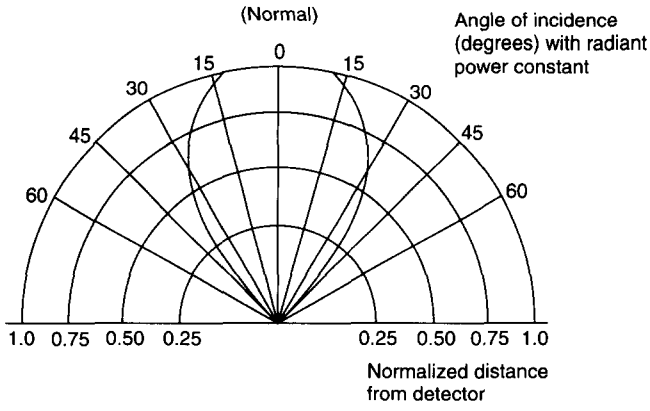


Figure A-5-4.3.2.3 Normalized sensitivity vs. angular displacement.

A-5-4.3.2.4 Virtually all radiant energy-sensing detectors exhibit some kind of fuel specificity. Where burned at uniform rates [J/sec (W)], different fuels emit different levels of radiant power in the ultraviolet, visible, and infrared portions of the spectrum. Under free-burn conditions, a fire of given surface area but of different fuels burns at different rates [J/sec (W)] and emits varying levels of radiation in each of the major portions of the spectrum. Most radiant energy detectors designed to detect flame are qualified based upon a defined fire under specific conditions. Where employing these detectors for fuels other than the defined fire, the designer should make certain that the appropriate adjustments to the maximum distance between the detector and the fire are made consistent with the fuel specificity of the detector.

A-5-4.3.2.6 The means by which this requirement has been satisfied include:

(a) Lens clarity monitoring and cleaning where a contaminated lens signal is rendered.

(b) Lens air purge.

The need to clean detector windows can be reduced by the provision of air purge devices. These devices are not foolproof, however, and are not a replacement for regular inspection and testing. Radiant energy-sensing detectors should not be placed in protective housings (e.g., behind glass) to keep them clean, unless such housings are listed for the purpose. Some optical materials are absorptive at the wavelengths used by the detector.

A-5-4.3.3.1 Spark/ember detectors are installed primarily to detect sparks and embers that could, if allowed to continue to burn, precipitate a much larger fire or explosion. Spark/ember detectors are typically mounted on some form of duct or conveyor, monitoring the fuel as it passes by. Usually, it is necessary to enclose the portion of the conveyor where the detectors are located, as these devices generally require a dark environment. Extraneous sources of radiant emissions that have been identified as interfering with the stability of spark/ember detectors include:

(a) Ambient light.

(b) Electromagnetic interference (EMI, RFI).

(c) Electrostatic discharge in the fuel stream.

A-5-4.3.3.2 There is a minimum ignition power (watts) for all combustible dusts. Where the spark or ember is incapable of delivering that quantity of power to the adjacent combustible material (dust), an expanding dust fire cannot occur. The minimum ignition power is determined by the fuel chemistry, fuel particle size, fuel concentration in air, and ambient conditions such as temperature and humidity.

A-5-4.3.3.5 The greater the angular displacement of the fire from the optical axis of the detector, the larger the fire must become before it is detected. This phenomenon establishes the field of view of the detector. Figure A-5-4.3.2.3 shows an example of the effective sensitivity versus angular displacement of a flame detector.

A-5-4.3.3.6 The means by which this requirement has been satisfied include:

(a) Lens clarity monitoring and cleaning where a contaminated lens signal is rendered.

(b) Lens air purge.

A-5-6.2 The waterflow device should be field adjusted so that an alarm is initiated in no more than 90 seconds after a sustained flow of at least 10 gpm (40 L/min).

Features that should be investigated to minimize alarm response time include elimination of trapped air in the sprinkler system piping, use of an excess pressure pump, use of pressure drop alarm-initiating devices, or a combination thereof.

Care should be used where choosing waterflow alarm-initiating devices for hydraulically calculated looped systems and those systems using small orifice sprinklers. Such systems might incorporate a single point flow of significantly less than 10 gpm (40 L/min). In such cases, additional waterflow alarm-initiating devices or the use of pressure drop-type waterflow alarm-initiating devices might be necessary.

Care should be used where choosing waterflow alarm-initiating devices for sprinkler systems utilizing on-off sprinklers to ensure that an alarm is initiated in the event of a waterflow condition. On-off sprinklers open at a predetermined temperature and close when the temperature reaches a predetermined lower temperature. With certain types of fires, waterflow might occur in a series of short bursts of 10 seconds' to 30 seconds' duration each. An alarm-initiating device with retard might not detect waterflow under these conditions. An excess pressure system or a system that operates on pressure drop should be considered to facilitate waterflow detection on sprinkler systems utilizing on-off sprinklers.

Excess pressure systems can be used with or without alarm valves. The following is a description of one type of excess pressure system with an alarm valve.

An excess pressure system with an alarm valve consists of an excess pressure pump with pressure switches to control the operation of the pump. The inlet of the pump is connected to the supply side of the alarm valve, and the outlet is connected to the sprinkler system. The pump control pressure switch is of the differential type, maintaining the sprinkler system pressure above the main pressure by a constant amount. Another switch monitors low sprinkler system pressure to initiate a supervisory signal in the event of a failure of the pump or other malfunction. An additional pressure switch can be used to stop pump operation in the event of a deficiency in water supply. Another pressure switch is connected to the alarm outlet of the alarm valve to initiate a waterflow alarm signal when waterflow exists. This type of system also inherently prevents false alarms due to water surges. The sprinkler retard chamber should be eliminated to enhance the detection capability of the system for short duration flows.

A-5-7 Appropriate means can include:

(a) Foam systems (flow of water).
(b) Pump activation.
(c) Differential pressure detectors.
(d) Halon (pressure detector).
(e) Carbon dioxide (pressure detector).

In any case, an alarm that activates the fire extinguishing system(s) or suppression system(s) may be permitted to be initiated from the detection system.

A-5-8.1.3 Coded Signal Designations. The following recommended coded signal designations for buildings having four floors and multiple basements are provided in Table A-5-8.1.3:

Table A-5-8.1.3 Recommended Coded Signal Designations

Location	Coded Signal
4th floor	2-4
3rd floor	2-3
2nd floor	2-2
1st floor	2-1
Basement	3-1
Subbasement	3-2

A-5-8.2.9 The current supply for location-designating lights at street boxes should be secured at lamp locations from the local electric utility company.

Alternating current power may be permitted to be superimposed on metallic fire alarm circuits for supplying designating lamps, or for control or actuation of equipment devices for fire alarm or other emergency signals, provided:

(a) Voltage between any wire and ground or between one wire and any other wire of the system does not exceed 150 volts, and the total resultant current in any line circuit does not exceed 1/4 ampere.

(b) Components such as coupling capacitors, transformers, chokes, or coils are rated for 600-volt working voltage and have a breakdown voltage of at least twice the working voltage plus 1000 volts.

(c) There is no interference with fire alarm service under any conditions.

A-5-8.2.12.3 The following is an excerpt from the FCC Rules and Regulations, Vol. V, Part 90, March 1979:

"Except for test purposes, each transmission must be limited to a maximum of 2 seconds and may be automatically repeated not more than two times at spaced intervals within the following 30 seconds; thereafter, the authorized cycle may not be reactivated for 1 minute."

A-5-10 See NFPA *101®, Life Safety Code®*, for definition of smoke compartment; NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*, for definition of duct systems; and NFPA 92A, *Recommended Practice for Smoke-Control Systems*, for definition of smoke zone.

A-5-10.1 Smoke detectors located in the open area(s) should be used rather than duct-type detectors because of the dilution effect in air ducts. Active smoke management systems installed in accordance with NFPA 92A, *Recommended Practice for Smoke-Control Systems*, or NFPA 92B, *Guide for Smoke Management Systems in Malls, Atria, and Large Areas*, should be controlled by total coverage open area detection.

A-5-10.2 Dilution of smoke-laden air by clean air from other parts of the building or dilution by outside air intakes can allow high densities of smoke in a single room with no appreciable smoke in the air duct at the detector location. Smoke might not be drawn from open areas where air conditioning systems or ventilating systems are shut down.

A-5-10.4 The purposes for which smoke detectors may be permitted to be applied in order to initiate control of smoke spread are:

(a) Prevention of the recirculation of dangerous quantities of smoke within a building.

(b) Selective operation of equipment to exhaust smoke from a building.

(c) Selective operation of equipment to pressurize smoke compartments.

(d) Operation of doors and dampers to close the openings in smoke compartments.

A-5-10.5.2.2 Detectors listed for the air velocity present may be permitted to be installed at the opening where the return air enters the common return air system. The detectors should be installed up to 12 in. (0.3 m) in front of or behind the opening and spaced according to the following opening dimensions [*see Figures A-5-10.5.2.2(a), (b), and (c)*]:

(a) *Width.*

1. Up to 36 in. (914 mm) — One detector centered in opening

2. Up to 72 in. (1829 mm) — Two detectors located at the ¼-points of the opening

3. Over 72 in. (1829 mm) — One additional detector for each full 24 in. (610 mm) of opening.

(b) *Depth.* The number and spacing of the detector(s) in the depth (vertical) of the opening should be the same as those given for the width (horizontal) above.

(c) *Orientation.* Detectors should be oriented in the most favorable position for smoke entry with respect to the direction of airflow. The path of a projected beam-type detector across the return air openings should be considered equivalent in coverage to a row of individual detectors.

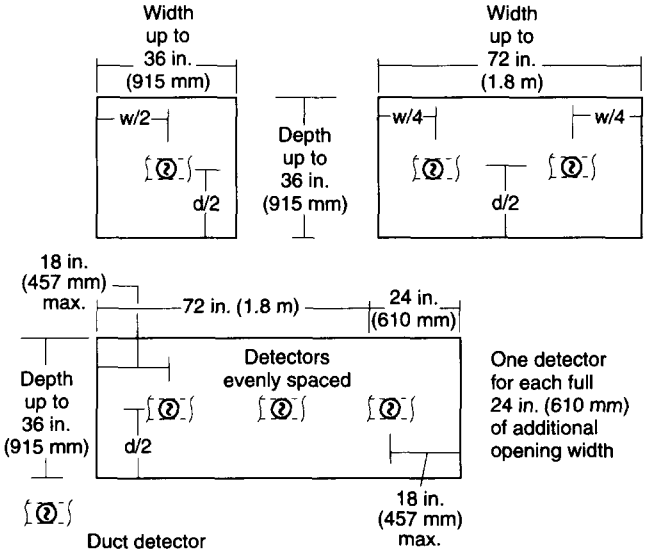


Figure A-5-10.5.2.2(a) Location of a smoke detector(s) in return air systems for selective operation of equipment.

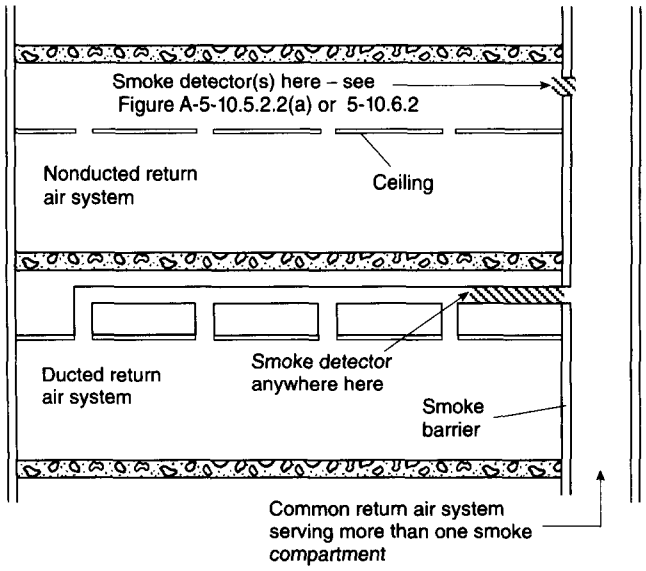


Figure A-5-10.5.2.2(b) Location of a smoke detector(s) in return air systems for selective operation of equipment.

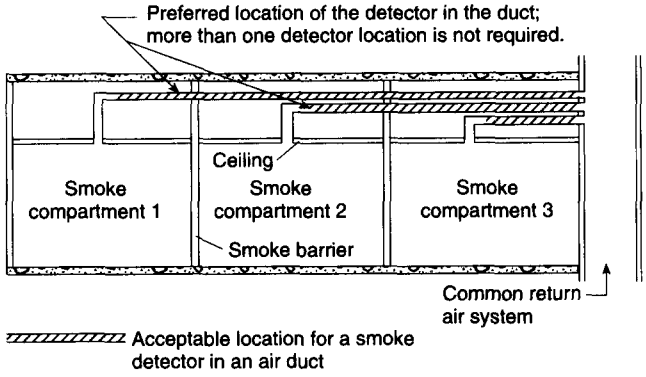


Figure A-5-10.5.2.2(c) Detector location in a duct that passes through smoke compartments not served by the duct.

A-5-10.6.2 Where duct detectors are used to initiate the operation of smoke dampers, they should be located so that the detector is between the last inlet or outlet upstream of the damper and the first inlet or outlet downstream of the damper.

In order to obtain a representative sample, stratification and dead air space should be avoided. Such conditions could be caused by return duct openings, sharp turns, or connections, as well as by long, uninterrupted straight runs. For this reason, duct smoke detectors should be located in the zone between 6 and 10 duct equivalent diameters of straight, uninterrupted run. In return air systems, the requirements of 5-10.5.2.2 take precedence over these considerations. [*See Figures A-5-10.6.2(a), (b), and (c).*]

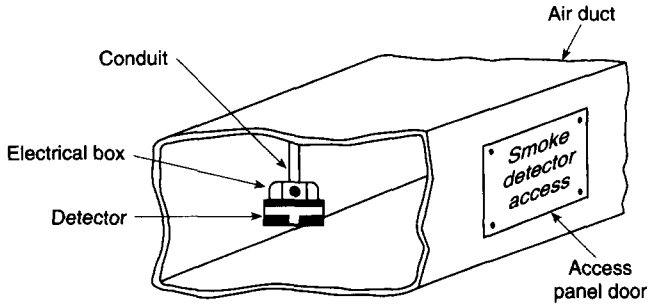


Figure A-5-10.6.2(a) Pendant-mounted air duct installation.

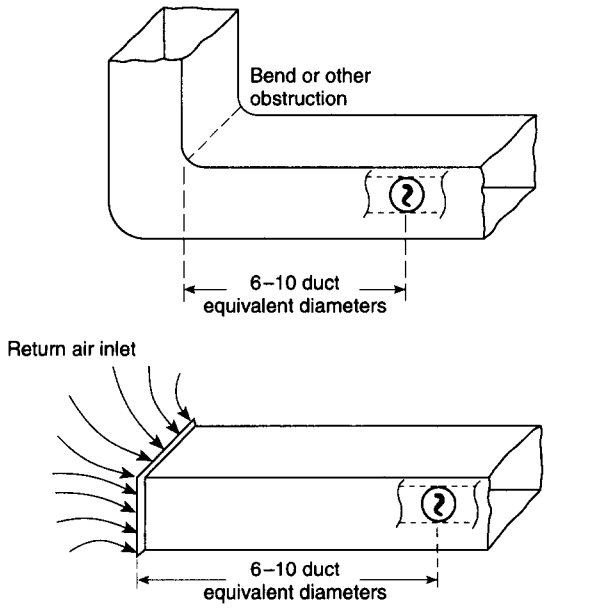


Figure A-5-10.6.2(b) Typical duct detector placement.

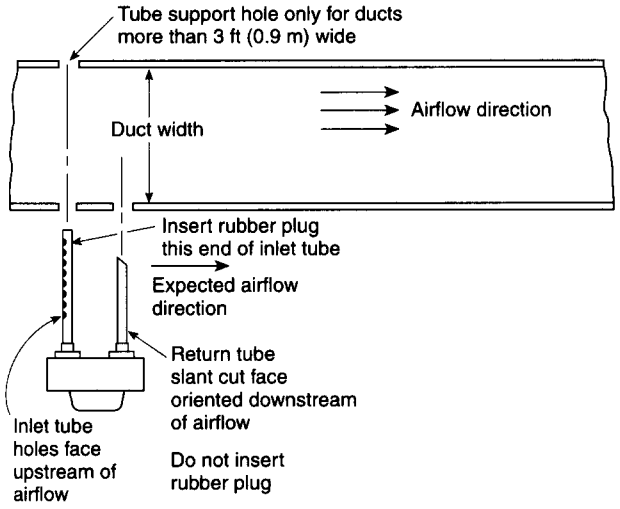


Figure A-5-10.6.2(c) Inlet tube orientation.

A-5-10.7.4.1.2 Where the depth of wall section above the door is 60 in. (1520 mm) or greater, additional detectors might be required as indicated by an engineering evaluation.

A-6-2.3 Use of Guards with Notification Appliances. Situations exist where supplemental enclosures are necessary to protect the physical integrity of a notification appliance. Protective enclosures should not interfere with the performance characteristics of the appliance. Where the enclosure degrades the performance, methods should be detailed in the installation instructions of the enclosure that clearly identify the degradation. For example, where the appliance signal is attenuated, it might be necessary to adjust the appliance spacings or appliance output.

A-6-3.2 The typical average ambient sound level for the occupancies specified in Table A-6-3.2 are intended only for design guidance purposes.

The typical average ambient sound levels specified should not be used in lieu of actual sound level measurements.

Table A-6-3.2 Average Ambient Sound Level According to Location

Locations	Average Ambient Sound Level
Business occupancies	55 dBA
Educational occupancies	45 dBA
Industrial occupancies	80 dBA
Institutional occupancies	50 dBA
Mercantile occupancies	40 dBA
Piers and water-surrounded structures	40 dBA
Places of assembly	55 dBA
Residential occupancies	35 dBA
Storage occupancies	30 dBA
Thoroughfares, high density urban	70 dBA
Thoroughfares, medium density urban	55 dBA
Thoroughfares, rural and suburban	40 dBA
Tower occupancies	35 dBA
Underground structures and windowless buildings	40 dBA
Vehicles and vessels	50 dBA

A-6-3.2.2 The constantly changing nature of pressure waves, which are detected by ear can be measured by electronic sound meters, and the resulting electronic waveforms can be processed and presented in a number of meaningful ways.

Most simple sound level meters quickly average a sound signal and present a root mean square (RMS) level to the meter movement or display. However, this quick average of impressed sound results in fast movements of the meter's output that are best sent when talking into the microphone; the meter quickly rises and falls with speech. However, when surveying the ambient sound levels to establish the increased level at which a notificaton appliance will properly function, the sound source needs to be averaged over a longer period of time. Moderately priced sound level meters have such a function, usually called L_{eq} or "equivalent sound level." For example, an L_{eq} of speech in a quiet room would cause the meter movement to rise gradually to a peak reading and slowly fall well after the speech is over.

L_{eq} readings can be misapplied in situations where the background ambient noises vary greatly during a 24-hour period. L_{eq} measurements should be taken over the period of occupancy.

A-6-4.4.1 Areas large enough to exceed the rectangular dimensions given in Figures A-6-4.4.1(a), (b), and (c) require additional appliances. Often, proper placement of appliances can be facilitated by breaking down the area into multiple squares and dimensions that fit most appropriately [*see Figures A-6-4.4.1(a), (b), (c), and (d)*]. An area 40 ft (12.2 m) wide and 74 ft (22.6 m) long can be covered with two 60-cd appliances. Irregular areas need more careful planning to make certain that at least one 15-cd appliance is installed for each 20-ft × 20-ft (6.09-m × 6.09-m) area.

A-6-4.4.1.1(a) A design that delivers 0.0375 lumens/ft^2 (0.4037 lumens/m^2) effective intensity to all occupied spaces where visible notification is required is considered to meet the minimum light intensity requirements of this paragraph.

A-6-4.4.1.1(c) The field of view is based on the focusing capability of the human eye, specified as 120 degrees in the IES *Handbook*. The apex of this angle is the viewer's eye. In order to ensure compliance with the requirements of 6-4.4.1.1, this angle should be increased to approximately 135 degrees.

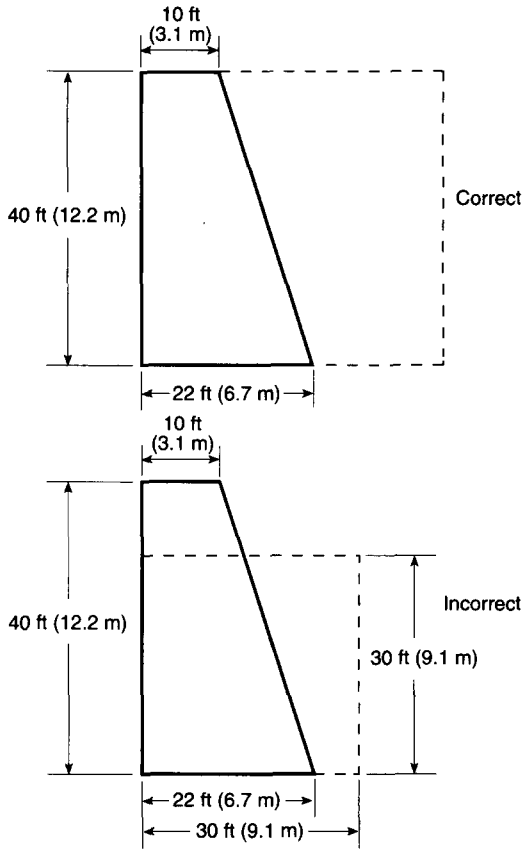
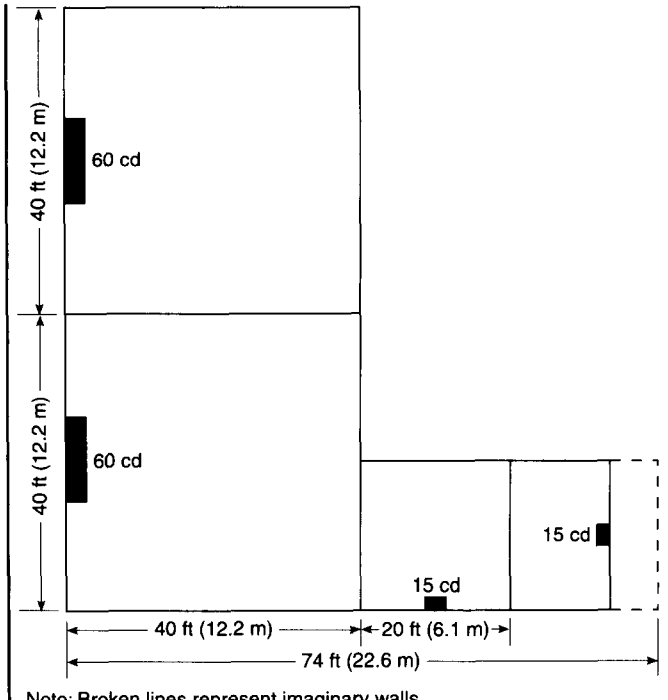


Figure A-6-4.4.1(a) Irregular area spacing.



Note: Broken lines represent imaginary walls.

Figure A-6-4.4.1(b) Spacing of wall-mounted visible appliances in rooms.

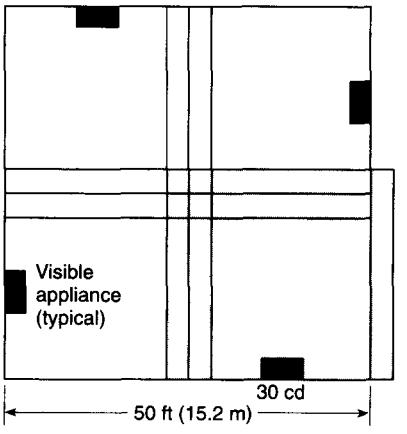


Figure A-6-4.4.1(c) Room spacing allocation — correct.

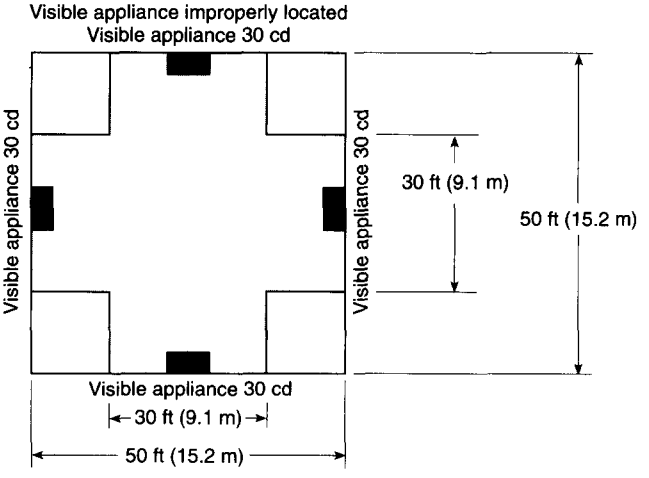


Figure A-6-4.4.1(d) Room spacing allocation — incorrect.

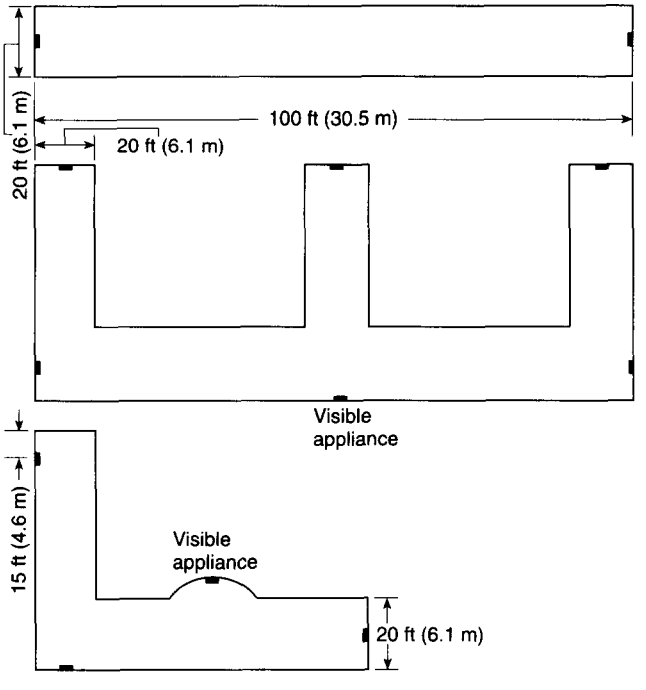


Figure A-6-4.4.2 Corridor and elevator area spacing allocation.

A-6-4.4.3 Effective intensity is the conventional method of equating the brightness of a flashing light to that of a steady-burning light as seen by a human observer. The units of effective intensity are expressed in candelas. For example, a flashing light that has an effective intensity of 15 candelas has the same apparent brightness to an observer as a 15-candela steady-burning light source.

A-6-8 Textual visible appliances are selected and installed to provide temporary text, permanent text, or symbols. Textual visible information should be of a size and visual quality that is easily read and is distinguishable from the distance and lighting conditions anticipated during a fire. Appliances that provide temporary text or symbols should be arranged to display, or should be easily retrievable to display on demand, current alarm information for the entire duration of the alarms.

Paragraph 6-8.1.2 references cathode ray tube (CRT) displays having 250 lines per frame and 250 points per line scan, which reflect the technology of the 1980s. This can be compared to 640 pixels × 480 pixels up to 1280 pixels × 1224 pixels in technologies found in the 1990s. The code requires the screen to refresh at a rate of 30 times per second as compared to 1990s'-style monitors that refresh at 60 to 72 times per second. Ten shades of grey represented the minimum technology of the 1980s. Sixty-four shades of grey are common today. The aspect ratio is the ratio of pixels in the x and y planes. The dot size at the time this code was written was 0.5 mm, as opposed to the current screen technology of 0.28 mm.

A-7-1.3 Advance Notification. Prior to any scheduled inspection or testing, the service company should consult with the building owner or owner's designated representative. Issues of advance notification in certain occupancies, including advance notification time, building posting, systems interruption and restoral, evacuation procedures, accommodation for evacuees, and other related issues, should be agreed upon by all parties prior to any inspection or testing.

A-7-1.6.2 The additional devices to be tested should be a sample representation of the types of devices and locations on the system.

A-7-2.1 Where the authority having jurisdiction strongly suspects significant deterioration or otherwise improper operation by a central station, a surprise inspection to test the operation of the central station should be made, but extreme caution should be exercised. This test is to be conducted without advising the central station, but the public fire service communications center is definitely to be contacted when manual alarms, waterflow alarms, or automatic fire detection systems are tested so that the fire department will not respond. In addition, persons normally receiving calls for supervisory alarms should be notified when items such as gate valves and functions such as pump power are tested. Confirmation of the authenticity of the test procedure should be obtained and should be a matter for resolution between plant management and the central station.

A-7-2.2 Test Methods. The following wiring diagrams [*see Figures A-7-2.2(a) through (oo)*] are representative of typical circuits encountered in the field and are not intended to be all-inclusive.

The noted styles are as indicated in Tables 3-5, 3-6, 3-7.1, and 4-5.3.2.2.2.3.

The noted systems are as indicated in NFPA 170, *Standard for Fire Safety Symbols*.

Since ground-fault detection is not required for all circuits, tests for ground-fault detection should be limited to those circuits equipped with ground-fault detection.

An individual point-identifying (addressable) initiating device operates on a signaling line circuit and not on a Style A, B, C, D, or E (Class B and Class A) initiating device circuit.

All of the following initiating device circuits are illustrative of either alarm or supervisory signaling. Alarm-initiating devices and supervisory initiating devices are not permitted on the same initiating device circuit.

In addition to losing its ability to receive an alarm from an initiating device located beyond an open fault, a Style A (Class B) initiating device circuit also loses its ability to receive an alarm when a single ground fault is present.

Style C and Style E (Class B and Class A) initiating device circuits can discriminate between an alarm condition and a wire-to-wire short. In these circuits, a wire-to-wire short provides a trouble indication. However, a wire-to-wire short prevents alarm operation. Shorting-type initiating devices cannot be used without an additional current or voltage limiting element.

Directly-connected system smoke detectors, commonly referred to as two-wire detectors, should be listed as being electrically and functionally compatible with the control unit and the specific subunit or module to which they are connected. Where the detectors and the units or modules are not compatible, it is possible that, during an alarm condition, the detector's visible indicator will illuminate, but no change of state to the alarm condition will occur at the control unit. Incompatibility can also prevent proper system operation at extremes of operating voltage, temperature, and other environmental conditions.

Where two or more two-wire detectors with integral relays are connected to a single initiating device circuit and their relay contacts are used to control essential building functions (e.g., fan shutdown, elevator recall), it should be clearly noted that the circuit might be capable of supplying only enough energy to support one detector/relay combination in an alarm mode. Where control of more than one building function is required, each detector/relay combination used to control separate functions should be connected to separate initiating device circuits, or they should be connected to an initiating device circuit that provides adequate power to allow all the detectors connected to the circuit to be in the alarm mode simultaneously. During acceptance and reacceptance testing, this feature should always be tested and verified.

A speaker is an alarm indicating appliance, and, where used in the following diagrams, the principle of operation and supervision is the same as for other audible alarm indicating appliances (e.g., bells, horns).

Testing of supervised remote relays is to be conducted in same manner as for indicating appliances.

(a) **Wiring Diagrams.**

NOTE: Where testing circuits, the correct wiring size, insulation type, and conductor fill should be verified in accordance with the requirements of NFPA 70, *National Electrical Code*.

A-7-2.2(a) Diagram of Nonpowered Alarm-Initiating or Supervisory-Initiating Devices (e.g., Manual Station or Valve Supervisory Switch) Connected to Style A, B, or C Initiating Device Circuits. Disconnect conductor at device or control unit, then reconnect. Temporarily connect a ground to either leg of conductors, then remove ground. Both operations should indicate audible and visual trouble

with subsequent restoral at control unit. Conductor-to-conductor short should initiate alarm, Style A and Style B (Class B) indicate trouble Style C (Class B). Style A (Class B) does not initiate alarm while in trouble condition.

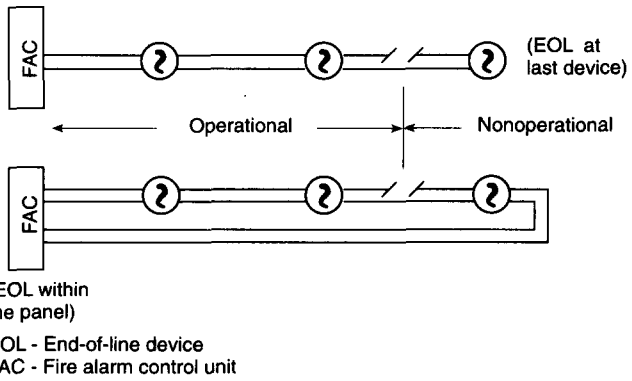


Figure A-7-2.2(a).

A-7-2.2(b) Diagram of Nonpowered Alarm-Initiating or Supervisory-Initiating Devices Connected to Style D or E Initiating Device Circuits. Disconnect a conductor at a device at midpoint in the circuit. Operate a device on either side of the device with the disconnected conductor. Reset control unit and reconnect conductor. Repeat test with a ground applied to either conductor in place of the disconnected conductor. Both operations should indicate audible and visual trouble, then alarm or supervisory indication with subsequent restoral.

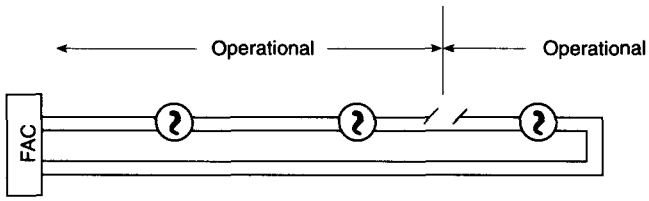


Figure A-7-2.2(b).

A-7-2.2(c) Diagram of Circuit-Powered (Two-Wire) Smoke Detectors for Style A, B, or C Initiating Device Circuits. Remove smoke detector where installed with plug-in base or disconnect conductor beyond first device from control unit. Activate smoke detector per manufacturer's recommendations between control unit and circuit break. Restore detector or circuit, or both. Control unit should indicate trouble where fault occurs and alarm where detectors are activated between the break and the control unit.

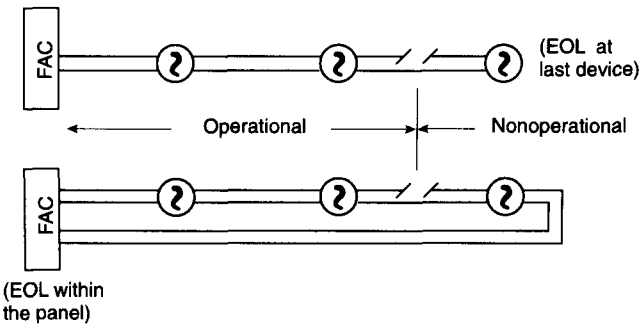


Figure A-7-2.2(c).

A-7-2.2(d) Diagram of Circuit-Powered (Two-Wire) Smoke Detectors for Style D or E Initiating Device Circuits. Disconnect conductor at a smoke detector or remove where installed with a plug-in base at midpoint in the circuit. Operate a device on either side of the device with the fault. Reset control unit and reconnect conductor or detector. Repeat test with a ground applied to either conductor in place of the disconnected conductor or removed device. Both operations should indicate audible and visual trouble, then alarm indication with subsequent restoral.

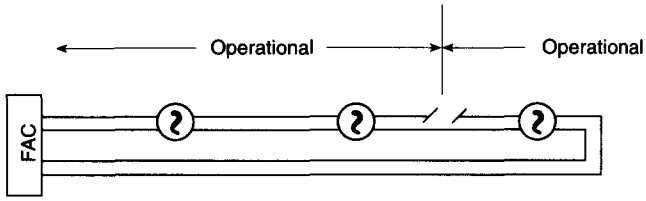


Figure A-7-2.2(d).

A-7-2.2(e) Diagram of Combination Alarm-Initiating Device and Indicating Appliance Circuits. Disconnect a conductor either at indicating or initiating device. Activate initiating device between the fault and the control unit. Activate additional smoke detectors between the device first activated and the control unit. Restore circuit, initiating devices, and control unit. Confirm that all indicating appliances on the circuit operate from the control unit up to the fault and that all smoke detectors tested and their associated ancillary functions, if any, operate.

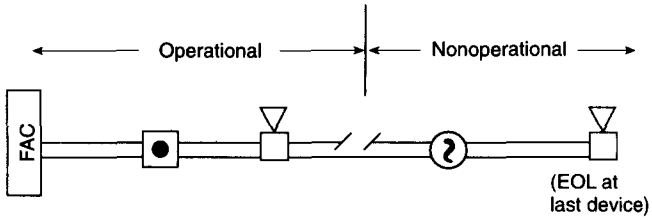


Figure A-7-2.2(e).

A-7-2.2(f) Diagram of Combination Alarm-Initiating Device and Indicating Appliance Circuits Arranged for Operation with a Single Open or Ground Fault. Testing of the circuit is similar to that described above. Confirm all indicating appliances operate on either side of fault.

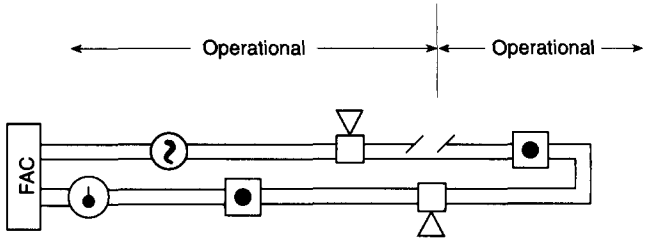


Figure A-7-2.2(f).

A-7-2.2(g) Diagram of Style A, B, or C Circuits with Four-Wire Smoke Detectors and an End-of-Line Power Supervision Relay. Testing of the circuit is similar to that described in A-7-2.2(c) and A-7-2.2(d). Disconnect a leg of the power supply circuit beyond the first device on the circuit. Activate initiating device between the fault and the control unit. Restore circuits, initiating devices, and control unit. Audible and visual trouble should indicate at the control unit where either the initiating or power circuit is faulted. All initiating devices between the circuit fault and the control unit should activate. In addition, removal of a smoke detector from a plug-in-type base can also break the power supply circuit. Where circuits contain various powered and nonpowered devices on the same initiating circuit, verify that the nonpowered devices beyond the power circuit fault can still initiate an alarm. A return loop should bebrought back to the last powered device and the power supervisory relay to incorporate into the end-of-line device.

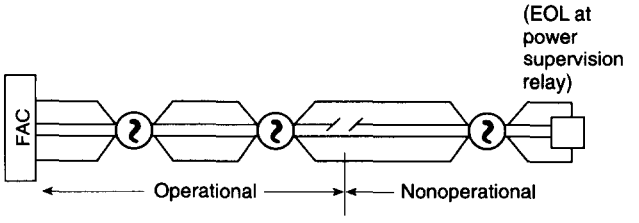


Figure A-7-2.2(g).

A-7-2.2(h) Diagram of Style A, B, or C Initiating Device Circuits with Four-Wire Smoke Detectors that Include Integral Individual Supervision Relays. Testing of the circuit is similar to that described in A-7-2.2(c) with the addition of a power circuit.

