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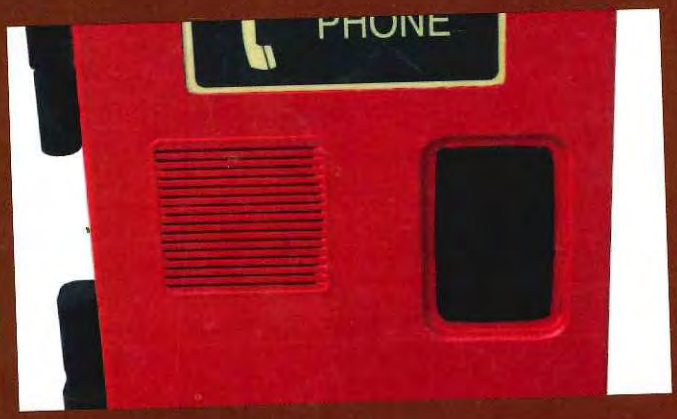

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National Training Center (NTC)

TC was founded in 2002 by Charles Aulner on the premise of providing the low voltage industry with empowerment through education and training.

Since then, NTC has grown into the most recognized name in training for the low voltage industry and has provided training to tens of thousands of technicians across the U.S. NTC offers training in all major product categories and has developed the most complete line of professional books for the industry. NTC provides live training, webinar classes and online training to meet any of your training needs.

NTC recognizes the difference high quality training can make for your business and committed to providing you and your employees with the very best training available.

While the low voltage industry is rapidly changing, NTC is dedicated to staying up to date with the newest technology and code requirements. NTC consistently updates their training and materials in order to ensure that you and your company are current with cutting edge industry practices.

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NTC's live training classes are the very best educational opportunities available for your company. Your employees will learn the latest techniques and technology in the industry. NTC's live training classes are engaging and relevant to your company's needs.

NTC offers training in all major product categories and is not manufacturer specific. Training is based on codes, standard industry practices and current technology. NTC provides training in the following areas: Fire Alarm, CCTV, Access Control, Security Systems, Residential A/V, and Networking for the Low Voltage Industry.

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About The Authors

The authors of this book have spent many years working in the industry. This industry experience is directly translated for your benefit in this book. You will notice that concepts are explained in plain language, not code language. We have used pictures and diagrams to illustrate these concepts and important points.

Charles Aulner began his career in this industry in 1992. Charles has worked as a technician out in the field. He has also worked in sales and several managerial positions in the industry with several well known companies. Bryan McLane started in this industry in 1982 and has worked in sales, technical support, systems design and management. Bryan has a broad base of knowledge spanning many categories and manufacturers in the low voltage industry.

Both of these industry professionals are committed to providing the best in training to the industry. Charles founded National Training Center, Inc. in 2002 for the purpose of providing the very best in training. Both Charles and Bryan are active instructors. They teach live classes all across the country in fire alarm systems, NICET Certification, CCTV Systems, Access Control Systems and many other low voltage subjects.

They have worked together since 1996 on several training programs and professional references just like this one. They write in a collaborative and mutually supporting way to provide you with the best publications available to the industry.

Bryan and Charles are both committed to training and education. In addition to their many years of industry experience, they both have dedicated almost a full year to organize, research, and write this book. It is the most complete and up to date book on fire alarm systems.

The authors believe training and education is the key to being successful in the industry. This is their way to giving back to an industry which has given so much to them over the years.

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Printed, 2009

Cover Pictures: Firelite Alarms and Evax Systems

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Printed in the United States of America

Published by National Training Center, Inc.
(702)648-8899 phone
(702)648-8111 fax

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Chapter 1

Importance of the Codes

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2003 edition

Photo courtesy ICC, p1.1

The fire alarm industry is code driven. Fire alarm systems are required to be specifically designed and follow the existing codes for the local jurisdiction where they are installed. The codes which govern the installation of fire alarm systems are important for two reasons:

1. Increase the effectiveness of fire alarm systems.
2. Increase the reliability of fire alarm systems.

The bottom line to this is life safety. There are several codes which specify fire alarm system requirements. These codes generally are designed to work together to enhance the overall level of life safety. In terms of fire alarm systems, each code has a very specific role to play. The codes which play the most important role in the design and installation of fire alarm systems are the comprehensive code sets developed and published by the National Fire Protection Association (NFPA) or the International Code Council (ICC). These codes are:

1.	NFPA 72®	National Fire Alarm Code®	How to install equipment
2.	NFPA 101®	Life Safety Code®	When systems are required
3.	IBC®	International Building Code®	When systems are required
4.	NFPA 5000®	Building Construction and Safety	When systems are required
5.	NFPA 70®	National Electric Code®	Wiring

It is important for industry professionals to understand that life safety is the primary purpose for installing fire alarm systems. Properly installed fire alarm systems will save lives. Failure to follow the code requirements could result in the failure to provide an adequate level of life safety. Those involved in fire alarm system design, installation and service have a responsibility to understand these codes and their requirements.

The process for using these codes starts with fire alarm system design. There are two types of fire alarm system design:

1. Prescriptive design
2. Performance based design

The requirements prescribed in the code apply to most of the fire alarm systems installed. These systems use the prescriptive design method. In other words, they follow the minimum requirements of the codes. Persons certified by the National Institute for Certification in Engineering Technologies (NICET) at level III or level IV are considered qualified to use the prescriptive design method. Sometimes though, circumstances exist where the minimum requirements prescribed in the code are not adequate enough to provide appropriate levels of life safety. Sometimes a greater degree of life safety may be necessary. In these cases, performance based design is required to meet the fire protection goals of the building.

Performance based design should only be done by certified Fire Protection Engineers. Fire protection engineering is a highly specialized degree program. These engineers are specifically trained to conduct engineering surveys for fire protection systems, including fire alarm systems. Performance based design is only needed when the level of protection prescribed by the code needs to be increased. Performance based design is always used to increase the requirements of the code.

Using the Codes

Using the codes to design and install fire alarm systems always starts with the International Building Code® (IBC) or NFPA 101®, the Life Safety Code®. These codes specify which building occupancies are required to have a fire alarm system installed. Additionally, they detail such things as the type of devices to be installed, building notification requirements and off premise monitoring requirements.

Next, NFPA 72®, the National Fire Alarm Code®, is used to determine the location and spacing requirements for fire detection devices, notification appliances, the minimum functions the system is required to provide, and maintenance testing and inspection requirements.