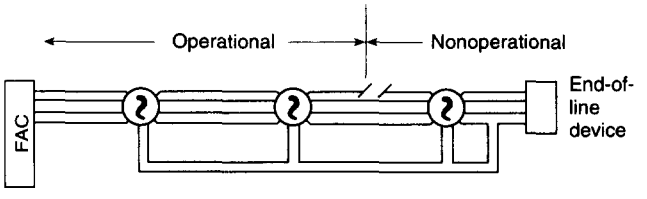


Figure A-7-2.2(h).

A-7-2.2(i) Diagram of Alarm Indicating Appliances Connected to Styles W and Y (Two-Wire) Circuits. Testing of the indicating appliances connected to Style W and Style Y (Class B) is similar to that described in A-7-2.2(c).

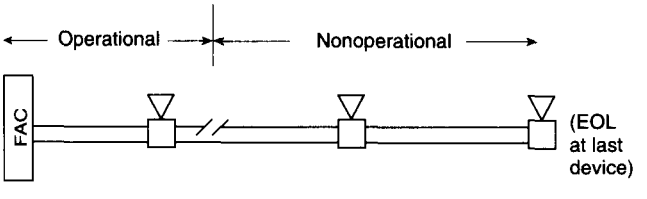


Figure A-7-2.2(i).

A-7-2.2(j) Diagram of Alarm Indicating Appliances Connected to Styles X and Z (Four-Wire) Circuits. Testing of the indicating appliances connected to Style X and Style Z (Class B and Class A) is similar to that described in A-7-2.2(d).

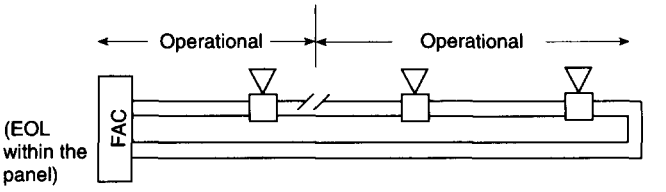


Figure A-7-2.2(j).

A-7-2.2(k) Diagram of System with a Supervised Audible Indicating Appliance Circuit and an Unsupervised Visible Indicating Appliance Circuit. Testing of the indicating appliances connected to Style X and Style Z (Class B and Class A) is similar to that described in A-7-2.2(d).

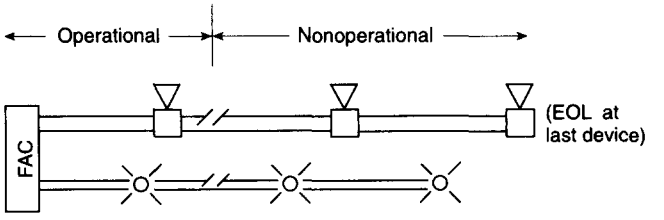


Figure A-7-2.2(k).

A-7-2.2(l) Diagram of System with Supervised Audible and Visible Indicating Appliance Circuits. Testing of the indicating appliances connected to Style X and Style Z (Class B and Class A) is similar to that described in A-7-2.2(d).

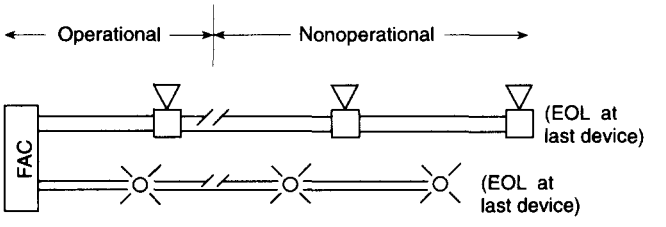


Figure A-7-2.2(l).

A-7-2.2(m) Diagram of Series Indicating Appliance Circuit, which No Longer Meets the Requirements of NFPA 72. An open fault in the circuit wiring should cause a trouble condition.

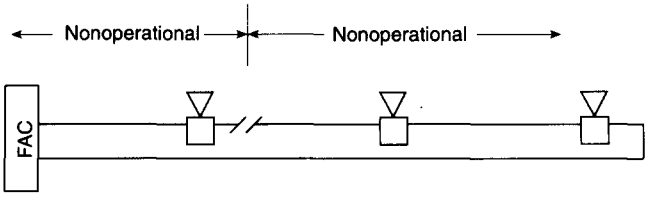


Figure A-7-2.2(m).

A-7-2.2(n) Diagram of a Supervised Series Supervisory-Initiating Circuit with Sprinkler Supervisory Valve Switches Connected, which No Longer Meets the Requirements of NFPA 72. An open fault in the circuit wiring of operation of the valve switch (or any supervisory signal device) should cause a trouble condition.

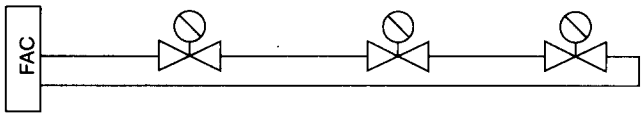


Figure A-7-2.2(n).

A-7-2.2(o) Diagram of Initiating Device Circuit with Parallel Waterflow Alarm Switches and a Series Supervisory Valve Switch, which No Longer Meets the Requirements of NFPA 72. An open fault in the circuit wiring or operation of the valve switch should cause a trouble signal.

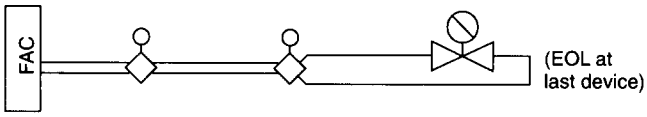


Figure A-7-2.2(o).

A-7-2.2(p) Diagram of a System Connected to a Municipal Fire Alarm Master Box Circuit. Disconnect a leg of municipal circuit at master box. Verify alarm sent to public communications center. Disconnect leg of auxiliary circuit. Verify trouble condition on control unit. Restore circuits. Activate control unit and send alarm signal to communications center. Verify control unit in trouble condition until master box reset.

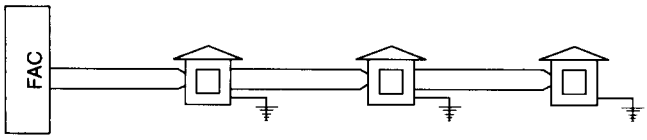


Figure A-7-2.2(p).

A-7-2.2(q) Diagram of an Auxiliary Circuit Connected to a Municipal Fire Alarm Master Box. For operation with a master box, an open or ground fault (where ground detection is provided) on the circuit should result in a trouble condition at the control unit. A trouble signal at the control unit should persist until the master box is reset. For operation with a shunt trip master box, an open fault in the auxiliary circuit should cause an alarm on the municipal system.

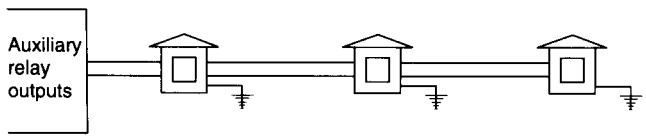


Figure A-7-2.2(q).

(b) **Circuit Styles.**

NOTE: Some testing laboratories and authorities having jurisdiction permit systems to be classified as a Style 7 (Class A) by the application of two circuits of the same style operating in parallel. An example of this is to take two series circuits, either Style 0.5 or Style 1.0 (Class B), and operate them in parallel. The logic is that if a condition occurs on one of the circuits, the other parallel circuit remains operative.

In order to understand the principles of the circuit, alarm receipt capability should be performed on a single circuit, and the style type, based on the performance, should be indicated on the record of completion.

Style 0.5. This signaling circuit operates as a series circuit in performance. This is identical to the historical series audible signaling circuits. Any type of break or ground in one of the conductors, or the internal of the multiple interface device, and the total circuit is rendered inoperative.

To test and verify this type of circuit, either a conductor should be lifted or an earth ground should be placed on a conductor or a terminal point where the signaling circuit attaches to the multiplex interface device.

A-7-2.2(r) Style 0.5(a) (Class B) Series. Style 0.5(a) functions so that, when a box is operated, the supervisory contacts open, making the succeeding devices nonoperative while the operating box sends a coded signal. Any alarms occurring in any successive devices will not be received at the receiving station during this period.

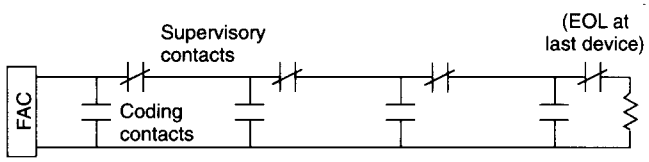


Figure A-7-2.2(r).

A-7-2.2(s) Style 0.5(b) (Class B) Shunt. The contact closes when the device is operated and remains closed to shunt out the remainder of the system until the code is complete.

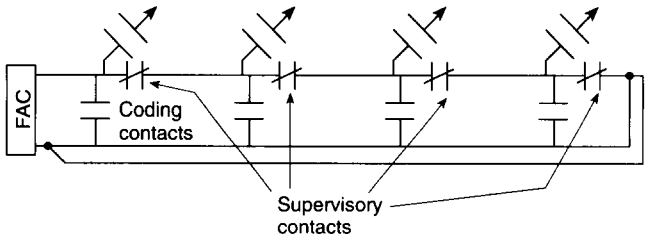


Figure A-7-2.2(s).

A-7-2.2(t) Style 0.5(c) (Class B) Positive Supervised Successive. An open or ground fault on the circuit should cause a trouble condition at the control unit.

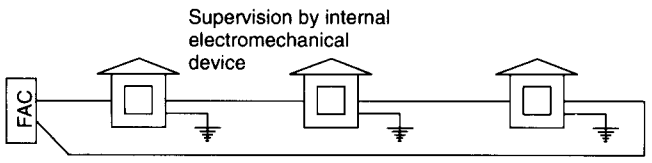


Figure A-7-2.2(t).

A-7-2.2(u) Style 1.0 (Class B). This is a series circuit identical to diagram for Style 0.5, except that the fire alarm system hardware has enhanced performance. A single earth ground can be placed on a conductor or multiplex interface device, and the circuit and hardware still have alarm operability.

If a conductor break or an internal fault occurs in the pathway of the circuit conductors, the entire circuit becomes inoperative.

To verify alarm receipt capability and the resulting trouble signal, place an earth ground on one of the conductors or at the point where the signaling circuit attaches to the multiplex interface device. One of the transmitters or an initiating devices should then be placed into alarm.

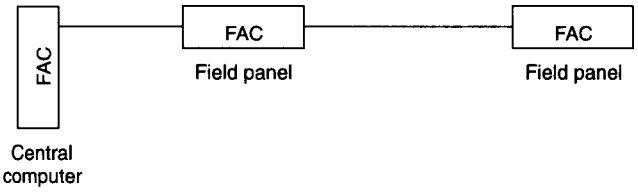


Figure A-7-2.2(u).

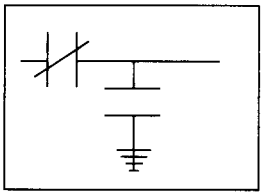


Figure A-7-2.2(v) Typical transmitter layout.

A-7-2.2(w) Typical McCulloh Loop. This is the central station McCulloh redundant-type circuit and has alarm receipt capability on either side of a single break.

(a) To test, lift one of the conductors and operate a transmitter or initiating device on each side of the break. This activity should be repeated for each conductor.

(b) Place an earth ground on a conductor and operate a single transmitter or initiating device to verify alarm receipt capability and trouble condition for each conductor.

(c) Repeat the instructions of (a) and (b) at the same time and verify alarm receipt capability, and verify that a trouble condition results.

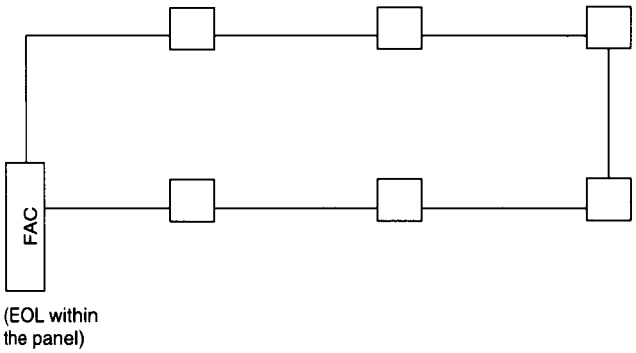


Figure A-7-2.2(w).

A-7-2.2(x) Style 3.0 (Class B). This is a parallel circuit whose multiplex interface devices transmit signal and operating power over the same conductors. The multiplex interface devices might be operable up to the point of a single break. Verify by lifting a conductor and causing an alarm condition on one of the units between the central alarm unit and the break. Either lift a conductor to verify the trouble condition or place an earth ground on the conductors. Test for all the valuations shown on the signaling table.

On ground-fault testing, verify alarm receipt capability by actuating a multiplex interface initiating device or a transmitter.

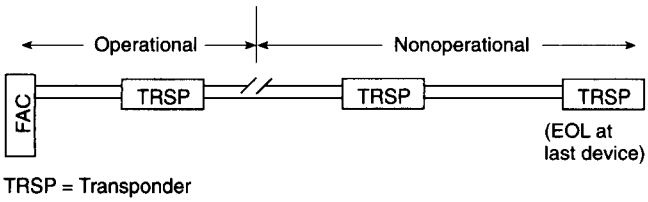


Figure A-7-2.2(x).

A-7-2.2(y) Style 3.5 (Class B). Repeat the instructions for Style 3.0 (Class B) and verify the trouble conditions by either lifting a conductor or placing a ground on the conductor.

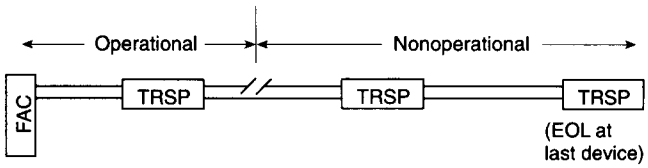


Figure A-7-2.2(y).

A-7-2.2(z) Style 4.0 (Class B). Repeat the instructions for Style 3.0 (Class B) and include a loss of carrier where the signal is being used.

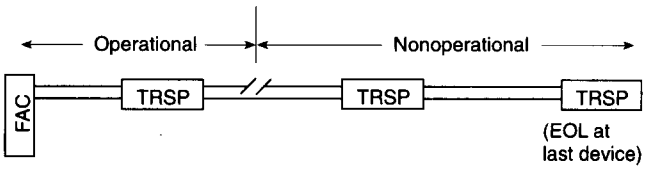


Figure A-7-2.2(z).

A-7-2.2(aa) Style 4.5 (Class B). Repeat the instructions for Style 3.5 (Class B). Verify alarm receipt capability while lifting a conductor by actuating a multiple interface device or transmitter on each side of the break.

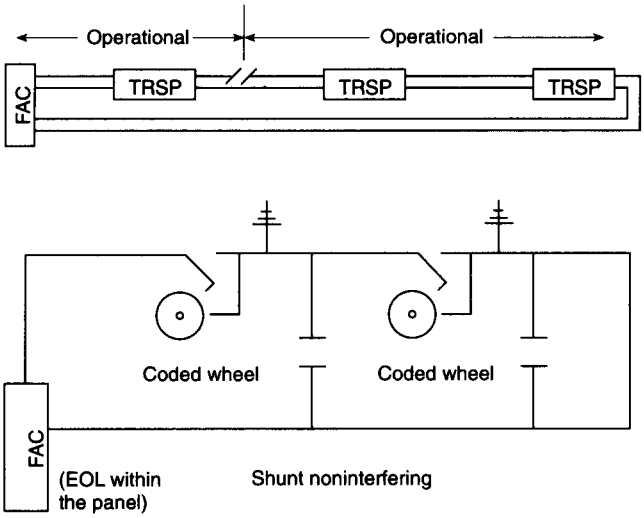


Figure A-7-2.2(aa).

A-7-2.2(bb) Style 5.0 (Class A). Verify the alarm receipt capability and trouble annunciation by lifting a conductor and actuating a multiplex interfacing device or a transmitter on each side of the break. For the earth ground verification, place an earth ground and certify alarm receipt capability and trouble annunciation by actuating a single multiplex interfacing device or a transmitter.

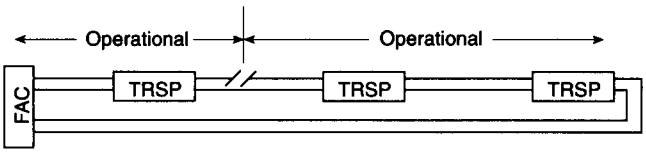


Figure A-7-2.2(bb).

A-7-2.2(cc) Style 6.0 (Class A). Repeat the instructions for Style 2.0 [(Class A (a) through (c)]. Verify the remaining steps for trouble annunciation for the various combinations.

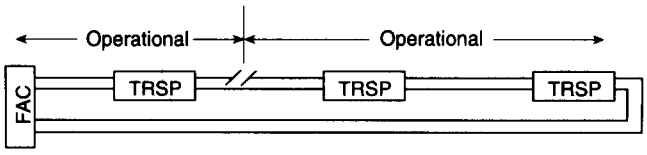


Figure A-7-2.2(cc).

A-7-2.2(dd) Style 6.0 (with Circuit Isolators) (Class A). For the portions of the circuits electrically located between the monitoring points of circuit isolators, follow the instructions for a Style 7.0 (Class A) circuit. It should be clearly noted that the alarm receipt capability for remaining portions of the circuit protection isolators is not the capability of the circuit, but is permitted with enhanced system capabilities.

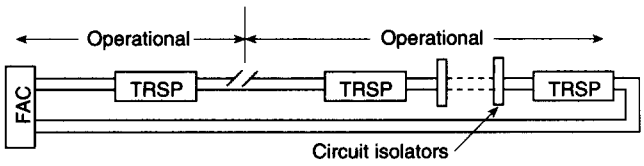


Figure A-7-2.2(dd).

A-7-2.2(ee) Style 7.0 (Class A). Repeat the instructions for testing of Style 6.0 (Class A) for alarm receipt capability and trouble annunciation.

NOTE 1: A portion of the circuit between the alarm processor or central supervising station and the first circuit isolator does not have alarm receipt capability in the presence of a wire-to-wire short. The same is true for the portion of the circuit from the last isolator to the alarm processor or the central supervising station.

NOTE 2: Some manufacturers of this type of equipment have isolators as part of the base assembly. Therefore, in the field, this component might not be readily observable without the assistance of the manufacturer's representative.

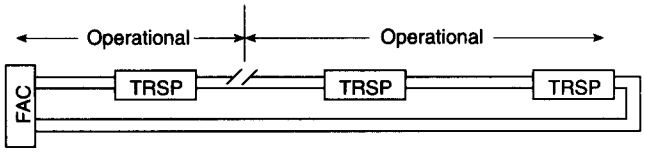


Figure A-7-2.2(ee).

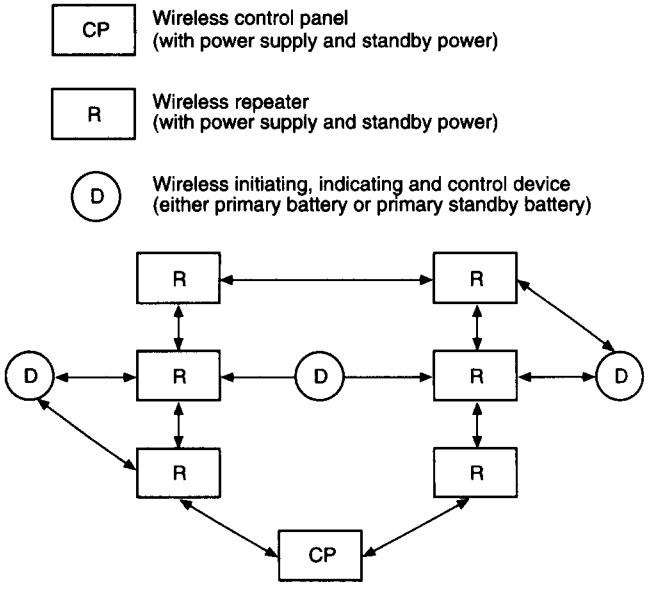
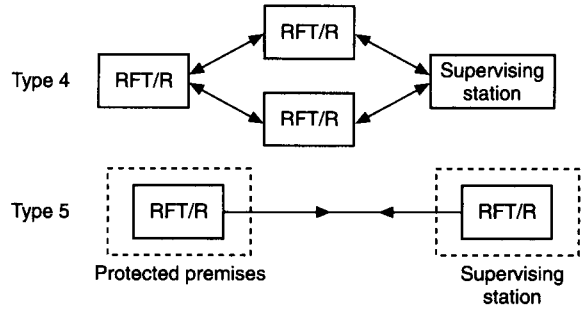
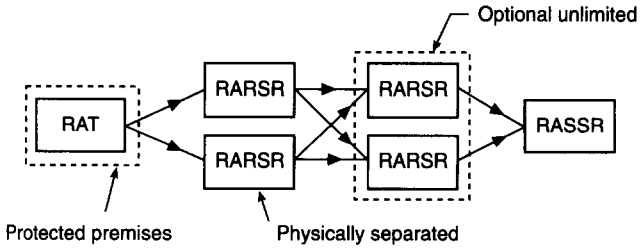


Figure A-7-2.2(ff) Low power radio (wireless) fire alarm system.



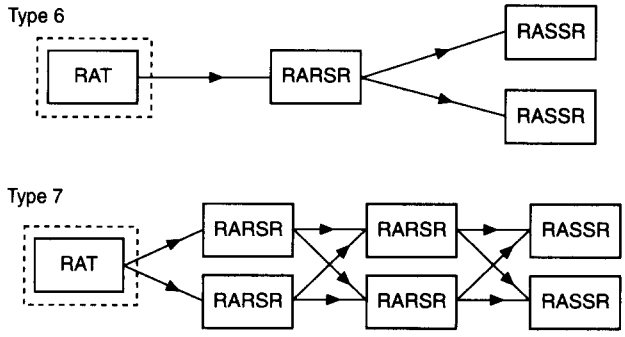
RFT/R = Radio frequency transmitter/receiver

Figure A-7-2.2(gg) Two-way RF multiplex systems.



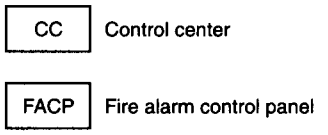
RAT = Radio alarm transmitter
RARSR = Radio alarm repeater station receiver
RASSR = Radio alarm supervising station receiver

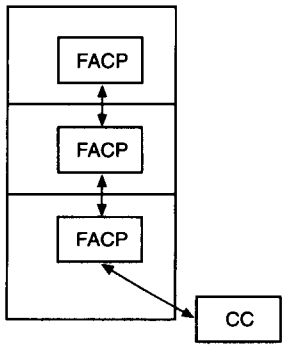
Figure A-7-2.2(hh) One-way radio alarm system.



RAT = Radio alarm transmitter
RARSR = Radio alarm repeater station receiver
RASSR = Radio alarm supervising station receiver

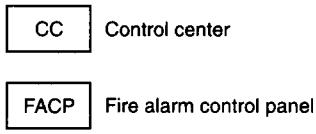
Figure A-7-2.2(ii) One-way radio alarm systems.

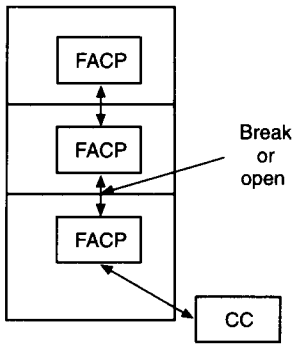




Style 4 fiber network where the panel has a two-way path communications capability. Using MultiMode Fiber for short distances, SingleMode Fiber if for long distances. Repeaters used to increase distances as needed.

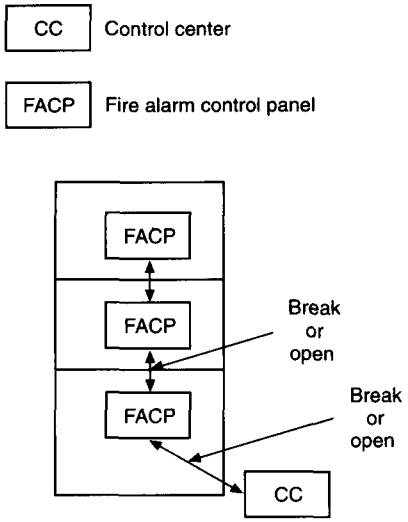
Figure A-7-2.2(jj) Style 4 fiber network.





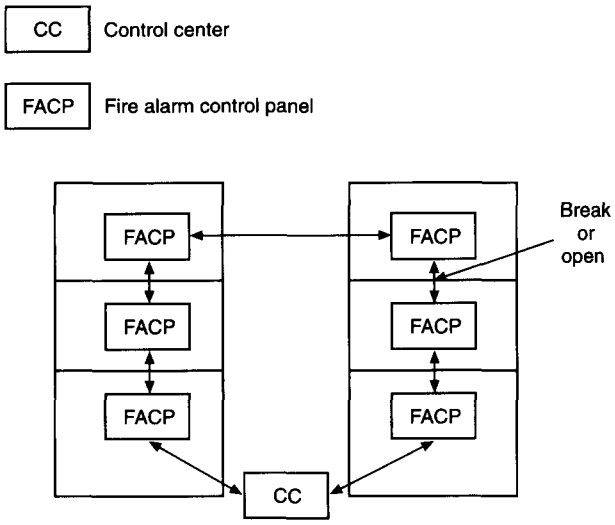
Style 4 fiber network where the panel has a two-way path communications capability. A single break separates the system into two LANs both with Style 4 capabilities.

Figure A-7-2.2(kk) Style 4 fiber network.



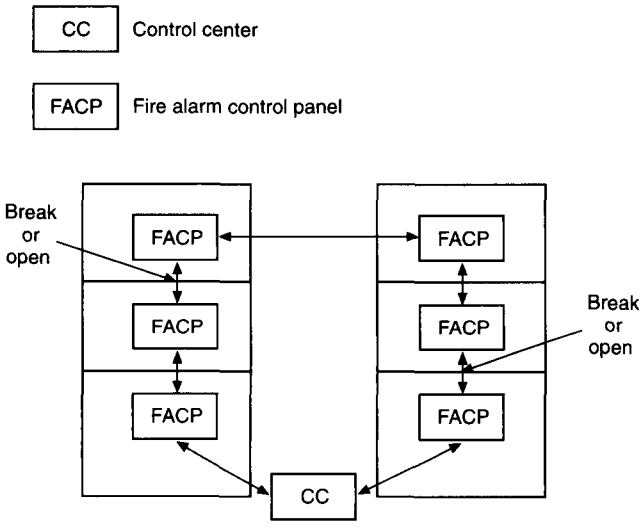
Style 4 fiber network where the panel has a two-way path communications capability. A double break isolates the panels and the control center in this case. In this case, there is one LAN and one isolated panel operating on its own. Control center is isolated completely with no communications with the network.

Figure A-7-2.2(ll) Style 4 fiber network.



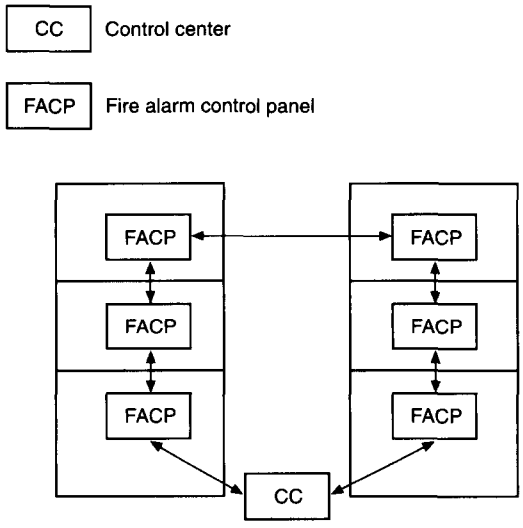
Style 7 fiber network where the panel has a two-way path communications capability, with one break. System remains as one LAN and meets Style 7.

Figure A-7-2.2(nn) Style 7 fiber network.



Style 7 fiber network where the panel has a two-way path communications capability with the two breaks now breaking into two LANs, both functioning as independent networks with the same Style 7 capabilities.

Figure A-7-2.2(mm) Style 7 fiber network.



Style 7 fiber network where the panel has a two-way path communications capability.

Figure A-7-2.2(oo) Style 7 fiber network.

To maximize battery life, the battery voltage for lead-acid cells should be maintained within the limits shown in the following table:

Table A-7-2.2(c)2 Voltage for Lead-Acid Batteries

Float Voltage	High Gravity Battery (Lead Calcium)	Low Gravity Battery (Lead Antimony)
Maximum	2.25 volts/cell	2.17 volts/cell
Minimum	2.20 volts/cell	2.13 volts/cell
High rate voltage		2.33 volts/cell

The following procedure is recommended for checking the state of charge for nickel-cadmium batteries:

(a) The battery charger is switched from float to high-rate mode.

(b) The current, as indicated on the charger ammeter, will immediately rise to the maximum output of the charger, and the battery voltage, as shown on the charger voltmeter, will start to rise at the same time.

(c) The actual value of the voltage rise is unimportant, since it depends on many variables; the length of time it takes for the voltage to rise is the important factor.

(d) If, for example, the voltage rises rapidly in a few minutes, then holds steady at the new value, the battery is fully charged. At the same time, the current will drop to slightly above its original value.

(e) In contrast, if the voltage rises slowly and the output current remains high, the high-rate charge should be continued until the voltage remains constant. Such a condition is an indication that the battery is not fully charged, and the float voltage should be increased slightly.

A-7-3.1 Equipment performance can be affected by building modifications, occupancy changes, changes in environmental conditions, device location, physical obstructions, device orientation, physical damage, improper installation, degree of cleanliness, or other obvious problems that might not be indicated through electrical supervision.

A-7-3.2 It is suggested that the annual test be conducted in segments so that all devices are tested annually.

A-7-3.2.1 Detector-Caused Unwanted Alarms. Detectors that cause unwanted alarms should be tested at their lower listed range (or at 0.5 percent obscuration if unmarked or unknown). Detectors that activate at less than this level should be replaced.

A-7-5.1 For final determination of record retention, refer to 7-3.2.1 for sensitivity options.

A-7-5.2.2(i) One method used to define the required sequence of operations and document the actual sequence of operations is an input/output matrix. [*See Figure A-7-5.2.2(i).*]

SYSTEM OUTPUTS

CONTROL UNIT ANNUNCIATION | NOTIFICATION | REQUIRED FIRE SAFETY CONTROL | SUPPLEMENTARY

SYSTEM INPUTS

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	BB	CC	DD	EE	FF	GG	
1	MANUAL FIRE ALARM BOXES – 1ST FLOOR	●	●					●			●			●	●			●							●				●		●			●	1
2	MANUAL FIRE ALARM BOXES – 2ND FLOOR	●	●						●			●		●	●			●							●				●			●		●	2
3	MANUAL FIRE ALARM BOXES – 3RD FLOOR	●	●							●			●	●	●			●							●				●				●	●	3
4	SMOKE DETECTORS – 1ST FLOOR	●	●					●			●			●	●			●	●			●			●				●					●	4
5	SMOKE DETECTORS – 2ND FLOOR	●	●						●			●		●	●			●	●				●		●				●					●	5
6	SMOKE DETECTORS – 3RD FLOOR	●	●							●			●	●	●			●	●					●	●				●					●	6
7	SMOKE DETECTORS – 1ST FLOOR ELEV. LOBBY	●	●					●			●			●	●			●		●					●				●					●	7
8	2ND FLOOR COMPUTER RM. SMOKE DET.-ZONE 1	●	●						●			●		●	●			●	●						●	●			●					●	8
9	2ND FLOOR COMPUTER RM. SMOKE DET.-ZONE 2	●	●						●			●		●	●			●	●						●		●	●	●					●	9
10	IN-DUCT SMOKE DETECTOR – SUPPLY FAN 1	●	●					●						●	●			●							●				●					●	10
11	IN-DUCT SMOKE DETECTOR – SUPPLY FAN 2	●	●					●						●	●			●							●				●					●	11
12	IN-DUCT SMOKE DETECTOR – 1ST FLOOR RETURN	●	●					●						●	●			●							●				●					●	12
13	IN-DUCT SMOKE DETECTOR – 2ND FLOOR RETURN	●	●						●					●	●			●							●				●					●	13
14	IN-DUCT SMOKE DETECTOR – 3RD FLOOR RETURN	●	●							●				●	●			●							●				●					●	14
15	HEAT DETECTORS – 1ST FLOOR MECH. RM.	●	●					●						●	●			●	●						●				●					●	15
16	HEAT DETECTORS – 2ND FLOOR STORAGE ROOM	●	●						●					●	●			●	●						●				●					●	16
17	HEAT DETECTORS – 3RD FLOOR JANITOR'S CLOSET	●	●							●				●	●			●							●				●					●	17
18	WATERFLOW – 1ST FLOOR	●	●					●						●	●			●	●		●	●			●				●	●	●			●	18
19	WATERFLOW – 2ND FLOOR	●	●						●					●	●			●	●		●		●		●				●	●		●		●	19
20	WATERFLOW – 3RD FLOOR	●	●							●				●	●			●	●		●			●	●				●	●			●	●	20
21	SPRINKLER CONTROL VALVE – 1ST FLOOR			●	●									●		●													●						21
22	SPRINKLER CONTROL VALVE – 2ND FLOOR			●	●									●		●													●						22
23	SPRINKLER CONTROL VALVE – 3RD FLOOR			●	●									●		●													●						23
24	FIRE PUMP RUNNING	●	●											●	●			●							●				●					●	24
25	FIRE PUMP POWER FAILURE/PHASE REVERSAL			●	●									●		●													●						25
26	FIRE ALARM AC POWER FAILURE			●	●											●																			26
27	FIRE ALARM SYSTEM LOW BATTERY					●	●										●																			27
28	OPEN CIRCUIT					●	●										●																			28
29	GROUND FAULT					●	●										●																			29
30	NOTIFICATION APPLIANCE CIRCUIT SHORT					●	●										●																			30
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	BB	CC	DD	EE	FF	GG	

ACTUATE COMMON ALARM SIGNAL INDICATOR
ACTUATE AUDIBLE ALARM SIGNAL
ACTUATE COMMON SUPERVISORY SIGNAL INDICATOR
ACTUATE AUDIBLE SUPERVISORY SIGNAL
ACTUATE COMMON TROUBLE SIGNAL INDICATOR
ACTUATE AUDIBLE COMMON TROUBLE SIGNAL
ACTUATE 1ST FLOOR (ZONE 1) ALARM INDICATOR
ACTUATE 2ND FLOOR (ZONE 2) ALARM INDICATOR
ACTUATE 3RD FLOOR (ZONE 3) ALARM INDICATOR
ACTUATE 1ST FLOOR EVACUATION SIGNALS
ACTUATE 2ND FLOOR EVACUATION SIGNALS
ACTUATE 3RD FLOOR EVACUATION SIGNALS
DISPLAY/PRINT CHANGE OF STATUS
TRANSMIT FIRE ALARM SIGNAL TO SUPERVISING STATION
TRANSMIT SUPERVISORY SIGNAL TO SUPERVISING STATION
TRANSMIT TROUBLE SIGNAL TO SUPERVISING STATION
RELEASE MAGNETICALLY HELD SMOKE DOORS
RECALL ELEVATORS TO PRIMARY RECALL FLOOR
RECALL ELEVATORS TO ALTERNATE RECALL FLOOR
CLOSE SMOKE/FIRE DAMPERS IN RATED WALLS
ACTUATE 1ST FLOOR SMOKE EXHAUST
ACTUATE 2ND FLOOR SMOKE EXHAUST
ACTUATE 3RD FLOOR SMOKE EXHAUST
UNLOCK EXITS
ACTUATE SUPPRESSION SYSTEM PRE-DISCHARGE ALARMS
INITIATE SUPPRESSION SYSTEM RELEASING SEQUENCE
ENERGIZE RELEASING SOLENOIDS
ACTUATE GRAPHICS SYSTEM – DISPLAY FLOOR MAP
PRESSURIZE STAIRWELLS
SHUTDOWN PROCESS #1
SHUTDOWN PROCESS #2
SHUTDOWN PROCESS #3
ACTUATE EXTERIOR STROBE AT F.D. RESPONSE POINT

Figure A-7-5.2.2(i) Typical input/output matrix.

Appendix B Engineering Guide for Automatic Fire Detector Spacing

This Appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

B-1 Introduction.

B-1.1 Scope. This appendix provides information intended to supplement Chapter 5 and includes a procedure for determining heat detector spacing based on the size and rate of growth of fire to be detected, various ceiling heights, and ambient temperature. The effects of ceiling height and the size and rate of growth of a flaming fire on smoke detector spacing are also treated. A procedure for analyzing the response of existing heat detection systems is also presented.

B-1.1.1 This appendix utilizes the results of fire research funded by the Fire Detection Institute to provide test data and analysis to the NFPA Technical Committee on Detection Devices. (*See reference 10 in Appendix C.*)

B-1.1.2 This appendix is based on full-scale fire tests in which all fires were geometrically growing flaming fires.

B-1.1.3 The tables and graphs in this guide were produced using test data and data correlations for wood fuels having a total heat of combustion of about 20,900 kJ/kg and a convective heat release rate fraction equal to 75 percent of the total heat release rate. Users should refer to references 12 and 13 in Appendix C for fuels or burning conditions substantially different from these conditions.

B-1.1.4 The guidance applicable to smoke detectors is limited to a theoretical analysis based on the flaming fire test data and is not intended to address the detection of smoldering fires.

B-1.2 Purpose. The purpose of this guide is to provide a performance basis for the location and spacing of heat or smoke detectors. A performance based approach differs from a prescriptive approach in that listed spacing is used as a starting point for the design of a fire detection system that meets specific performance objectives, considering the individual building/room characteristics, potential fire growth rates, and damageability characteristics of the targets (e.g., building occupants, equipment and contents, or structures).

B-1.2.1 Establishing Design Objectives.

B-1.2.1.1 Fire detection system design should be based upon established design objectives that can include life safety, property protection, business interruption, or protection of the environment. The owner/occupant might define these in terms of maximum allowable loss (e.g., all occupants shall have sufficient egress time, 10-minute maximum downtime of equipment, or waste-basket maximum fire size.) These objectives are then put into engineering terms by the designer (e.g.; detection of a 100 kW-fire).

B-1.2.1.2 There is a difference between maximum fire size and detected fire size. Although a fire has been detected, this does not mean that it stops growing or is extinguished. Fires typically grow exponentially until they either become ventilation controlled, until the fuel is consumed, or until manual or automatic extinguishment, or both, begins. Figure B-2.2.3.2 shows that there can be a significant increase in the heat release rate with only a small change in time due to the exponential growth rate of the fire.

B-1.2.2 Factors Affecting Attainment of Objectives.

B-1.2.2.1 A performance based analysis should consider the factors that delay manual extinguishment or suppression activities once appropriate personnel are notified. These factors can include fire department dispatch time, response time to fire site, building access, incident location, equipment set-up, and suppressant discharge. Delays are also possible with automatic fire extinguishing system(s) or suppression system(s). Delay can be introduced by alarm verification or crossed zone detection systems, filling and discharge times of pre-action systems, delays in agent release required for occupant evacuation (i.e., CO_2 systems), and the time required to achieve extinguishment.

B-1.2.2.2 A performance based analysis also should consider the interaction between the expected fire, the space in which it is located, and the response of the specific detector to the expected fire in that space. Important factors to be considered regarding the fire include the type and quantity of fuel, fuel configuration, and fuel location within the space in relation to the walls, corners, and ceilings. These factors together allow for estimates of fire growth and smoke production rates. Paragraph B-2.2 provides guidance in evaluating fire development potentials.

B-1.2.2.3 Factors to be considered in the evaluation of the room or space to be protected include the physical configurations of the space, environmental factors present, and mechanical (HVAC) systems that could affect detector performance. Physical configuration parameters include floor area, ceiling height, ceiling configuration (e.g., flat vs. sloped, beamed vs. smooth), and thermodynamic properties of walls, floors, and ceilings. Environmental factors to consider include electromagnetic or radio frequency interference, ambient temperature and humidity conditions, and availability of free oxygen to support combustion.

B-1.2.2.4 Once the design objectives, the room, and the potential fire characteristics are well understood, the designer can select an appropriate detection strategy. Important factors to consider include the type of detector, sensitivity to expected fire signatures, and freedom from nuisance response to environmental factors.

B-1.2.3 Design. This guide provides a method for modifying the listed spacing of both rate-of-rise and fixed-temperature heat detectors required to achieve detector response to a geometrically growing flaming fire at a specific fire size, taking into account the height of the ceiling on which the detectors are mounted and the fire safety objectives for the space. This procedure also allows modification of listed spacing of fixed-temperature heat detectors to account for variation of ambient temperature (T_o) from standard test conditions.

B-1.2.4 Analysis. This guide can be used to estimate the fire size that can be detected by an existing array of listed heat detectors installed at a given spacing for a given ceiling height in known ambient conditions.

B-1.2.5 This guide is also intended to explain the effect of rate of fire growth and fire size of a flaming fire, as well as the effect of ceiling height on the spacing and response of smoke detectors.

B-1.2.6 This methodology utilizes theories of fire development, fire plume dynamics, and detector performance, which are the major factors influencing detector response. However, it does not consider several lesser phenomena

that, in general, are unlikely to have significant influence. A discussion of ceiling drag, heat loss to the ceiling, radiation to the detector from a fire, re-radiation of heat from a detector to its surroundings, and the heat of fusion of eutectic materials in fusible elements of heat detectors and their possible limitations on the design method are provided in references 4, 11, and 16 in Appendix C.

B-1.3 Relationship to Listed Spacings. Listed spacings for heat detectors are based on relatively large fires (approximately 1200 Btu/sec), burning at a constant rate. [The listed spacing is based on the distance from a fire at which an ordinary degree heat detector actuates prior to operation of a 160°F (71°C) sprinkler installed at a 10-ft (3-m) spacing.] [*See Figure A-5-2.4.1(c).*]

Design spacing for this type of fire can be determined using the material in Chapter 5.

Where smaller or larger fires and varying growth rates are to be considered, the designer can use the material presented in this guide.

B-1.4 Required Data. The following data are necessary in order to use the methods in this guide for either analysis or design.

B-1.4.1 Analysis.

T_o	Ambient temperature
H	Ceiling height or clearance above fuel
T_s	Detector operating temperature (heat detectors only)
ΔT_s/min	Rate of temperature change set point for rate-of-rise heat detectors
RTI	Response time index for the detector (heat detectors only) or its listed spacing
α or t_g	Fuel fire intensity coefficient or t_g, the fire growth time
S	The actual installed spacing of the existing detectors

B-1.4.2 Design.

T_o	Ambient temperature
H	Ceiling height or clearance above fuel
T_s	Detector operating temperature (heat detectors only)
ΔT_s/min	Rate of temperature change set point for rate-of-rise heat detectors
RTI	Response time index for the detector (heat detectors only) or its listed spacing
α or t_g	Fuel fire intensity coefficient or t_g, the fire growth time
Q_d or t_d	The threshold fire size at which response must occur or the time to detector response

B-1.4.3 The terms and data in B-1.4.1 are defined in more detail in the following sections.

B-1.4.4 Fire Detection and Analysis Worksheet. Figure B-1.4.4 is a fire detection and analysis worksheet, which is provided to assist in using this guide.

B-2 Fire Development and Ceiling Height Considerations.

B-2.1 General. The purpose of this section is to discuss the effects of ceiling height and the selection of a threshold fire size that can be used as the basis for determination of type and spacing of automatic fire detectors in a specific situation.

B-2.1.1 A detector ordinarily operates sooner in detecting a fire if it is nearer to the fire.

B-2.1.2 Generally, height is the most important single dimension in cases where ceiling heights exceed 16 ft (4.9 m).

B-2.1.3 As smoke and heat rise from a fire, they tend to spread in the general form of an inverted cone. Therefore, the concentration within the cone varies inversely as a variable exponential function of the distance from the source. This effect is very significant in the early stages of a fire, because the angle of the cone is wide. As a fire intensifies, the angle of the cone narrows and the significance of the effect of height is lessened.

B-2.1.4 High Ceilings. As the ceiling height increases, a larger-size fire is necessary to actuate the same detector in the same length of time. In view of this, it is mandatory that the designer of a fire detection system calling for heat detectors consider the size of the fire and rate of heat release that may be permitted to develop before detection is ultimately obtained.

B-2.1.5 The most sensitive detectors suitable for the maximum ambient temperature at heights above 30 ft (9.1 m) should be employed.

B-2.1.6 The spacing recommended by testing laboratories for the location of detectors is an indication of their relative sensitivity. This applies with each detection principle; however, detectors operating on various physical principles have different inherent sensitivities to different types of fires and fuels.

B-2.1.7 Reduction of listed spacing may be required for any of the following purposes:

(a) Faster response of the device to a fire;

(b) Response of the device to a smaller fire;

(c) Accommodation to room geometry;

(d) Other special considerations, such as air movement or a ceiling or other obstruction.

B-2.2 Fire Development.

B-2.2.1 Fire development varies depending on the combustion characteristics of the fuels involved and the physical configuration of the fuels. After ignition, most fires grow in an accelerating pattern.

B-2.2.2 Fire Size.

B-2.2.2.1 Fires can be characterized by their rate of heat release, measured in terms of the number of Btus per second (kW) generated. Typical maximum heat release rates, Q_m, for a number of different fuels and fuel configurations are provided in Tables B-2.2.2.1(a) and (b).

In Table B-2.2.2.1(a):

$$Q_m = qA$$

where:

Q_m = the maximum or peak heat release rate in Btu/sec
q = the heat release rate density per unit floor area in Btu/sec/ft^2
A = the floor area of the fuel in ft^2.

I. Input Data for Design and Analysis (*B-2*)

Detector Type

		Fixed-Temp HD	*Rate-of-Rise HD*	*Smoke Detector*		
Compartment Characteristics	H =				ft	Ceiling height or clearance above fuel (*see B-2.1, B-2.3*)
	T_o =				°F	Ambient temperature (*see B-3.2.3, B-6.4*)
Detector Characteristics (see B-3)	T_s =				°F	Detector operating temperature (*see B-3.1.4*)
	ΔT =				°F	Temperature differential (*Calculate using:* T_s-T_o)
	LS =				ft	Listed spacing of detector
	τ_o =				sec	Detector time constant (*see Table B-3.2.2 and B-6.3*)
	or					
	RTI =				$ft^{1/2}sec^{1/2}$	Response time index (*see Table B-3.2.2*) *Calculate using:* RTI = $\tau_o \sqrt{5}$
Fire Development (see B-2.2)	t_g =		s (t_g = 600) m (t_g = 300) f (t_g = 150)	s (t_g = 600) m (t_g = 300) f (t_g = 150)	sec	Fire growth time to 1000 Btu/sec → *Select, or circle, a fire growth time*
	or					
	α =				Btu/sec^3	Fire intensity coefficient → *Calculate using:* $\alpha = 1000/t_g^2$

s(low)	m(edium)	f(ast)	
≥ 400	≥150 and <400	< 150	sec
≤ 0.0062	≥0.0444 and <0.0062	>0.0444	Btu/sec^3

[*see B-2.2.3, B-3.3.2(b), B-5.6.2(b)*]

IIa. Input Data for *Design* (B-3)

IIa.1 Establish Design Objectives

Determine the size of the fire at which detector response is desired using either 1 or 2:

1. *Select* Q_d = _____ Btu/sec [see B-2.2.4, Table B-2.2.2.1(a), (b), or B-2.2.2.3], or

2. *Calculate* Q_d using the time after ignition at which detector response is desired, t_d, using: $Q_d = \alpha t_d^2$ = _____ Btu/sec

IIa.2 Calculate Detector Response

Fixed-Temperature HD (B-3.2)	*Rate-of-Rise HD (B-3.3)*	*Smoke Detector (B-5)*
1. Fill in the variables: Q_d = _____ Btu/sec t_g = _____ sec, or α = _____ Btu/sec^3 τ_o = _____ sec, or RTI = _____ $ft^{1/2}$ $sec^{1/2}$ ΔT = _____ °F and H = _____ ft 2. Using Q_d and t_g (or α), select the appropriate design table (a) through (y) from Table B-3.2.4: _____ 3. Using τ_o (or RTI), ΔT, and H, determine the installed spacing: _____ ft	1. Fill in the variables: Fire growth (s,m,f) = _____ H = _____ ft Q_d = _____ Btu/sec 2. Select installed spacing from Table B-3.3.2(a): _____ ft 3. Select spacing modifier from Table B-3.3.2(b): x _____ 4. Calculate installed spacing: _____ft	1. Fill in the variables: Fire growth (s,m,f) = _____ H = _____ ft Q_d = _____ Btu/sec 2. Using fire growth (s, m, or f), select Figure B-5.5.1(a), (b), or (c): _____ 3. Using H and Q_d, determine the installed spacing: _____ ft

IIb. Input Data for *Analysis* of an Existing Heat Detection System (B-4)

1. Fill in the variables:
   S = _____ ft (installed spacing of the existing heat detector)
   t_g = _____ sec, or α = _____ Btu/sec^3
   τ_o = _____ sec, or RTI = _____ $ft^{1/2}sec^{1/2}$
   ΔT = _____ °F and H = _____ ft
2. Using S and t_g (or α), select an analysis table (a) - (nn) from Table B-4: _____
3. Using τ_o (or RTI), ΔT, and H, determine the fire size at detector response Q_d = _____ Btu/sec
4. Calculate the time to detector response using: $t_d = \sqrt{\frac{Q_d}{\alpha}} = \sqrt{\frac{\text{Btu/sec}}{\text{Btu/sec}^3}}$ = _____ sec

Figure B-1.4.4 Fire detection and analysis worksheet.

Table B-2.2.2.1(a) Maximum Heat Release Rates

Warehouse Materials	Growth Time (t_g) (sec)	Heat Release Density (q) (Btu/sec/ft^2)	Classification (s = slow, m = medium, f = fast)
1. Wood pallets, stack, 1 1/2 ft high (6%–12% moisture)	325	125	f–m
2. Wood pallets, stack, 5 ft high (6%–12% moisture)	200	460	f–m
3. Wood pallets, stack, 10 ft high (6%–12% moisture)	125	940	f
4. Wood pallets, stack, 16 ft high (6%–12% moisture)	125	1500	f
5. Mail bags, filled, stored 5 ft high	190	35	m
6. Cartons, compartmented, stacked 15 ft high	60	150	f
7. Paper, vertical rolls, stacked 20 ft high	16–28	—	†
8. Cotton (also PE, PE/cot, acrylic/nylon/PE), garments in 12-ft high racks	21–42	—	†
9. Cartons on pallets, rack storage, 15 ft–30 ft high	40–275	—	f–m
10. Paper products, densely packed in cartons, rack storage, 20 ft high	480	—	s
11. PE letter trays, filled, stacked 5 ft high on cart	180	750	m
12. PE trash barrels in cartons, stacked 15 ft high	55	175	f
13. FRP shower stalls in cartons, stacked 15 ft high	85	125	f
14. PE bottles, packed in item 6	85	550	f
15. PE bottles in cartons, stacked 15 ft high	75	175	f
16. PE pallets, stacked 3 ft high	150	—	f
17. PE pallets, stacked 6 ft–8 ft high	30–60	—	f
18. PU mattress, single, horizontal	125	—	f
19. PE insulation board, rigid foam, stacked 15 ft high	8	170	†
20. PS jars, packed in item 6	55	1250	f
21. PS tubs nested in cartons, stacked 14 ft high	120	475	f
22. PS toy parts in cartons, stacked 15 ft high	125	180	f
23. PS insulation board, rigid, stacked 14 ft high	6	290	†
24. PVC bottles, packed in item 6	95	300	†
25. PP tubs, packed in item 6	100	390	†
26. PP and PE film in rolls, stacked 14 ft high	40	550	†
27. Distilled spirits in barrels, stacked 20 ft high	25–40	—	†
28. Methyl alcohol	—	65	—
29. Gasoline	—	290	—
30. Kerosene	—	290	—
31. Diesel oil	—	175	—

For SI units: 1 ft = 0.305 m.
NOTE: The heat release rates per unit floor area are for fully involved combustibles, assuming 100 percent combustion efficiency. The growth times shown are those required to exceed 1000 Btu/sec heat release rate for developing fires, assuming 100 percent combustion efficiency.
(PE = polyethylene; PS = polystyrene; PVC = polyvinyl chloride; PP = polypropylene; PU = polyurethane; FRP = fiberglass-reinforced polyester.)
†Fire growth rate exceeds design data.

Table B-2.2.2.1(b) Maximum Heat Release Rates from Fire Detection Institute Analysis

Materials	Approximate Values (Btu/sec)
Medium wastebasket with milk cartons	100
Large barrel with milk cartons	140
Upholstered chair with polyurethane foam	350
Latex foam mattress (heat at room door)	1200
Furnished living room (heat at open door)	4000–8000

B-2.2.2.2 Example. A particular hazard analysis is to be based on a fire scenario involving a 10-ft × 10-ft (3-m × 3-m) stack of wood pallets 5 ft (1.5 m) high. Approximately what peak heat release rate can be expected?

From Table B-2.2.2.1(a), the heat release rate density (q) for 5-ft (1.5-m) high wood pallets is about 330 Btu/sec/ft^2.

The area is 10 ft × 10 ft = 100 ft^2 (3 m × 3 m = 9 m^2)

$Q_m = qA = 330 \times 100 = 33{,}000$ Btu/sec.

The fire would have a medium to fast fire growth rate reaching 1000 Btu/sec (1055 kW) in about 90 seconds to 190 seconds.

B-2.2.2.3 The National Institute of Standards and Technology (the former National Bureau of Standards) has developed a large-scale calorimeter for measuring the heat release rates of burning furniture. Two reports issued by NIST (*see references 3 and 14 in Appendix C*) describe the apparatus and data collected during two test series.

Test data from 40 furniture calorimeter tests have been used to verify independently the power-law fire growth model, $Q = \alpha t^2$ (*see reference 16 in Appendix C*). In this case, Q is the instantaneous heat release rate, α is the fire intensity coefficient, and t is time. The fire growth time, t_g, is arbitrarily defined as the time after established burning when the fire would reach a burning rate of 1000 Btu/sec (1055 kW). In terms of t_g:

$$\alpha = 1000/t_g^2 \text{ Btu/sec}^3$$

$$\alpha = 1055/t_g^2 \text{ kW/sec}^2$$

and

$$Q = (1000/t_g^2)t^2 \text{ Btu/sec}$$

$$Q = (1055/t_g^2)t^2 \text{ kW}.$$

Graphs of heat release data from the 40 furniture calorimeter tests can be found in reference 8 in Appendix C. Best fit power-law fire growth curves have been superimposed on

the graphs. Data from these curves can be used with this guide to design or analyze fire detection systems that need to respond to similar items burning under a flat ceiling. Table B-2.2.2.3 is a summary of the data.

For reference, the table contains the test numbers used in the original NIST reports. The virtual time of origin, t_v, is the time at which the fires began to obey the power-law fire growth model. Prior to t_v, the fuels might have smoldered but did not burn vigorously with an open flame. The model curves are then predicted by the following:

$Q = \alpha(t - t_v)^2$ Btu/sec or kW

$Q = (1000/t_g^2)(t - t_v)^2$ Btu/sec

$Q = (1055/t_g^2)(t - t_v)^2$ kW.

Figure B-2.2.2.3 is an example of actual test data with a power-law curve superimposed. This shows how the model can be used to approximate the growth phase of the fire.

For tests 19, 21, 29, 42, and 67, different power-law curves were used to model the initial and the latter realms of burning. In examples such as these, engineers should choose the fire growth parameter that best describes the realm of burning to which the detection system is being designed to respond.

In addition to heat release rate data, the original NIST reports contain data on particulate conversion and radiation from the test specimens. These data can be used to determine the threshold fire size (heat release rate) at which tenability becomes endangered or the point at which additional fuel packages might become involved in the fire.

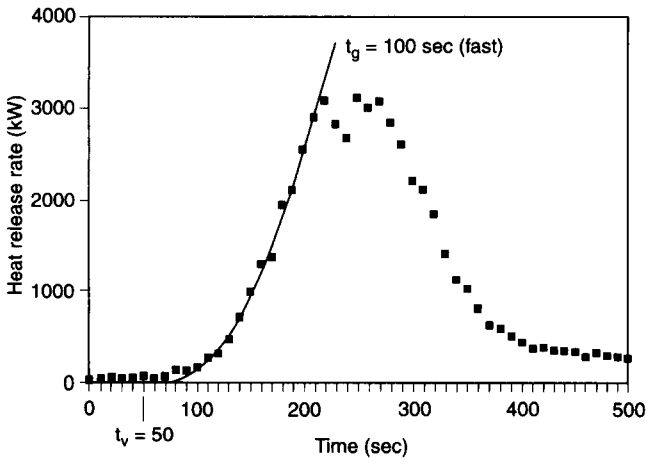


Figure B-2.2.2.3 Test 38, foam sofa.

B-2.2.2.4 A fire detection system can be designed to detect a fire of a certain size in terms of its heat release rate. This is called the threshold fire size (Q_d). The threshold size is the rate of heat release at which detection is desired.

B-2.2.2.5 Flame height can be used to assist in determining the fire size desired for detector response. As shown in Figure B-2.2.2.5, flame height and fire size are directly related (*see reference 2 in Appendix C*). In Figure B-2.2.2.5:

$H_f = 0.584\ (kQ)^{0.4}$

where:

H_f = flame height (ft)

k = wall effect factor

use:

k = 1 where there are no nearby walls

k = 2 where the fuel package is near a wall

k = 4 where the fuel package is in a corner

Q = heat release rate (Btu/sec).

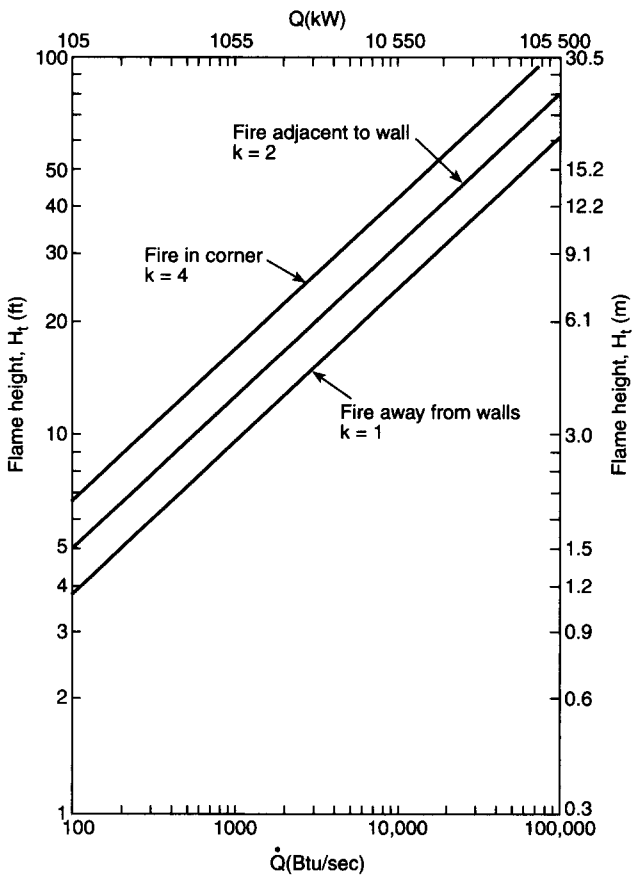


Figure B-2.2.2.5 Heat release vs. flame height.

B-2.2.2.6 Example. The design objective for a particular compartment is to detect a fire before it exceeds the height of the occupants [6 ft (1.83 m)]. What is the heat release rate that would be expected for flames 6 ft (1.83 m) high, assuming the fire is not near any walls?

From Figure B-2.2.2.5, the heat release rate is approximately 330 Btu/sec, or:

$H_f = 0.584\ (kQ)^{0.4}$

$6 = 0.584\ (1*Q)^{0.4}$

Q = 338 Btu/sec

B-2.2.3 Fire Growth.

B-2.2.3.1 A second important consideration concerning fire development is the time (t_g) it takes for fire to reach a given heat release rate. Table B-2.2.2.1(a) and Table B-2.2.2.3 provide the times necessary to reach a heat release rate of 1000 Btu/sec (1055 kW) for a variety of materials in various configurations.

Table B-2.2.2.3 Furniture Heat Release Rates

Test No.	Item/Mass/Description	Growth Time (t_g) (sec)	Classification (s = slow, m = medium, f = fast)	Fuel Fire Intensity Coefficient (α) (kW/sec^2)	Virtual Time (t_v) (sec)	Maximum Heat Release Rates (kW)
Test 15	Metal wardrobe, 41.4 kg (total)	50	f	0.4220	10	750
Test 18	Chair F33 (trial love seat), 39.2 kg	400	s	0.0066	140	950
Test 19	Chair F21, 28.15 kg (initial)	175	m	0.0344	110	350
Test 19	Chair F21, 28.15 kg (later)	50	f	0.4220	190	2000
Test 21	Metal wardrobe, 40.8 kg (total) (initial)	250	m	0.0169	10	250
Test 21	Metal wardrobe, 40.8 kg (total) (average)	120	f	0.0733	60	250
Test 21	Metal wardrobe, 40.8 kg (total) (later)	100	f	0.1055	30	140
Test 22	Chair F24, 28.3 kg	350	m	0.0086	400	700
Test 23	Chair F23, 31.2 kg	400	s	0.0066	100	700
Test 24	Chair F22, 31.9 kg	2000	s	0.0003	150	300
Test 25	Chair F26, 19.2 kg	200	m	0.0264	90	800
Test 26	Chair F27, 29.0 kg	200	m	0.0264	360	900
Test 27	Chair F29, 14.0 kg	100	f	0.1055	70	1850
Test 28	Chair F28, 29.2 kg	425	s	0.0058	90	700
Test 29	Chair F25, 27.8 kg (later)	60	f	0.2931	175	700
Test 29	Chair F25, 27.8 kg (initial)	100	f	0.1055	100	2000
Test 30	Chair F30, 25.2 kg	60	f	0.2931	70	950
Test 31	Chair F31 (love seat), 39.6 kg	60	F	0.2931	145	2600
Test 37	Chair F31 (love seat), 40.4 kg	80	f	0.1648	100	2750
Test 38	Chair F32 (sofa), 51.5 kg	100	f	0.1055	50	3000
Test 39	1/2-in. plywood wardrobe with fabrics, 68.5 kg	35	†	0.8612	20	3250
Test 40	1/2-in. plywood wardrobe with fabrics, 68.32 kg	35	†	0.8612	40	3500
Test 41	1/8-in. plywood wardrobe with fabrics, 36.0 kg	40	†	0.6594	40	6000
Test 42	1/8-in. plywood wardrobe with fire-retardant int. fin. (initial growth)	70	f	0.2153	50	2000
Test 42	1/8-in. plywood wardrobe with fire-retardant int. fin. (later growth)	30	†	1.1722	100	5000
Test 43	Repeat of 1/2-in. plywood wardrobe, 67.62 kg	30	†	1.1722	50	3000
Test 44	1/8-in. plywood wardrobe with fire-retardant latex paint, 37.26 kg	90	f	0.1302	30	2900
Test 45	Chair F21, 28.34 kg	100	f	0.1055	120	2100
Test 46	Chair F21, 28.34 kg	45	†	0.5210	130	2600
Test 47	Chair, adj. back metal frame, foam cushions, 20.82 kg	170	m	0.0365	30	250
Test 48	Easy chair C07, 11.52 kg	175	m	0.0344	90	950
Test 49	Easy chair F34, 15.68 kg	200	m	0.0264	50	200
Test 50	Chair, metal frame, minimum cushion, 16.52 kg	200	m	0.0264	120	3000
Test 51	Chair, molded fiberglass, no cushion, 5.28 kg	120	f	0.0733	20	35
Test 52	Molded plastic patient chair, 11.26 kg	275	m	0.0140	2090	700
Test 53	Chair, metal frame, padded seat and back, 15.54 kg	350	m	0.0086	50	280
Test 54	Love seat, metal frame, foam cushions, 27.26 kg	500	s	0.0042	210	300
Test 56	Chair, wood frame, latex foam cushions, 11.2 kg	500	s	0.0042	50	85
Test 57	Love seat, wood frame, foam cushions, 54.6 kg	350	m	0.0086	500	1000
Test 61	Wardrobe, 3/4-in. particleboard, 120.33 kg	150	m	0.0469	0	1200
Test 62	Bookcase, plywood with aluminum frame, 30.39 kg	65	f	0.2497	40	25
Test 64	Easy chair, molded flexible urethane frame, 15.98 kg	1000	s	0.0011	750	450
Test 66	Easy chair, 23.02 kg	76	f	0.1827	3700	600
Test 67	Mattress and boxspring, 62.36 kg (later)	350	m	0.0086	400	500
Test 67	Mattress and boxspring, 62.36 kg (initial)	1100	s	0.0009	90	400

For SI units: 1 ft = 0.305 m; 1000 Btu/sec = 1055 kW; 1 lb = 0.453 kg.
†Fire growth exceeds design data.

B-2.2.3.2 For purposes of this guide, fires are classified as being either slow-, medium-, or fast-developing. (*See Figure B-2.2.3.2.*)

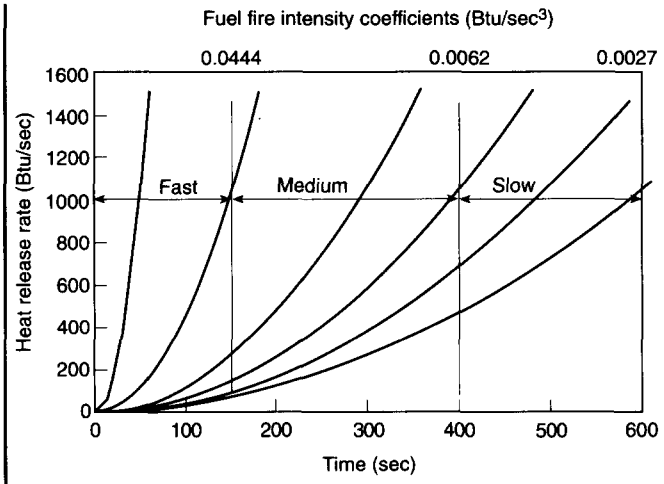


Figure B-2.2.3.2 Power-law heat release rates.

B-2.2.3.2.1 A slow-developing fire is defined as a fire that takes 400 or more seconds (6 minutes, 40 seconds) from the time that established burning occurs until the fire reaches a heat release rate of 1000 Btu/sec (1055 kW). Using the relationships discussed in B-2.2.2.3, this corresponds to an α of 0.0062 Btu/sec^3 (0.0066 kW/sec^2) or less.

B-2.2.3.2.2 A medium-developing fire takes 150 seconds (2 minutes, 30 seconds) or more and less than 400 seconds (6 minutes, 40 seconds) from the time that established burning occurs until the fire reaches a heat release rate of 1000 Btu/sec (1055 kW). Using the relationships discussed in B-2.2.2.3, this corresponds to $0.0444 \leq \alpha < 0.0062$ Btu/sec^3 ($0.0469 \leq \alpha < 0.0066$ kW/sec^2).

B-2.2.3.2.3 A fast-developing fire is a fire that takes less than 150 seconds (2 minutes, 30 seconds) from the time that established burning occurs until the fire reaches a heat release rate of 1000 Btu/sec (1055 kW). Using the relationships discussed in B-2.2.2.3, this corresponds to an α greater than 0.0444 Btu/sec^3 (0.0469 kW/sec^2).

B-2.2.3.3 The design fires used in this guide grow according to the following equation:

$$Q = (1000/t_g^2)t^2$$

where:

Q is the heat release rate in Btu/sec

t_g is the fire growth time (149 sec = fast, 150 sec – 399 sec = medium, 400 sec = slow)

t_g is the time (sec) after established burning occurs.

B-2.2.4 Selection of Fire Size. The selection of threshold fire size, Q_d, should be based on an understanding of the characteristics of a specified space and the fire safety objectives for that space.

For example, in a particular installation it might be desirable to detect a typical wastebasket fire. Table B-2.2.2.1(b) includes data for a fire involving a comparable array of combustibles, specifically milk cartons in a wastebasket. Such a fire is indicated to produce a peak heat release rate of 100 Btu/sec.

B-2.3 Ceiling Height.

B-2.3.1 The Fire Detection Institute data are based on the height of the ceiling above the fire. In this guide, it is recommended that the designer use the actual distance from floor to ceiling, since the ceiling height will thereby be more conservative and actual detector response will improve where the potential fuel in a room is above floor level.

B-2.3.2 Where the designer desires to consider the height of the potential fuel in the room, the distance between the fuel and the ceiling should be used in place of the ceiling height in the tables and graphs. This should be considered only where the minimum height of the potential fuel is always constant and where the concept is approved to the authority having jurisdiction.

B-2.3.3 The procedures presented in this guide are based on an analysis of test data for ceiling heights up to 30 ft (9.1 m). No data was analyzed for ceilings greater than 30 ft (9.1 m); therefore, in such installations, engineering judgment and the manufacturer's recommendations should be used.

B-2.4 Stratification.

B-2.4.1 When stratification occurs, the smoke/heat being transported from a fire might not be able to reach detectors mounted at a particular level above the fire. This is due to the fact that cooler air is continually entrained throughout the height of the fire plume, resulting in cooling of the smoke and fire plume gases and a reduction in buoyancy. To determine whether or not the rising smoke/heat from an axisymetric fire plume will stratify below detectors, the following expression can be applied where the ambient temperature increases linearly with increasing elevation:

$$Z_m = 14.7\, Q_c^{1/4}\, \Delta T_o^{-3/8} \text{ ft} = 5.54\, Q_c^{1/4}\, \Delta T_o^{-3/8} \text{ m}$$

where:

Z_m = maximum height of smoke rise above the fire surface [ft (m)]

ΔT_o = difference between the ambient temperature at the location of detectors and the ambient temperature at the level of the fire surface [°F(°C)]

Q_c = convective portion of the heat release rate [Btu/sec (kW)].

The convective portion of the heat release rate, Q_c, can be estimated as 70 percent of the heat release rate.

As an alternative to using the noted expression to calculate directly the maximum height to which smoke/heat in the fire will rise, Figure B-2.4.1 can be used to determine Z_m for given fires.

Where Z_m, as calculated or determined graphically, is greater than the installed height of detectors, smoke/heat from a rising fire plume is predicted to reach the detectors. Where the compared values of Z_m and the installed height of detectors are comparable heights, the prediction that smoke/heat will reach the detectors might not be a reliable expectation.

B-2.4.2 The theoretical basis for the stratification calculation is based upon the works of Morton, Taylor, and Turner (*see reference 15 in Appendix C*); and Heskestad (*see reference 9 in Appendix C*). For further information regarding the derivation of the expression defining Z_m, the user is referred to the work of Klote and Milke (*see reference 13 in Appendix C*).

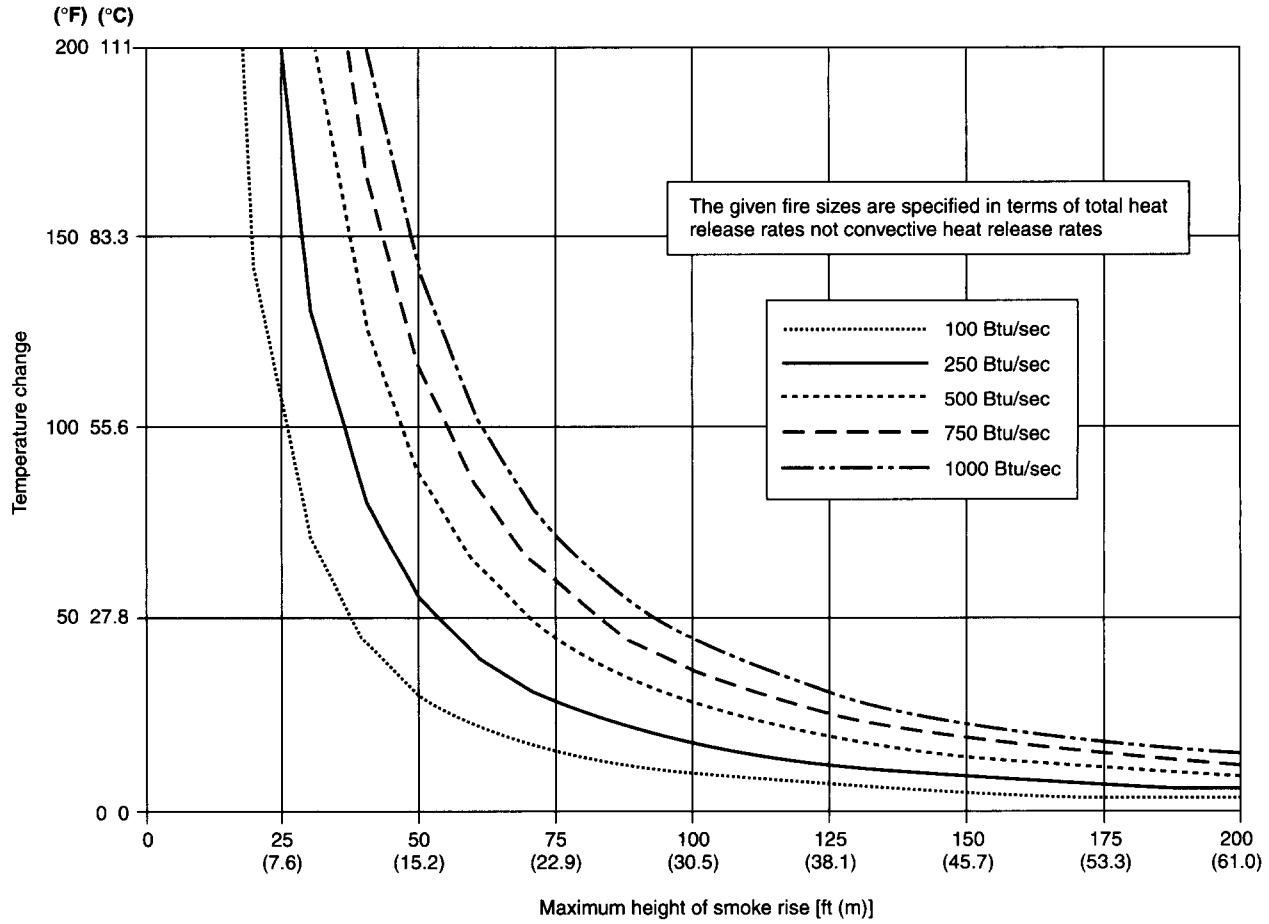


Figure B-2.4.1 Temperature change and maximum height of smoke rise for given fire sizes.

B-3 Heat Detector Spacing.

B-3.1 General.

B-3.1.1 This section discusses procedures for the determination of installed spacing of listed heat detectors used to detect flaming fires.

B-3.1.2 The determination of the installed spacing of heat detectors using these procedures adjusts the listed spacing to reflect the effects of ceiling height, threshold fire size, rate of fire development, and, for fixed temperature detectors, the ambient temperature and the temperature rating of the detector.

B-3.1.3 Other factors that affect detector response, such as beams and joists, are covered in Chapter 5.

B-3.1.4 The difference between the rated temperature of a fixed temperature detector (T_s) and the maximum ambient temperature (T_o) at the ceiling should be as small as possible. To reduce unwanted alarms, the difference between operating temperature and ambient temperature should be not less than 20°F (11°C).

B-3.1.5 Listed rate-of-rise heat detectors are designed to activate at a nominal rate of temperature rise of 15°F (8°C) per minute.

B-3.1.6 The listed spacing of a detector is an indicator of the detector's sensitivity. Given the same temperature rating, a detector listed for a 50-ft (15.2-m) spacing is more sensitive than a detector listed for a 20-ft (6.1-m) spacing.

B-3.1.7 Where using combination detectors incorporating both fixed temperature and rate-of-rise heat detection principles to detect a geometrically growing fire, the data herein for rate-of-rise detectors should be used in selecting an installed spacing, because the rate-of-rise principle controls the response.

B-3.1.8 Rate-compensated detectors are not specifically covered by this guide. However, a conservative approach to predicting their performance is to use the fixed-temperature heat detector guidance contained herein.

B-3.2 Fixed-Temperature Heat Detector Spacing. Tables B-3.2.2 and B-3.2.4(a) through (y) are to be used to determine the installed spacing of fixed-temperature heat detectors. The analytical basis for the tables is presented in another portion of this guide. This subsection describes how the tables are to be used.

B-3.2.1 With the exception of ceiling height, the nearest value shown in the tables provides sufficient accuracy for these calculations. Interpolation is permitted but not necessary, except for ceiling height.

B-3.2.2 Time Constant.

(a) Given the detector's listed spacing and the detector's rated temperature (T_s), Table B-3.2.2 should be used to find the detector time constant (τ_o). The time constant is a measure of the detector's sensitivity. (*See B-6.3.*)

(b) The response time index (RTI) can also be used to describe the sensitivity of a fixed-temperature heat detector. (*See B-6.3.*)

Table B-3.2.2 Time Constants (τ_o) for Any Listed Heat Detector†

Listed Spacing (ft)	ULI						FMRC All Temps.
	128°	135°	145°	160°	170°	196°	
10	400	330	262	195	160	97	196
15	250	190	156	110	89	45	110
20	165	135	105	70	52	17	70
25	124	100	78	48	32		48
30	95	80	61	36	22		36
40	71	57	41	18			
50	59	44	30				
70	36	24	9				

For SI units: 1 ft = 0.305 m.

NOTE 1: These time constants are based on an analysis of the Underwriters Laboratories Inc. and Factory Mutual listing test procedures. Plunge test (*see reference 8 in Appendix C*) results performed on the detector to be used will give a more accurate time constant. See Section B-5 for a further discussion of detector time constants.

NOTE 2: These time constants can be converted to response time index (RTI) values by multiplying by 5 ft/sec (1.5 m/sec). (*See B-3-3.*)

†At a reference velocity of 5 ft/sec (1.5 m/sec).

B-3.2.3 Minimum Ambient Temperature.

(a) The minimum ambient temperature (T_o) expected at the ceiling of the space to be protected is estimated. The temperature change (ΔT) of the detector required for detection ($\Delta T = T_s - T_o$) is calculated.

(b) Selection of the minimum ambient temperature necessitates engineering judgment. Use of the absolute minimum ambient temperature results in the most conservative designs. This is true because it is then assumed that the detector has to absorb enough energy to raise its temperature from the low ambient value up to its operating temperature. A review of historical data might show very low ambient temperatures that occur relatively infrequently, such as every 100 years.

Depending on actual design considerations, it might be more prudent to use an average minimum ambient temperature. In any case, a sensitivity analysis should be performed to determine the effect of changing the ambient temperature on the design results.

B-3.2.4 Having determined the detector's sensitivity (time constant or RTI) (*see B-3.2.2*), the temperature change of the detector required for detection (*see B-3.2.3*), the threshold fire size (*see B-2.2.4*), the fire growth rate (*see B-2.2.3*), and the ceiling height, Tables B-3.2.4(a) through (y) are used to determine the required installed spacing. Table B-3.2.4 provides an index to the tables.