Also, NFPA 70®, National Electrical Code®, is used to determine appropriate wiring techniques and requirements for the fire alarm system. Always remember, these codes only specify the minimum requirements for fire alarm systems. It is always permitted to exceed the minimum requirements specified by the code.

NFPA 101® Life Safety Code® and International Building Code®

2003 edition
Photo courtesy ICC, ,p1.2

2003 edition
Photo courtesy National Fire Protection Association©, p1.3

NFPA 101® the Life Safety Code®, the IBC® and NFPA 5000® are used to determine which building occupancies are required to have a fire alarm system. All of these codes are used. Some jurisdictions adopt the IBC® and others adopt NFPA 101® and NFPA 5000®. NFPA 101® and NFPA 5000® requirements are the same. They provide the requirements for fire alarm system design. The occupancy chapters are identified in the following table:

NFPA 101® Occupancy Classification	**IBC Use Group**
Assembly	Group A
Educational	Group E
Day Care	Group E
Health Care	Group I, Group I-2
Ambulatory Health Care	Group I-1, Group I-3
Detection and Corrections	Group I-3
One and Two Family Dwellings	Group R-3
Lodging / Rooming Houses	Group R-1
Hotels	Group R-1
Apartments	Group R-2
Residential Board and Care	Group R-4

NFPA 101® Occupancy Classification	IBC Use Group
Mercantile	Group M, Covered Malls
Business	Group B
Industrial	Group F, Lumber Mills
Storage	Group H High Piled Combustible Storage Aerosol Storage Battery Rooms
High Rise	High Rise
Special Structures	Special Amusement Buildings Atriums connecting 3 or more stories Underground Buildings Underground Bldgs w/smoke exhaust Residential Aircraft Hangers Airport Traffic Control Towers

Diagram, NTC d1.1

The NFPA 101®, NFPA 5000® and International Building Code® are filled with trade offs. An example of common types of trade offs are as follows:

1. Hotels which are only 2 stories or less, and have exterior exits for each room shall not require a fire alarm system
2. Buildings with automatic detection throughout shall not require pull stations. This is because the code recognizes that automatic detection is superior to manual actuation

The codes are designed to be used together. They are designed to be complimentary in the way they lay out requirements.

The NFPA 101®, NFPA 5000® and IBC® have a specific role, which is to identify which building occupancies require the protection of a fire alarm system and what type of protection will work the best.

NFPA 72® National Fire Alarm Code®

2002 edition
Photo courtesy of National Fire Protection Association©, p1.4

NFPA 72® is used to detail the installation requirements for fire alarm systems. NFPA 72® tells us how to install fire alarm systems and their components.

In 1899, the first edition of a code detailing fire alarm requirements was published. This code was developed, written and published by insurance authorities. The insurance companies wanted to provide that insured buildings were properly protected with fire alarm systems. It was in their best interests. Properly protected buildings would have less fire damage and the insurance companies would save money on claims. The code of 1899 was just a small pamphlet containing only 6 pages. The fire alarm code was updated in 1931 and again in 1936. It grew to 38 pages in length. It remained under the control of the insurance authorities.

In 1950, the responsibility for developing, writing and publishing the fire alarm code fell under the control of the National Fire Protection Association (NFPA)®. The NFPA® named it NFPA 72® National Fire Alarm Code®. The 1950 version of NFPA 72® was expanded to 53 pages. The 1950 version of NFPA 72® was priced at 25 cents. Since 1950, the fire alarm code has been updated regularly. Normally these updates are on a 3 year cycle. The updates to the code frequently are the result of real life fires which cause law suits, injury, or death. The code is the result of system failures over time. Most code requirements exist because of injury, death or litigation resulting from fire alarm system failures and inadequacy.

The requirements of the code exist because someone was seriously injured, or they died. Failure to follow the minimum requirements of the code will put someone's life in jeopardy.

The code has been in development for more than a century. The first half of the code's life was based on the technology of the period from the 1890s thru the 1960s. Much of the language used in the code is still based on this period in fire alarm history. For example, the code lists requirements for manual fire alarm boxes. The code does not identify these devices as pull stations.

Our society and our industry have undergone massive changes in the last 30 years. The code has changed to reflect much of this. Our history has several experiments in technology. Some technologies still have specialized uses today. Some of these were just a flash in the pan. Some are still in limited use in small pockets of the country. Here are a few examples:

1. Active multiplex systems (derived channel)
2. McColloh transmission technology
3. One and two-way RF (radio) transmission
4. Direct connect and direct wire technology
5. Public fire reporting systems

Requirements for these technologies are listed in the code. It can make the code difficult to understand and to read. Since 1993, the code has been organized into 8 major parts. NFPA 72® lists the installation requirements for fire alarm systems as follows:

1. Fundamental requirements (Focuses on control equipment functions)
2. Initiating devices (Location and spacing requirements for detection devices)
3. Protected premise (Requirements for fire alarm equipment installed in a building)
4. Notification appliances (Location, spacing, audibility and visible requirements)
5. Supervising station (Requirements for monitored systems and their communications methods)
6. Public fire alarm systems (Requirements for street box systems)
7. Inspection testing and maintenance
8. Household fire alarm systems

NFPA 72® does not identify which buildings are required to have a fire alarm system installed; however, it does specify how a fire alarm system is required to be installed. Here are a few examples:

1. Smoke detectors are permitted to be spaced at 30' intervals on flat ceilings
2. Pull stations shall be mounted at a height of 3.5' – 4.5'
3. Audible notification appliances shall be mounted at 90 inches above the finished floor and a minimum of 6 inches down from the ceiling

NFPA 70® National Electrical Code®

2005 edition
Photo courtesy of National Fire Protection Association©, p1.5

Wiring requirements for fire alarm systems are specifically detailed in the National Electrical Code®. Every fire alarm installation is required to comply with the requirements of the National Electrical Code®. Every fire alarm installation requires appropriate wiring. Article 760 of the National Electrical Code® specifies the wiring requirements for fire alarm systems. This article of the code identifies two types of fire alarm cable: Non Power Limited fire alarm cable and Power Limited fire alarm cable.

Power Limited fire alarm cable is the most common type used for fire alarm systems. Power limited is used for all low voltage fire alarm wiring. Non Power Limited fire alarm cable is virtually never used with today's fire alarm systems. Non Power Limited cable was used for old 120-volt fire alarm systems and circuits. Since these circuits are no longer used, neither is Non Power Limited fire alarm cable.