Table B-3.2.4 Design Tables Index

	Threshold Fire Size (Btu/sec) Q_d	Fire Growth Period (sec) t_g	Fuel Fire Intensity Coefficient (Btu/sec^5) α
Table B-3.2.4(a)	250	50	0.400
Table B-3.2.4(b)	250	150	0.044
Table B-3.2.4(c)	250	300	0.011
Table B-3.2.4(d)	250	500	0.004
Table B-3.2.4(e)	250	600	0.003
Table B-3.2.4(f)	500	50	0.400
Table B-3.2.4(g)	500	150	0.044
Table B-3.2.4(h)	500	300	0.011
Table B-3.2.4(i)	500	500	0.004
Table B-3.2.4(j)	500	600	0.003
Table B-3.2.4(k)	750	50	0.400
Table B-3.2.4(l)	750	150	0.044
Table B-3.2.4(m)	750	300	0.011
Table B-3.2.4(n)	750	500	0.004
Table B-3.2.4(o)	750	600	0.003
Table B-3.2.4(p)	1000	50	0.400
Table B-3.2.4(q)	1000	150	0.044
Table B-3.2.4(r)	1000	300	0.011
Table B-3.2.4(s)	1000	500	0.004
Table B-3.2.4(t)	1000	600	0.003
Table B-3.2.4(u)	2000	50	0.400
Table B-3.2.4(v)	2000	150	0.044
Table B-3.2.4(w)	2000	300	0.011
Table B-3.2.4(x)	2000	500	0.004
Table B-3.2.4(y)	2000	600	0.003

Table B-3.2.4(a)
Q_d, Threshold Fire Size at Response: 250 Btu/sec
t_g: 50 seconds to 1000 Btu/sec
α: 0.400 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	7	5	2	0	0	0	0
25	56	60	6	3	1	0	0	0	0
25	56	80	5	2	0	0	0	0	0
25	56	100	4	2	0	0	0	0	0
25	56	120	4	1	0	0	0	0	0
25	56	140	3	1	0	0	0	0	0
50	112	40	5	3	1	0	0	0	0
50	112	60	4	2	0	0	0	0	0
50	112	80	3	1	0	0	0	0	0
50	112	100	3	0	0	0	0	0	0
50	112	120	2	0	0	0	0	0	0
50	112	140	2	0	0	0	0	0	0
75	168	40	4	2	0	0	0	0	0
75	168	60	3	1	0	0	0	0	0
75	168	80	2	0	0	0	0	0	0
75	168	100	2	0	0	0	0	0	0
75	168	120	2	0	0	0	0	0	0
75	168	140	1	0	0	0	0	0	0
100	224	40	3	1	0	0	0	0	0
100	224	60	2	0	0	0	0	0	0
100	224	80	2	0	0	0	0	0	0
100	224	100	1	0	0	0	0	0	0
100	224	120	1	0	0	0	0	0	0
100	224	140	1	0	0	0	0	0	0
125	280	40	3	0	0	0	0	0	0
125	280	60	2	0	0	0	0	0	0
125	280	80	1	0	0	0	0	0	0
125	280	100	1	0	0	0	0	0	0
125	280	120	0	0	0	0	0	0	0
125	280	140	0	0	0	0	0	0	0
150	335	40	2	0	0	0	0	0	0
150	335	60	2	0	0	0	0	0	0
150	335	80	1	0	0	0	0	0	0
150	335	100	0	0	0	0	0	0	0
150	335	120	0	0	0	0	0	0	0
150	335	140	0	0	0	0	0	0	0
175	391	40	2	0	0	0	0	0	0
175	391	60	1	0	0	0	0	0	0
175	391	80	1	0	0	0	0	0	0
175	391	100	0	0	0	0	0	0	0
175	391	120	0	0	0	0	0	0	0
175	391	140	0	0	0	0	0	0	0
200	447	40	2	0	0	0	0	0	0
200	447	60	1	0	0	0	0	0	0
200	447	80	0	0	0	0	0	0	0
200	447	100	0	0	0	0	0	0	0
200	447	120	0	0	0	0	0	0	0
200	447	140	0	0	0	0	0	0	0
225	503	40	2	0	0	0	0	0	0
225	503	60	1	0	0	0	0	0	0
225	503	80	0	0	0	0	0	0	0
225	503	100	0	0	0	0	0	0	0
225	503	120	0	0	0	0	0	0	0
225	503	140	0	0	0	0	0	0	0
250	559	40	2	0	0	0	0	0	0
250	559	60	0	0	0	0	0	0	0
250	559	80	0	0	0	0	0	0	0
250	559	100	0	0	0	0	0	0	0
250	559	120	0	0	0	0	0	0	0
250	559	140	0	0	0	0	0	0	0
275	615	40	1	0	0	0	0	0	0
275	615	60	0	0	0	0	0	0	0
275	615	80	0	0	0	0	0	0	0
275	615	100	0	0	0	0	0	0	0
275	615	120	0	0	0	0	0	0	0
275	615	140	0	0	0	0	0	0	0
300	671	40	1	0	0	0	0	0	0
300	671	60	0	0	0	0	0	0	0
300	671	80	0	0	0	0	0	0	0
300	671	100	0	0	0	0	0	0	0
300	671	120	0	0	0	0	0	0	0
300	671	140	0	0	0	0	0	0	0
325	727	40	1	0	0	0	0	0	0
325	727	60	0	0	0	0	0	0	0
325	727	80	0	0	0	0	0	0	0
325	727	100	0	0	0	0	0	0	0
325	727	120	0	0	0	0	0	0	0
325	727	140	0	0	0	0	0	0	0
350	783	40	1	0	0	0	0	0	0
350	783	60	0	0	0	0	0	0	0
350	783	80	0	0	0	0	0	0	0
350	783	100	0	0	0	0	0	0	0
350	783	120	0	0	0	0	0	0	0
350	783	140	0	0	0	0	0	0	0
375	839	40	0	0	0	0	0	0	0
375	839	60	0	0	0	0	0	0	0
375	839	80	0	0	0	0	0	0	0
375	839	100	0	0	0	0	0	0	0
375	839	120	0	0	0	0	0	0	0
375	839	140	0	0	0	0	0	0	0
400	894	40	0	0	0	0	0	0	0
400	894	60	0	0	0	0	0	0	0
400	894	80	0	0	0	0	0	0	0
400	894	100	0	0	0	0	0	0	0
400	894	120	0	0	0	0	0	0	0
400	894	140	0	0	0	0	0	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m; 1000 Btu/sec = 1055 kW.

Table B-3.2.4(b)
Q_d, Threshold Fire Size at Response: 250 Btu/sec
t_g: 150 Seconds to 1000 Btu/sec
α: 0.044 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	15	12	9	6	3	0	0
25	56	60	12	9	6	3	0	0	0
25	56	80	10	7	4	1	0	0	0
25	56	100	9	6	2	0	0	0	0
25	56	120	8	4	1	0	0	0	0
25	56	140	7	4	1	0	0	0	0
50	112	40	11	9	6	3	1	0	0
50	112	60	9	6	3	1	0	0	0
50	112	80	7	5	2	0	0	0	0
50	112	100	6	4	1	0	0	0	0
50	112	120	6	3	1	0	0	0	0
50	112	140	5	2	0	0	0	0	0
75	168	40	9	7	4	2	0	0	0
75	168	60	7	5	2	0	0	0	0
75	168	80	6	3	1	0	0	0	0
75	168	100	5	3	0	0	0	0	0
75	168	120	4	2	0	0	0	0	0
75	168	140	4	1	0	0	0	0	0
100	224	40	8	6	3	1	0	0	0
100	224	60	6	4	2	0	0	0	0
100	224	80	5	3	1	0	0	0	0
100	224	100	4	2	0	0	0	0	0
100	224	120	4	1	0	0	0	0	0
100	224	140	3	1	0	0	0	0	0
125	280	40	7	5	2	1	0	0	0
125	280	60	5	3	1	0	0	0	0
125	280	80	4	2	0	0	0	0	0
125	280	100	4	1	0	0	0	0	0
125	280	120	3	1	0	0	0	0	0
125	280	140	3	0	0	0	0	0	0
150	335	40	6	4	2	0	0	0	0
150	335	60	5	2	1	0	0	0	0
150	335	80	4	2	0	0	0	0	0
150	335	100	3	1	0	0	0	0	0
150	335	120	3	0	0	0	0	0	0
150	335	140	2	0	0	0	0	0	0
175	391	40	6	3	1	0	0	0	0
175	391	60	4	2	0	0	0	0	0
175	391	80	3	1	0	0	0	0	0
175	391	100	3	1	0	0	0	0	0
175	391	120	2	0	0	0	0	0	0
175	391	140	2	0	0	0	0	0	0
200	447	40	5	3	1	0	0	0	0
200	447	60	4	2	0	0	0	0	0
200	447	80	3	1	0	0	0	0	0
200	447	100	3	0	0	0	0	0	0
200	447	120	2	0	0	0	0	0	0
200	447	140	2	0	0	0	0	0	0
225	503	40	5	3	1	0	0	0	0
225	503	60	4	2	0	0	0	0	0
225	503	80	3	1	0	0	0	0	0
225	503	100	2	0	0	0	0	0	0
225	503	120	2	0	0	0	0	0	0
225	503	140	2	0	0	0	0	0	0
250	559	40	5	2	0	0	0	0	0
250	559	60	3	1	0	0	0	0	0
250	559	80	3	0	0	0	0	0	0
250	559	100	2	0	0	0	0	0	0
250	559	120	2	0	0	0	0	0	0
250	559	140	1	0	0	0	0	0	0
275	615	40	4	2	0	0	0	0	0
275	615	60	3	1	0	0	0	0	0
275	615	80	2	0	0	0	0	0	0
275	615	100	2	0	0	0	0	0	0
275	615	120	2	0	0	0	0	0	0
275	615	140	1	0	0	0	0	0	0
300	671	40	4	2	0	0	0	0	0
300	671	60	3	1	0	0	0	0	0
300	671	80	2	0	0	0	0	0	0
300	671	100	2	0	0	0	0	0	0
300	671	120	1	0	0	0	0	0	0
300	671	140	1	0	0	0	0	0	0
325	727	40	4	2	0	0	0	0	0
325	727	60	3	1	0	0	0	0	0
325	727	80	2	0	0	0	0	0	0
325	727	100	2	0	0	0	0	0	0
325	727	120	1	0	0	0	0	0	0
325	727	140	1	0	0	0	0	0	0
350	783	40	4	2	0	0	0	0	0
350	783	60	3	0	0	0	0	0	0
350	783	80	2	0	0	0	0	0	0
350	783	100	2	0	0	0	0	0	0
350	783	120	1	0	0	0	0	0	0
350	783	140	1	0	0	0	0	0	0
375	839	40	3	1	0	0	0	0	0
375	839	60	2	0	0	0	0	0	0
375	839	80	2	0	0	0	0	0	0
375	839	100	1	0	0	0	0	0	0
375	839	120	1	0	0	0	0	0	0
375	839	140	0	0	0	0	0	0	0
400	894	40	3	1	0	0	0	0	0
400	894	60	2	0	0	0	0	0	0
400	894	80	2	0	0	0	0	0	0
400	894	100	1	0	0	0	0	0	0
400	894	120	1	0	0	0	0	0	0
400	894	140	0	0	0	0	0	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m; 1000 Btu/sec = 1055 kW.

Table B-3.2.4(c)
Q_d, Threshold Fire Size at Response: 250 Btu/sec
t_g: 300 Seconds to 1000 Btu/sec
α: 0.011 Btu/sec^3

τ	RTI	ΔT	Ceiling Height (ft) 4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	21	18	14	10	6	3	0
25	56	60	17	13	9	5	2	0	0
25	56	80	14	10	6	3	0	0	0
25	56	100	12	8	4	1	0	0	0
25	56	120	11	7	3	0	0	0	0
25	56	140	10	6	2	0	0	0	0
50	112	40	17	4	11	7	4	2	0
50	112	60	13	0	7	4	1	0	0
50	112	80	11	8	5	2	0	0	0
50	112	100	10	6	3	0	0	0	0
50	112	120	8	5	2	0	0	0	0
50	112	140	8	4	1	0	0	0	0
75	168	40	14	1	8	6	3	1	0
75	168	60	11	8	5	3	1	0	0
75	168	80	9	6	3	1	0	0	0
75	168	100	8	5	2	0	0	0	0
75	168	120	7	4	1	0	0	0	0
75	168	140	6	3	1	0	0	0	0
100	224	40	12	10	7	4	2	0	0
100	224	60	10	7	4	2	0	0	0
100	224	80	8	5	3	1	0	0	0
100	224	100	7	4	2	0	0	0	0
100	224	120	6	3	1	0	0	0	0
100	224	140	5	3	0	0	0	0	0
125	280	40	11	9	6	3	1	0	0
125	280	60	9	6	3	1	0	0	0
125	280	80	7	4	2	0	0	0	0
125	280	100	6	3	1	0	0	0	0
125	280	120	5	3	1	0	0	0	0
125	280	140	5	2	0	0	0	0	0
150	335	40	10	8	5	3	1	0	0
150	335	60	8	5	3	1	0	0	0
150	335	80	6	4	2	0	0	0	0
150	335	100	6	3	1	0	0	0	0
150	335	120	5	2	0	0	0	0	0
150	335	140	4	2	0	0	0	0	0
175	391	40	9	7	4	2	1	0	0
175	391	60	7	5	2	1	0	0	0
175	391	80	6	3	1	0	0	0	0
175	391	100	5	3	1	0	0	0	0
175	391	120	4	2	0	0	0	0	0
175	391	140	4	1	0	0	0	0	0
200	447	40	9	6	4	2	0	0	0
200	447	60	7	4	2	0	0	0	0
200	447	80	5	3	1	0	0	0	0
200	447	100	5	2	0	0	0	0	0
200	447	120	4	2	0	0	0	0	0
200	447	140	3	1	0	0	0	0	0
225	503	40	8	6	3	2	0	0	0
225	503	60	6	4	2	0	0	0	0
225	503	80	5	3	1	0	0	0	0
225	503	100	4	2	0	0	0	0	0
225	503	120	4	1	0	0	0	0	0
225	503	140	3	1	0	0	0	0	0
250	559	40	8	5	3	1	0	0	0
250	559	60	6	3	1	0	0	0	0
250	559	80	5	2	0	0	0	0	0
250	559	100	4	2	0	0	0	0	0
250	559	120	3	1	0	0	0	0	0
250	559	140	3	1	0	0	0	0	0
275	615	40	7	5	3	1	0	0	0
275	615	60	6	3	1	0	0	0	0
275	615	80	4	2	0	0	0	0	0
275	615	100	4	1	0	0	0	0	0
275	615	120	3	1	0	0	0	0	0
275	615	140	3	0	0	0	0	0	0
300	671	40	7	5	2	1	0	0	0
300	671	60	5	3	1	0	0	0	0
300	671	80	4	2	0	0	0	0	0
300	671	100	3	1	0	0	0	0	0
300	671	120	3	1	0	0	0	0	0
300	671	140	3	0	0	0	0	0	0
325	727	40	7	4	2	0	0	0	0
325	727	60	5	3	1	0	0	0	0
325	727	80	4	2	0	0	0	0	0
325	727	100	3	1	0	0	0	0	0
325	727	120	3	1	0	0	0	0	0
325	727	140	2	0	0	0	0	0	0
350	783	40	6	4	2	0	0	0	0
350	783	60	5	2	1	0	0	0	0
350	783	80	4	2	0	0	0	0	0
350	783	100	3	1	0	0	0	0	0
350	783	120	3	0	0	0	0	0	0
350	783	140	2	0	0	0	0	0	0
375	839	40	6	4	2	0	0	0	0
375	839	60	4	2	0	0	0	0	0
375	839	80	4	1	0	0	0	0	0
375	839	100	3	1	0	0	0	0	0
375	839	120	2	0	0	0	0	0	0
375	839	140	2	0	0	0	0	0	0
400	894	40	6	3	2	0	0	0	0
400	894	60	4	2	0	0	0	0	0
400	894	80	3	1	0	0	0	0	0
400	894	100	3	1	0	0	0	0	0
400	894	120	2	0	0	0	0	0	0
400	894	140	2	0	0	0	0	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI Units: 1 ft = 0.305 m; 1000 Btu/sec = 1055 kW.

Table B-3.2.4(d)
Q_d, Threshold Fire Size at Response: 250 Btu/sec
t_g: 500 Seconds to 1000 Btu/sec
α: 0.004 Btu/sec^5

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	26	22	17	13	9	5	1
25	56	60	20	16	11	7	3	0	0
25	56	80	17	12	8	4	0	0	0
25	56	100	15	10	5	1	0	0	0
25	56	120	13	8	4	0	0	0	0
25	56	140	11	7	2	0	0	0	0
50	112	40	21	18	14	11	7	4	1
50	112	60	17	13	9	6	2	0	0
50	112	80	14	10	6	3	0	0	0
50	112	100	12	8	4	1	0	0	0
50	112	120	11	7	3	0	0	0	0
50	112	140	9	6	2	0	0	0	0
75	168	40	18	15	12	9	6	3	0
75	168	60	14	11	8	5	2	0	0
75	168	80	12	9	5	2	0	0	0
75	168	100	10	7	4	1	0	0	0
75	168	120	9	6	2	0	0	0	0
75	168	140	8	5	1	0	0	0	0
100	224	40	16	14	10	7	4	0	0
100	224	60	13	10	7	4	1	0	0
100	224	80	11	8	4	2	0	0	0
100	224	100	9	6	3	0	0	0	0
100	224	120	8	5	2	0	0	0	0
100	224	140	7	4	1	0	0	0	0
125	280	40	15	12	9	6	4	1	0
125	280	60	12	9	6	3	1	0	0
125	280	80	10	7	4	1	0	0	0
125	280	100	8	5	2	0	0	0	0
125	280	120	7	4	1	0	0	0	0
125	280	140	6	3	1	0	0	0	0
150	335	40	14	11	8	5	3	1	0
150	335	60	11	8	5	3	1	0	0
150	335	80	9	6	3	1	0	0	0
150	335	100	8	5	2	0	0	0	0
150	335	120	7	4	1	0	0	0	0
150	335	140	6	3	1	0	0	0	0
175	391	40	13	10	7	5	2	1	0
175	391	60	10	7	4	2	0	0	0
175	391	80	8	5	3	1	0	0	0
175	391	100	7	4	2	0	0	0	0
175	391	120	6	3	1	0	0	0	0
175	391	140	5	3	0	0	0	0	0
200	447	40	12	9	7	4	2	1	0
200	447	60	9	7	4	2	0	0	0
200	447	80	8	5	2	1	0	0	0
200	447	100	6	4	1	0	0	0	0
200	447	120	6	3	1	0	0	0	0
200	447	140	5	2	0	0	0	0	0
225	503	40	11	9	6	4	2	0	0
225	503	60	9	6	4	1	0	0	0
225	503	80	7	5	2	0	0	0	0
225	503	100	6	3	1	0	0	0	0
225	503	120	5	3	1	0	0	0	0
225	503	140	5	2	0	0	0	0	0
250	559	40	11	8	6	3	1	0	0
250	559	60	8	6	3	1	0	0	0
250	559	80	7	4	2	0	0	0	0
250	559	100	6	3	1	0	0	0	0
250	559	120	5	2	0	0	0	0	0
250	559	140	4	2	0	0	0	0	0
275	615	40	10	8	5	3	1	0	0
275	615	60	8	5	3	1	0	0	0
275	615	80	6	4	2	0	0	0	0
275	615	100	5	3	1	0	0	0	0
275	615	120	5	2	0	0	0	0	0
275	615	140	4	2	0	0	0	0	0
300	671	40	10	1	0	0	7	5	3
300	671	60	7	0	0	0	5	3	1
300	671	80	6	0	0	0	4	1	0
300	671	100	5	0	0	0	3	1	0
300	671	120	4	0	0	0	2	0	0
300	671	140	4	0	0	0	2	0	0
325	727	40	9	1	0	0	7	4	2
325	727	60	7	0	0	0	5	2	1
325	727	80	6	0	0	0	3	1	0
325	727	100	5	0	0	0	2	0	0
325	727	120	4	0	0	0	2	0	0
325	727	140	4	0	0	0	1	0	0
350	783	40	9	1	0	0	6	4	2
350	783	60	7	0	0	0	4	2	0
350	783	80	6	0	0	0	3	1	0
350	783	100	5	0	0	0	2	0	0
350	783	120	4	0	0	0	2	0	0
350	783	140	3	0	0	0	1	0	0
375	839	40	9	0	0	0	6	4	2
375	839	60	6	0	0	0	4	2	0
375	839	80	5	0	0	0	3	1	0
375	839	100	4	0	0	0	2	0	0
375	839	120	4	0	0	0	2	0	0
375	839	140	3	0	0	0	1	0	0
400	894	40	8	0	0	0	6	4	2
400	894	60	6	0	0	0	4	2	0
400	894	80	5	0	0	0	3	1	0
400	894	100	4	0	0	0	2	0	0
400	894	120	4	0	0	0	1	0	0
400	894	140	3	0	0	0	1	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m; 1000 Btu/sec = 1055 kW.

Table B-3.2.4(e)
Q_d, Threshold Fire Size at Response: 250 Btu/sec
t_g: 600 Seconds to 1000 Btu/sec
α: 0.003 Btu/sec^5

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	28	23	18	14	9	5	2
25	56	60	22	17	12	8	4	0	0
25	56	80	18	13	8	4	0	0	0
25	56	100	15	10	6	2	0	0	0
25	56	120	13	8	4	0	0	0	0
25	56	140	12	7	3	0	0	0	0
50	112	40	23	19	15	12	8	4	1
50	112	60	18	14	10	6	3	0	0
50	112	80	15	11	7	3	0	0	0
50	112	100	13	9	5	1	0	0	0
50	112	120	11	7	3	0	0	0	0
50	112	140	10	6	2	0	0	0	0
75	168	40	20	17	13	10	7	3	1
75	168	60	16	12	9	5	2	0	0
75	168	80	13	10	6	3	0	0	0
75	168	100	11	8	4	1	0	0	0
75	168	120	10	6	3	0	0	0	0
75	168	140	9	5	2	0	0	0	0
100	224	40	18	15	12	9	5	3	0
100	224	60	14	11	8	4	2	0	0
100	224	80	12	8	5	2	0	0	0
100	224	100	10	7	4	1	0	0	0
100	224	120	9	5	2	0	0	0	0
100	224	140	8	5	1	0	0	0	0
125	280	40	16	14	10	7	5	2	0
125	280	60	13	10	7	4	1	0	0
125	280	80	11	8	4	2	0	0	0
125	280	100	9	6	3	0	0	0	0
125	280	120	8	5	2	0	0	0	0
125	280	140	7	4	1	0	0	0	0
150	335	40	15	12	9	7	4	2	0
150	335	60	12	9	6	3	1	0	0
150	335	80	10	7	4	1	0	0	0
150	335	100	8	5	3	0	0	0	0
150	335	120	7	4	2	0	0	0	0
150	335	140	7	4	1	0	0	0	0
175	391	40	14	11	9	6	3	1	0
175	391	60	11	8	5	3	1	0	0
175	391	80	9	6	3	1	0	0	0
175	391	100	8	5	2	0	0	0	0
175	391	120	7	4	1	0	0	0	0
175	391	140	6	3	1	0	0	0	0
200	447	40	13	11	8	5	3	1	0
200	447	60	10	8	5	2	1	0	0
200	447	80	8	6	3	1	0	0	0
200	447	100	7	4	2	0	0	0	0
200	447	120	6	4	1	0	0	0	0
200	447	140	6	3	1	0	0	0	0
225	503	40	12	10	7	5	2	1	0
225	503	60	10	7	4	2	0	0	0
225	503	80	8	5	3	1	0	0	0
225	503	100	7	4	2	0	0	0	0
225	503	120	6	3	1	0	0	0	0
225	503	140	5	3	0	0	0	0	0
250	559	40	12	9	7	4	2	1	0
250	559	60	9	7	4	2	0	0	0
250	559	80	8	5	2	1	0	0	0
250	559	100	6	4	1	0	0	0	0
250	559	120	6	3	1	0	0	0	0
250	559	140	5	2	0	0	0	0	0
275	615	40	11	9	6	4	2	0	0
275	615	60	9	6	4	1	0	0	0
275	615	80	7	5	2	0	0	0	0
275	615	100	6	3	1	0	0	0	0
275	615	120	5	3	1	0	0	0	0
275	615	140	5	2	0	0	0	0	0
300	671	40	11	8	6	3	1	0	0
300	671	60	8	6	3	1	0	0	0
300	671	80	7	4	2	0	0	0	0
300	671	100	6	3	1	0	0	0	0
300	671	120	5	2	0	0	0	0	0
300	671	140	4	2	0	0	0	0	0
325	727	40	10	8	5	3	1	0	0
325	727	60	8	5	3	1	0	0	0
325	727	80	6	4	2	0	0	0	0
325	727	100	6	3	1	0	0	0	0
325	727	120	5	2	0	0	0	0	0
325	727	140	4	2	0	0	0	0	0
350	783	40	10	7	5	3	1	0	0
350	783	60	8	5	3	1	0	0	0
350	783	80	6	4	2	0	0	0	0
350	783	100	5	3	1	0	0	0	0
350	783	120	5	2	0	0	0	0	0
350	783	140	4	2	0	0	0	0	0
375	839	40	10	7	5	3	1	0	0
375	839	60	7	5	3	1	0	0	0
375	839	80	6	3	1	0	0	0	0
375	839	100	5	3	1	0	0	0	0
375	839	120	4	2	0	0	0	0	0
375	839	140	4	1	0	0	0	0	0
400	894	40	9	7	4	2	1	0	0
400	894	60	7	5	2	1	0	0	0
400	894	80	6	3	1	0	0	0	0
400	894	100	5	2	0	0	0	0	0
400	894	120	4	2	0	0	0	0	0
400	894	140	4	1	0	0	0	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m; 1000 Btu/sec = 1055 kW.

Table B-3.2.4(f)
Q_d, Threshold Fire Size at Response: 500 Btu/sec
t_g: 50 Seconds to 1000 Btu/sec
α: 0.400 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	13	11	8	5	2	1	0
25	56	60	11	8	5	3	1	0	0
25	56	80	9	6	4	1	0	0	0
25	56	100	8	5	3	1	0	0	0
25	56	120	7	4	2	0	0	0	0
25	56	140	7	4	1	0	0	0	0
50	112	40	10	7	5	2	1	0	0
50	112	60	8	5	3	1	0	0	0
50	112	80	7	4	2	0	0	0	0
50	112	100	6	3	1	0	0	0	0
50	112	120	5	3	0	0	0	0	0
50	112	140	5	2	0	0	0	0	0
75	168	40	8	6	3	1	0	0	0
75	168	60	6	4	2	0	0	0	0
75	168	80	5	3	1	0	0	0	0
75	168	100	4	2	0	0	0	0	0
75	168	120	4	2	0	0	0	0	0
75	168	140	3	1	0	0	0	0	0
100	224	40	7	4	2	0	0	0	0
100	224	60	5	3	1	0	0	0	0
100	224	80	4	2	0	0	0	0	0
100	224	100	4	1	0	0	0	0	0
100	224	120	3	1	0	0	0	0	0
100	224	140	3	0	0	0	0	0	0
125	280	40	6	4	2	0	0	0	0
125	280	60	5	2	0	0	0	0	0
125	280	80	4	2	0	0	0	0	0
125	280	100	3	1	0	0	0	0	0
125	280	120	3	0	0	0	0	0	0
125	280	140	2	0	0	0	0	0	0
150	335	40	5	3	1	0	0	0	0
150	335	60	4	2	0	0	0	0	0
150	335	80	3	1	0	0	0	0	0
150	335	100	3	0	0	0	0	0	0
150	335	120	2	0	0	0	0	0	0
150	335	140	2	0	0	0	0	0	0
175	391	40	5	3	1	0	0	0	0
175	391	60	4	2	0	0	0	0	0
175	391	80	3	1	0	0	0	0	0
175	391	100	2	0	0	0	0	0	0
175	391	120	2	0	0	0	0	0	0
175	391	140	2	0	0	0	0	0	0
200	447	40	5	2	0	0	0	0	0
200	447	60	3	1	0	0	0	0	0
200	447	80	3	0	0	0	0	0	0
200	447	100	2	0	0	0	0	0	0
200	447	120	2	0	0	0	0	0	0
200	447	140	1	0	0	0	0	0	0
225	503	40	4	2	0	0	0	0	0
225	503	60	3	1	0	0	0	0	0
225	503	80	2	0	0	0	0	0	0
225	503	100	2	0	0	0	0	0	0
225	503	120	2	0	0	0	0	0	0
225	503	140	1	0	0	0	0	0	0
250	559	40	4	2	0	0	0	0	0
250	559	60	3	1	0	0	0	0	0
250	559	80	2	0	0	0	0	0	0
250	559	100	2	0	0	0	0	0	0
250	559	120	1	0	0	0	0	0	0
250	559	140	1	0	0	0	0	0	0
275	615	40	4	2	0	0	0	0	0
275	615	60	3	0	0	0	0	0	0
275	615	80	2	0	0	0	0	0	0
275	615	100	2	0	0	0	0	0	0
275	615	120	1	0	0	0	0	0	0
275	615	140	1	0	0	0	0	0	0
300	671	40	3	1	0	0	0	0	0
300	671	60	2	0	0	0	0	0	0
300	671	80	2	0	0	0	0	0	0
300	671	100	1	0	0	0	0	0	0
300	671	120	1	0	0	0	0	0	0
300	671	140	0	0	0	0	0	0	0
325	727	40	3	1	0	0	0	0	0
325	727	60	2	0	0	0	0	0	0
325	727	80	2	0	0	0	0	0	0
325	727	100	1	0	0	0	0	0	0
325	727	120	1	0	0	0	0	0	0
325	727	140	0	0	0	0	0	0	0
350	783	40	3	1	0	0	0	0	0
350	783	60	2	0	0	0	0	0	0
350	783	80	2	0	0	0	0	0	0
350	783	100	1	0	0	0	0	0	0
350	783	120	0	0	0	0	0	0	0
350	783	140	0	0	0	0	0	0	0
375	839	40	3	1	0	0	0	0	0
375	839	60	2	0	0	0	0	0	0
375	839	80	1	0	0	0	0	0	0
375	839	100	1	0	0	0	0	0	0
375	839	120	0	0	0	0	0	0	0
375	839	140	0	0	0	0	0	0	0
400	894	40	3	0	0	0	0	0	0
400	894	60	2	0	0	0	0	0	0
400	894	80	1	0	0	0	0	0	0
400	894	100	1	0	0	0	0	0	0
400	894	120	0	0	0	0	0	0	0
400	894	140	0	0	0	0	0	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m; 1000 Btu/sec = 1055 kW.

Table B-3.2.4(g)
Q_d, Threshold Fire Size at Response: 500 Btu/sec
t_g: 150 Seconds to 1000 Btu/sec
α: 0.400 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	24	22	18	15	11	8	5
25	56	60	20	17	13	10	6	3	0
25	56	80	17	14	10	6	3	0	0
25	56	100	15	11	8	4	1	0	0
25	56	120	13	10	6	3	0	0	0
25	56	140	12	8	5	1	0	0	0
50	112	40	19	16	14	11	8	5	2
50	112	60	15	13	10	7	4	1	0
50	112	80	13	10	7	4	2	0	0
50	112	100	11	9	5	3	0	0	0
50	112	120	10	7	4	1	0	0	0
50	112	140	9	6	3	1	0	0	0
75	168	40	16	14	11	8	5	3	1
75	168	60	13	10	8	5	2	1	0
75	168	80	11	8	5	3	1	0	0
75	168	100	10	7	4	2	0	0	0
75	168	120	8	6	3	1	0	0	0
75	168	140	8	5	2	0	0	0	0
100	224	40	14	12	9	6	4	2	1
100	224	60	11	9	6	4	2	0	0
100	224	80	10	7	4	2	0	0	0
100	224	100	8	6	3	1	0	0	0
100	224	120	7	5	2	0	0	0	0
100	224	140	7	4	2	0	0	0	0
125	280	40	13	10	8	5	3	1	0
125	280	60	10	8	5	3	1	0	0
125	280	80	8	6	3	1	0	0	0
125	280	100	7	5	2	1	0	0	0
125	280	120	6	4	2	0	0	0	0
125	280	140	6	3	1	0	0	0	0
150	335	40	12	9	7	4	2	1	0
150	335	60	9	7	4	2	1	0	0
150	335	80	8	5	3	1	0	0	0
150	335	100	7	4	2	0	0	0	0
150	335	120	6	3	1	0	0	0	0
150	335	140	5	3	1	0	0	0	0
175	391	40	11	8	6	4	2	0	0
175	391	60	8	6	4	2	0	0	0
175	391	80	7	5	2	1	0	0	0
175	391	100	6	4	2	0	0	0	0
175	391	120	5	3	1	0	0	0	0
175	391	140	5	2	0	0	0	0	0
200	447	40	10	8	5	3	1	0	0
200	447	60	8	5	3	1	0	0	0
200	447	80	7	4	2	0	0	0	0
200	447	100	6	3	1	0	0	0	0
200	447	120	5	2	1	0	0	0	0
200	447	140	4	2	0	0	0	0	0
225	503	40	9	7	5	3	1	0	0
225	503	60	7	5	3	1	0	0	0
225	503	80	6	4	2	0	0	0	0
225	503	100	5	3	1	0	0	0	0
225	503	120	5	2	0	0	0	0	0
225	503	140	4	2	0	0	0	0	0
250	559	40	9	7	4	2	1	0	0
250	559	60	7	5	2	1	0	0	0
250	559	80	6	3	1	0	0	0	0
250	559	100	5	3	1	0	0	0	0
250	559	120	4	2	1	0	0	0	0
250	559	140	4	2	0	0	0	0	0
275	615	40	8	6	4	2	0	0	0
275	615	60	7	4	2	0	0	0	0
275	615	80	5	3	1	0	0	0	0
275	615	100	5	2	0	0	0	0	0
275	615	120	4	2	0	0	0	0	0
275	615	140	3	1	0	0	0	0	0
300	671	40	8	6	3	2	0	0	0
300	671	60	6	4	2	0	0	0	0
300	671	80	5	3	1	0	0	0	0
300	671	100	4	2	0	0	0	0	0
300	671	120	4	2	0	0	0	0	0
300	671	140	3	1	0	0	0	0	0
325	727	40	8	5	3	1	0	0	0
325	727	60	6	4	2	0	0	0	0
325	727	80	5	3	1	0	0	0	0
325	727	100	4	2	0	0	0	0	0
325	727	120	3	1	0	0	0	0	0
325	727	140	3	1	0	0	0	0	0
350	783	40	7	5	3	1	0	0	0
350	783	60	6	3	1	0	0	0	0
350	783	80	5	2	0	0	0	0	0
350	783	100	4	2	0	0	0	0	0
350	783	120	3	1	0	0	0	0	0
350	783	140	3	1	0	0	0	0	0
375	839	40	7	5	3	1	0	0	0
375	839	60	5	3	1	0	0	0	0
375	839	80	4	2	0	0	0	0	0
375	839	100	4	2	0	0	0	0	0
375	839	120	3	1	0	0	0	0	0
375	839	140	3	0	0	0	0	0	0
400	894	40	7	4	2	1	0	0	0
400	894	60	5	3	1	0	0	0	0
400	894	80	4	2	0	0	0	0	0
400	894	100	3	1	0	0	0	0	0
400	894	120	3	1	0	0	0	0	0
400	894	140	3	0	0	0	0	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI uits: 1 ft = 0.305 m; 1000 Btu/sec = 1055 kW.

Table B-3.2.4(h)
Q_d, Threshold Fire Size at Response: 500 Btu/sec
t_g: 300 Seconds to 1000 Btu/sec
α: 0.011 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	34	30	25	21	17	13	9
25	56	60	27	23	18	14	10	6	2
25	56	80	23	18	14	9	5	2	0
25	56	100	20	15	11	7	3	0	0
25	56	120	18	13	8	4	1	0	0
25	56	140	16	11	7	3	0	0	0
50	112	40	27	24	21	17	14	10	7
50	112	60	22	18	15	11	8	4	1
50	112	80	18	15	11	8	4	1	0
50	112	100	16	12	9	5	2	0	0
50	112	120	14	11	7	3	0	0	0
50	112	140	13	9	5	2	0	0	0
75	168	40	23	21	18	14	11	8	5
75	168	60	19	16	13	9	6	3	1
75	168	80	16	13	9	6	3	1	0
75	168	100	14	11	7	4	1	0	0
75	168	120	12	9	6	3	0	0	0
75	168	140	11	8	4	1	0	0	0
100	224	40	21	18	15	12	9	6	4
100	224	60	17	14	11	8	5	2	0
100	224	80	14	11	8	5	2	0	0
100	224	100	12	9	6	3	1	0	0
100	224	120	11	8	5	2	0	0	0
100	224	140	10	7	4	1	0	0	0
125	280	40	19	16	14	11	8	5	3
125	280	60	15	12	10	7	4	2	0
125	280	80	13	10	7	4	2	0	0
125	280	100	11	8	5	3	1	0	0
125	280	120	10	7	4	2	0	0	0
125	280	140	9	6	3	1	0	0	0
150	335	40	17	15	12	10	7	4	2
150	335	60	14	11	8	6	3	1	0
150	335	80	12	9	6	4	1	0	0
150	335	100	10	7	5	2	0	0	0
150	335	120	9	6	3	1	0	0	0
150	335	140	8	5	3	1	0	0	0
175	391	40	16	14	11	9	6	4	2
175	391	60	13	10	8	5	3	1	0
175	391	80	11	8	5	3	1	0	0
175	391	100	9	7	4	2	0	0	0
175	391	120	8	6	3	1	0	0	0
175	391	140	7	5	2	0	0	0	0
200	447	40	15	13	10	8	5	3	1
200	447	60	12	10	7	4	2	1	0
200	447	80	10	8	5	3	1	0	0
200	447	100	9	6	4	1	0	0	0
200	447	120	8	5	3	1	0	0	0
200	447	140	7	4	2	0	0	0	0
225	503	40	14	12	10	7	5	3	1
225	503	60	11	9	6	4	2	0	0
225	503	80	10	7	4	2	1	0	0
225	503	100	8	6	3	1	0	0	0
225	503	120	7	5	2	1	0	0	0
225	503	140	6	4	2	0	0	0	0
250	559	40	14	11	9	6	4	2	1
250	559	60	11	8	6	3	2	0	0
250	559	80	9	6	4	2	0	0	0
250	559	100	8	5	3	1	0	0	0
250	559	120	7	4	2	0	0	0	0
250	559	140	6	4	1	0	0	0	0
275	615	40	13	11	8	6	4	2	1
275	615	60	10	8	5	3	1	0	0
275	615	80	9	6	4	2	0	0	0
275	615	100	7	5	3	1	0	0	0
275	615	120	6	4	2	0	0	0	0
275	615	140	6	3	1	0	0	0	0
300	671	40	12	10	8	5	3	2	0
300	671	60	10	7	5	3	1	0	0
300	671	80	8	6	3	1	0	0	0
300	671	100	7	5	2	1	0	0	0
300	671	120	6	4	2	0	0	0	0
300	671	140	6	3	1	0	0	0	0
325	727	40	12	10	7	5	3	1	0
325	727	60	9	7	5	2	1	0	0
325	727	80	8	5	3	1	0	0	0
325	727	100	7	4	2	0	0	0	0
325	727	120	6	3	1	0	0	0	0
325	727	140	5	3	1	0	0	0	0
350	783	40	12	9	7	4	3	1	0
350	783	60	9	7	4	2	1	0	0
350	783	80	7	5	3	1	0	0	0
350	783	100	6	4	2	0	0	0	0
350	783	120	6	3	1	0	0	0	0
350	783	140	5	3	1	0	0	0	0
375	839	40	11	9	6	4	2	1	0
375	839	60	9	6	4	2	0	0	0
375	839	80	7	5	3	1	0	0	0
375	839	100	6	4	2	0	0	0	0
375	839	120	5	3	1	0	0	0	0
375	839	140	5	2	0	0	0	0	0
400	894	40	11	8	6	4	2	1	0
400	894	60	8	6	4	2	0	0	0
400	894	80	7	4	2	1	0	0	0
400	894	100	6	3	1	0	0	0	0
400	894	120	5	3	1	0	0	0	0
400	894	140	5	2	0	0	0	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m; 1000 Btu/sec = 1055 kW.