NFPA 70® details the requirements for wiring methods. This includes such things as conduit use and fill limitations, box fill requirements, classification of wiring, and proper methods for installing cable. This code is an important tool that everyone involved in fire alarm system design, installation and service should have readily available.

Summary

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Each of these codes has an important function in the design, installation and service of fire alarm systems. Properly using these codes is the very foundation of sound fire alarm system design and operation. These codes have a specific use:

NFPA 101® / IBC®	When fire alarm systems are required
NFPA 72®	How to install fire alarm equipment
NFPA 70®	Wiring requirements for fire alarm systems

Professionals in the fire alarm industry have a responsibility to have access to these codes and be familiar with their requirements. The codes have been developed over a very long period of time. Following the requirements of the codes ensures installation of the most reliable fire alarm systems. Since fire alarm systems are life safety systems, it is important to design and install the most effective and reliable systems. Following the requirements of the codes ensures that the most effective and reliable systems are installed. Additionally, meeting the requirements of the codes makes good business.

Chapter 2

Job Planning, Bidding, and Contracts

Job planning is one of the most critical aspects of fire alarm system design and installation. It can also be confusing. What type of documentation is required for each step of the process? What exactly are the steps of the process? None of this is really clarified in any of the standard references for our industry. Some of the documentation is referred to, but no single reference clearly lays out what is specifically required in terms of documentation.

It is our goal to clarify the steps in the process and the documentation required throughout the process. This information has been gathered from several resources and included in this section. The information has also been organized in a manner which is easy to understand. The process for planning, bidding and submitting for approval is as follows:

1. Fire alarm system design / planning
2. Specifications
3. Bidding / awarding the contract
4. Submittals
    a. Contract drawings
    b. Riser diagrams
    c. Point to point diagrams
    d. Specification sheets
5. Plans review and approvals
6. Installation and Installation Changes
7. As Built drawings
8. Final Acceptance Test

There are several pieces of documentation required throughout this process. Typical fire alarm system documents are as follows:

1. Fire alarm system narrative
2. Specifications
3. Fire alarm system contract drawings
    a. Riser diagram

   b. Point to point diagram
   c. Floor plan with all fire alarm system devices & components
   d. Specification sheets
4. Battery calculations
5. Voltage drop calculations
6. As built drawings
7. Record of completion

Being familiar with each of these is critical to providing customers with proper Fire Protection Systems. The steps are a combination of standard industry practice and code requirements. Some of these requirements may differ based on the specific jurisdiction involved.

Fire Alarm System Design / Planning

This is the initial planning of the fire alarm system and is general in nature. The architect or engineer decides whether a fire alarm system is required based on the appropriate Building Code or Life Safety Code®. Additionally, the fire protection goals of the building owner should be taken into account during this part of the process. The initial design may be as simple as stating that a conventional or addressable system shall be used, or as detailed as providing an initial design which includes all anticipated devices. In either case, the appropriates codes are required to be followed.

Specifications

The specification is the document used to prepare job bids. It is a legal, contractual document. The specification is normally written by a professional in the fire alarm or fire protection field. If the specification is written by someone other than a fire alarm professional or fire protection engineer, it should be reviewed for accuracy, completeness and compliance. This review should be done by someone with a NICET Level III or IV certification.

The specification should include the following information:

1. General clauses
2. Technical Instructions
3. Acceptance of the system

An example of a Specification for a fire alarm system is as follows:

I. Purpose: To ensure the fire alarm system functions properly.

II. Applicability: Requirements apply to the fire alarm system installed for _____ located at _____.

III. Revisions and Circulation of Specification: The owner is responsible for reviewing and revising these specifications as needed. The owner or representative can be reached at: Name_____ Phone_____
Address_____
Revisions become effective on the date they are published. Contracts are based on the revision in force on the opening bid date. Specification copies will automatically be provided to interested parties (Designer, manufacturer etc)

IV. General Requirements: Full compliance with the specification is required. All submittals are required to meet the requirements of this specification and it is the contractor's responsibility to ensure they do.

i. The fire alarm system shall comply with all applicable codes (NFPA 72®, IBC®, NEC®, any local or regional requirements).

ii. The system shall be nominal 24 VDC and all equipment appropriately listed for the purpose used. All equipment shall be new and all equipment shall have a minimum of 1yr warranty from the date of acceptance testing. All labor shall have a minimum of 1 yr warranty from the date of acceptance testing.

iii. The fire alarm control shall be expandable for future use. The zones of the system shall be configured according to the contract drawings. The front of the panel shall annunciate the following:

1. Power on indicator: Steady Green light
2. Alarm signal: Red light
3. Trouble signal: Amber light
4. Supervisory signal

iv. The power supply of the fire alarm control shall have continuous rating so that all zones and functions can be powered indefinitely in full alarm condition.

v. The system shall include transient protective devices to prevent damage or nuisance alarms from nearby lightning strikes, line voltage fluctuations or stray current.

vi. Notification requirements. The notification requirements for the fire alarm system shall meet or exceed the requirements of the appropriate Building Code or Life Safety Code® and ADA requirements.

vii. Annunciation and Graphic display. The requirements for annunciation and graphic display should be detailed in this section. The fire alarm control shall be provided with an alarm silence switch. Alarm resound shall occur with any subsequent alarm signal. All annunciators shall provide both audible and visual indication of alarm resound as well.

viii. Individual zone identification at the fire alarm control and all annunciators shall be required. This identification shall be permitted to be engraved labels, graphic display, framed directories. Label tape or handwritten labels shall not be permitted.

ix. Separate Zoning. Elevator recall detectors shall be separately zoned. The fire alarm control shall initiate the recall signal and shall be triggered only by the elevator lobby detectors. The recall signal shall not be initiated by detector based relays. Automatic fire extinguishing systems shall be separately zoned.

x. Standby Power. The fire alarm system shall have a secondary power source in order to provide emergency power. Signals shall not be lost during the switch from primary to secondary power supplies. Standby batteries shall meet the requirements of NFPA 72® or the local codes and shall have a 20 percent safety factor.

xi. Types of Circuits. This system shall require a minimum circuit capability of class b.

xii. Fire alarm system wiring shall be color coded and permanent wire markers shall be used at the control panel. All junction box covers shall be red in color.

xiii. All wiring shall comply with the NFPA 70 (NEC®) or local codes. Initiating device circuits shall be a minimum of 16 AWG. Notification appliance circuits shall be a minimum of 14 AWG.