Table B-3.2.4(i)
Q_d, Threshold Fire Size at Response: 500 Btu/sec
t_g: 500 Seconds to 1000 Btu/sec
α: 0.004 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	41	35	30	25	20	16	11
25	56	60	32	26	21	16	12	7	3
25	56	80	27	21	16	11	7	3	0
25	56	100	23	17	12	8	4	0	0
25	56	120	20	15	10	5	1	0	0
25	56	140	18	13	8	3	0	0	0
50	112	40	34	30	26	22	18	14	10
50	112	60	27	23	18	14	10	6	3
50	112	80	23	18	14	10	6	2	0
50	112	100	20	15	11	7	3	0	0
50	112	120	17	13	9	5	1	0	0
50	112	140	16	11	7	3	0	0	0
75	168	40	30	26	23	19	15	12	8
75	168	60	24	20	16	13	9	5	2
75	168	80	20	16	12	9	5	2	0
75	168	100	17	14	10	6	2	0	0
75	168	120	15	11	8	4	1	0	0
75	168	140	14	10	6	2	0	0	0
100	224	40	27	24	20	17	14	10	7
100	224	60	21	18	15	11	8	4	2
100	224	80	18	15	11	8	4	1	0
100	224	100	16	12	9	5	2	0	0
100	224	120	14	10	7	5	3	0	0
100	224	140	13	9	5	2	0	0	0
125	280	40	25	22	19	15	12	9	6
125	280	60	20	17	13	10	7	4	1
125	280	80	16	13	10	7	4	1	0
125	280	100	14	11	8	5	2	0	0
125	280	120	13	9	6	3	0	0	0
125	280	140	11	8	5	2	0	0	0
150	335	40	23	20	17	14	11	8	5
150	335	60	18	15	12	9	6	3	1
150	335	80	15	12	9	6	3	1	0
150	335	100	13	10	7	4	1	0	0
150	335	120	12	9	5	3	0	0	0
150	335	140	11	7	4	1	0	0	0
175	391	40	21	19	16	13	10	7	4
175	391	60	17	14	11	8	5	3	1
175	391	80	14	11	8	5	3	1	0
175	391	100	12	9	6	3	1	0	0
175	391	120	11	8	5	2	0	0	0
175	391	140	10	7	4	1	0	0	0
200	447	40	20	18	15	12	9	6	4
200	447	60	16	13	10	7	5	2	1
200	447	80	13	11	8	5	2	0	0
200	447	100	12	9	6	3	1	0	0
200	447	120	10	7	4	2	0	0	0
200	447	140	9	6	3	1	0	0	0
225	503	40	19	17	14	11	8	6	3
225	503	60	15	13	10	7	4	2	0
225	503	80	13	10	7	4	2	0	0
225	503	100	11	8	5	3	1	0	0
225	503	120	10	7	4	2	0	0	0
225	503	140	9	6	3	1	0	0	0
250	559	40	18	16	13	10	8	5	3
250	559	60	14	12	9	6	4	2	0
250	559	80	12	9	7	4	2	0	0
250	559	100	10	8	5	2	1	0	0
250	559	120	9	6	4	1	0	0	0
250	559	140	8	6	3	1	0	0	0
275	615	40	17	15	12	10	7	5	2
275	615	60	14	11	8	6	3	1	0
275	615	80	12	9	6	3	1	0	0
275	615	100	10	7	5	2	0	0	0
275	615	120	9	6	3	1	0	0	0
275	615	140	8	5	3	1	0	0	0
300	671	40	17	14	12	9	6	4	2
300	671	60	13	11	8	5	3	1	0
300	671	80	11	8	6	3	1	0	0
300	671	100	10	7	4	2	0	0	0
300	671	120	8	6	3	1	0	0	0
300	671	140	8	5	2	0	0	0	0
325	727	40	16	14	11	9	6	4	2
325	727	60	13	10	8	5	3	1	0
325	727	80	11	8	5	3	1	0	0
325	727	100	9	7	4	2	0	0	0
325	727	120	8	5	3	1	0	0	0
325	727	140	7	5	2	0	0	0	0
350	783	40	16	13	11	8	6	3	2
350	783	60	12	10	7	5	2	1	0
350	783	80	10	8	5	3	1	0	0
350	783	100	9	6	4	2	0	0	0
350	783	120	8	5	3	1	0	0	0
350	783	140	7	4	2	0	0	0	0
375	839	40	15	13	10	8	5	3	1
375	839	60	12	9	7	4	2	1	0
375	839	80	10	7	5	2	1	0	0
375	839	100	8	6	3	1	0	0	0
375	839	120	7	5	2	1	0	0	0
375	839	140	7	4	2	0	0	0	0
400	894	40	14	12	10	7	5	3	1
400	894	60	11	9	6	4	2	1	0
400	894	80	9	7	4	2	1	0	0
400	894	100	8	6	3	1	0	0	0
400	894	120	7	5	2	1	0	0	0
400	894	140	6	4	2	0	0	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m; 1000 Btu/sec = 1055 kW.

Table B-3.2.4(j)
Q_d, Threshold Fire Size at Response: 500 Btu/sec
t_g: 600 Seconds to 1000 Btu/sec
α: 0.003 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	43	37	31	26	21	17	12
25	56	60	34	27	22	17	12	8	4
25	56	80	28	22	16	12	7	3	0
25	56	100	24	18	13	8	4	0	0
25	56	120	21	15	10	6	1	0	0
25	56	140	19	13	8	4	0	0	0
50	112	40	36	32	27	23	19	15	11
50	112	60	29	24	20	15	11	7	3
50	112	80	24	19	15	10	6	2	0
50	112	100	21	16	11	7	3	0	0
50	112	120	18	14	9	5	1	0	0
50	112	140	17	12	7	3	0	0	0
75	168	40	32	29	25	21	17	13	9
75	168	60	26	22	18	14	10	6	3
75	168	80	21	17	13	9	6	2	0
75	168	100	19	14	10	6	3	0	0
75	168	120	17	12	8	4	1	0	0
75	168	140	15	11	7	3	0	0	0
100	224	40	29	26	22	19	15	12	8
100	224	60	23	20	16	12	9	5	2
100	224	80	19	16	12	8	5	2	0
100	224	100	17	13	9	6	2	0	0
100	224	120	15	11	7	4	1	0	0
100	224	140	14	10	6	2	0	0	0
125	280	40	27	24	20	17	14	10	7
125	280	60	21	18	15	11	8	5	2
125	280	80	18	15	11	8	4	1	0
125	280	100	16	12	9	5	2	0	0
125	280	120	14	10	7	3	1	0	0
125	280	140	12	9	5	2	0	0	0
150	335	40	25	22	19	16	13	9	6
150	335	60	20	17	14	10	7	4	1
150	335	80	17	14	10	7	4	1	0
150	335	100	15	11	8	5	2	0	0
150	335	120	13	10	6	3	0	0	0
150	335	140	12	8	5	2	0	0	0
175	391	40	23	21	18	15	12	8	6
175	391	60	19	16	13	9	6	3	1
175	391	80	16	13	9	6	3	1	0
175	391	100	14	10	7	4	1	0	0
175	391	120	12	9	6	3	0	0	0
175	391	140	11	8	4	2	0	0	0
200	447	40	22	19	17	14	11	8	5
200	447	60	18	15	12	9	6	3	1
200	447	80	15	12	9	6	3	1	0
200	447	100	13	10	7	4	1	0	0
200	447	120	11	8	5	2	0	0	0
200	447	140	10	7	4	1	0	0	0
225	503	40	21	18	16	13	10	7	4
225	503	60	17	14	11	8	5	3	1
225	503	80	14	11	8	5	3	1	0
225	503	100	12	9	6	3	1	0	0
225	503	120	11	8	5	2	0	0	0
225	503	140	10	7	4	1	0	0	0
250	559	40	20	18	15	12	9	6	4
250	559	60	16	13	10	7	5	2	1
250	559	80	13	11	8	5	2	0	0
250	559	100	12	9	6	3	1	0	0
250	559	120	10	7	4	2	0	0	0
250	559	140	9	6	3	1	0	0	0
275	615	40	19	17	14	11	8	6	3
275	615	60	15	13	10	7	4	2	0
275	615	80	13	10	7	4	2	0	0
275	615	100	11	8	5	3	1	0	0
275	615	120	10	7	4	2	0	0	0
275	615	140	9	6	3	1	0	0	0
300	671	40	18	16	13	11	8	5	3
300	671	60	15	12	9	6	4	2	0
300	671	80	12	10	7	4	2	0	0
300	671	100	11	8	5	2	1	0	0
300	671	120	9	7	4	1	0	0	0
300	671	140	8	6	3	1	0	0	0
325	727	40	18	15	13	10	7	5	3
325	727	60	14	11	9	6	4	2	0
325	727	80	12	9	6	4	2	0	0
325	727	100	10	7	5	2	1	0	0
325	727	120	9	6	4	1	0	0	0
325	727	140	8	5	3	1	0	0	0
350	783	40	17	15	12	9	7	4	2
350	783	60	13	11	8	6	3	1	0
350	783	80	11	9	6	3	1	0	0
350	783	100	10	7	4	2	0	0	0
350	783	120	9	6	3	1	0	0	0
350	783	140	8	5	2	1	0	0	0
375	839	40	17	14	12	9	6	4	2
375	839	60	13	11	8	5	3	1	0
375	839	80	11	8	6	3	1	0	0
375	839	100	9	7	4	2	0	0	0
375	839	120	8	6	3	1	0	0	0
375	839	140	7	5	2	0	0	0	0
400	894	40	16	14	11	9	6	4	2
400	894	60	13	10	7	5	3	1	0
400	894	80	11	8	5	3	1	0	0
400	894	100	9	6	4	2	0	0	0
400	894	120	8	5	3	1	0	0	0
400	894	140	7	5	2	0	0	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m;1000 Btu/sec = 1055 kW.

Table B-3.2.4(k)
Q_d, Threshold Fire Size at Response: 750 Btu/sec
t_g: 50 Seconds to 1000 Btu/sec
α: 0.400 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	18	15	13	10	7	4	2
25	56	60	15	12	9	6	4	1	0
25	56	80	13	10	7	4	2	0	0
25	56	100	11	9	6	3	1	0	0
25	56	120	10	7	4	2	0	0	0
25	56	140	9	6	4	1	0	0	0
50	112	40	14	11	9	6	3	2	0
50	112	60	11	9	6	3	1	0	0
50	112	80	9	7	4	2	0	0	0
50	112	100	8	6	3	1	0	0	0
50	112	120	7	5	2	0	0	0	0
50	112	140	7	4	2	0	0	0	0
75	168	40	11	9	6	4	2	0	0
75	168	60	9	7	4	2	0	0	0
75	168	80	8	5	3	1	0	0	0
75	168	100	7	4	2	0	0	0	0
75	168	120	6	3	1	0	0	0	0
75	168	140	5	3	1	0	0	0	0
100	224	40	10	7	5	3	1	0	0
100	224	60	8	5	3	1	0	0	0
100	224	80	7	4	2	0	0	0	0
100	224	100	6	3	1	0	0	0	0
100	224	120	5	3	1	0	0	0	0
100	224	140	4	2	0	0	0	0	0
125	280	40	9	6	4	2	0	0	0
125	280	60	7	5	2	1	0	0	0
125	280	80	6	3	1	0	0	0	0
125	280	100	5	3	1	0	0	0	0
125	280	120	4	2	0	0	0	0	0
125	280	140	4	2	0	0	0	0	0
150	335	40	8	6	3	1	0	0	0
150	335	60	6	4	2	0	0	0	0
150	335	80	5	3	1	0	0	0	0
150	335	100	4	2	0	0	0	0	0
150	335	120	4	2	0	0	0	0	0
150	335	140	3	1	0	0	0	0	0
175	391	40	7	5	3	1	0	0	0
175	391	60	6	3	1	0	0	0	0
175	391	80	5	2	0	0	0	0	0
175	391	100	4	2	0	0	0	0	0
175	391	120	3	1	0	0	0	0	0
175	391	140	3	1	0	0	0	0	0
200	447	40	7	4	2	1	0	0	0
200	447	60	5	3	1	0	0	0	0
200	447	80	4	2	0	0	0	0	0
200	447	100	4	1	0	0	0	0	0
200	447	120	3	1	0	0	0	0	0
200	447	140	3	0	0	0	0	0	0
225	503	40	6	4	2	0	0	0	0
225	503	60	5	3	1	0	0	0	0
225	503	80	4	2	0	0	0	0	0
225	503	100	3	1	0	0	0	0	0
225	503	120	3	1	0	0	0	0	0
225	503	140	2	0	0	0	0	0	0
250	559	40	6	4	2	0	0	0	0
250	559	60	4	2	0	0	0	0	0
250	559	80	4	2	0	0	0	0	0
250	559	100	3	1	0	0	0	0	0
250	559	120	3	0	0	0	0	0	0
250	559	140	2	0	0	0	0	0	0
275	615	40	6	3	1	0	0	0	0
275	615	60	4	2	0	0	0	0	0
275	615	80	3	1	0	0	0	0	0
275	615	100	3	1	0	0	0	0	0
275	615	120	2	0	0	0	0	0	0
275	615	140	2	0	0	0	0	0	0
300	671	40	5	3	1	0	0	0	0
300	671	60	4	2	0	0	0	0	0
300	671	80	3	1	0	0	0	0	0
300	671	100	3	0	0	0	0	0	0
300	671	120	2	0	0	0	0	0	0
300	671	140	2	0	0	0	0	0	0
325	727	40	5	3	1	0	0	0	0
325	727	60	4	2	0	0	0	0	0
325	727	80	3	1	0	0	0	0	0
325	727	100	2	0	0	0	0	0	0
325	727	120	2	0	0	0	0	0	0
325	727	140	2	0	0	0	0	0	0
350	783	40	5	3	1	0	0	0	0
350	783	60	4	1	0	0	0	0	0
350	783	80	3	1	0	0	0	0	0
350	783	100	2	0	0	0	0	0	0
350	783	120	2	0	0	0	0	0	0
350	783	140	2	0	0	0	0	0	0
375	839	40	5	2	0	0	0	0	0
375	839	60	3	1	0	0	0	0	0
375	839	80	3	0	0	0	0	0	0
375	839	100	2	0	0	0	0	0	0
375	839	120	2	0	0	0	0	0	0
375	839	140	1	0	0	0	0	0	0
400	894	40	4	2	0	0	0	0	0
400	894	60	3	1	0	0	0	0	0
400	894	80	2	0	0	0	0	0	0
400	894	100	2	0	0	0	0	0	0
400	894	120	2	0	0	0	0	0	0
400	894	140	1	0	0	0	0	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m;1000 Btu/sec = 1055 kW.

Table B-3.2.4(l)
Q_d, Threshold Fire Size at Response: 750 Btu/sec
t_g: 150 Seconds to 1000 Btu/sec
α: 0.044 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	32	29	26	22	18	15	11
25	56	60	26	23	19	15	12	8	4
25	56	80	23	19	15	11	8	4	1
25	56	100	20	16	12	8	5	1	0
25	56	120	18	14	10	6	3	0	0
25	56	140	16	12	8	5	1	0	0
50	112	40	25	23	20	17	14	11	8
50	112	60	21	18	15	12	8	5	3
50	112	80	18	15	12	8	5	2	0
50	112	100	16	13	9	6	3	1	0
50	112	120	14	11	8	4	2	0	0
50	112	140	13	10	6	3	1	0	0
75	168	40	22	19	17	14	11	8	5
75	168	60	18	15	12	9	6	4	1
75	168	80	15	12	9	6	4	1	0
75	168	100	13	10	7	5	2	0	0
75	168	120	12	9	6	3	1	0	0
75	168	140	11	8	5	2	0	0	0
100	224	40	19	17	14	12	9	6	4
100	224	60	16	13	10	8	5	3	1
100	224	80	13	11	8	5	3	1	0
100	224	100	12	9	6	3	1	0	0
100	224	120	10	8	5	2	1	0	0
100	224	140	9	7	4	1	0	0	0
125	280	40	17	15	13	10	7	5	3
125	280	60	14	12	9	6	4	2	1
125	280	80	12	9	7	4	2	0	0
125	280	100	10	8	5	3	1	0	0
125	280	120	9	7	4	2	0	0	0
125	280	140	8	6	3	1	0	0	0
150	335	40	16	14	11	9	6	4	2
150	335	60	13	10	8	5	3	1	0
150	335	80	11	8	6	3	1	0	0
150	335	100	9	7	4	2	1	0	0
150	335	120	8	6	3	1	0	0	0
150	335	140	8	5	3	1	0	0	0
175	391	40	15	13	10	8	5	3	2
175	391	60	12	9	7	5	2	1	0
175	391	80	10	8	5	3	1	0	0
175	391	100	9	6	4	2	0	0	0
175	391	120	8	5	3	1	0	0	0
175	391	140	7	4	2	0	0	0	0
200	447	40	14	12	9	7	4	3	1
200	447	60	11	9	6	4	2	1	0
200	447	80	9	7	4	2	1	0	0
200	447	100	8	6	3	1	0	0	0
200	447	120	7	5	2	1	0	0	0
200	447	140	6	4	2	0	0	0	0
225	503	40	13	11	8	6	4	2	1
225	503	60	10	8	6	3	2	0	0
225	503	80	9	6	4	2	0	0	0
225	503	100	8	5	3	1	0	0	0
225	503	120	7	4	2	0	0	0	0
225	503	140	6	4	1	0	0	0	0
250	559	40	12	10	8	5	3	2	0
250	559	60	10	7	5	3	1	0	0
250	559	80	8	6	4	2	0	0	0
250	559	100	7	5	2	1	0	0	0
250	559	120	6	4	2	0	0	0	0
250	559	140	6	3	1	0	0	0	0
275	615	40	12	10	7	5	3	1	0
275	615	60	9	7	5	3	1	0	0
275	615	80	8	5	3	1	0	0	0
275	615	100	7	4	2	1	0	0	0
275	615	120	6	4	2	0	0	0	0
275	615	140	5	3	1	0	0	0	0
300	671	40	11	9	7	4	3	1	0
300	671	60	9	7	4	2	1	0	0
300	671	80	7	5	3	1	0	0	0
300	671	100	6	4	2	0	0	0	0
300	671	120	6	3	1	0	0	0	0
300	671	140	5	3	1	0	0	0	0
325	727	40	11	9	6	4	2	1	0
325	727	60	9	6	4	2	1	0	0
325	727	80	7	5	3	1	0	0	0
325	727	100	6	4	2	0	0	0	0
325	727	120	5	3	1	0	0	0	0
325	727	140	5	2	1	0	0	0	0
350	783	40	10	8	6	4	2	1	0
350	783	60	8	6	4	2	0	0	0
350	783	80	7	4	2	1	0	0	0
350	783	100	6	3	2	0	0	0	0
350	783	120	5	3	1	0	0	0	0
350	783	140	5	2	0	0	0	0	0
375	839	40	10	8	5	3	2	0	0
375	839	60	8	6	3	2	0	0	0
375	839	80	6	4	2	0	0	0	0
375	839	100	6	3	1	0	0	0	0
375	839	120	5	3	1	0	0	0	0
375	839	140	4	2	0	0	0	0	0
400	894	40	10	7	5	3	2	0	0
400	894	60	8	5	3	1	0	0	0
400	894	80	6	4	2	0	0	0	0
400	894	100	5	3	1	0	0	0	0
400	894	120	5	2	1	0	0	0	0
400	894	140	4	2	0	0	0	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m;1000 Btu/sec = 1055 kW.

Table B-3.2.4(m)
Q_d, Threshold Fire Size at Response: 750 Btu/sec
t_g: 300 Seconds to 1000 Btu/sec
α: 0.011 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	43	39	34	30	25	21	17
25	56	60	35	30	25	21	16	12	8
25	56	80	30	24	20	15	11	6	3
25	56	100	26	21	16	11	7	3	0
25	56	120	23	18	13	9	4	1	0
25	56	140	21	15	11	6	2	0	0
50	112	40	36	32	29	25	21	17	14
50	112	60	29	25	21	17	14	10	6
50	112	80	24	21	17	13	9	5	2
50	112	100	21	17	13	10	6	2	0
50	112	120	19	15	11	7	3	0	0
50	112	140	17	13	9	5	2	0	0
75	168	40	31	28	25	22	18	15	11
75	168	60	25	22	18	15	12	8	5
75	168	80	21	18	14	11	7	4	1
75	168	100	19	15	12	8	5	2	0
75	168	120	17	13	10	6	3	0	0
75	168	140	15	12	8	4	1	0	0
100	224	40	28	25	22	19	16	13	10
100	224	60	22	19	16	13	10	7	4
100	224	80	19	16	13	10	6	3	1
100	224	100	17	14	10	7	4	1	0
100	224	120	15	12	8	5	2	0	0
100	224	140	14	10	7	4	1	0	0
125	280	40	25	23	20	17	14	11	8
125	280	60	20	18	15	12	9	6	3
125	280	80	17	14	11	8	5	3	1
125	280	100	15	12	9	6	3	1	0
125	280	120	14	11	7	4	2	0	0
125	280	140	12	9	6	3	1	0	0
150	335	40	23	21	18	15	13	10	7
150	335	60	19	16	13	10	8	5	2
150	335	80	16	13	10	7	5	2	0
150	335	100	14	11	8	5	3	1	0
150	335	120	13	10	7	4	1	0	0
150	335	140	11	8	5	3	0	0	0
175	391	40	22	20	17	14	11	9	6
175	391	60	18	15	12	9	7	4	2
175	391	80	15	12	9	7	4	2	0
175	391	100	13	10	7	5	2	0	0
175	391	120	12	9	6	3	1	0	0
175	391	140	11	8	5	2	0	0	0
200	447	40	21	18	16	13	10	8	5
200	447	60	17	14	11	9	6	4	2
200	447	80	14	11	9	6	3	1	0
200	447	100	12	10	7	4	2	0	0
200	447	120	11	8	5	3	1	0	0
200	447	140	10	7	4	2	0	0	0
225	503	40	20	17	15	12	9	7	5
225	503	60	16	13	11	8	5	3	1
225	503	80	13	11	8	5	3	1	0
225	503	100	12	9	6	4	2	0	0
225	503	120	10	8	5	2	1	0	0
225	503	140	9	7	4	2	0	0	0
250	559	40	19	16	14	11	9	6	4
250	559	60	15	12	10	7	5	3	1
250	559	80	13	10	7	5	3	1	0
250	559	100	11	8	6	3	1	0	0
250	559	120	10	7	4	2	1	0	0
250	559	140	9	6	4	1	0	0	0
275	615	40	18	16	13	10	8	6	3
275	615	60	14	12	9	7	4	2	1
275	615	80	12	9	7	4	2	1	0
275	615	100	10	8	5	3	1	0	0
275	615	120	9	7	4	2	0	0	0
275	615	140	8	6	3	1	0	0	0
300	671	40	17	15	12	10	7	5	3
300	671	60	14	11	9	6	4	2	1
300	671	80	11	9	6	4	2	1	0
300	671	100	10	7	5	3	1	0	0
300	671	120	9	6	4	2	0	0	0
300	671	140	8	5	3	1	0	0	0
325	727	40	16	14	12	9	7	5	3
325	727	60	13	11	8	6	3	2	0
325	727	80	11	9	6	4	2	0	0
325	727	100	10	7	5	2	1	0	0
325	727	120	8	6	3	1	0	0	0
325	727	140	8	5	3	1	0	0	0
350	783	40	16	14	11	9	6	4	2
350	783	60	13	10	8	5	3	1	0
350	783	80	11	8	6	3	1	0	0
350	783	100	9	7	4	2	1	0	0
350	783	120	8	6	3	1	0	0	0
350	783	140	7	5	2	1	0	0	0
375	839	40	15	13	11	8	6	4	2
375	839	60	12	10	7	5	3	1	0
375	839	80	10	8	5	3	1	0	0
375	839	100	9	6	4	2	0	0	0
375	839	120	8	5	3	1	0	0	0
375	839	140	7	5	2	1	0	0	0
400	894	40	15	13	10	8	5	3	2
400	894	60	12	9	7	5	3	1	0
400	894	80	10	7	5	3	1	0	0
400	894	100	8	6	4	2	0	0	0
400	894	120	7	5	3	1	0	0	0
400	894	140	7	4	2	0	0	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m; 1000 Btu/sec = 1055 kW.

Table B-3.2.4(n)
Q_d, Threshold Fire Size at Response: 750 Btu/sec
t_g: 500 Seconds to 1000 Btu/sec
α: 0.004 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	52	45	39	34	29	24	20
25	56	60	41	34	28	23	18	14	9
25	56	80	34	28	22	17	12	8	4
25	56	100	29	23	18	13	8	4	0
25	56	120	26	20	14	10	5	1	0
25	56	140	23	17	12	7	3	0	0
50	112	40	44	40	35	30	26	22	18
50	112	60	35	30	26	21	17	12	8
50	112	80	30	25	20	15	11	7	3
50	112	100	26	21	16	12	7	3	0
50	112	120	23	18	13	9	5	1	0
50	112	140	21	16	11	7	3	0	0
75	168	40	39	35	31	27	24	20	16
75	168	60	31	27	23	19	15	11	7
75	168	80	26	22	18	14	10	6	3
75	168	100	23	19	15	10	7	3	0
75	168	120	20	16	12	8	4	1	0
75	168	140	18	14	10	6	2	0	0
100	224	40	35	32	29	25	21	18	14
100	224	60	28	25	21	17	14	10	6
100	224	80	24	20	16	13	9	5	2
100	224	100	21	17	13	10	6	2	0
100	224	120	19	15	11	7	4	0	0
100	224	140	17	13	9	5	2	0	0
125	280	40	32	30	26	23	20	16	13
125	280	60	26	23	19	16	12	9	6
125	280	80	22	19	15	12	8	5	2
125	280	100	19	16	12	9	5	2	0
125	280	120	17	14	10	7	3	0	0
125	280	140	16	12	8	5	2	0	0
150	335	40	30	28	25	21	18	15	12
150	335	60	24	21	18	15	11	8	5
150	335	80	21	17	14	11	7	4	1
150	335	100	18	15	11	8	5	2	0
150	335	120	16	13	9	6	3	0	0
150	335	140	15	11	8	4	1	0	0
175	391	40	28	26	23	20	17	14	10
175	391	60	23	20	17	14	10	7	4
175	391	80	19	16	13	10	7	4	1
175	391	100	17	14	11	7	4	1	0
175	391	120	15	12	9	5	2	0	0
175	391	140	14	10	7	4	1	0	0
200	447	40	27	24	22	18	16	12	10
200	447	60	22	19	16	13	10	7	4
200	447	80	18	15	12	9	6	3	1
200	447	100	16	13	10	7	4	1	0
200	447	120	14	11	8	5	2	0	0
200	447	140	13	10	7	4	1	0	0
225	503	40	26	23	20	17	14	12	9
225	503	60	20	18	15	12	9	6	3
225	503	80	17	14	11	8	6	3	1
225	503	100	15	12	9	6	3	1	0
225	503	120	13	11	7	4	2	0	0
225	503	140	12	9	6	3	1	0	0
250	559	40	24	22	19	16	14	11	8
250	559	60	19	17	14	11	8	5	3
250	559	80	16	14	11	8	5	3	1
250	559	100	14	12	9	6	3	1	0
250	559	120	13	10	7	4	2	0	0
250	559	140	12	9	6	3	1	0	0
275	615	40	23	21	18	16	13	10	7
275	615	60	19	16	13	10	8	5	3
275	615	80	16	13	10	7	5	2	1
275	615	100	14	11	8	5	3	1	0
275	615	120	12	9	7	4	1	0	0
275	615	140	11	8	5	3	1	0	0
300	671	40	22	20	18	15	12	9	7
300	671	60	18	15	13	10	7	5	2
300	671	80	15	13	10	7	4	2	0
300	671	100	13	11	8	5	2	1	0
300	671	120	12	9	6	3	1	0	0
300	671	140	11	8	5	2	0	0	0
325	727	40	22	19	17	14	11	9	6
325	727	60	17	15	12	9	7	4	2
325	727	80	15	12	9	6	4	2	0
325	727	100	13	10	7	5	2	1	0
325	727	120	11	9	6	3	1	0	0
325	727	140	10	7	5	2	0	0	0
350	783	40	21	19	16	13	11	8	6
350	783	60	17	14	12	9	6	4	2
350	783	80	14	12	9	6	4	2	0
350	783	100	12	10	7	4	2	0	0
350	783	120	11	8	5	3	1	0	0
350	783	140	10	7	4	2	0	0	0
375	839	40	20	18	16	13	10	8	5
375	839	60	16	14	11	8	6	3	2
375	839	80	14	11	8	6	3	1	0
375	839	100	12	9	7	4	2	0	0
375	839	120	11	8	5	3	1	0	0
375	839	140	10	7	4	2	0	0	0
400	894	40	20	17	15	12	10	7	5
400	894	60	16	13	11	8	5	3	1
400	894	80	13	11	8	5	3	1	0
400	894	100	11	9	6	4	2	0	0
400	894	120	10	8	5	3	1	0	0
400	894	140	9	7	4	2	0	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m;1000 Btu/sec = 1055 kW.

Table B-3.2.4(o)
Q_d, Threshold Fire Size at Response: 750 Btu/sec
t_g: 600 Seconds to 1000 Btu/sec
α: 0.003 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	55	47	41	35	30	25	21
25	56	60	43	36	29	24	19	14	10
25	56	80	36	28	23	18	13	8	4
25	56	100	31	24	18	13	9	4	0
25	56	120	27	20	15	10	6	1	0
25	56	140	24	18	12	8	3	0	0
50	112	40	47	42	37	32	28	23	19
50	112	60	37	32	27	22	18	13	9
50	112	80	31	26	21	16	12	8	4
50	112	100	27	22	17	12	8	4	0
50	112	120	24	19	14	9	5	1	0
50	112	140	22	16	11	7	3	0	0
75	168	40	42	38	34	29	25	21	17
75	168	60	33	29	25	20	16	12	8
75	168	80	28	24	19	15	11	7	3
75	168	100	24	20	15	11	7	3	0
75	168	120	22	17	13	9	5	1	0
75	168	140	20	15	11	6	3	0	0
100	224	40	38	35	31	27	23	19	16
100	224	60	30	27	23	19	15	11	7
100	224	80	26	22	18	14	10	6	3
100	224	100	22	18	14	10	7	3	0
100	224	120	20	16	12	8	4	1	0
100	224	140	18	14	10	6	2	0	0
125	280	40	35	32	29	25	22	18	14
125	280	60	28	25	21	17	14	10	7
125	280	80	24	20	16	13	9	6	2
125	280	100	21	17	13	10	6	3	0
125	280	120	19	15	11	7	4	1	0
125	280	140	17	13	9	5	2	0	0
150	335	40	33	30	27	23	20	17	13
150	335	60	26	23	20	16	13	9	6
150	335	80	22	19	15	12	8	5	2
150	335	100	19	16	12	9	5	2	0
150	335	120	17	14	10	7	3	0	0
150	335	140	16	12	8	5	2	0	0
175	391	40	31	28	25	22	19	15	12
175	391	60	25	22	18	15	12	9	5
175	391	80	21	18	14	11	8	4	2
175	391	100	18	15	12	8	5	2	0
175	391	120	16	13	10	6	3	0	0
175	391	140	15	11	8	5	1	0	0
200	447	40	29	27	24	21	17	14	11
200	447	60	23	21	17	14	11	8	5
200	447	80	20	17	14	10	7	4	1
200	447	100	17	14	11	8	4	2	0
200	447	120	15	12	9	6	3	0	0
200	447	140	14	11	7	4	1	0	0
225	503	40	28	26	23	19	16	13	10
225	503	60	22	20	17	13	10	7	4
225	503	80	19	16	13	10	7	4	1
225	503	100	16	13	10	7	4	1	0
225	503	120	15	12	8	5	2	0	0
225	503	140	13	10	7	4	1	0	0
250	559	40	27	24	21	18	15	12	10
250	559	60	21	19	16	13	10	7	4
250	559	80	18	15	12	9	6	3	1
250	559	100	16	13	10	7	4	1	0
250	559	120	14	11	8	5	2	0	0
250	559	140	13	10	7	4	1	0	0
275	615	40	26	23	20	18	15	12	9
275	615	60	21	18	15	12	9	6	4
275	615	80	17	15	12	9	6	3	1
275	615	100	15	12	9	6	3	1	0
275	615	120	13	11	7	5	2	0	0
275	615	140	12	9	6	3	1	0	0
300	671	40	25	22	20	17	14	11	8
300	671	60	20	17	14	11	8	6	3
300	671	80	17	14	11	8	5	3	1
300	671	100	15	12	9	6	3	1	0
300	671	120	13	10	7	4	2	0	0
300	671	140	12	9	6	3	1	0	0
325	727	40	24	22	19	16	13	10	8
325	727	60	19	16	14	11	8	5	3
325	727	80	16	13	10	8	5	2	1
325	727	100	14	11	8	5	3	1	0
325	727	120	12	10	7	4	2	0	0
325	727	140	11	8	5	3	1	0	0
350	783	40	23	21	18	15	13	10	7
350	783	60	18	16	13	10	7	5	3
350	783	80	15	13	10	7	5	2	1
350	783	100	13	11	8	5	3	1	0
350	783	120	12	9	6	4	1	0	0
350	783	140	11	8	5	3	1	0	0
375	839	40	22	20	17	15	12	9	7
375	839	60	18	15	13	10	7	5	2
375	839	80	15	12	10	7	4	2	0
375	839	100	13	10	8	5	0	1	0
375	839	120	12	9	6	3	1	0	0
375	839	140	11	8	5	2	0	0	0
400	894	40	22	19	17	14	11	9	6
400	894	60	17	15	12	9	7	4	2
400	894	80	15	12	9	6	4	2	0
400	894	100	13	10	7	5	2	1	0
400	894	120	11	9	6	3	1	0	0
400	894	140	10	7	5	2	0	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m;1000 Btu/sec = 1055 kW.

Table B-3.2.4(p)
Q_d, Threshold Fire Size at Response: 1000 Btu/sec
t_g: 50 Seconds to 1000 Btu/sec
α: 0.400 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	22	20	17	14	11	8	5
25	56	60	18	16	13	10	7	4	2
25	56	80	16	13	10	7	4	2	0
25	56	100	14	11	8	5	3	0	0
25	56	120	13	10	7	4	1	0	0
25	56	140	12	9	6	3	1	0	0
50	112	40	17	15	12	9	7	4	2
50	112	60	14	11	9	6	4	2	0
50	112	80	12	9	7	4	2	0	0
50	112	100	11	8	5	3	1	0	0
50	112	120	10	7	4	2	0	0	0
50	112	140	9	6	3	1	0	0	0
75	168	40	14	12	9	7	4	2	1
75	168	60	12	9	7	4	2	1	0
75	168	80	10	7	5	3	1	0	0
75	168	100	9	6	4	2	0	0	0
75	168	120	8	5	3	1	0	0	0
75	168	140	7	4	2	0	0	0	0
100	224	40	12	10	8	5	3	1	0
100	224	60	10	8	5	3	1	0	0
100	224	80	8	6	4	2	0	0	0
100	224	100	7	5	3	1	0	0	0
100	224	120	7	4	2	0	0	0	0
100	224	140	6	4	1	0	0	0	0
125	280	40	11	9	6	4	2	1	0
125	280	60	9	7	4	2	1	0	0
125	280	80	8	5	3	1	0	0	0
125	280	100	7	4	2	0	0	0	0
125	280	120	6	3	1	0	0	0	0
125	280	140	5	3	1	0	0	0	0
150	335	40	0	8	5	3	2	0	0
150	335	60	8	6	3	2	0	0	0
150	335	80	7	4	2	0	0	0	0
150	335	100	6	3	2	0	0	0	0
150	335	120	5	3	1	0	0	0	0
150	335	140	5	2	0	0	0	0	0
175	391	40	9	7	5	3	1	0	0
175	391	60	7	5	3	1	0	0	0
175	391	80	6	4	2	0	0	0	0
175	391	100	5	3	1	0	0	0	0
175	391	120	5	2	0	0	0	0	0
175	391	140	4	2	0	0	0	0	0
200	447	40	9	6	4	2	1	0	0
200	447	60	7	5	2	1	0	0	0
200	447	80	6	3	1	0	0	0	0
200	447	100	5	3	1	0	0	0	0
200	447	120	4	2	0	0	0	0	0
200	447	140	4	2	0	0	0	0	0
225	503	40	8	6	4	2	0	0	0
225	503	60	6	4	2	0	0	0	0
225	503	80	5	3	1	0	0	0	0
225	503	100	5	2	0	0	0	0	0
225	503	120	4	2	0	0	0	0	0
225	503	140	3	1	0	0	0	0	0
250	559	40	8	5	3	1	0	0	0
250	559	60	6	4	2	0	0	0	0
250	559	80	5	3	1	0	0	0	0
250	559	100	4	2	0	0	0	0	0
250	559	120	4	2	0	0	0	0	0
250	559	140	3	1	0	0	0	0	0
275	615	40	7	5	3	1	0	0	0
275	615	60	6	3	1	0	0	0	0
275	615	80	5	2	0	0	0	0	0
275	615	100	4	2	0	0	0	0	0
275	615	120	3	1	0	0	0	0	0
275	615	140	3	1	0	0	0	0	0
300	671	40	7	5	3	1	0	0	0
300	671	60	5	3	1	0	0	0	0
300	671	80	4	2	0	0	0	0	0
300	671	100	4	2	0	0	0	0	0
300	671	120	3	1	0	0	0	0	0
300	671	140	3	1	0	0	0	0	0
325	727	40	7	4	2	1	0	0	0
325	727	60	5	3	1	0	0	0	0
325	727	80	4	2	0	0	0	0	0
325	727	100	3	1	0	0	0	0	0
325	727	120	3	1	0	0	0	0	0
325	727	140	3	0	0	0	0	0	0
350	783	40	6	4	2	0	0	0	0
350	783	60	5	3	1	0	0	0	0
350	783	80	4	2	0	0	0	0	0
350	783	100	3	1	0	0	0	0	0
350	783	120	3	1	0	0	0	0	0
350	783	140	2	0	0	0	0	0	0
375	839	40	6	4	2	0	0	0	0
375	839	60	5	2	0	0	0	0	0
375	839	80	4	2	0	0	0	0	0
375	839	100	3	1	0	0	0	0	0
375	839	120	3	0	0	0	0	0	0
375	839	140	2	0	0	0	0	0	0
400	894	40	6	4	2	0	0	0	0
400	894	60	4	2	0	0	0	0	0
400	894	80	3	1	0	0	0	0	0
400	894	100	3	1	0	0	0	0	0
400	894	120	2	0	0	0	0	0	0
400	894	140	2	0	0	0	0	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m;1000 Btu/sec = 1055 kW.