xiv. Fire alarm circuits shall not be run in raceways which include AC power or control wiring. AC wiring within the fire alarm control panel shall be separated from other circuits. The enclosure shall have an appropriate warning label.

xv. The jacket (insulation) for fire alarm circuits shall be protected from damage by using the appropriately listed fittings at all places where the circuits enter panels or boxes and at all terminations.

xvi. All installation conductors shall be checked for grounds, opens and shorts. The minimum resistance to ground is 10 megaohms. The minimum resistance between any conductors shall be 10 megaohms.

xvii. All installation conductors shall be monitored for integrity (supervised) such that the occurrence of a single open or ground fault will initiate a trouble signal. Removal of any initiating device, notification appliance, module or battery connection shall initiate a trouble signal.

xviii. If the fire alarm control panel is located in an area which is not continuously occupied, a remote annunciator shall be required. Additionally a smoke detector shall be located within 21 feet of the panel.

xix. Pull stations (manual fire alarm boxes) shall require a key or allen type wrench for reset. Certain locations may require a protective cover with alarm to reduce nuisance alarm signals.

V. Requirements for Detectors. Automatic detectors shall have a separate base to facilitate testing and maintenance. Each detector or base shall use a light to indicate alarm condition.

i. All duct detectors and under floor detectors shall use a remote indicator identified with a permanent label.

ii. Factors affecting the effective response to the appropriate fire signature shall be considered in detector placement.

iii. Detectors shall not be located within 3 feet of an air supply vent.

iv. Smoke detectors shall not be installed until after construction cleanup. If they are installed prior to construction cleanup, all detectors shall be replaced with new detectors.

v. All 2 wire smoke detectors shall be compatibility listed with the control panel.

vi. HVAC shutdown and other control functions shall be accomplished from the fire alarm control panel.

vii. Duct detector installation shall adhere to the manufacturer's documented instructions.

viii. Each detector shall be assigned an individual identification number. The identification number shall be indicated on the plans and permanently mounted to the detector or its base.

ix. The location of detectors shall be appropriately dimensioned on the plans.

x. The temperature rating of heat detectors shall be indicated on the plans and on the bill of materials.

VI. Motorized Fire Dampers (Smoke Dampers). Indicate any requirements for the interface between fire dampers and the fire alarm system.

VII. Automatic smoke doors. Automatic smoke doors require wall mounted magnetic door holders and separate heavy duty closers or combination door control / smoke detector units.

VIII. Sprinkler system connections. Waterflow switches shall be listed. Each waterflow switch shall be provided with an appropriate retard to prevent nuisance alarms. Provisions shall be made for testing the waterflow switches in accordance with NFPA 72® requirements.

i. Sprinkler control valve supervision shall initiate a supervisory (not a trouble) signal.

IX. Verification of System Performance. Upon completion of the installation every device in the system shall be tested for proper operation according to NFPA 72®. The warranty period shall begin after the completion of acceptance testing.

X. The owner shall be provided with 3 copies of the as built drawings, copies of the manufacturer's technical documents and installation instructions.

i. The owner shall be instructed in the proper operation of the system and all periodic testing and inspection requirements according to NFPA 72®. Basic operating instructions shall be suitably framed and located at the fire alarm control panel.

ii. The contractor shall provide a quote to the owner for regular preventive maintenance and testing of the fire alarm system.

Design drawings are normally included with the specification. These drawings are intended to provide the required information about the project needed to design the fire alarm system. These are to scale drawings provided by the architect or engineer. The fire alarm contractor can use them for "take-offs." The fire alarm "take-offs" is the information the contractor takes off of the document to determine the fire alarm system requirements including number and type of devices and equipment locations.

When the specification is complete, the bidding phase of this process can commence. Fire alarm system contractors use the specification to identify, detail and develop pricing for the fire alarm system. Do not forget the importance of consulting the code to ensure compliance with the requirements. Check the national codes, but do not forget about the requirements your local jurisdiction may have. Both have to be met.

Bidding

Once the specifications are written, the job is usually offered to contractors for bidding. The job may require attendance at bid meetings or a written response. It is always in your best interests to schedule a meeting with the building owner or general contractor. Many details may come out in a meeting that are not available on paper.

Use the codes to determine the requirements for the fire alarm system. This is a critical step in the bidding process. Providing an accurate or complete bid requires ensuring the code requirements are met.

The International Building Code IBC® and / or NFPA 5000®, NFPA 101® the Life Safety Code are critical references for determining fire alarm requirements. Fire alarm system requirements start with this code. The specific fire alarm requirements are determined based on the building occupancy or classification. The use of the building and the number of building occupants are important in the selection of fire alarm equipment. Some occupancies may require smoke detectors; others may only require manual pull stations. Some occupancies may require connection to a monitoring station; others may require only a local system. The type of fire alarm system required is based on the occupancy / classification of the building.

The National Fire Alarm Code®, NFPA 72® specifies requirements for all fire alarm systems. This code specifies "how" fire alarm equipment shall be installed. NFPA 72® details the spacing and location requirements for fire alarm equipment such as smoke detectors and pull stations. NFPA 72® provides the requirements for spacing and location of notification appliances. In order to determine how the fire alarm system is required to be installed, NFPA 72® is the reference which must be consulted.

NFPA 70®, National Electrical Code® (NEC)®, applies to all fire alarm systems. Wiring requirements are specifically detailed in this reference. Fire alarm system wiring requirements are located in article 760 and following these requirements will ensure

proper functioning of the system. Failure to follow the requirements of the code will result in system problems, nuisance alarms and worse, possible failure of the system. Identifying all of the code requirements will ensure you have a proper, complete and accurate bid. There are several vendors of software which can help you with determining estimated hours of labor, suggested margins on equipment and other important pricing matters.

Submittals

Once the building owner or designated representative has awarded the contract for the installation of the fire alarm system, submittal documents have to be prepared. Fire Alarm system submittals include all of the documents required to be submitted to the authority having jurisdiction (AHJ) in order to receive approval. The submittal documents include the following:

1. Contract drawings
   These are the drawings prepared by the architect or engineer and provide required information about the building for planning purposes. The fire alarm contractor takes the contract drawings and adds the fire alarm system components. The fire alarm system contract drawings should be professionally prepared. Some fire alarm companies have CAD personnel on staff to prepare these drawings. Other fire alarm companies contract with engineering firms for this service. Either way, the specific locations, quantities and wiring of all fire alarm equipment are detailed on the fire alarm contract drawings.

2. Riser Diagrams
   The riser diagram serves as the summary of the fire alarm system and usually is attached as the first page of the contract drawings. The riser diagram illustrates linear connections from the fire alarm control panel to initiating devices, notification appliances and other fire alarm equipment. It provides device counts, conductor counts and circuit zoning information.

3. Point to Point Diagrams
   These diagrams show actual fire alarm control panel terminal connections and typical fire alarm devices. Every fire alarm system control panel manufacturer provides point to point diagrams in their installation instructions. Most panels have them located on the inside of the control panel as well.

4. Equipment Specification Sheets
   Normally included with fire alarm system submittals are the cut sheets (equipment specification documents which show appropriate listings) for the fire alarm control panel, initiating devices, notification appliances and any other equipment which will be part of the fire alarm system. These documents are available from the manufacturer of the equipment, normally downloadable from their website.

5. Voltage Drop Calculations
   Ensuring that adequate wire sizes are used is one of the most important aspects of planning a fire alarm system installation. Because of this fact, many AHJ's require the submittal of voltage drop calculations. These calculations demonstrate that the size of wire used is appropriate for the load associated with the installed fire alarm equipment. Fire alarm circuits (especially notification circuits) are required to deliver appropriate voltage to each device in order to ensure proper operation. The voltage range for the device is listed on the cut sheet. The voltage drop calculations have to demonstrate that the appropriate voltage is available for every device. Normally these are done using spreadsheets. Most manufacturers have them available on their websites. For an example of how to perform a voltage drop calculation, refer to Appendix B in this book.

6. Battery calculations: The National Fire Alarm Code®, NFPA 72®, requires adequate standby power be available for the fire alarm system. Battery calculations prove that the battery size is capable of meeting the code requirement. Battery size is determined by the standby current consumption and alarm current consumption of the fire alarm system for the prescribed period each are required. Most manufacturers provide battery calculation spreadsheets on their websites. For an example of how to perform a battery calculation, refer to Appendix F in this book.

Once all of the above documentation has been collected, it should be reviewed for accuracy and completeness. This review should be done by a qualified individual as indicated by NICET Certification at Level III, or by a fire protection engineer. Many jurisdictions require the Contract Drawings to be signed by a qualified person prior to plans review.

Plans Review

The plans review process is usually performed by the AHJ. Most jurisdictions require that the plans for the fire alarm system be reviewed and approved prior to the start of the installation. Some jurisdictions require a fee be paid for the plans review. The submittal documents are provided to the plans review department. The AHJ reviews all of the documents to ensure that the codes and local requirements are being met. Any shortcomings, mistakes, or additions are indicated by plans review personnel and then returned to the fire alarm contractor for correction. The fire alarm contractor resubmits the corrected documents for approval. When the AHJ determines all of the requirements are met, then the submittals are approved and installation can begin.

Caution: Once the fire alarm system design has been approved changes may still occur to the approved design. There are several reasons for this. The actual layout of the building and other systems may dictate changes to the fire alarm system design. Additionally, the AHJ who inspects the installation may have different requirements than those approved

by plans review. The fire alarm contractor has to be flexible and deal with these situations in a professional manner.

Fire Alarm System Installation and Changes to the Design

Now the installation of the fire alarm system can begin. The approved contract drawings should be followed as closely as possible. Wire runs and device locations should follow the approved plans. Make sure the proper codes are followed for device spacing and mounting heights. Changes to the original design will inevitably occur. When this happens, documentation is important.

Change Orders

Change orders are used to identify any changes in device requirements or fire alarm system installation from the original contract drawings. It may happen that a light fixture or HVAC diffuser is located where a smoke detector is also required. Due to the conflict, an additional detector has to be added in order to provide the required coverage. A change order is required for this situation. A new door may be added and an extra pull station then is needed. A change order is required for this situation. The AHJ may require additional detectors in a specific area. A change order is required for this situation. The change orders keep track of the changes to the original contract drawings and provide a mechanism for passing on these extra job costs to the building owner.

Professionalism

Maintaining a professional attitude throughout the installation process is extremely important. The fire alarm contractor will encounter workers from other trades on the jobsite. The fire alarm contractor's job is much easier when a professional attitude and mutual respect exist.

Completion of the installation

Once the installation of the fire alarm system is complete, the fire alarm contractor is ready for testing of the system. The fire alarm system contractor should complete a thorough 100% test of the fire alarm system including all wiring, devices and control functions according to NFPA 72®. This 100% test should be performed prior to scheduling the final acceptance test with the building owner and the AHJ.

As Built Drawings

As built drawings are "modified" contract drawings. The contract drawings detailed the original fire alarm system design. Due to changes required during construction, the original contract drawings do not accurately reflect the actual installation of the system. Therefore a final set of drawings are required which accurately show the actual installation of the fire alarm system. This set of final "As Built" drawings should be professionally completed. Many fire alarm contractors have CAD personnel on staff to produce these. Others may contract this service.

Final Acceptance Test

After the fire alarm contractor has successfully tested the entire system and completed the as built drawings, the final acceptance test can be scheduled. The final acceptance test is

a 100% test of the fire alarm system. The following persons are required to be present for the final acceptance test:

1. Fire alarm contractor
2. Authority Having Jurisdiction
3. Building owner or designated representative

Prior to the beginning of the test, the building owner must be given the as built drawings, literature pertaining to the operation and installation of the fire alarm system, and any site specific software for the fire alarm control panel. The fire alarm contractor must complete the Record of Completion as well. This document can be found in NFPA 72® or downloaded from the NFPA® website. The record of completion is required to be signed by the fire alarm contractor and the AHJ. An example of this document is located in Appendix C of this book.

The final acceptance test should be conducted using the testing form located in NFPA 72®. This testing form is located in Appendix C of this book. Every device shall be tested. If any discrepancies are found, a follow up test shall be scheduled once the discrepancies are corrected. Some jurisdictions charge for any return visits. Upon successful completion of the final acceptance test, the AHJ may issue a Certificate of Occupancy to the building owner.

Caution: Sometimes construction delays may postpone the opening of a building. Building owners want to open as soon as possible. They may encourage you to complete the fire alarm system so they can be issued the Certificate of Occupancy. It is not appropriate to violate the code in a rush to meet the building owner's desire on this issue. Smoke detectors must not be installed until after the cleanup of all construction trades is complete. If smoke detectors are installed prior to construction cleanup then all detectors must be replaced once construction cleanup is complete.