Table B-3.2.4(q)
Q_d, Threshold Fire Size at Response: 1000 Btu/sec
t_g: 150 Seconds to 1000 Btu/sec
α: 0.044 Btu/sec³

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	39	36	32	28	25	21	17
25	56	60	32	28	24	21	17	13	9
25	56	80	27	24	20	16	12	8	4
25	56	100	24	20	16	12	8	4	1
25	56	120	22	18	14	10	6	2	0
25	56	140	20	16	12	8	4	0	0
50	112	40	31	29	26	22	19	16	13
50	112	60	25	23	19	16	13	9	6
50	112	80	22	19	15	12	9	6	3
50	112	100	19	16	13	9	6	3	0
50	112	120	17	14	11	7	4	1	0
50	112	140	16	13	9	6	2	0	0
75	168	40	27	24	22	19	16	13	10
75	168	60	22	19	16	13	10	7	4
75	168	80	19	16	13	10	7	4	2
75	168	100	16	14	11	7	4	2	0
75	168	120	15	12	9	6	3	1	0
75	168	140	13	10	7	4	2	0	0
100	224	40	24	22	19	16	13	10	8
100	224	60	19	17	14	11	8	6	3
100	224	80	16	14	11	8	5	3	1
100	224	100	14	12	9	6	3	1	0
100	224	120	13	10	7	5	2	0	0
100	224	140	12	9	6	3	1	0	0
125	280	40	21	19	17	14	11	9	6
125	280	60	17	15	12	10	7	4	2
125	280	80	15	12	10	7	4	2	1
125	280	100	13	10	8	5	3	1	0
125	280	120	12	9	6	4	1	0	0
125	280	140	11	8	5	3	1	0	0
150	335	40	20	18	15	13	10	7	5
150	335	60	16	14	11	8	6	4	2
150	335	80	14	11	9	6	3	2	0
150	335	100	12	9	7	4	2	1	0
150	335	120	11	8	5	3	1	0	0
150	335	140	10	7	4	2	1	0	0
175	391	40	18	16	14	11	9	6	4
175	391	60	15	13	10	7	5	3	1
175	391	80	13	10	8	5	3	1	0
175	391	100	11	9	6	4	2	0	0
175	391	120	10	7	5	2	1	0	0
175	391	140	9	6	4	2	0	0	0
200	447	40	17	15	13	10	8	5	3
200	447	60	14	12	9	7	4	2	1
200	447	80	12	9	7	4	2	1	0
200	447	100	10	8	5	3	1	0	0
200	447	120	9	7	4	2	1	0	0
200	447	140	8	6	3	1	0	0	0
225	503	40	16	14	12	9	7	5	3
225	503	60	13	11	8	6	4	2	1
225	503	80	11	9	6	4	2	1	0
225	503	100	10	7	5	3	1	0	0
225	503	120	9	6	4	2	0	0	0
225	503	140	8	5	3	1	0	0	0
250	559	40	16	13	11	9	6	4	2
250	559	60	12	10	8	5	3	2	0
250	559	80	11	8	6	3	2	0	0
250	559	100	9	7	4	2	1	0	0
250	559	120	8	6	3	1	0	0	0
250	559	140	7	5	3	1	0	0	0
275	615	40	15	13	10	8	6	4	2
275	615	60	12	10	7	5	3	1	0
275	615	80	10	8	5	3	1	0	0
275	615	100	9	6	4	2	0	0	0
275	615	120	8	5	3	1	0	0	0
275	615	140	7	5	2	1	0	0	0
300	671	40	14	12	10	7	5	3	2
300	671	60	11	9	7	4	2	1	0
300	671	80	10	7	5	3	1	0	0
300	671	100	8	6	4	2	0	0	0
300	671	120	7	5	3	1	0	0	0
300	671	140	7	4	2	0	0	0	0
325	727	40	14	12	9	7	5	3	1
325	727	60	11	9	6	4	2	1	0
325	727	80	9	7	4	2	1	0	0
325	727	100	8	6	3	1	0	0	0
325	727	120	7	5	2	1	0	0	0
325	727	140	6	4	2	0	0	0	0
350	783	40	13	11	9	6	4	2	1
350	783	60	10	8	6	4	2	1	0
350	783	80	9	6	4	2	1	0	0
350	783	100	8	5	3	1	0	0	0
350	783	120	7	4	2	1	0	0	0
350	783	140	6	4	2	0	0	0	0
375	839	40	13	11	8	6	4	2	1
375	839	60	10	8	5	3	2	0	0
375	839	80	8	6	4	2	0	0	0
375	839	100	7	5	3	1	0	0	0
375	839	120	6	4	2	0	0	0	0
375	839	140	6	3	1	0	0	0	0
400	894	40	12	10	8	5	3	2	1
400	894	60	10	7	5	3	1	0	0
400	894	80	8	6	4	2	0	0	0
400	894	100	7	5	3	1	0	0	0
400	894	120	6	4	2	0	0	0	0
400	894	140	6	3	1	0	0	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m;1000 Btu/sec = 1055 kW.

Table B-3.2.4(r)
Q_d, Threshold Fire Size at Response: 1000 Btu/sec
t_g: 300 Seconds to 1000 Btu/sec
α: 0.011 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	52	47	42	37	32	28	23
25	56	60	42	36	31	26	22	17	13
25	56	80	35	30	25	20	15	11	7
25	56	100	31	25	20	15	11	7	3
25	56	120	28	22	17	12	8	4	0
25	56	140	25	19	14	10	5	1	0
50	112	40	43	40	36	32	28	24	20
50	112	60	35	31	27	23	19	15	11
50	112	80	30	25	21	17	13	9	5
50	112	100	26	22	18	13	9	6	2
50	112	120	23	19	15	11	7	3	0
50	112	140	21	17	12	8	4	1	0
75	168	40	37	35	31	28	24	21	17
75	168	60	30	27	24	20	16	13	9
75	168	80	26	22	19	15	11	8	4
75	168	100	23	19	15	12	8	5	1
75	168	120	20	17	13	9	6	2	0
75	168	140	19	15	11	7	4	1	0
100	224	40	34	31	28	25	22	18	15
100	224	60	27	24	21	18	14	11	8
100	224	80	23	20	17	13	10	7	4
100	224	100	20	17	14	10	7	4	1
100	224	120	18	15	12	8	5	2	0
100	224	140	17	13	10	6	3	0	0
125	280	40	31	29	26	23	19	16	13
125	280	60	25	22	19	16	13	10	7
125	280	80	21	18	15	12	9	6	3
125	280	100	19	16	13	9	6	3	1
125	280	120	17	14	10	7	4	1	0
125	280	140	15	12	9	6	3	0	0
150	335	40	29	27	24	21	18	15	12
150	335	60	23	21	18	15	12	9	6
150	335	80	20	17	14	11	8	5	2
150	335	100	17	14	11	8	5	3	1
150	335	120	16	13	10	6	4	1	0
150	335	140	14	11	8	5	2	0	0
175	391	40	27	25	22	19	16	13	11
175	391	60	22	19	16	13	10	8	5
175	391	80	18	16	13	10	7	4	2
175	391	100	16	13	10	8	5	2	0
175	391	120	15	12	9	6	3	1	0
175	391	140	13	10	7	4	2	0	0
200	447	40	25	23	21	18	15	12	9
200	447	60	20	18	15	12	10	7	4
200	447	80	17	15	12	9	6	4	2
200	447	100	15	13	10	7	4	2	0
200	447	120	14	11	8	5	3	1	0
200	447	140	12	10	7	4	2	0	0
225	503	40	24	22	19	17	14	11	9
225	503	60	19	17	14	11	9	6	4
225	503	80	16	14	11	8	6	3	1
225	503	100	14	12	9	6	4	2	0
225	503	120	13	10	7	5	2	1	0
225	503	140	12	9	6	3	1	0	0
250	559	40	23	21	18	16	13	10	8
250	559	60	18	16	13	11	8	5	3
250	559	80	16	13	10	8	5	3	1
250	559	100	14	11	8	6	3	1	0
250	559	120	12	10	7	4	2	0	0
250	559	140	11	8	6	3	1	0	0
275	615	40	22	20	17	15	12	9	7
275	615	60	18	15	13	10	7	5	3
275	615	80	15	12	10	7	5	2	1
275	615	100	13	11	8	5	3	1	0
275	615	120	12	9	6	4	2	0	0
275	615	140	11	8	5	3	1	0	0
300	671	40	21	19	16	14	11	9	6
300	671	60	17	15	12	9	7	4	2
300	671	80	14	12	9	7	4	2	1
300	671	100	13	10	7	5	3	1	0
300	671	120	11	9	6	3	1	0	0
300	671	140	10	8	5	3	1	0	0
325	727	40	20	18	16	13	11	8	6
325	727	60	16	14	11	9	6	4	2
325	727	80	14	11	9	6	4	2	1
325	727	100	12	10	7	4	2	1	0
325	727	120	11	8	6	3	1	0	0
325	727	140	10	7	5	2	1	0	0
350	783	40	20	18	15	13	10	8	5
350	783	60	16	13	11	8	6	4	2
350	783	80	13	11	8	6	3	2	0
350	783	100	12	9	7	4	2	1	0
350	783	120	10	8	5	3	1	0	0
350	783	140	9	7	4	2	1	0	0
375	839	40	19	17	14	12	9	7	5
375	839	60	15	13	10	8	5	3	2
375	839	80	13	10	8	5	3	1	0
375	839	100	11	9	6	4	2	0	0
375	839	120	10	7	5	3	1	0	0
375	839	140	9	6	4	2	0	0	0
400	894	40	18	16	14	11	9	7	4
400	894	60	15	12	10	7	5	3	1
400	894	80	12	10	7	5	3	1	0
400	894	100	11	8	6	3	2	0	0
400	894	120	10	7	5	2	1	0	0
400	894	140	9	6	4	2	0	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m; 1000 Btu/sec = 1055 kW.

Table B-3.2.4(s)
Q_d, Threshold Fire Size at Response: 1000 Btu/sec
t_g: 500 Seconds to 1000 Btu/sec
α: 0.004 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	62	54	48	42	37	31	27
25	56	60	49	41	35	29	24	19	15
25	56	80	41	33	27	22	17	12	8
25	56	100	35	28	22	17	12	8	4
25	56	120	31	24	18	13	9	4	0
25	56	140	28	21	16	11	6	2	0
50	112	40	53	48	43	38	33	29	24
50	112	60	42	37	32	27	22	18	14
50	112	80	35	30	25	20	16	11	7
50	112	100	31	25	20	16	11	7	3
50	112	120	27	22	17	12	8	4	0
50	112	140	25	19	14	10	6	2	0
75	168	40	47	43	39	35	31	26	22
75	168	60	38	33	29	25	20	16	12
75	168	80	32	27	23	19	14	10	6
75	168	100	28	23	19	14	10	6	3
75	168	120	25	20	16	11	7	3	0
75	168	140	22	18	13	9	5	1	0
100	224	40	43	40	36	32	28	24	20
100	224	60	34	31	27	23	19	15	11
100	224	80	29	25	21	17	13	9	6
100	224	100	25	21	17	13	9	6	2
100	224	120	23	19	15	11	7	3	0
100	224	140	21	16	12	8	5	1	0
125	280	40	39	37	33	30	26	22	19
125	280	60	32	28	25	21	17	14	10
125	280	80	27	23	20	16	12	9	5
125	280	100	24	20	16	12	9	5	2
125	280	120	21	17	14	10	6	3	0
125	280	140	19	15	11	8	4	1	0
150	335	40	37	34	31	28	24	21	17
150	335	60	30	27	23	20	16	13	9
150	335	80	25	22	18	15	11	8	5
150	335	100	22	19	15	12	8	5	2
150	335	120	20	16	13	9	6	2	0
150	335	140	18	14	11	7	4	1	0
175	391	40	35	32	29	26	23	19	16
175	391	60	28	25	22	18	15	12	8
175	391	80	24	20	17	14	10	7	4
175	391	100	21	18	14	11	7	4	1
175	391	120	19	15	12	8	5	2	0
175	391	140	17	13	10	7	3	1	0
200	447	40	33	30	28	24	21	18	15
200	447	60	26	24	20	17	14	11	8
200	447	80	22	19	16	13	10	7	4
200	447	100	20	17	13	10	7	4	1
200	447	120	18	14	11	8	5	2	0
200	447	140	16	13	9	6	3	1	0
225	503	40	31	29	26	23	20	17	14
225	503	60	25	22	19	16	13	10	7
225	503	80	21	18	15	12	9	6	3
225	503	100	19	16	13	9	6	3	1
225	503	120	17	14	10	7	4	2	0
225	503	140	15	12	9	6	3	0	0
250	559	40	30	28	25	22	19	16	13
250	559	60	24	21	18	15	12	9	7
250	559	80	20	18	15	11	8	6	3
250	559	100	18	15	12	9	6	3	1
250	559	120	16	13	10	7	4	1	0
250	559	140	14	11	8	5	2	0	0
275	615	40	29	27	24	21	18	15	12
275	615	60	23	20	18	15	12	9	6
275	615	80	20	17	14	11	8	5	3
275	615	100	17	14	11	8	5	3	1
275	615	120	15	12	9	6	4	1	0
275	615	140	14	11	8	5	2	0	0
300	671	40	28	25	23	20	17	14	11
300	671	60	22	20	17	14	11	8	5
300	671	80	19	16	13	10	7	5	2
300	671	100	16	14	11	8	5	2	1
300	671	120	15	12	9	6	3	1	0
300	671	140	13	10	7	5	2	0	0
325	727	40	27	25	22	19	16	13	11
325	727	60	21	19	16	13	10	8	5
325	727	80	18	16	13	10	7	4	2
325	727	100	16	13	10	7	5	2	0
325	727	120	14	11	8	6	3	1	0
325	727	140	13	10	7	4	2	0	0
350	783	40	26	24	21	18	15	13	10
350	783	60	21	18	15	13	10	7	5
350	783	80	18	15	12	9	7	4	2
350	783	100	15	13	10	7	4	2	0
350	783	120	14	11	8	5	3	1	0
350	783	140	12	10	7	4	2	0	0
375	839	40	25	23	20	18	15	12	9
375	839	60	20	18	15	12	9	7	4
375	839	80	17	14	12	9	6	4	2
375	839	100	15	12	9	7	4	2	0
375	839	120	13	11	8	5	3	1	0
375	839	140	12	9	6	4	1	0	0
400	894	40	24	22	20	17	14	11	9
400	894	60	19	17	14	12	9	6	4
400	894	80	16	14	11	8	6	3	1
400	894	100	14	12	9	6	4	2	0
400	894	120	13	10	7	5	2	1	0
400	894	140	12	9	6	4	1	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m; 1000 Btu/sec = 1055 kW.

Table B-3.2.4(t)
Q_d, Threshold Fire Size at Response: 1000 Btu/sec
t_g: 600 Seconds to 1000 Btu/sec
α: 0.003 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	65	56	50	43	38	33	28
25	56	60	51	43	36	30	25	20	15
25	56	80	42	34	28	23	18	13	8
25	56	100	36	29	23	17	13	8	4
25	56	120	32	25	19	14	9	5	1
25	56	140	29	21	16	11	6	2	0
50	112	40	56	51	45	40	35	30	26
50	112	60	45	39	33	28	23	19	14
50	112	80	37	31	26	21	16	12	8
50	112	100	33	26	21	16	12	7	3
50	112	120	29	23	18	13	8	4	0
50	112	140	26	20	15	10	6	2	0
75	168	40	50	46	42	37	32	28	24
75	168	60	40	35	31	26	22	17	13
75	168	80	34	29	24	20	15	11	7
75	168	100	30	25	20	15	11	7	3
75	168	120	26	21	17	12	8	4	0
75	168	140	24	19	14	10	5	2	0
100	224	40	46	43	38	34	30	26	22
100	224	60	37	33	28	24	20	16	12
100	224	80	31	27	23	18	14	10	6
100	224	100	27	23	18	14	10	6	3
100	224	120	24	20	15	11	7	3	0
100	224	140	22	17	13	9	5	1	0
125	280	40	43	40	36	32	28	24	21
125	280	60	34	31	27	23	19	15	11
125	280	80	29	25	21	17	13	10	6
125	280	100	25	21	17	13	10	6	2
125	280	120	23	19	15	11	7	3	0
125	280	140	21	16	12	8	5	1	0
150	335	40	40	37	34	30	26	23	19
150	335	60	32	29	25	21	18	14	11
150	335	80	27	24	20	16	12	9	5
150	335	100	24	20	16	13	9	5	2
150	335	120	21	17	14	10	6	3	0
150	335	140	19	15	12	8	4	1	0
175	391	40	38	35	32	28	25	21	18
175	391	60	30	27	24	20	17	13	10
175	391	80	26	22	19	15	12	8	5
175	391	100	22	19	15	12	8	5	2
175	391	120	20	17	13	9	6	3	0
175	391	140	18	15	11	7	4	1	0
200	447	40	36	33	30	27	24	20	17
200	447	60	29	26	22	19	16	12	9
200	447	80	24	21	18	14	11	8	4
200	447	100	21	18	15	11	8	4	2
200	447	120	19	16	12	9	5	2	0
200	447	140	17	14	10	7	4	1	0
225	503	40	34	32	29	26	22	19	16
225	503	60	27	25	21	18	15	12	8
225	503	80	23	20	17	14	10	7	4
225	503	100	20	17	14	11	7	4	1
225	503	120	18	15	12	8	5	2	0
225	503	140	17	13	10	6	3	1	0
250	559	40	33	30	27	24	21	18	15
250	559	60	26	23	20	17	14	11	8
250	559	80	22	19	16	13	10	7	4
250	559	100	19	16	13	10	7	4	1
250	559	120	17	14	11	8	5	2	0
250	559	140	16	13	9	6	3	1	0
275	615	40	31	29	26	23	20	17	14
275	615	60	25	23	19	16	13	10	7
275	615	80	21	18	15	12	9	6	3
275	615	100	19	16	13	9	6	3	1
275	615	120	17	14	11	7	4	2	0
275	615	140	15	12	9	6	3	0	0
300	671	40	30	28	25	22	19	16	13
300	671	60	24	22	19	16	13	10	7
300	671	80	21	18	15	12	9	6	3
300	671	100	18	15	12	9	6	3	1
300	671	120	16	13	10	7	4	1	0
300	671	140	15	12	8	5	3	0	0
325	727	40	29	27	24	21	18	15	13
325	727	60	23	21	18	15	12	9	6
325	727	80	20	17	14	11	8	5	3
325	727	100	17	15	12	8	6	3	1
325	727	120	16	13	10	7	4	1	0
325	727	140	14	11	8	5	2	0	0
350	783	40	28	26	23	21	18	15	12
350	783	60	23	20	17	14	11	9	6
350	783	80	19	17	14	11	8	5	3
350	783	100	17	14	11	8	5	3	1
350	783	120	15	12	9	6	3	1	0
350	783	140	14	11	8	5	2	0	0
375	839	40	28	25	23	20	17	14	11
375	839	60	22	19	17	14	11	8	5
375	839	80	19	16	13	10	7	5	2
375	839	100	16	14	11	8	5	2	1
375	839	120	15	12	9	6	3	1	0
375	839	140	13	10	7	5	2	0	0
400	894	40	27	25	22	19	16	13	11
400	894	60	21	19	16	13	10	8	5
400	894	80	18	15	13	10	7	4	2
400	894	100	16	13	10	7	5	2	1
400	894	120	14	11	8	6	3	1	0
400	894	140	13	10	7	4	2	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m; 1000 Btu/sec = 1055 kW.

Table B-3.2.4(u)
Q_d, Threshold Fire Size at Response: 2000 Btu/sec
t_g: 50 Seconds to 1000 Btu/sec
α: 0.400 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	35	33	31	28	25	21	18
25	56	60	30	27	24	21	18	15	11
25	56	80	26	23	20	17	14	10	7
25	56	100	23	21	17	14	11	7	4
25	56	120	21	18	15	12	8	5	2
25	56	140	20	17	13	10	7	3	1
50	112	40	28	26	23	21	18	15	12
50	112	60	23	21	18	15	13	10	7
50	112	80	20	18	15	12	9	6	4
50	112	100	18	15	13	10	7	4	2
50	112	120	16	14	11	8	5	3	1
50	112	140	15	12	10	7	4	2	0
75	168	40	24	22	19	17	14	11	9
75	168	60	20	17	15	12	9	7	4
75	168	80	17	15	12	9	7	4	2
75	168	100	15	13	10	7	5	3	1
75	168	120	14	11	8	6	3	1	0
75	168	140	13	10	7	5	2	1	0
100	224	40	21	19	17	14	11	9	6
100	224	60	17	15	13	10	7	5	3
100	224	80	15	13	10	7	5	3	1
100	224	100	13	11	8	6	3	2	0
100	224	120	12	10	7	4	2	1	0
100	224	140	11	8	6	3	2	0	0
125	280	40	19	17	15	12	10	7	5
125	280	60	16	13	11	8	6	4	2
125	280	80	13	11	9	6	4	2	1
125	280	100	12	10	7	5	2	1	0
125	280	120	11	8	6	3	2	0	0
125	280	140	10	7	5	3	1	0	0
150	335	40	18	16	13	11	8	6	4
150	335	60	14	12	10	7	5	3	1
150	335	80	12	10	7	5	3	1	0
150	335	100	11	8	6	4	2	0	0
150	335	120	10	7	5	3	1	0	0
150	335	140	9	6	4	2	0	0	0
175	391	40	16	14	12	9	7	5	3
175	391	60	13	11	9	6	4	2	1
175	391	80	11	9	7	4	2	1	0
175	391	100	10	8	5	3	1	0	0
175	391	120	9	7	4	2	1	0	0
175	391	140	8	6	3	2	0	0	0
200	447	40	15	13	11	8	6	4	2
200	447	60	12	10	8	5	3	2	0
200	447	80	11	8	6	4	2	1	0
200	447	100	9	7	5	3	1	0	0
200	447	120	8	6	4	2	0	0	0
200	447	140	8	5	3	1	0	0	0
225	503	40	15	12	10	8	5	3	2
225	503	60	12	9	7	5	3	1	0
225	503	80	10	8	5	3	2	0	0
225	503	100	9	6	4	2	1	0	0
225	503	120	8	5	3	1	0	0	0
225	503	140	7	5	3	1	0	0	0
250	559	40	14	12	9	7	5	3	2
250	559	60	11	9	6	4	2	1	0
250	559	80	9	7	5	3	1	0	0
250	559	100	8	6	4	2	0	0	0
250	559	120	7	5	3	1	0	0	0
250	559	140	7	4	2	1	0	0	0
275	615	40	13	11	9	6	4	2	1
275	615	60	10	8	6	4	2	1	0
275	615	80	9	7	4	2	1	0	0
275	615	100	8	5	3	2	0	0	0
275	615	120	7	5	2	1	0	0	0
275	615	140	6	4	2	0	0	0	0
300	671	40	13	10	8	6	4	2	1
300	671	60	10	8	5	3	2	0	0
300	671	80	8	6	4	2	1	0	0
300	671	100	7	5	3	1	0	0	0
300	671	120	7	4	2	1	0	0	0
300	671	140	6	4	2	0	0	0	0
325	727	40	12	10	8	5	3	2	1
325	727	60	10	7	5	3	1	0	0
325	727	80	8	6	4	2	0	0	0
325	727	100	7	5	3	1	0	0	0
325	727	120	6	4	2	0	0	0	0
325	727	140	6	3	1	0	0	0	0
350	783	40	12	9	7	5	3	2	0
350	783	60	9	7	5	3	1	0	0
350	783	80	8	5	3	2	0	0	0
350	783	100	7	4	2	1	0	0	0
350	783	120	6	4	2	0	0	0	0
350	783	140	5	3	1	0	0	0	0
375	839	40	11	9	7	4	3	1	0
375	839	60	9	7	4	2	1	0	0
375	839	80	7	5	3	1	0	0	0
375	839	100	6	4	2	0	0	0	0
375	839	120	6	3	2	0	0	0	0
375	839	140	5	3	1	0	0	0	0
400	894	40	11	9	6	4	2	1	0
400	894	60	9	6	4	2	1	0	0
400	894	80	7	5	3	1	0	0	0
400	894	100	6	4	2	0	0	0	0
400	894	120	5	3	1	0	0	0	0
400	894	140	5	3	1	0	0	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m; 1000 Btu/sec = 1055 kW.

Table B-3.2.4(v)
Q_d, Threshold Fire Size at Response: 2000 Btu/sec
t_g: 150 Seconds to 1000 Btu/sec
α: 0.044 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	60	57	53	49	44	40	36
25	56	60	50	46	41	37	32	28	23
25	56	80	43	38	34	29	25	20	16
25	56	100	38	33	28	24	19	15	11
25	56	120	34	29	25	20	15	11	7
25	56	140	31	26	21	17	13	8	4
50	112	40	49	47	44	40	37	33	30
50	112	60	40	38	34	31	27	23	19
50	112	80	35	32	28	24	21	17	13
50	112	100	31	28	24	20	16	12	9
50	112	120	28	24	21	17	13	9	6
50	112	140	26	22	18	14	10	7	3
75	168	40	43	41	38	35	32	28	25
75	168	60	35	33	30	26	23	20	16
75	168	80	30	28	24	21	18	14	11
75	168	100	27	24	21	17	14	10	7
75	168	120	24	21	18	14	11	8	4
75	168	140	22	19	16	12	9	5	2
100	224	40	38	36	34	31	28	25	22
100	224	60	31	29	26	23	20	17	14
100	224	80	27	25	22	18	15	12	9
100	224	100	24	21	18	15	12	9	6
100	224	120	22	19	16	13	9	6	3
100	224	140	20	17	14	11	7	4	2
125	280	40	35	33	31	28	25	22	19
125	280	60	29	27	24	21	18	15	12
125	280	80	25	22	19	16	13	11	8
125	280	100	22	19	16	13	10	7	5
125	280	120	20	17	14	11	8	5	3
125	280	140	18	15	12	9	6	4	1
150	335	40	32	31	28	26	23	20	17
150	335	60	27	24	22	19	16	13	10
150	335	80	23	20	18	15	12	9	6
150	335	100	20	18	15	12	9	6	4
150	335	120	18	16	13	10	7	4	2
150	335	140	17	14	11	8	5	3	1
175	391	40	30	29	26	24	21	18	15
175	391	60	25	23	20	17	15	12	9
175	391	80	21	19	16	14	11	8	6
175	391	100	19	16	14	11	8	6	3
175	391	120	17	15	12	9	6	4	2
175	391	140	16	13	10	7	5	2	1
200	447	40	29	27	25	22	19	17	14
200	447	60	23	21	19	16	13	11	8
200	447	80	20	18	15	12	10	7	5
200	447	100	18	15	13	10	7	5	3
200	447	120	16	14	11	8	5	3	1
200	447	140	15	12	9	7	4	2	1
225	503	40	27	26	23	21	18	15	13
225	503	60	22	20	18	15	12	10	7
225	503	80	19	17	14	11	9	6	4
225	503	100	17	14	12	9	7	4	2
225	503	120	15	13	10	7	5	3	1
225	503	140	14	11	9	6	4	2	0
250	559	40	26	24	22	19	17	14	12
250	559	60	21	19	16	14	11	9	6
250	559	80	18	16	13	11	8	6	4
250	559	100	16	14	11	8	6	4	2
250	559	120	14	12	9	7	4	2	1
250	559	140	13	11	8	5	3	1	0
275	615	40	25	23	21	18	16	13	11
275	615	60	20	18	16	13	11	8	6
275	615	80	17	15	13	10	7	5	3
275	615	100	15	13	10	8	5	3	2
275	615	120	14	11	9	6	4	2	1
275	615	140	12	10	7	5	3	1	0
300	671	40	24	22	20	17	15	12	10
300	671	60	19	17	15	12	10	7	5
300	671	80	17	14	12	9	7	5	3
300	671	100	15	12	10	7	5	3	1
300	671	120	13	11	8	6	3	2	0
300	671	140	12	10	7	5	2	1	0
325	727	40	23	21	19	16	14	11	9
325	727	60	19	17	14	12	9	7	5
325	727	80	16	14	11	9	6	4	2
325	727	100	14	12	9	7	4	2	1
325	727	120	13	10	8	5	3	1	0
325	727	140	11	9	7	4	2	1	0
350	783	40	22	20	18	16	13	11	8
350	783	60	18	16	13	11	9	6	4
350	783	80	15	13	11	8	6	4	2
350	783	100	13	11	9	6	4	2	1
350	783	120	12	10	7	5	3	1	0
350	783	140	11	9	6	4	2	1	0
375	839	40	22	20	17	15	12	10	8
375	839	60	17	15	13	10	8	6	4
375	839	80	15	13	10	8	5	3	2
375	839	100	13	11	8	6	4	2	1
375	839	120	12	9	7	5	3	1	0
375	839	140	11	8	6	3	2	0	0
400	894	40	21	19	17	14	12	9	7
400	894	60	17	15	12	10	8	5	3
400	894	80	14	12	10	7	5	3	2
400	894	100	13	10	8	5	3	2	1
400	894	120	11	9	6	4	2	1	0
400	894	140	10	8	5	3	2	0	0

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m; 1000 Btu/sec = 1055 kW.

Table B-3.2.4(w)
Q_d, Threshold Fire Size at Response: 2000 Btu/sec
t_g: 300 Seconds to 1000 Btu/sec
α: 0.011 Btu/sec^3

τ	RTI	ΔT	Ceiling Height (ft) 4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	79	73	66	60	55	49	44
25	56	60	64	56	50	44	39	33	29
25	56	80	54	46	40	34	29	24	20
25	56	100	47	40	33	28	23	18	14
25	56	120	42	35	29	23	18	14	9
25	56	140	38	31	25	20	15	10	6
50	112	40	67	63	58	54	49	44	40
50	112	60	54	49	45	40	35	30	26
50	112	80	46	41	36	31	27	22	18
50	112	100	41	35	30	26	21	17	12
50	112	120	36	31	26	21	17	13	8
50	112	140	33	28	23	18	14	9	5
75	168	40	59	56	52	48	44	40	36
75	168	60	48	44	40	36	32	28	24
75	168	80	41	37	33	29	24	20	16
75	168	100	36	32	28	23	19	15	11
75	168	120	33	28	24	20	15	11	7
75	168	140	30	25	21	17	12	9	5
100	224	40	53	51	48	44	41	37	33
100	224	60	43	40	37	33	29	25	22
100	224	80	37	34	30	26	22	19	15
100	224	100	33	29	25	22	18	14	10
100	224	120	30	26	22	18	14	10	7
100	224	140	27	23	19	15	11	8	4
125	280	40	49	47	44	41	37	34	31
125	280	60	40	37	34	31	27	23	20
125	280	80	34	31	28	24	21	17	14
125	280	100	30	27	23	20	16	13	9
125	280	120	27	24	20	17	13	9	6
125	280	140	25	22	18	14	11	7	4
150	335	40	46	44	41	38	35	32	28
150	335	60	37	35	32	28	25	22	18
150	335	80	32	29	26	23	19	16	12
150	335	100	28	25	22	19	15	12	8
150	335	120	26	22	19	15	12	9	5
150	335	140	23	20	17	13	10	6	3
175	391	40	43	41	39	36	33	29	26
175	391	60	35	33	30	27	23	20	17
175	391	80	30	28	24	21	18	15	11
175	391	100	27	24	21	17	14	11	8
175	391	120	24	21	18	14	11	8	5
175	391	140	22	19	16	12	9	6	3
200	447	40	41	39	37	34	31	28	25
200	447	60	33	31	28	25	22	19	16
200	447	80	29	26	23	20	17	14	10
200	447	100	25	22	19	16	13	10	7
200	447	120	23	20	17	14	10	7	4
200	447	140	21	18	15	11	8	5	2
225	503	40	39	37	35	32	29	26	23
225	503	60	32	30	27	24	21	18	15
225	503	80	27	25	22	19	16	13	10
225	503	100	24	21	18	15	12	9	6
225	503	120	22	19	16	13	10	7	4
225	503	140	20	17	14	11	8	5	2
250	559	40	37	36	33	30	28	25	22
250	559	60	30	28	25	23	19	17	14
250	559	80	26	24	21	18	15	12	9
250	559	100	23	20	17	14	11	8	6
250	559	120	21	18	15	12	9	6	3
250	559	140	19	16	13	10	7	4	2
275	615	40	36	34	32	29	26	23	20
275	615	60	29	27	24	21	18	16	13
275	615	80	25	23	20	17	14	11	8
275	615	100	22	19	17	14	11	8	5
275	615	120	20	17	14	11	8	6	3
275	615	140	18	15	12	9	7	4	2
300	671	40	35	33	30	28	25	22	19
300	671	60	28	26	23	20	18	15	13
300	671	80	24	22	19	16	13	10	8
300	671	100	21	19	16	13	10	7	5
300	671	120	19	16	14	11	8	5	3
300	671	140	17	15	12	9	6	4	1
325	727	40	33	32	29	27	24	21	18
325	727	60	27	25	22	20	17	14	11
325	727	80	23	21	18	15	12	10	7
325	727	100	20	18	15	12	10	7	4
325	727	120	18	16	13	10	7	5	2
325	727	140	17	14	11	8	6	3	1
350	783	40	32	31	28	26	23	20	17
350	783	60	26	24	21	19	16	13	11
350	783	80	22	20	17	15	12	9	7
350	783	100	20	17	15	12	9	6	4
350	783	120	18	15	12	10	7	4	2
350	783	140	16	14	11	8	5	3	1
375	839	40	31	30	27	25	22	19	16
375	839	60	25	23	21	18	15	13	10
375	839	80	22	19	17	14	11	9	6
375	839	100	19	17	14	11	9	6	4
375	839	120	17	15	12	9	6	4	2
375	839	140	16	13	10	8	5	3	1
400	894	40	30	29	26	24	21	18	16
400	894	60	25	23	20	17	15	12	9
400	894	80	21	19	16	13	11	8	5
400	894	100	19	16	13	11	8	6	3
400	894	120	17	14	11	9	6	4	2
400	894	140	15	13	10	7	5	2	1

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m;1000 Btu/sec = 1055 kW.

Table B-3.2.4(x)
Q_d, Threshold Fire Size at Response: 2000 Btu/sec
t_g: 500 Seconds to 1000 Btu/sec
α: 0.004 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	92	82	74	67	60	54	49
25	56	60	72	62	55	48	42	36	31
25	56	80	61	51	43	37	32	26	22
25	56	100	52	43	36	30	25	20	15
25	56	120	46	37	31	25	20	15	10
25	56	140	42	33	27	21	16	11	7
50	112	40	81	74	68	62	56	51	46
50	112	60	64	57	51	45	40	35	30
50	112	80	54	47	41	35	30	25	20
50	112	100	47	40	34	29	23	19	14
50	112	120	42	35	29	24	19	14	10
50	112	140	38	31	25	20	15	11	6
75	168	40	73	68	63	58	53	48	43
75	168	60	58	53	47	42	37	33	28
75	168	80	49	44	38	33	28	24	19
75	168	100	43	37	32	27	22	18	13
75	168	120	39	33	27	22	18	13	9
75	168	140	35	29	24	19	14	10	6
100	224	40	67	63	58	54	50	45	41
100	224	60	54	49	45	40	35	31	27
100	224	80	46	41	36	31	27	23	18
100	224	100	40	35	30	26	21	17	13
100	224	120	36	31	26	21	17	13	9
100	224	140	33	27	23	18	14	10	6
125	280	40	62	59	55	51	47	43	38
125	280	60	50	46	42	38	33	29	25
125	280	80	43	38	34	30	25	21	17
125	280	100	37	33	29	24	20	16	12
125	280	120	34	29	25	20	16	12	8
125	280	140	31	26	22	17	13	9	5
150	335	40	58	55	52	48	44	40	36
150	335	60	47	44	40	36	32	28	24
150	335	80	40	36	32	28	24	20	16
150	335	100	35	31	27	23	19	15	11
150	335	120	32	27	23	19	15	11	8
150	335	140	29	25	20	16	12	9	5
175	391	40	55	53	49	46	42	38	35
175	391	60	44	41	38	34	30	26	23
175	391	80	38	34	31	27	23	19	15
175	391	100	33	30	26	22	18	14	11
175	391	120	30	26	22	18	15	11	7
175	391	140	27	23	20	16	12	8	4
200	447	40	52	50	47	44	40	36	33
200	447	60	42	39	36	32	29	25	21
200	447	80	36	33	29	26	22	18	15
200	447	100	32	28	25	21	17	14	10
200	447	120	29	25	21	18	14	10	7
200	447	140	26	22	19	15	11	8	4
225	503	40	50	48	45	42	38	35	31
225	503	60	40	38	34	31	27	24	20
225	503	80	35	31	28	24	21	17	14
225	503	100	30	27	24	20	16	13	9
225	503	120	27	24	20	17	13	10	6
225	503	140	25	21	18	14	11	7	4
250	559	40	48	46	43	40	37	33	30
250	559	60	39	36	33	30	26	23	19
250	559	80	33	30	27	23	20	17	13
250	559	100	29	26	23	19	16	12	9
250	559	120	26	23	20	16	13	9	6
250	559	140	24	21	17	14	10	7	4
275	615	40	46	44	41	38	35	32	29
275	615	60	37	35	32	28	25	22	19
275	615	80	32	29	26	22	19	16	13
275	615	100	28	25	22	18	15	12	8
275	615	120	25	22	19	15	12	9	5
275	615	140	23	20	16	13	10	6	3
300	671	40	45	43	40	37	34	31	27
300	671	60	36	34	31	27	24	21	18
300	671	80	31	28	25	22	18	15	12
300	671	100	27	24	21	18	14	11	8
300	671	120	24	21	18	15	11	8	5
300	671	140	22	19	16	13	9	6	3
325	727	40	43	41	39	36	33	30	26
325	727	60	35	32	30	26	23	20	17
325	727	80	30	27	24	21	18	14	11
325	727	100	26	23	20	17	14	11	8
325	727	120	24	21	17	14	11	8	5
325	727	140	22	19	15	12	9	6	3
350	783	40	42	40	37	35	31	28	25
350	783	60	34	31	29	26	22	19	16
350	783	80	29	26	23	20	17	14	11
350	783	100	25	23	19	16	13	10	7
350	783	120	23	20	17	14	11	7	5
350	783	140	21	18	15	12	8	5	3
375	839	40	41	39	36	33	30	27	24
375	839	60	33	31	28	25	22	19	16
375	839	80	28	25	22	19	16	13	10
375	839	100	25	22	19	16	13	10	7
375	839	120	22	19	16	13	10	7	4
375	839	140	20	17	14	11	8	5	2
400	894	40	40	38	35	32	29	27	24
400	894	60	32	30	27	24	21	18	15
400	894	80	27	25	22	19	16	13	10
400	894	100	24	21	18	15	12	9	6
400	894	120	22	19	16	13	10	7	4
400	894	140	20	17	14	11	8	5	2

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m;1000 Btu/sec = 1055 kW.