Summary

The process of job planning for fire alarm systems will certainly determine the effectiveness of the protection ultimately installed. Preparing clear and accurate documentation throughout this process is also critical to maintaining the level of protection the system will provide. There are many players in the job planning process. It is the intent and desire of all of them to provide the best possible fire alarm system for the building. Over the years specific steps have evolved in this process. The critical steps to ensure job planning is compliant are as follows:

1. Fire alarm system design / planning
2. Specifications
3. Bidding / awarding the contract
4. Submittals
    a. Contract drawings
    b. Riser diagrams
    c. Point to point diagrams

   d. Specification Sheets
5. Plans review and approvals
6. Installation and Installation Changes
7. As Built drawings
8. Final Acceptance Test

As a fire alarm professional, it is your responsibility to be familiar with each of these steps and the expectations for you, your company and the fire alarm systems you install and service.

Chapter 3

International Building Code® and Life Safety Code® Requirements

Introduction to the International Building Code®

2003 edition
Photo courtesy ICC, p3.1

The design of a fire alarm system always has to start with the building code. The most popular building code used today is the International Building Code® (IBC®). This code is produced by the International Code Council® (ICC®). The IBC® specifies the fire alarm system requirements for all of the different types of buildings. The IBC® classifies buildings by Use Group. Some Use Groups have several subdivisions called Classifications.

Section 907 of the IBC® applies to new construction only. The current edition of the IBC® applies to NEW Construction. The intent of the IBC® is that new buildings follow the current code requirements. Existing buildings are evaluated for compliance using the Building Code in effect at the time of construction. This intent is detailed in section 3401.2 as follows:

"Devices or safeguards which are required by this code shall be maintained in conformance with the code edition under which installed."

Therefore, installing companies should keep the outdated editions of the building code used during the installation of every fire alarm system. This is a common industry practice and should be a policy of your company.

Section 907 of the IBC® divides these Use Groups as follows for fire alarm systems:

Chapter and Section	Title
907.2.1	Group A Assembly (300 or more)
907.2.1.1	Group A Assembly (1,000 or more)
907.2.2	Group B Business (500 or more)
907.2.3	Group E Educational (and Daycare more than 5 over 2 1/2 yrs old)
907.2.4	Group F Factory
907.2.5	Group H High Hazard Occupancies
907.2.6	Group I Institutional
907.2.6.1	Group I-2 Hospital Facilities, Mental, Nursing Homes, Detoxification
907.2.6.2	Group I-3 More Than 5 Under Restraint or Security
907.2.7	Group M Mercantile (500 or more)
907.2.8	Group R-1 Boarding House, Hotel, Motel
907.2.9	Group R-2 Apartments, Dormitories, Time Share, Fraternities
907.2.10.1.2	Group R-3 Households (no more than 2 dwellings)
	Group R-4 Residential Assisted Living (more than 5, less than 16)
	Group I-1 Residential Assisted Living (more than 16)
907.2.11	Special Amusement Buildings
907.2.12	High Rise Buildings
907.2.13	Atriums Connecting More than 2 stories
907.2.14	High Piled Combustible Storage Areas
907.2.15	Delayed Egress Locks
907.2.16	Aerosol Storage Use
907.2.17	Lumber, Plywood, Veneer Mills
907.2.18	Underground Buildings With Smoke Exhaust Systems
907.2.19	Underground Buildings
907.2.20	Covered Mall Buildings
907.2.21	Residential Aircraft Hangars
907.2.22	Airport Traffic Control Towers
907.2.23	Battery Rooms

General Fire Alarm System Requirements from the IBC®

The requirements listed in this book are a guideline only. It is important to refer to the actual code when determining requirements for a specific project.

The IBC® requires that construction documents for fire alarm systems be prepared and submitted for review and approval. The construction documents required are as follows:

1. A floor plan which indicates the use of each room.
2. The location of fire alarm devices (initiating and notification).
3. Control equipment and trouble signaling equipment.
4. Power connections.
5. Battery calculation sheets.
6. Installation conductor types and sizes.
7. Voltage drop calculations.
8. Manufacturer's specification sheets.
9. Details of ceiling heights and construction.
10. Annunciation.
11. The interface of fire safety and control functions.

Additional documentation may be required by your local jurisdiction. The IBC®, just like the National Fire Alarm Code®, requires all fire alarm equipment be listed for its intended purpose. Some use groups may require a manual, automatic or manual and automatic fire alarm system. Automatic detection systems use smoke detectors. Heat detectors may be accepted in areas where smoke detectors are not appropriate.

Group A
Includes: Theaters, churches coliseums, nightclubs, etc.

Assembly occupancies with 300 or more occupants require a manual fire alarm system. If the building is equipped with an automatic sprinkler system, which activates fire alarm notification appliances upon waterflow, then the manual pull stations are not be required throughout the building.

Assembly occupancies with 1,000 or more occupants shall require a voice evacuation system. The voice evacuation system must use prerecorded messages which may be overridden for the purpose of giving live voice instructions. Live voice instructions can only be given from an approved, constantly attended location

The voice evacuation system for an assembly occupancy must be connected to an emergency power system as defined by NFPA 70® (NEC®) Article 700 (Engine Driven Generator).

Group B
Includes: Business offices

Business occupancies with 500 or more occupants (or 100 or more above or below the level of exit discharge) require a manual fire alarm system. Manual pull stations are not required when the building is equipped with an automatic sprinkler system which activates fire alarm notification devices upon waterflow.

Group E
Includes: Facilities with 6 or more occupants for educational purposes through 12th grade

Educational occupancies require a manual fire alarm system. If the building has an automatic sprinkler system, it is required to be connected to the fire alarm system. If automatic smoke detectors are employed they are required to be connected to the fire alarm system.

Exception: No fire alarm system is required for occupant loads less than 50

Exception: Manual fire alarm boxes are not required where all of the following apply:

1. Interior corridors are protected by smoke det with alarm verification.
2. Assembly areas are protected by heat or other automatic detectors.
3. Shops and labs are protected by heat or other automatic detectors.
4. Off premise monitoring is provided.
5. The evacuation signal can be initiated from a central point.
6. Normally occupied areas are provided with a 2 way communications system to a constantly attended location.

Group F
Includes: Facilities used for assembly / disassembly, fabricating, manufacturing etc

Factory occupancies which are 2 or more stories in height and have an occupant load of 500 or more above or below the level of exit discharge, require a manual fire alarm system. Manual pull stations are not required when the building is equipped with an automatic sprinkler system which activates fire alarm notification devices upon waterflow.

Group H
Includes: Manufacturing, processing, storing of materials which are a health hazard

The following high hazard occupancies require a manual fire alarm system:

1. H-5 High hazard occupancies. These are semiconductor fabrication facilities and comparable research & development areas where hazardous production materials (HPM) are used.
2. H occupancies used for the manufacture of organic coatings.

Group H continued

An automatic smoke detection system is required for H occupancies with:

1. Highly toxic gases.
2. Organic peroxides.
3. Oxidizers

Group I
Includes: Hospitals, nursing homes, mental facilities, adult daycare, detox facilities, detention and jail facilities

Institutional occupancies require a manual fire alarm system and an automatic detection system. An electrically supervised automatic detection system is required in waiting areas that are open to corridors.

Group I-2
Includes: Hospitals, nursing homes, mental & detox facilities

Corridors in nursing homes, detox facilities and any spaces which open to the corridors require automatic fire detectors connected to the fire alarm system.

Exception: Corridor detectors are not required in compartments which contain patient sleeping rooms when the sleeping rooms are equipped with automatic smoke detectors. The sleeping room smoke detectors are required to provide a visual signal on the corridor side of the room & an audible and visual signal at the attending nurse's station.

Exception: Corridor detectors are not required in smoke compartments which contain patient sleeping rooms where each unit door has an automatic door closing device with integral smoke detectors on the unit side. The smoke detectors need to be listed and provide required alerting.

Group I-3
Includes: More than 5 persons under restraint or security

Detention type occupancies require a manual and automatic fire alarm system installed for alerting staff.

Initiation: Actuation of an extinguishing system, manual fire alarm box or fire detector is required to initiate an automatic signal to notify the staff. Presignal systems are not permitted to be used.

Group I continued

Manual fire alarm boxes: Pull stations are not required to be located throughout the facility provided 1 pull station is located at a constantly attended location. The constantly attended location is required to be able to observe the areas where the pull stations have been omitted. Pull stations may be locked in areas with detainees provided staff members are present and they have the ability to unlock the devices.

Smoke detectors: Automatic smoke detectors are required throughout resident housing areas including sleeping rooms, day rooms, activity rooms and other areas normally accessible to residents.

Exception: Other equivalent arrangements may be used in order to avoid damage and tampering (protective guards, locate detectors in exhaust ducts)

Exception: Automatic smoke detectors are not required in sleeping units in the Use condition 2 or 3 type facilities (low security not locked cells)

Exception: Smoke detectors are not required in sleeping units with 4 or less occupants where the compartments are provided throughout with an approved automatic sprinkler system

Group M
Includes: Mercantile occupancies with 500 or more occupants, or more than 100 occupants above or below the level of exit discharge. Group M does not include covered malls.

Mercantile occupancies require a manual fire alarm system. Manual pull stations are not required when the building is equipped with an automatic sprinkler system which activates fire alarm notification devices upon waterflow.

Occupant notification: Alarm notification appliances are required. During times when the building is occupied voice evacuation systems may be used instead of alarm notification appliances.

Group R-1
Includes: Boarding houses, hotels and motels

A manual fire alarm system is required for Group R-1 occupancies.

Exception: Buildings not more than 2 stories, where all guest rooms are separated by a 1 hour rated fire wall. Additionally each guest room must have an exit directly to a public way, exit court or yard.

Group R-1 continued

Exception: Manual fire alarm boxes are not be required when all of the following conditions are met:

1. The building is equipped with an automatic sprinkler system.
2. The alarm notification appliances will activate upon waterflow.
3. 1 manual station is located at an approved location.

An automatic fire alarm system is required for Group R-1 occupancies. Detectors are required to be installed throughout all corridors serving guestrooms.

Exception: Automatic detectors are not required in buildings which do not have interior corridors serving guest rooms. Each guest room is required to have a means of egress door opening directly to an exterior exit access that leads directly to an exit.

Group R-1 occupancies require smoke alarms in all sleeping rooms and in suites outside each sleeping room as well. If the building does not have an automatic sprinkler system, then each smoke alarm is required to be connected to an emergency standby system (engine driven generator) and be annunciated by guestroom at a constantly attended location from which the fire alarm system can be manually activated.

Group R-2
Includes: Apartments, Dormitories, Fraternities / Sororities, Time shares.

A manual fire alarm system is required for Group R-2 occupancies where:

1. Any dwelling unit or sleeping room is 3 or more stories above the level of exit discharge.
2. Any dwelling unit or sleeping room is 1 story below the level of exit discharge.
3. The building contains more than 16 dwelling or sleeping units.

Exception: Buildings not more than 2 stories, where all guest rooms are separated by a 1 hour rated fire wall. Additionally each guest room must have an exit directly to a public way, exit court or yard.

Exception: Manual fire alarm boxes are not be required when all of the following conditions are met:

1. The building is equipped with an automatic sprinkler system.
2. The alarm notification appliances will activate upon waterflow.
3. 1 manual station is located at an approved location.

Exception: Automatic detectors are not required in buildings which do not have interior corridors serving guest rooms. Each guest room is required to have a means of egress door opening directly to an exterior exit access that leads directly to an exit.

Group R-2 continued

Smoke alarms are required in Group R-2 occupancies. They shall be installed in each sleeping area, outside each sleeping area and on each floor.

Groups R-2, R-3, R-4 and I-1
Includes: R-2 Apartments, Dormitories, Fraternities / Sororities, Time shares
R-3 Household dwelling units (no more than 2)
R-4 Residential assisted living (more than 5, less than 16)

Single or multiple station smoke alarms are required regardless of occupant load in each of these locations:

1. On the ceiling or wall outside each sleeping area in the immediate vicinity of the bedrooms.
2. In each room used for sleeping purposes.
3. On each floor, including basements

Group I-1 is not required to have smoke alarms if the building is equipped with an automatic fire detection system.

Smoke alarm power source. Smoke alarms must be powered from the building wiring where the source is commercial and each smoke requires a back up battery. Smoke alarms must emit a signal for low batteries. Wiring must be permanent without a disconnecting switch other than as required for overcurrent protection.

Exception: Group R-1 does not require smoke alarms to have battery backup where they are connected to the emergency system.