Table B-3.2.4(y)
Q_d, Threshold Fire Size at Response: 2000 Btu/sec
t_g: 600 Seconds to 1000 Btu/sec
α: 0.003 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Installed Spacing of Detectors						
25	56	40	96	85	78	68	62	56	50
25	56	60	75	64	56	49	43	37	32
25	56	80	63	52	44	38	32	27	22
25	56	100	54	44	37	31	25	20	15
25	56	120	48	38	31	25	20	15	11
25	56	140	43	34	27	21	16	12	7
50	112	40	86	78	71	64	58	53	48
50	112	60	68	60	53	47	41	36	31
50	112	80	57	49	42	36	31	26	21
50	112	100	49	41	35	29	24	19	15
50	112	120	44	36	30	24	19	15	10
50	112	140	40	32	26	21	16	11	7
75	168	40	78	72	66	61	55	50	45
75	168	60	62	56	50	44	39	34	29
75	168	80	52	46	40	34	30	25	20
75	168	100	46	39	33	28	23	19	14
75	168	120	41	34	28	23	19	14	10
75	168	140	37	30	25	20	15	11	6
100	224	40	72	67	62	57	52	48	43
100	224	60	57	52	47	42	37	32	28
100	224	80	49	43	38	33	28	24	19
100	224	100	43	37	32	27	22	18	13
100	224	120	38	32	27	22	18	13	9
100	224	140	35	29	24	19	14	10	6
125	280	40	67	63	59	54	50	45	41
125	280	60	54	49	45	40	35	31	27
125	280	80	46	41	36	31	27	23	18
125	280	100	40	35	30	26	21	17	13
125	280	120	36	31	26	21	17	13	9
125	280	140	33	27	23	18	14	10	6
150	335	40	63	60	56	52	47	43	39
150	335	60	51	47	42	38	34	30	26
150	335	80	43	39	34	30	26	22	18
150	335	100	38	33	29	25	20	16	12
150	335	120	34	29	25	21	16	12	8
150	335	140	31	26	22	17	13	9	5
175	391	40	60	57	53	49	45	41	37
175	391	60	48	44	41	36	32	28	24
175	391	80	41	37	33	29	25	21	17
175	391	100	36	32	28	24	19	15	12
175	391	120	32	28	24	20	16	12	8
175	391	140	29	25	21	17	13	9	5
200	447	40	57	54	51	47	43	40	36
200	447	60	46	43	39	35	31	27	23
200	447	80	39	35	32	28	24	20	16
200	447	100	34	30	26	23	19	15	11
200	447	120	31	27	23	19	15	11	7
200	447	140	28	24	20	16	12	8	5
225	503	40	54	52	49	45	42	38	34
225	503	60	44	41	37	34	30	26	22
225	503	80	37	34	30	26	23	19	15
225	503	100	33	29	25	22	18	14	11
225	503	120	30	26	22	18	14	11	7
225	503	140	27	23	19	15	12	8	4
250	559	40	52	50	47	43	40	36	33
250	559	60	42	39	36	32	29	25	21
250	559	80	36	33	29	25	22	18	15
250	559	100	32	28	24	21	17	14	10
250	559	120	28	25	21	17	14	10	7
250	559	140	26	22	19	15	11	8	4
275	615	40	50	48	45	42	39	35	32
275	615	60	41	38	35	31	28	24	21
275	615	80	35	32	28	25	21	18	14
275	615	100	30	27	24	20	17	13	10
275	615	120	27	24	20	17	13	10	6
275	615	140	25	22	18	14	11	7	4
300	671	40	49	47	44	40	37	34	30
300	671	60	39	37	33	30	27	23	20
300	671	80	33	31	27	24	20	17	13
300	671	100	29	26	23	19	16	12	9
300	671	120	26	23	20	16	13	9	6
300	671	140	24	21	17	14	10	7	4
325	727	40	47	45	42	39	36	33	29
325	727	60	38	35	32	29	26	22	19
325	727	80	32	30	26	23	20	16	13
325	727	100	29	25	22	19	15	12	9
325	727	120	26	22	19	16	12	9	6
325	727	140	23	20	17	13	10	7	3
350	783	40	46	44	41	38	35	32	28
350	783	60	37	34	31	28	25	22	18
350	783	80	31	29	25	22	19	16	12
350	783	100	28	25	21	18	15	12	8
350	783	120	25	22	18	15	12	9	5
350	783	140	23	20	16	13	9	6	3
375	839	40	44	42	40	37	34	31	27
375	839	60	36	33	30	27	24	21	18
375	839	80	31	28	25	21	18	15	12
375	839	100	27	24	21	18	14	11	8
375	839	120	24	21	18	15	11	8	5
375	839	140	22	19	16	12	9	6	3
400	894	40	43	41	39	36	33	30	26
400	894	60	35	32	30	26	23	20	17
400	894	80	30	27	24	21	18	14	11
400	894	100	26	23	20	17	14	11	8
400	894	120	23	21	17	14	11	8	5
400	894	140	21	18	15	12	9	6	3

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m;1000 Btu/sec = 1055 kW.

B-3.2.5 Installed spacings listed as zero (0) in the tables indicate that the detector chosen will not respond within the design objectives.

B-3.2.6 Example.

Input:

Ceiling height: 8 ft (2.4 m)

Detector type: Fixed temperature 135°F (57°C)

Listed spacing: 30 ft (9.1 m)

Fire:

Q_d: 500 Btu/sec (527 kW)

Fire growth rate: slow

t_g: 600 sec

α: 0.003 Btu/sec^3

Environmental conditions:

T_o: 55°F (12.8°C)

Required installed spacing:

From Table B-3.2.2, the detector time constant (τ_o) is 80 seconds.

(RTI = 80 $\sqrt{5}$ = 180 ft$^{1/2}$ sec$^{1/2}$)

$\Delta T = T_s - T_o = 135 - 55 = 80°F$

From Table B-3.2.4(j):

For τ_o = 75 sec — spacing = 17 ft (5.18 m)

For τ_o = 100 sec — spacing = 16 ft (4.9 m)

By interpolation:

Spacing = 17 − [(17 − 16/80 − 75/100 − 75)] = 16.8, rounded to 17.0 ft.

For SI units: 1 ft = 0.305 m.

NOTE: Interpolation for τ_o = 80 seconds was not required, but was included for demonstration. Where the ceiling height is 16 ft (4.9 m), the required spacing would be 8.8 ft (2.68 m). Using the detector in the above example, at a ceiling height of 28 ft (8.53 m), no practical spacing would ensure detection of the fire at the threshold fire size of 500 Btu/sec (527 kW). A more sensitive detector would need to be used. Alternatively, the design objectives could be changed to accept a larger fire. These results clearly illustrate the need to consider ceiling height in the design of a detection system.

B-3.3 Rate-of-Rise Heat Detector Spacing.

B-3.3.1 Tables B-3.3.2(a) and B-3.3.2(b) are to be used to determine the installed spacing of rate-of-rise heat detectors. The analytical basis for the tables is presented in Section B-6. This section shows how the tables are to be used.

B-3.3.2 Installed Spacings.

(a) Table B-3.3.2(a) provides installed spacings for rate-of-rise heat detectors required to achieve detection for a specific threshold fire size, fire growth rate, and ceiling height. This table may be permitted to be used directly to determine installed spacings for 50-ft (15.2-m) listed spacing detectors.

(b) Tables B-3.3.2(a) and B-3.3.2(b) use the following values for t_g:

Fast fire growth rate, t_g = 150 sec

Medium fire growth rate, t_g = 300 sec

Slow fire growth rate, t_g = 600 sec.

B-3.3.3 For rate-of-rise heat detectors with a listed spacing of other than 50 ft (15.2 m), installed spacing obtained from Table B-3.3.2(a) is to be multiplied by the modifier shown in Table B-3.3.2(b) for the appropriate listed spacing and fire growth rate. This takes into account the difference in sensitivity between the detector and a 50-ft (15.2-m) listed detector.

B-3.3.4 Having determined the threshold fire size (*see B-2.2.2*), the fire growth rate (*see B-2.2.3*), the detector's listed spacing, and the ceiling height, Table B-3.3.2(a) is used to determine the correct spacing for 50-ft (15.2-m) listed detectors. Table B-3.3.2(b) is used to determine the spacing modifier. The required installed spacing is determined by multiplying the correct spacing by the spacing modifier.

B-3.3.5 Example.

Input:

Ceiling height: 12 ft (3.7 m)

Detector type: Combination rate-of-rise, fixed temperature, 30-ft (9.1-m) listed spacing

Q_d: 500 Btu/sec

Fire growth rate: medium

Spacing:

From Table B-3.3.2(a), installed spacing = 18 ft (5.5 m)

From Table B-3.3.2(b), spacing modifier = 0.86

Installed spacing = 18 × 0.86 = 15.5 ft (4.7 m)

NOTE: This answer may be permitted to be rounded to either 15 ft (4.6 m) or 16 ft (4.9 m). Use of 15 ft (4.6 m) would be slightly conservative. However, depending on field conditions, use of 16 ft (4.9 m) might fit the space better.

B-3.4 Design Curves.

B-3.4.1 The design curves [Figures B-3.4.1 (a) through (i)] also may be permitted to be used to determine the installed spacings of heat detectors. However, they are not as comprehensive as the tables, because the tables include additional fire growth rates, fire sizes, and detector sensitivities.

B-3.4.1.1 Fixed-Temperature Heat Detectors. Figures B-3.4.1(a) through (f) can be used directly to determine the installed spacing for fixed-temperature heat detectors having listed spacings of 30 ft and 50 ft (9.1 m and 15.2 m), respectively, where the difference between the detectors' rated temperature (T_s) and the ambient temperature (T_o) is 65°F (36°C). Where ΔT is not 65°F (36°C), the tables previously discussed in B-3.2 should be used.

B-3.4.1.2 Rate-of-Rise Heat Detectors. Figures B-3.4.1(g), (h), and (i) can be used directly to determine the installed spacing for rate-of-rise heat detectors having a listed spacing of 50 ft (15.2 m).

B-3.4.2 To use the curves, the same format is to be followed as is used with the tables. The designer first determines how large a fire can be tolerated before detection can occur. This is the threshold fire size, Q_d. Curves are presented, in most cases, for values of Q_d = 1000, 750, 500, 250, and 100 Btu/sec (1055, 791, 527, 264, and 105 kW). Interpolation between values of Q_d on a given graph is permitted. Table B-2.2.2.1(a) and Table B-2.2.2.3 also contain examples of various fuels and their fire growth rates under specified conditions.

I. Input Data for Design and Analysis (*B-2*)

		Detector Type: Fixed-Temp HD	Rate-of-Rise HD	Smoke Detector		
Compartment Characteristics	H =	8			ft	Ceiling height or clearance above fuel (*see B-2.1, B-2.3*)
	T_o =	55			°F	Ambient temperature (*see B-3.2.3, B-6.4*)
Detector Characteristics (see B-3)	T_s =	135			°F	Detector operating temperature (*see B-3.1.4*)
	ΔT =	80			°F	Temperature differential (*Calculate using:* T_s-T_o)
	LS =	30			ft	Listed spacing of detector
	τ_o =	80			sec	Detector time constant (*see Table B-3.2.2 and B-6.3*)
	or RTI =	/			$ft^{1/2}sec^{1/2}$	Response time index (*see Table B-3.2.2*) *Calculate using:* RTI = $\tau_o \sqrt{5}$
Fire Development (see B-2.2)	t_g =	600	s (t_g = 600) m (t_g = 300) f (t_g = 150)	s (t_g = 600) m (t_g = 300) f (t_g = 150)	sec	Fire growth time to 1000 Btu/sec *Select, or circle, a fire growth time*
	or α =	/			Btu/sec^3	Fire intensity coefficient *Calculate using:* $\alpha = 1000/t_g^2$

s(low)	m(edium)	f(ast)	
≥ 400	≥150 and <400	< 150	sec
≤ 0.0062	≥0.0444 and <0.0062	>0.0444	Btu/sec^3

[see B-2.2.3, B-3.3.2(b), B-5.6.2(b)]

IIa. Input Data for *Design* (B-3)

IIa.1 Establish Design Objectives

Determine the size of the fire at which detector response is desired using either 1 or 2:

1. *Select* Q_d = 500 Btu/sec [see B-2.2.4, Table B-2.2.2.1(a), (b), or B-2.2.2.3], or

2. *Calculate* Q_d using the time after ignition at which detector response is desired, t_d, using: $Q_d = \alpha t_d^2$ = _____ Btu/sec

IIa.2 Calculate Detector Response

Fixed-Temperature HD (B-3.2)	*Rate-of-Rise HD (B-3.3)*	*Smoke Detector (B-5)*
1. Fill in the variables: Q_d = 500 Btu/sec t_g = 600 sec, or α = _____ Btu/sec^3 τ_o = 80 sec, or RTI = _____ $ft^{1/2}$ $sec^{1/2}$ ΔT = 80 °F and H = 8 ft 2. Using Q_d and t_g (or α), select the appropriate design table (a) through (y) from Table B-3.2.4: B-3.2.4 (j) 3. Using τ_o (or RTI), ΔT, and H, determine the installed spacing: 17 ft	1. Fill in the variables: Fire growth (s,m,f) = _____ H = _____ ft Q_d = _____ Btu/sec 2. Select installed spacing from Table B-3.3.2(a): _____ ft 3. Select spacing modifier from Table B-3.3.2(b): x _____ 4. Calculate installed spacing: _____ft	1. Fill in the variables: Fire growth (s,m,f) = _____ H = _____ ft Q_d = _____ Btu/sec 2. Using fire growth (s, m, or f), select Figure B-5.5.1(a), (b), or (c): _____ 3. Using H and Q_d, determine the installed spacing: _____ ft

IIb. Input Data for *Analysis* of an Existing Heat Detection System (B-4)

1. Fill in the variables:
   S = _____ ft (installed spacing of the existing heat detector)
   t_g = _____ sec, or α = _____ Btu/sec^3
   τ_o = _____ sec, or RTI = _____ $ft^{1/2}sec^{1/2}$
   ΔT = _____ °F and H = _____ ft
2. Using S and t_g (or α), select an analysis table (a) - (nn) from Table B-4: _____
3. Using τ_o (or RTI), ΔT, and H, determine the fire size at detector response Q_d = _____ Btu/sec
4. Calculate the time to detector response using: $t_d = \sqrt{\frac{Q_d}{\alpha}} = \sqrt{\frac{\text{Btu/sec}}{\text{Btu/sec}^3}}$ = _____ sec

Figure B-3.2.6 Completed worksheet for B-3.2.6, Example.

Table B-3.3.2(a) Installed Spacings for Rate-of-Rise Heat Detectors (Threshold Fire Size and Growth Rate)

Ceiling Height (ft)	Q_d = 1000 Btu/sec			Q_d = 750 Btu/sec			Q_d = 500 Btu/sec			Q_d = 250 Btu/sec			Q_d = 100 Btu/sec		
	s	m	f	s	m	f	s	m	f	s	m	f	s	m	f
4	28	32	32	26	28	27	22	24	23	16	17	16	11	11	10
5	27	31	31	25	27	27	21	23	22	15	16	15	10	10	9
6	26	30	31	24	26	27	20	22	22	15	15	15	9	9	9
7	25	29	30	23	26	26	19	21	21	14	14	14	9	9	8
8	24	29	30	22	25	26	18	21	21	13	13	14	8	8	8
9	23	28	29	21	24	25	17	20	20	12	13	13	7	7	7
10	22	27	29	20	23	25	16	19	20	12	12	13	7	7	7
11	21	27	28	18	23	24	15	19	19	11	12	12	6	6	6
12	20	26	26	17	22	24	15	18	19	10	11	12	5	5	5
13	19	25	27	16	22	23	14	18	18	9	11	11	5	5	5
14	18	24	27	15	21	22	13	17	18	9	10	11		4	
15	16	24	26	14	20	21	12	17	17	8	10	10			
16	15	23	25	13	19	21	11	16	16	7	9	10			
17	14	22	25	12	19	20	10	15	16	6	9	9			
18	13	22	24	11	18	20	9	14	15		8	8			
19	12	21	23	10	17	19	8	14	14		8	8			
20	11	20		9	16	19	7	13	14		7	7			
21	10	19		8	15	18		12	13		7				
22	9	19		7	15	17		12	13		6				
23	8	18			14	17		11	12		5				
24		17			13	16		11	11		5				
25		16			12	15		10	10		4				
26		15			12	15		9	10						
27		14			11	14		9							
28		13			11	13		8							
29		13			10			8							
30		12			10			7							

s = slow fire, m = medium fire, f = fast fire.
For SI units: 1 ft = 0.305 m.

Table B-3.3.2(b) Spacing Modifiers for Rate-of-Rise Heat Detectors

	Fire Growth Rate		
Listed Spacing (ft)	Slow	Medium	Fast
15	0.57	0.55	0.45
20	0.72	0.63	0.62
25	0.84	0.78	0.76
30	0.92	0.86	0.85
40	0.98	0.96	0.95
50	1.00	1.00	1.00
70	1.00	1.01	1.02

For SI units: 1 ft = 0.305 m.

B-3.4.3 Once a threshold size and expected fire growth rate have been selected, an installed detector spacing can be obtained from Figures B-3.4.1(a) through (i) for a specific detector's listed spacing, ambient temperature, and ceiling height. As in B-3.2.6, to determine the installed spacing of 135°F (57°C) fixed-temperature heat detectors with a listed spacing of 30 ft (9.1 m) and to detect a slowly developing fire at a threshold fire size of 500 Btu/sec (527 kW) in a room 10 ft (3 m) high with an ambient temperature of 70°F (21°C), the examples outlined in B-3.4.3.1 and B-3.4.3.2 are used.

B-3.4.3.1 Example 1.

Input:

Ceiling height: 10 ft (3 m)

Detector type: Fixed temperature 135°F (57°C)

Listed spacing: 30 ft (9.1 m)

Fire:

Q_d: 500 Btu/sec (527 kW)

Fire growth rate: slow

t_g: 600 sec

I. Input Data for Design and Analysis (*B-2*)

		Detector Type: Fixed-Temp HD	Rate-of-Rise HD	Smoke Detector		
Compartment Characteristics	H =		12		ft	Ceiling height or clearance above fuel (*see B-2.1, B-2.3*)
	T_o =				°F	Ambient temperature (*see B-3.2.3, B-6.4*)
Detector Characteristics (see B-3)	T_s =				°F	Detector operating temperature (*see B-3.1.4*)
	ΔT =				°F	Temperature differential (*Calculate using:* T_s-T_o)
	LS =		30		ft	Listed spacing of detector
	τ_o =				sec	Detector time constant (*see Table B-3.2.2 and B-6.3*)
	or RTI =				$ft^{1/2}sec^{1/2}$	Response time index (*see Table B-3.2.2*) *Calculate using:* RTI = $\tau_o\sqrt{5}$
Fire Development (see B-2.2)	t_g =		s (t_g = 600) m (t_g = 300) f (t_g = 150)	s (t_g = 600) m (t_g = 300) f (t_g = 150)	sec	Fire growth time to 1000 Btu/sec — *Select, or circle, a fire growth time*
	or α =				Btu/sec^3	Fire intensity coefficient — *Calculate using:* α = $1000/t_g^2$

s(low)	m(edium)	f(ast)	
≥ 400	≥150 and <400	< 150	sec
≤ 0.0062	≥0.0444 and <0.0062	>0.0444	Btu/sec^3

[*see B-2.2.3, B-3.3.2(b), B-5.6.2(b)*]

IIa. Input Data for *Design* (B-3)

IIa.1 Establish Design Objectives

Determine the size of the fire at which detector response is desired using either 1 or 2:

1. *Select* Q_d = 500 Btu/sec [see B-2.2.4, Table B-2.2.2.1(a), (b), or B-2.2.2.3], or

2. *Calculate* Q_d using the time after ignition at which detector response is desired, t_d, using: $Q_d = \alpha t_d^2$ = _____ Btu/sec

IIa.2 Calculate Detector Response

Fixed-Temperature HD (B-3.2)	*Rate-of-Rise HD (B-3.3)*	*Smoke Detector (B-5)*
1. Fill in the variables: Q_d = _____ Btu/sec t_g = _____ sec, or α = _____ Btu/sec^3 τ_o = _____ sec, or RTI = _____ $ft^{1/2}$ $sec^{1/2}$ ΔT = _____ °F and H = _____ ft 2. Using Q_d and t_g (or α), select the appropriate design table (a) through (y) from Table B-3.2.4: _____ 3. Using τ_o (or RTI), ΔT, and H, determine the installed spacing: _____ ft	1. Fill in the variables: Fire growth (s,m,f) = m H = 12 ft Q_d = 500 Btu/sec 2. Select installed spacing from Table B-3.3.2(a): 18 ft 3. Select spacing modifier from Table B-3.3.2(b): x 0.86 4. Calculate installed spacing: 15.5 ft	1. Fill in the variables: Fire growth (s,m,f) = _____ H = _____ ft Q_d = _____ Btu/sec 2. Using fire growth (s, m, or f), select Figure B-5.5.1(a), (b), or (c): _____ 3. Using H and Q_d, determine the installed spacing: _____ ft

IIb. Input Data for *Analysis* of an Existing Heat Detection System (B-4)

1. Fill in the variables:
   S = _____ ft (installed spacing of the existing heat detector)
   t_g = _____ sec, or α = _____ Btu/sec^3
   τ_o = _____ sec, or RTI = _____ $ft^{1/2}sec^{1/2}$
   ΔT = _____ °F and H = _____ ft
2. Using S and t_g (or α), select an analysis table (a) - (nn) from Table B-4: _____
3. Using τ_o (or RTI), ΔT, and H, determine the fire size at detector response Q_d = _____ Btu/sec
4. Calculate the time to detector response using: $t_d = \sqrt{\frac{Q_d}{\alpha}} = \sqrt{\frac{\text{Btu/sec}}{\text{Btu/sec}^3}}$ = _____ sec

Figure B-3.3.5 Completed worksheet for B-3.3.5, Example.

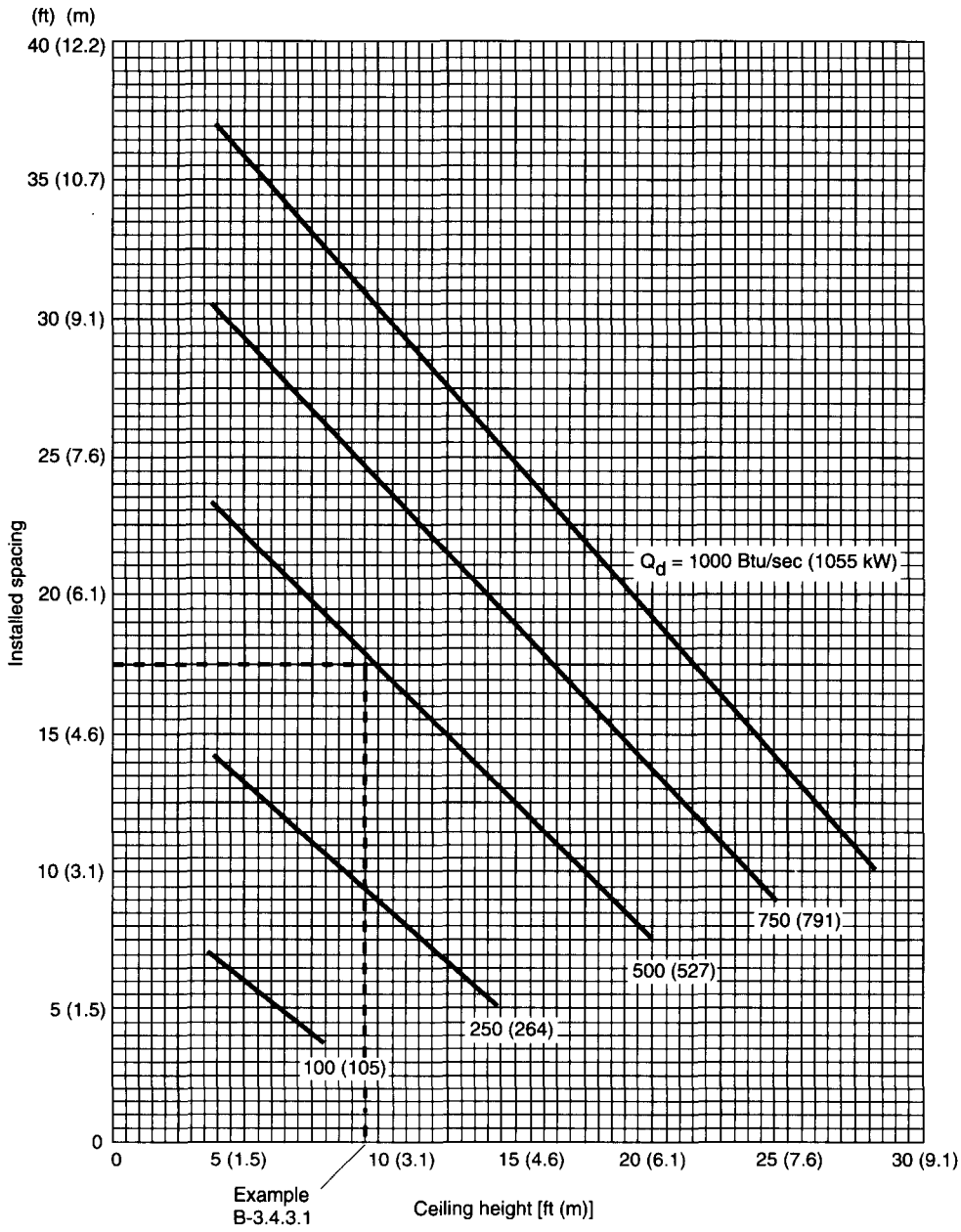


Figure B-3.4.1(a) Heat detector, fixed temperature, 30-ft (9.1-m) listed spacing, slow fire [ΔT = 65°F (36.1°C)].

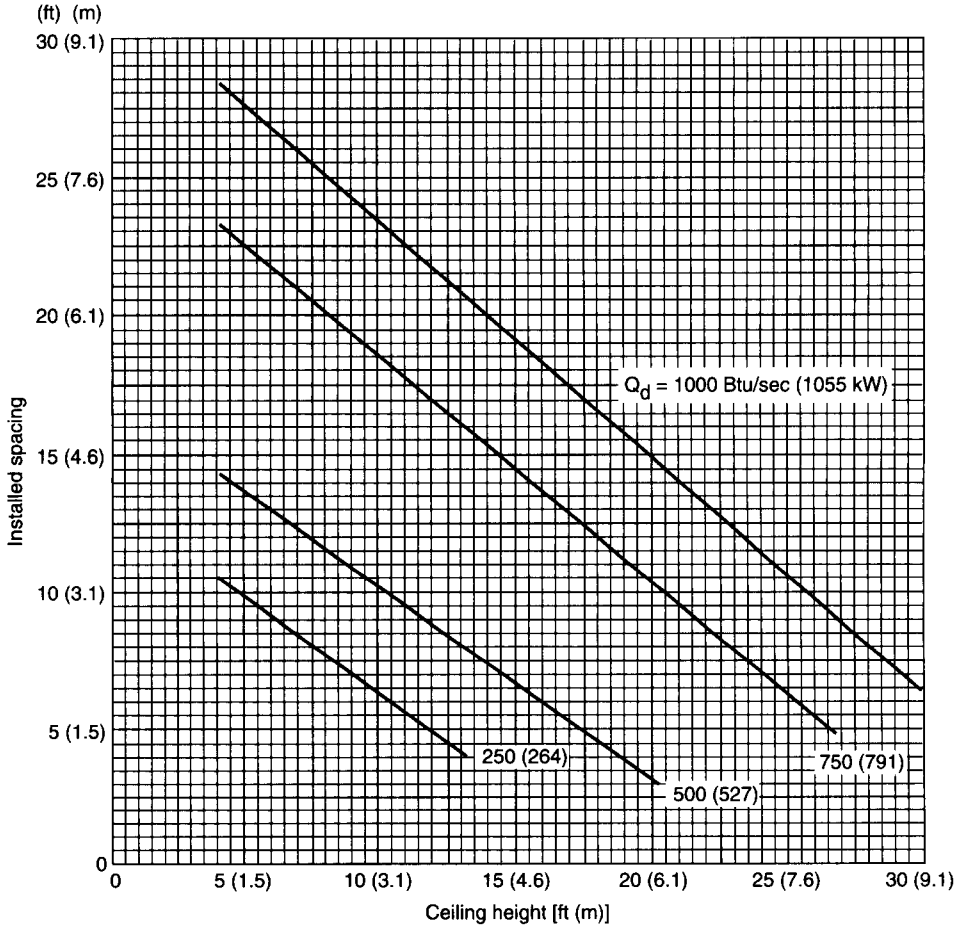


Figure B-3.4.1(b) Heat detector, fixed temperature, 30-ft (9.1-m) listed spacing, medium fire [ΔT = 65°F (36°C)].

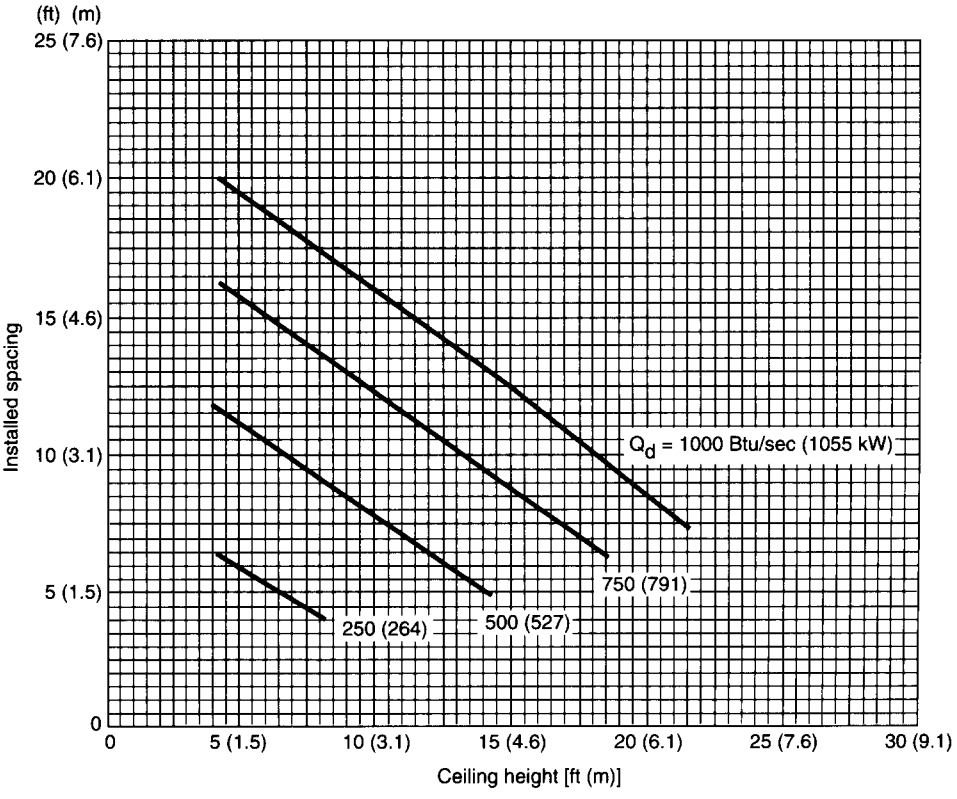


Figure B-3.4.1(c) Heat detector, fixed temperature, 30-ft (9.1-m) listed spacing, fast fire [ΔT = 65°F (36°C)].

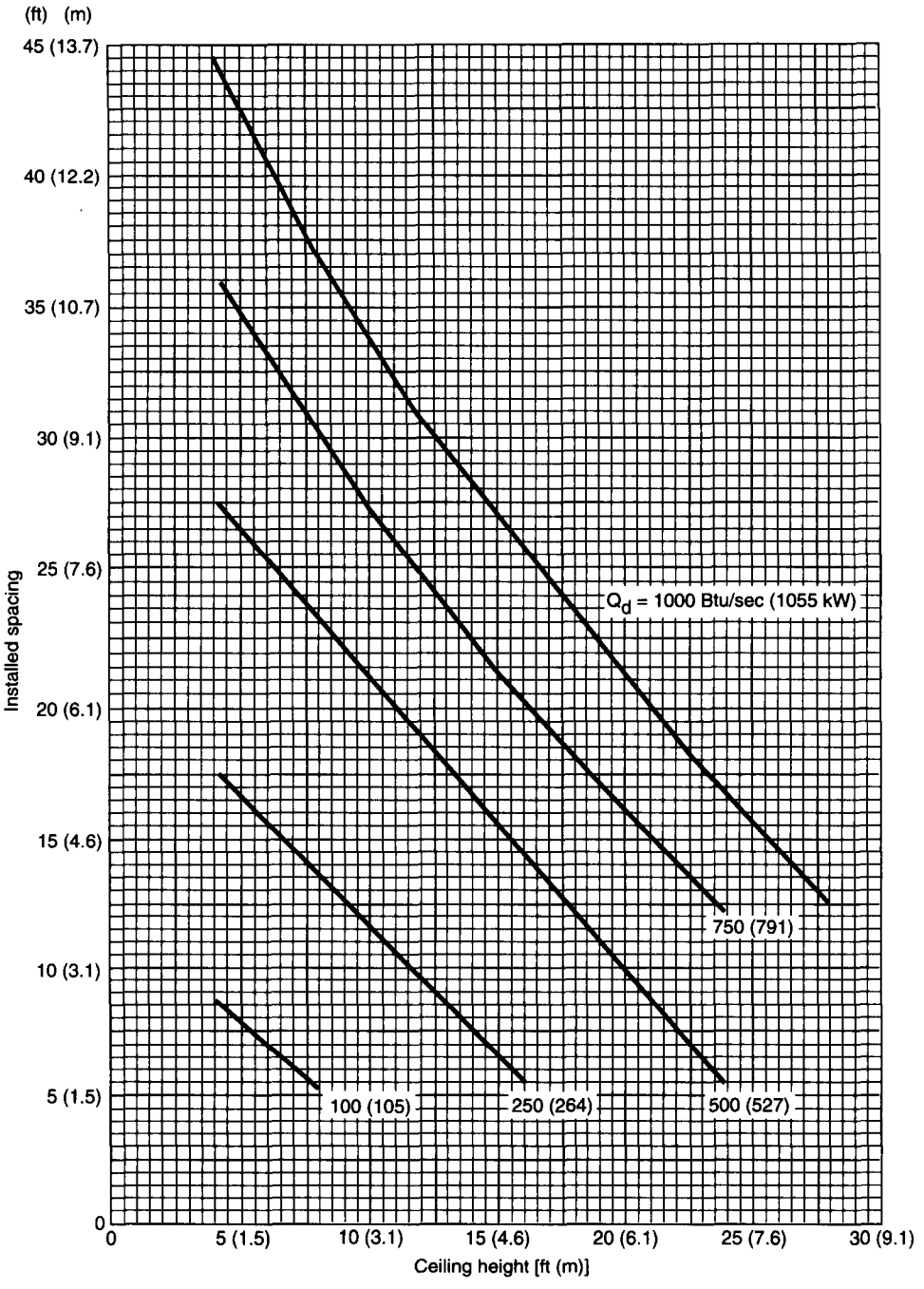


Figure B-3.4.1(d) Heat detector, fixed temperature, 50-ft (15.2-m) listed spacing, slow fire [ΔT = 65°F (36°C)].

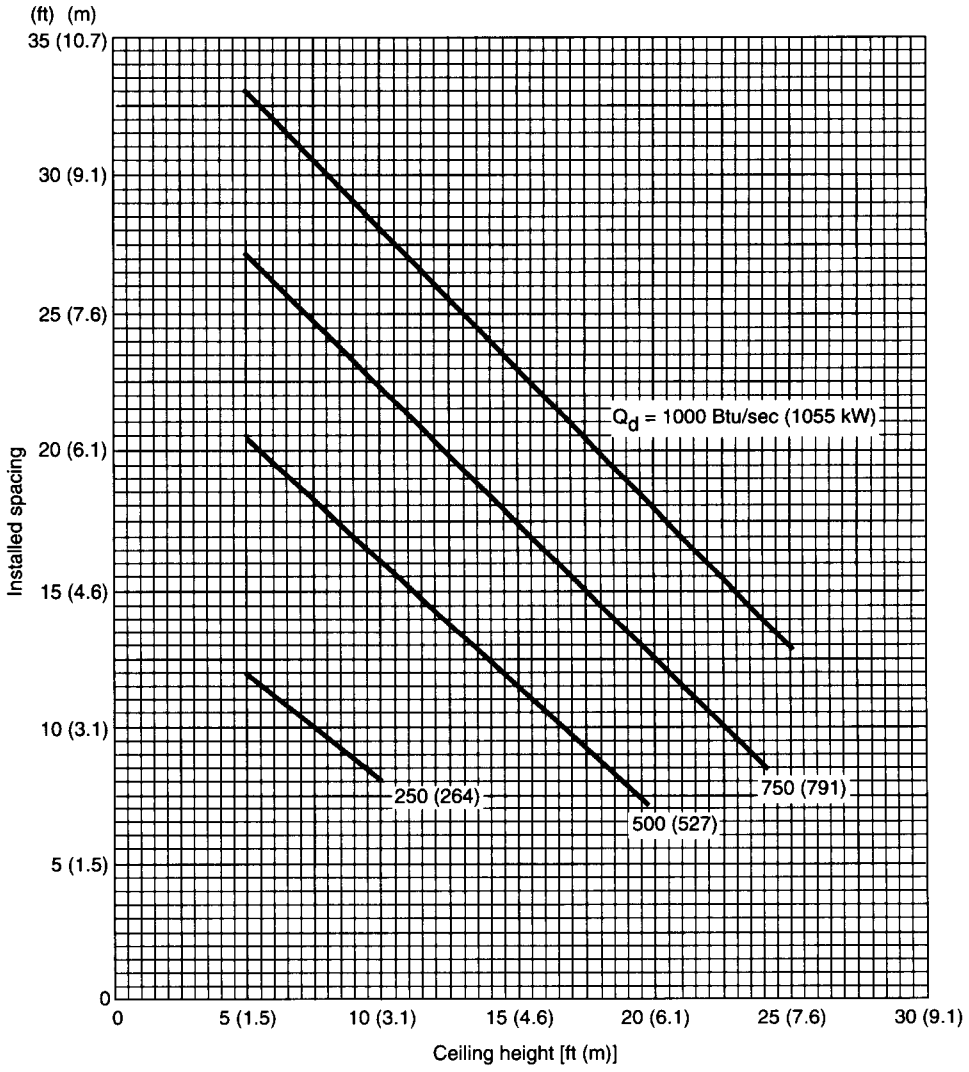


Figure B-3.4.1(e) Heat detector, fixed temperature, 50-ft (15.2-m) listed spacing, medium fire [ΔT = 65°F (36°C)].

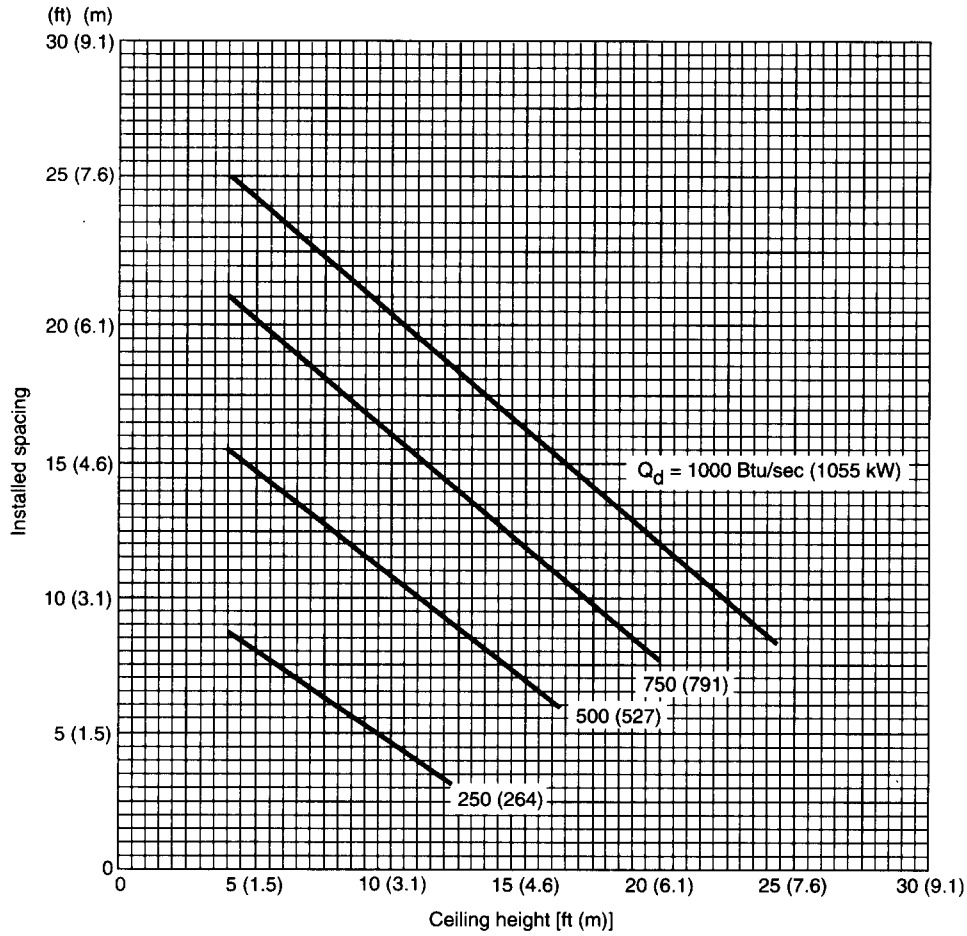


Figure B-3.4.1(f) Heat detector, fixed temperature, 50-ft (15.2-m) listed spacing, fast fire [ΔT = 65°F (36°C)].

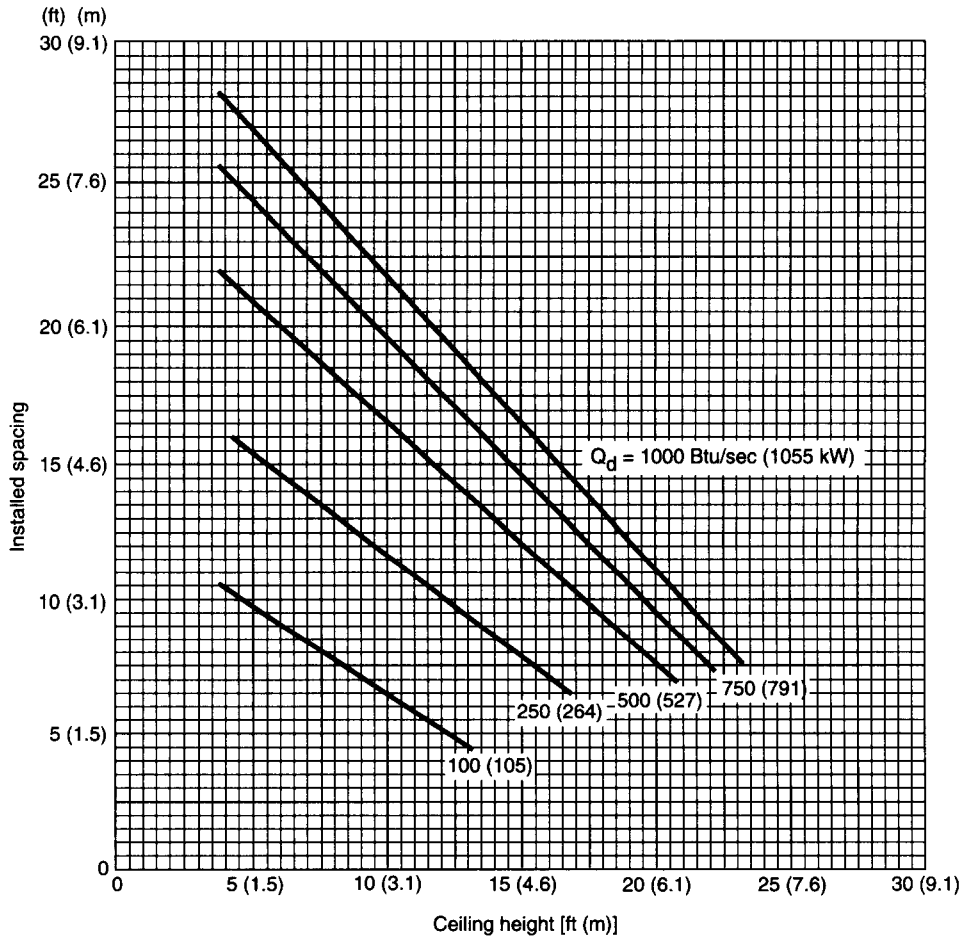


Figure B-3.4.1(g) Heat detector, rate-of-rise, 50-ft (15.2-m) listed spacing, slow fire.

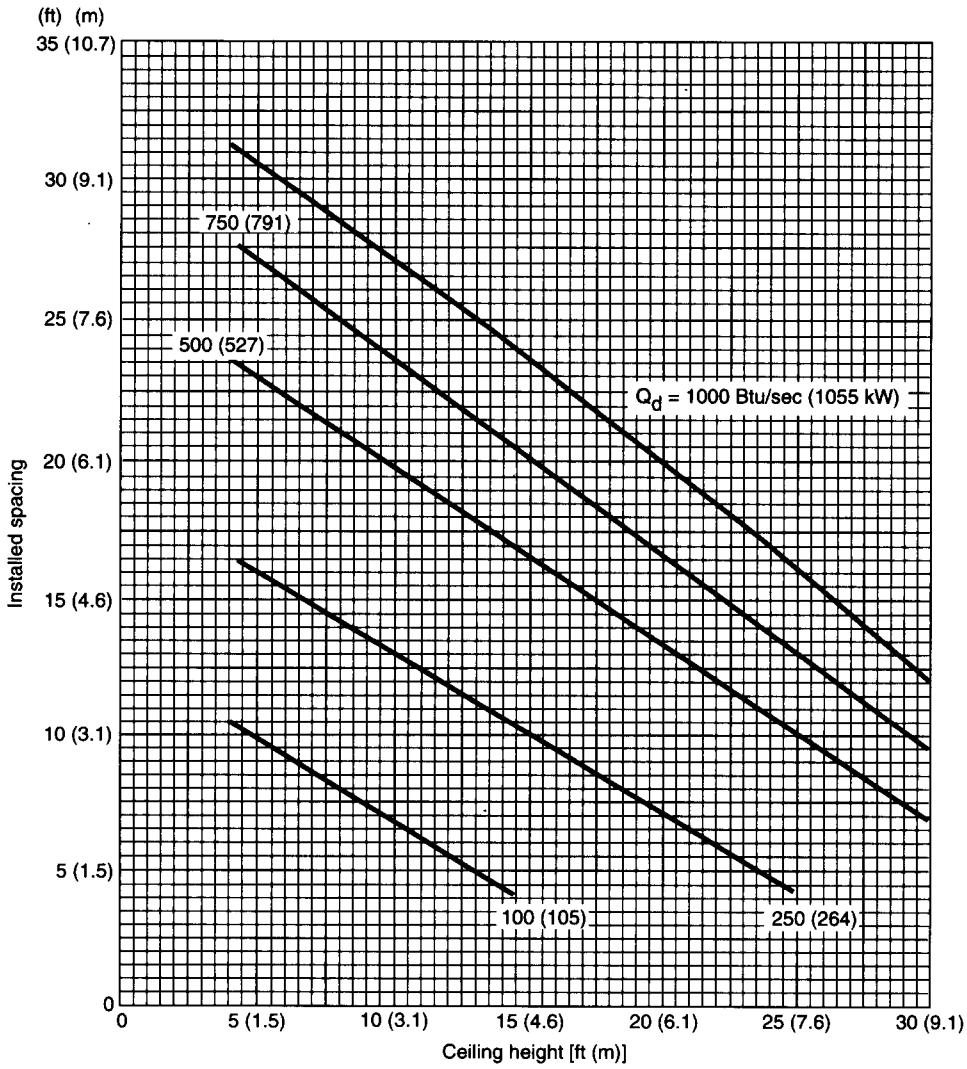


Figure B-3.4.1(h) Heat detector, rate-of-rise, 50-ft (15.2-m) listed spacing, medium fire.

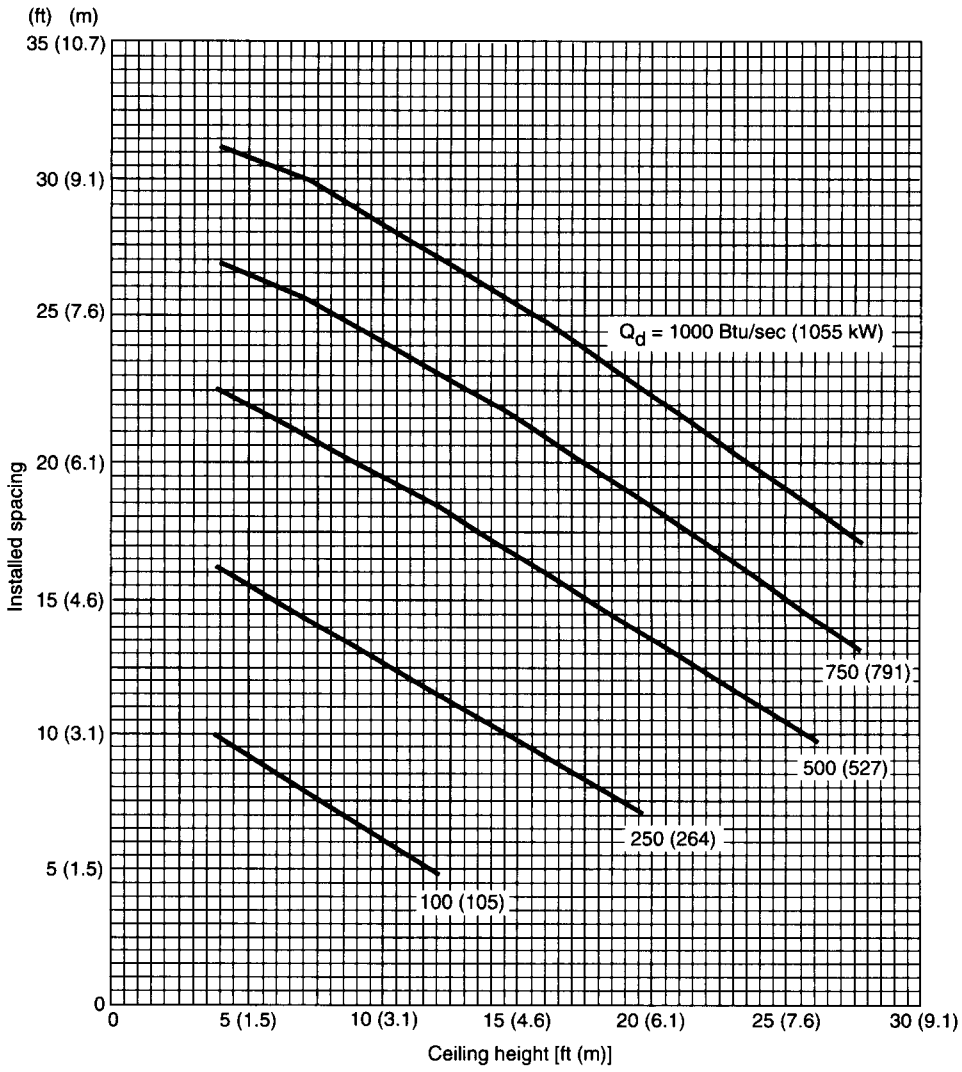


Figure B-3.4.1(i) Heat detector, rate-of-rise, 50-ft (15.2-m) listed spacing, fast fire.

Environmental conditions:

T_o: 70°F (21°C)

$\Delta T = 135 - 70 = 65°F$ (36°C)

Required installed spacing:

From Figure B-3.4.1(a), an installed spacing of 18 ft (5.2 m) (17.5 ft rounded to 18 ft) is used.

It should be noted that, where the ceiling height is 15 ft (4.6 m), the same graph gives an installed spacing of 12 ft (3.5 m). A ceiling height of 20 ft (6.1 m) would require a spacing of 8 ft (2.4 m). This change in spacing clearly illustrates the need to consider ceiling height in the design of a detection system.

B-3.4.3.2 Example 2.

Input:

Ceiling height: 10 ft (3 m)

Detector type: Combination rate-of-rise and fixed temperature

Listed spacing: 50 ft (15.2 m)

Fire:

Q_d: 500 Btu/sec (527 kW)

Fire growth rate: fast

t_g: 150 sec

Environmental conditions:

T_o: 70°F (21°C)

ΔT: 65°F (36°C)

Spacing:

From Figure B-3.4.1(i), an installed spacing of 20 ft (6.1 m) (19.5 ft rounded to 20 ft) is used.

A 30-ft (9.1-m) fixed temperature detector would require a 7.5-ft (2.5-m) spacing.

If the fire growth rate is slow, as in Example 1, the rate-of-rise detector would require an installed spacing of 16 ft (4.9 m).

B-4 Analysis of Existing Heat Detection Systems.

(a) **Use of Tables B-4(a) through (nn).** Tables B-4(a) through (nn) can be used to determine the size fire (heat release rate) to which existing fixed-temperature heat detection systems will respond. Table B-4 provides an index to Tables B-4 (a) through (nn).

The use of the analysis tables is similar to that described for new designs. The difference is that the spacing of the existing detectors needs to be known. An estimate of the fire intensity coefficient (α) or the fire growth time (t_g) also has to be made for the fuel that is expected to burn.

(b) **Example.**

Input:

Ceiling height: 8 ft (2.4 m)

Detector type: Fixed temperature 135°F (57°C)

Listed spacing: 30 ft (9.1 m)

Installed spacing: 15 ft (4.6 m)

Fire:

Fire growth rate: slow

t_g: 600 sec

α: 0.003 Btu/sec^3

Environmental conditions:

T_o: 55°F (12.8°C)

Threshold fire size (Q_d) at detector response:

From Table B-3.2.2, the detector time constant (τ_o) is 80 seconds.

$\Delta T = T_s - T_o = 135 - 55 = 80°F$

From Table B-4(t):

For τ_o = 75 sec: Q_d = 418 Btu/sec

For τ_o = 100 sec: Q_d = 472 Btu/sec

By interpolation:

$Q_d = 418 - [(75 - 80)(418 - 472)/(75 - 100)]$

Q_d = 429 Btu/sec

Table B-4 Analysis Tables Index

	Installed Spacing (ft)	Fire Growth Rate (sec) τ_g	Fuel Fire Intensity Coefficient (Btu/sec^5) α
Table B-4(a)	8	50	0.400
Table B-4(b)	8	150	0.044
Table B-4(c)	8	300	0.011
Table B-4(d)	8	500	0.004
Table B-4(e)	8	600	0.003
Table B-4(f)	10	50	0.400
Table B-4(g)	10	150	0.044
Table B-4(h)	10	300	0.011
Table B-4(i)	10	500	0.004
Table B-4(j)	10	600	0.003
Table B-4(k)	12	50	0.400
Table B-4(l)	12	150	0.044
Table B-4(m)	12	300	0.011
Table B-4(n)	12	500	0.004
Table B-4(o)	12	600	0.003
Table B-4(p)	15	50	0.400
Table B-4(q)	15	150	0.044
Table B-4(r)	15	300	0.011
Table B-4(s)	15	500	0.004
Table B-4(t)	15	600	0.003
Table B-4(u)	20	50	0.400
Table B-4(v)	20	150	0.044
Table B-4(w)	20	300	0.011
Table B-4(x)	20	500	0.004
Table B-4(y)	20	600	0.003
Table B-4(z)	25	50	0.400
Table B-4(aa)	25	150	0.044
Table B-4(bb)	25	300	0.011
Table B-4(cc)	25	500	0.004
Table B-4(dd)	25	600	0.003
Table B-4(ee)	30	50	0.400
Table B-4(ff)	30	150	0.044
Table B-4(gg)	30	300	0.011
Table B-4(hh)	30	500	0.004
Table B-4(ii)	30	600	0.003
Table B-4(jj)	50	50	0.400
Table B-4(kk)	50	150	0.044
Table B-4(ll)	50	300	0.011
Table B-4(mm)	50	500	0.004
Table B-4(nn)	50	600	0.003

I. Input Data for Design and Analysis (*B-2*)

		Detector Type: Fixed-Temp HD	Rate-of-Rise HD	Smoke Detector		
Compartment Characteristics	H =	8			ft	Ceiling height or clearance above fuel (*see B-2.1, B-2.3*)
	T_o =	55			°F	Ambient temperature (*see B-3.2.3, B-6.4*)
Detector Characteristics (see B-3)	T_s =	135			°F	Detector operating temperature (*see B-3.1.4*)
	ΔT =	80			°F	Temperature differential (*Calculate using:* T_s-T_o)
	LS =	30			ft	Listed spacing of detector
	τ_o = or	80			sec	Detector time constant (*see Table B-3.2.2 and B-6.3*)
	RTI =	/			$ft^{1/2}sec^{1/2}$	Response time index (*see Table B-3.2.2*) *Calculate using:* RTI = $\tau_o \sqrt{5}$
Fire Development (see B-2.2)	t_g = or	600	s (t_g = 600) m (t_g = 300) f (t_g = 150)	s (t_g = 600) m (t_g = 300) f (t_g = 150)	sec	Fire growth time to 1000 Btu/sec *Select, or circle, a fire growth time*
	α =	0.003			Btu/sec^3	Fire intensity coefficient *Calculate using:* α = $1000/t_g^2$

s(low)	m(edium)	f(ast)	
≥ 400	≥150 and <400	< 150	sec
≤ 0.0062	≥0.0444 and <0.0062	>0.0444	Btu/sec^3

[*see B-2.2.3, B-3.3.2(b), B-5.6.2(b)*]

IIa. Input Data for *Design* (B-3)

IIa.1 Establish Design Objectives

Determine the size of the fire at which detector response is desired using either 1 or 2:

1. *Select* Q_d = _____ Btu/sec [see B-2.2.4, Table B-2.2.2.1(a), (b), or B-2.2.2.3], or

2. *Calculate* Q_d using the time after ignition at which detector response is desired, t_d, using: $Q_d = \alpha t_d^2$ =_____ Btu/sec

IIa.2 Calculate Detector Response

Fixed-Temperature HD (B-3.2)	*Rate-of-Rise HD (B-3.3)*	*Smoke Detector (B-5)*
1. Fill in the variables: Q_d =_____ Btu/sec t_g =_____ sec, or α = _____ Btu/sec^3 τ_o =_____ sec, or RTI = _____ $ft^{1/2}$ $sec^{1/2}$ ΔT = _____ °F and H = _____ ft 2. Using Q_d and t_g (or α), select the appropriate design table (a) through (y) from Table B-3.2.4:_____ 3. Using τ_o (or RTI), ΔT, and H, determine the installed spacing: _____ ft	1. Fill in the variables: Fire growth (s,m,f) =_____ H = _____ ft Q_d = _____ Btu/sec 2. Select installed spacing from Table B-3.3.2(a): _____ ft 3. Select spacing modifier from Table B-3.3.2(b): x _____ 4. Calculate installed spacing: _____ft	1. Fill in the variables: Fire growth (s,m,f) = _____ H = _____ ft Q_d = _____ Btu/sec 2. Using fire growth (s, m, or f), select Figure B-5.5.1(a), (b), or (c): _____ 3. Using H and Q_d, determine the installed spacing: _____ ft

IIb. Input Data for *Analysis* of an Existing Heat Detection System (B-4)

1. Fill in the variables:
   S = 15 ft (installed spacing of the existing heat detector)
   t_g = 600 sec, or α = 0.003 Btu/sec^3
   τ_o = 80 sec, or RTI = / $ft^{1/2}sec^{1/2}$
   ΔT = 80 °F and H = 8 ft
2. Using S and t_g (or α), select an analysis table (a) - (nn) from Table B-4: B-4(t)
3. Using τ_o (or RTI), ΔT, and H, determine the fire size at detector response Q_d = 429 Btu/sec
4. Calculate the time to detector response using: $t_d = \sqrt{\frac{Q_d}{\alpha}} = \sqrt{\frac{429 \text{ Btu/sec}}{0.003 \text{ Btu/sec}^3}}$ = 379 sec

Figure B-4 Completed worksheet for B-4(b), Example.

Table B-4(a)
Installed Spacing of Heat Detector: 8 ft
t_g: 50 Seconds to 1000 Btu/sec
α: 0.400 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Fire Size at Detector Response (Btu/sec)						
25	56	40	300	402	535	668	832	1016	1219
25	56	60	368	508	687	877	1106	1365	1657
25	56	80	450	618	838	1102	1381	1722	2110
25	56	100	512	716	985	1308	1661	2090	2585
25	56	120	573	815	1132	1517	1949	2473	3082
25	56	140	654	919	1282	1730	2265	2870	3601
50	112	40	422	571	755	926	1136	1366	1614
50	112	60	546	738	976	1211	1496	1811	2157
50	112	80	642	883	1181	1484	1846	2251	2699
50	112	100	754	1033	1383	1752	2194	2692	3248
50	112	120	865	1179	1582	2018	2542	3138	3810
50	112	140	928	1305	1773	2318	2895	3592	4386
75	168	40	542	722	908	1137	1389	1659	1948
75	168	60	702	932	1219	1492	1826	2193	2589
75	168	80	813	1111	1472	1824	2245	2710	3217
75	168	100	931	1289	1718	2146	2656	3221	3844
75	168	120	1016	1451	1955	2464	3063	3733	4475
75	168	140	1149	1629	2193	2778	3470	4247	5115
100	224	40	625	841	1101	1332	1614	1920	2246
100	224	60	802	1087	1427	1742	2122	2535	2978
100	224	80	944	1305	1728	2128	2604	3125	3687
100	224	100	1050	1503	2012	2501	3074	3703	4388
100	224	120	1222	1723	2298	2867	3537	4276	5088
100	224	140	1360	1925	2573	3226	3995	4849	5791
125	280	40	729	967	1208	1501	1820	2160	2519
125	280	60	912	1238	1622	1972	2394	2850	3337
125	280	80	1036	1472	1959	2409	2936	3508	4123
125	280	100	1233	1730	2294	2830	3461	4150	4895
125	280	120	1398	1968	2614	3240	3976	4782	5661
125	280	140	1561	2201	2926	3642	4484	5411	6246
150	335	40	793	1066	1340	1664	2013	2384	2775
150	335	60	979	1362	1797	2187	2649	3145	3674
150	335	80	1185	1656	2186	2673	3247	3868	4533
150	335	100	1378	1933	2554	3138	3825	4570	5373
150	335	120	1568	2201	2911	3590	4389	5259	6202
150	335	140	1757	2462	3257	4033	4944	5942	7027
175	391	40	882	1175	1468	1818	2195	2595	3016
175	391	60	1046	1483	1965	2391	2890	3425	3993
175	391	80	1301	1819	2397	2923	3542	4210	4923
175	391	100	1520	2127	2802	3431	4170	4970	5827
175	391	120	1734	2423	3193	3923	4782	5713	6718
175	391	140	1947	2712	3573	4405	5382	6447	7601
200	447	40	925	1257	1586	1964	2369	2797	3247
200	447	60	1168	1625	2136	2587	3121	3692	4298
200	447	80	1415	1977	2599	3162	3825	4537	5295
200	447	100	1658	2313	3040	3711	4501	5352	6262
200	447	120	1897	2637	3464	4242	5158	6148	7212
200	447	140	2133	2952	3875	4761	5802	6932	8152
225	503	40	968	1337	1754	2111	2537	2991	3468
225	503	60	1254	1747	2294	2774	3342	3949	4590
225	503	80	1527	2129	2794	3392	4096	4851	5653
225	503	100	1794	2494	3268	3980	4819	5720	6681
225	503	120	2057	2845	3724	4549	5520	6567	7689
225	503	140	2317	3185	4168	5104	6206	7400	8683
250	559	40	1011	1417	1865	2247	2698	3177	3681
250	559	60	1339	1866	2447	2955	3556	4197	4873
250	559	80	1637	2278	2982	3614	4358	5155	5999
250	559	100	1928	2669	3489	4241	5126	6076	7087
250	559	120	2215	3046	3890	4842	5870	6972	8150
250	559	140	2499	3412	4356	5431	6597	7852	9197
275	615	40	1093	1513	1981	2380	2854	3358	3887
275	615	60	1424	1982	2596	3131	3763	4437	5147
275	615	80	1746	2422	3165	3829	4612	5449	6334
275	615	100	2061	2840	3618	4488	5424	6421	7479
275	615	120	2371	3242	4128	5129	6209	7365	8597
275	615	140	2679	3633	4622	5753	6977	8291	9697
300	671	40	1151	1595	2089	2508	3005	3533	4087
300	671	60	1507	2096	2740	3301	3964	4670	5413
300	671	80	1853	2563	3259	4032	4859	5735	6661
300	671	100	2192	3007	3820	4734	5714	6756	7862
300	671	120	2526	3434	4359	5409	6540	7748	9033
300	671	140	2859	3849	4881	6066	7346	8718	10183
325	727	40	1208	1677	2194	2633	3152	3704	4282
325	727	60	1589	2207	2804	3461	4160	4898	5672
325	727	80	1959	2701	3428	4236	5100	6014	6978
325	727	100	2322	3171	4018	4973	5996	7084	8234
325	727	120	2680	3623	4585	5682	6862	8121	9457
325	727	140	3038	4061	5133	6371	7706	9135	10657
350	783	40	1265	1756	2297	2754	3296	3871	4472
350	783	60	1671	2315	2937	3623	4352	5119	5925
350	783	80	2064	2836	3592	4435	5335	6287	7289
350	783	100	2451	3331	4211	5207	6272	7403	8599
350	783	120	2834	3808	4805	5949	7177	8485	9872
350	783	140	3218	4270	5380	6669	8058	9542	11121
375	839	40	1321	1835	2398	2874	3437	4034	4658
375	839	60	1751	2422	3069	3782	4539	5336	6172
375	839	80	2169	2969	3753	4630	5565	6553	7592
375	839	100	2579	3489	4401	5436	6543	7716	8955
375	839	120	2987	3990	5021	6210	7486	8842	10279
375	839	140	3303	4445	5620	6961	8403	9941	11575
400	894	40	1377	1912	2423	2982	3574	4193	4840
400	894	60	1831	2527	3197	3937	4723	5549	6415
400	894	80	2272	3100	3911	4821	5791	6814	7890
400	894	100	2707	3645	4586	5660	6807	8023	9304
400	894	120	3141	4169	5233	6466	7788	9192	10677
400	894	140	3456	4640	5857	7247	8741	10332	12020

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m; 1000 Btu/sec = 1055 kW.

Table B-4(b)
Installed Spacing of Heat Detector: 8 ft
t_g: 50 Seconds to 1000 Btu/sec
α: 0.044 Btu/sec^3

			Ceiling Height (ft)						
τ	RTI	ΔT	4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Fire Size at Detector Response (Btu/sec)						
25	56	40	118	167	232	311	400	507	631
25	56	60	154	226	322	440	584	752	952
25	56	80	194	286	415	579	781	1026	1309
25	56	100	228	346	512	726	993	1319	1699
25	56	120	263	409	614	883	1221	1633	2118
25	56	140	299	473	721	1049	1462	1969	2573
50	112	40	171	237	320	410	517	638	775
50	112	60	224	317	435	574	728	913	1126
50	112	80	281	397	550	735	949	1205	1504
50	112	100	329	474	666	901	1185	1516	1912
50	112	120	377	552	785	1074	1428	1846	2347
50	112	140	424	630	906	1254	1683	2202	2808
75	168	40	216	296	395	498	620	756	906
75	168	60	283	395	533	683	861	1063	1291
75	168	80	352	492	668	876	1107	1381	1696
75	168	100	413	585	803	1063	1360	1714	2125
75	168	120	472	678	939	1255	1622	2063	2578
75	168	140	531	770	1076	1451	1901	2427	3055
100	224	40	255	349	462	577	713	863	1027
100	224	60	343	467	622	788	983	1202	1446
100	224	80	416	578	776	996	1254	1548	1880
100	224	100	488	685	929	1214	1530	1904	2333
100	224	120	559	792	1081	1424	1811	2273	2806
100	224	140	636	898	1234	1637	2101	2656	3301
125	280	40	291	397	523	650	799	962	1140
125	280	60	391	532	704	885	1097	1333	1593
125	280	80	476	657	877	1114	1392	1705	2056
125	280	100	558	779	1046	1342	1690	2086	2534
125	280	120	647	899	1214	1571	1992	2476	3029
125	280	140	723	1017	1382	1813	2300	2878	3543
150	335	40	325	443	581	719	880	1056	1246
150	335	60	435	593	781	976	1204	1456	1733
150	335	80	531	732	971	1226	1523	1855	2224
150	335	100	634	869	1157	1473	1842	2259	2728
150	335	120	720	999	1340	1719	2164	2671	3245
150	335	140	805	1128	1522	1967	2491	3093	3780
175	391	40	357	486	637	784	957	1145	1347
175	391	60	478	650	854	1063	1307	1574	1866
175	391	80	584	803	1061	1332	1649	1999	2386
175	391	100	694	952	1262	1598	1989	2427	2915
175	391	120	790	1094	1460	1861	2330	2860	3456
175	391	140	892	1236	1656	2125	2675	3301	4011
200	447	40	396	530	676	846	1031	1230	1444
200	447	60	519	705	924	1146	1405	1687	1995
200	447	80	646	873	1148	1435	1769	2138	2543
200	447	100	752	1031	1363	1718	2129	2588	3096
200	447	120	870	1188	1576	1998	2490	3042	3660
200	447	140	959	1337	1785	2277	2852	3503	4236
225	503	40	425	570	726	906	1102	1312	1538
225	503	60	558	759	992	1227	1500	1797	2119
225	503	80	693	939	1231	1533	1885	2271	2694
225	503	100	809	1108	1461	1833	2265	2744	3272
225	503	120	926	1274	1686	2130	2645	3220	3859
225	503	140	1026	1434	1909	2425	3025	3700	4456
250	559	40	453	608	774	964	1170	1392	1628
250	559	60	596	810	1041	1304	1591	1902	2239
250	559	80	738	1002	1311	1629	1997	2401	2841
250	559	100	876	1185	1556	1946	2397	2896	3444
250	559	120	982	1358	1794	2258	2795	3392	4053
250	559	140	1107	1531	2029	2567	3192	3891	4671
275	615	40	480	645	820	1021	1237	1469	1716
275	615	60	646	863	1103	1379	1680	2005	2355
275	615	80	783	1063	1389	1722	2107	2527	2984
275	615	100	921	1256	1647	2054	2525	3043	3611
275	615	120	1039	1440	1898	2382	2941	3560	4242
275	615	140	1177	1624	2146	2706	3355	4078	4881
300	671	40	507	681	865	1075	1301	1543	1801
300	671	60	680	911	1163	1452	1766	2105	2469
300	671	80	827	1123	1445	1811	2213	2650	3123
300	671	100	967	1325	1736	2161	2650	3187	3774
300	671	120	1109	1523	2000	2503	3083	3723	4427
300	671	140	1246	1715	2260	2842	3514	4261	5087
325	727	40	533	717	909	1129	1365	1616	1884
325	727	60	714	959	1222	1524	1851	2203	2580
325	727	80	881	1184	1517	1899	2317	2770	3259
325	727	100	1014	1393	1823	2264	2772	3328	3933
325	727	120	1169	1601	2100	2622	3222	3884	4608
325	727	140	1314	1803	2371	2974	3670	4440	5288
350	783	40	559	751	952	1181	1426	1688	1965
350	783	60	747	1005	1280	1594	1933	2298	2688
350	783	80	917	1239	1589	1986	2418	2887	3392
350	783	100	1072	1462	1885	2365	2892	3466	4089
350	783	120	1228	1679	2197	2737	3359	4041	4786
350	783	140	1380	1890	2480	3104	3822	4615	5486
375	839	40	584	785	994	1232	1486	1757	2045
375	839	60	780	1050	1336	1662	2014	2391	2795
375	839	80	953	1294	1658	2070	2518	3002	3523
375	839	100	1122	1528	1967	2464	3009	3601	4242
375	839	120	1286	1754	2292	2851	3492	4195	4960
375	839	140	1446	1975	2587	3231	3971	4787	5681
400	894	40	609	818	1036	1282	1545	1826	2122
400	894	60	813	1094	1392	1729	2093	2483	2899
400	894	80	989	1348	1726	2153	2615	3114	3651
400	894	100	1171	1593	2048	2562	3123	3733	4393
400	894	120	1343	1829	2359	2962	3623	4346	5132
400	894	140	1511	2058	2692	3356	4118	4956	5872

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m; 1000 Btu/sec = 1055 kW.

Table B-4(c)
Installed Spacing of Heat Detector: 8 ft
t_g: 300 Seconds to 1000 Btu/sec
α: 0.011 Btu/sec^3

τ	RTI	ΔT	Ceiling Height (ft) 4.0	8.0	12.0	16.0	20.0	24.0	28.0
			Fire Size at Detector Response (Btu/sec)						
25	56	40	70	104	152	211	285	374	477
25	56	60	95	149	223	321	443	592	767
25	56	80	122	196	302	442	620	838	1099
25	56	100	148	246	387	575	815	1110	1463
25	56	120	174	299	479	719	1027	1405	1858
25	56	140	201	354	576	873	1253	1721	2283
50	112	40	101	144	200	267	345	439	547
50	112	60	136	200	284	389	517	668	849
50	112	80	172	257	372	520	703	926	1187
50	112	100	205	315	465	661	906	1206	1560
50	112	120	239	374	563	811	1124	1508	1963
50	112	140	273	437	666	970	1356	1830	2399
75	168	40	127	178	242	318	402	502	616
75	168	60	170	245	339	453	586	746	931
75	168	80	215	311	438	595	786	1012	1280
75	168	100	255	378	540	745	998	1303	1661
75	168	120	296	445	646	903	1223	1612	2072
75	168	140	336	514	756	1069	1461	1942	2510
100	224	40	150	209	281	361	455	561	682
100	224	60	201	286	390	514	654	821	1013
100	224	80	253	361	500	667	864	1099	1374
100	224	100	300	436	611	827	1088	1397	1764
100	224	120	347	511	725	993	1322	1714	2183
100	224	140	393	587	843	1167	1568	2055	2628
125	280	40	171	237	317	403	504	618	745
125	280	60	230	323	437	567	719	893	1093
125	280	80	289	408	557	736	941	1184	1466
125	280	100	342	490	678	906	1173	1493	1867
125	280	120	395	573	801	1081	1420	1819	2294
125	280	140	447	656	926	1262	1674	2163	2748
150	335	40	192	264	350	443	551	671	805
150	335	60	261	360	482	619	780	963	1170
150	335	80	322	451	612	801	1015	1267	1557
150	335	100	381	542	742	981	1258	1587	1969
150	335	120	440	631	873	1166	1511	1923	2406
150	335	140	497	721	1006	1356	1778	2276	2867
175	391	40	211	289	383	481	596	723	863
175	391	60	287	394	525	670	839	1030	1245
175	391	80	353	493	664	859	1087	1348	1646
175	391	100	419	591	803	1055	1341	1679	2070
175	391	120	482	687	943	1248	1603	2025	2517
175	391	140	545	784	1083	1447	1875	2387	2987
200	447	40	229	314	413	518	639	772	919
200	447	60	311	426	566	719	896	1095	1318
200	447	80	384	533	715	918	1156	1427	1733
200	447	100	454	638	862	1119	1421	1770	2169
200	447	120	523	741	1010	1328	1694	2126	2626
200	447	140	596	844	1158	1535	1974	2497	3106
225	503	40	247	337	443	553	680	820	973
225	503	60	335	458	606	766	951	1158	1389
225	503	80	413	572	763	976	1223	1503	1819
225	503	100	489	684	919	1186	1499	1858	2267
225	503	120	569	794	1075	1406	1782	2225	2735
225	503	140	639	902	1230	1621	2072	2605	3224
250	559	40	264	360	471	587	720	866	1025
250	559	60	357	488	644	811	1005	1220	1458
250	559	80	441	610	811	1032	1289	1578	1902
250	559	100	522	728	975	1252	1576	1945	2363
250	559	120	607	844	1138	1474	1868	2322	2842
250	559	140	682	959	1301	1705	2167	2712	3341
275	615	40	280	382	499	620	759	911	1076
275	615	60	380	518	681	856	1057	1280	1525
275	615	80	469	646	856	1086	1352	1651	1984
275	615	100	555	771	1028	1316	1650	2029	2457
275	615	120	643	893	1199	1546	1953	2418	2948
275	615	140	723	1014	1369	1779	2261	2817	3456
300	671	40	297	403	520	652	797	955	1126
300	671	60	401	546	717	899	1108	1338	1591
300	671	80	496	682	901	1140	1415	1722	2064
300	671	100	593	813	1081	1378	1723	2113	2550
300	671	120	679	941	1259	1617	2035	2512	3052
300	671	140	763	1067	1436	1858	2352	2921	3571
325	727	40	317	425	546	684	834	998	1174
325	727	60	422	574	753	941	1157	1395	1656
325	727	80	522	716	945	1192	1476	1792	2143
325	727	100	623	854	1132	1439	1795	2194	2641
325	727	120	713	988	1317	1687	2116	2604	3155
325	727	140	802	1119	1502	1936	2442	3023	3684
350	783	40	332	445	571	714	871	1040	1222
350	783	60	443	602	787	982	1206	1451	1719
350	783	80	548	750	987	1242	1535	1861	2220
350	783	100	653	894	1182	1499	1865	2274	2731
350	783	120	747	1033	1375	1755	2196	2694	3256
350	783	140	841	1171	1566	2012	2531	3123	3795
375	839	40	347	465	596	744	906	1081	1269
375	839	60	463	629	821	1023	1253	1506	1781
375	839	80	573	783	1029	1292	1594	1928	2296
375	839	100	682	933	1232	1558	1933	2353	2820
375	839	120	781	1078	1431	1822	2274	2784	3356
375	839	140	885	1221	1629	2086	2618	3222	3906
400	894	40	362	485	620	774	941	1121	1314
400	894	60	483	655	846	1062	1300	1560	1842
400	894	80	604	817	1070	1341	1651	1994	2371
400	894	100	710	971	1280	1615	2001	2430	2907
400	894	120	814	1122	1486	1888	2351	2872	3454
400	894	140	919	1270	1690	2160	2704	3320	4015

NOTE: Detector time constant at a reference velocity of 5 ft/sec (1.5m/sec).
For SI units: 1 ft = 0.305 m; 1000 Btu/sec = 1055 kW.