Interconnection: Where more than 1 smoke alarm is required in any single dwelling unit, they shall be interconnected such that the activation of any smoke alarm will cause all smoke alarms within the dwelling unit to activate. The alarm is required to be clearly heard in all bedrooms over background noise and with intervening doors closed.

All smoke alarms must be tested in accordance with the requirements of NFPA 72®.

Special Amusement Buildings
An automatic smoke detection system is required for special amusement buildings. Smoke detectors may be replaced with other automatic detectors in areas which are not appropriate for the installation of smoke detectors.

Activation of any smoke detector, sprinkler system or any other automatic detector requires the sounding of an alarm at a constantly attended location from which emergency action can be taken.

Special Amusement Buildings continued

The activation of any two detectors, or any detector with alarm verification, or the sprinkler system must automatically:

1. Cause illumination of the means of egress with light of not less than 1 foot candle (11 lux) at the walking surface level.
2. Stop any conflicting or confusing sounds and visual distractions.
3. Activate approved directional exit markings that will become apparent in an emergency. Such system response must also include activation of a prerecorded message, clearly audible throughout the special amusement building instructing occupants to proceed to the nearest exit. Alarm signals must be distinctive. All wiring must be supervised according to NFPA 72®.

Emergency Voice / alarm communications. A voice evacuation system must be installed and audible throughout the entire building.

High Rise Buildings
High rise is defined as more than 75 feet above the lowest level of fire department access.

High rise buildings must be equipped with an automatic fire alarm system and a voice evacuation system. There are some exceptions:

1. Air traffic control towers
2. Open parking garages
3. Assembly occupancies intended for viewing outdoor activities (Group A-5)
4. Low hazard special occupancies
5. Buildings with an occupancy in Group H-1, H-2, or H-3

Smoke detectors are required and must be connected to the fire alarm system. The activation of any smoke detector must operate the voice evacuation system. Smoke detectors are required in the following areas:

1. In each mechanical equipment, electrical, telephone equipment, transformer or similar room which is not provided with sprinkler protection
2. Elevator machine rooms and elevator lobbies.
3. In the main and exhaust air plenum of each air conditioning system having a capacity greater than 2,000 cfm.
4. At each connection to a vertical duct or riser serving two or more stories from a return air duct or plenum of an air conditioning system. In group R-1 and R-2 a listed smoke detector is allowed to be used in each return air riser carrying not more than 5,000 cfm and serving not more than 10 air inlet openings.

High Rise Buildings continued

Emergency voice / alarm communications.
The operation of any automatic fire detector, waterflow device, or manual station shall automatically sound an alert tone followed by voice instructions giving approved information and directions on a general or selective basis to the following terminal areas on the alarm floor and the floor below and the floor above:

1. Elevator lobbies
2. Corridors
3. Rooms and tenant spaces exceeding 1,000 square feet in area
4. Dwelling units or sleeping units in Group R-2 occupancies
5. Sleeping units in Group R-1 occupancies
6. Areas of refuge

A manual override for all emergency voice / alarm communications systems must be provided for all paging zones. The system is required to have live voice capability. The installation of the voice evacuation system is required comply with NFPA 72®.

Fire department communications system.
An approved 2 way communication system designed and installed according to NFPA 72® must be provided for fire department use. This communication system must be provided between the fire command center and the following locations:

1. Elevators
2. Elevator lobbies
3. Emergency and standby power rooms
4. Fire pump rooms
5. Areas of refuge
6. Inside enclosed stairways
7. At each floor level within the enclosed stairway

Exception: Fire department radio systems where approved by the fire department.

Atriums Connecting More than Two Stories
A fire alarm system is required in occupancies with an atrium that connects more than two stories. The system must be activated by:

1. A required automatic fire alarm system
2. Sprinkler waterflow devices
3. Required manual fire alarm boxes

Occupancy Groups A, E or M also require a voice evacuation system

High Piled Combustible Storage Area
An automatic fire detection system is required to be installed throughout high piled combustible storage areas.

Delayed Egress Locks
Where delayed egress locks are installed on means of egress doors, an automatic smoke or heat detection system must be installed.

Aerosol Storage Uses
Aerosol storage areas are required to be provided with a manual fire alarm system.

Lumber, Plywood and Veneer Mills
Lumber, plywood and veneer mills must be provided with a manual fire alarm system.

Underground Buildings with Smoke Exhaust System
A minimum of one smoke detector listed for the purpose must be installed in the following areas:

1. Mechanical equipment, electrical, transformer, telephone equipment, elevator machine or similar rooms
2. Elevator lobbies
3. The main return and exhaust air plenum of each air conditioning system serving more than one story and located in a serviceable area downstream of the last duct inlet.
4. Each connection to a vertical duct or riser serving 2 or more floors from return air ducts or plenums of heating, ventilating and air conditioning systems except that in group R occupancies a listed smoke detector is allowed to be used in each return air riser carrying not more than 5,000 cfm and not serving more than 10 air inlet openings.

Activation of the smoke exhaust system is required to activate an alarm at a constantly attended location.

Underground Buildings
Where the lowest level of the structure is more than 60 feet below the level of exit discharge, a manual fire alarm system is required. Additionally a voice evacuation system shall be required.

Covered Mall Buildings
Covered mall buildings exceeding 50,000 square feet must be provided with a voice evacuation system.

Residential Aircraft Hangars
A minimum of 1 smoke alarm is required in a residential aircraft hangar and shall be interconnected with the residential smoke alarms.

Airport Traffic Control Towers
An automatic fire detection system is required in airport traffic control towers.

Battery Rooms
An approved automatic smoke detection system is required in areas containing stationary lead acid battery systems having a liquid capacity of more than 50 gallons. The detection system shall be supervised by an approved central, remote or proprietary station service or a local alarm that will sound an audible signal at a constantly attended location.

NFPA 101® The Life Safety Code®

2003 edition
Photo courtesy National Fire Protection Association©, p3.2

The occupancy classification determines the fire alarm requirements for the building. NFPA 101® helps the fire alarm system designer determine what type of fire alarm equipment is required and how the system is required to operate. NFPA 5000® details the same requirements as NFPA 101®. Therefore we will list only the NFPA 101® requirements. Keep in mind they are the same as NFPA 500®. There are 15 occupancy classifications and some of these have both New and Existing chapters.

The New chapters apply to buildings which are being designed and built. Existing chapters apply to those buildings which are already occupied and being used. Some occupancies only have one chapter. The requirements for these occupancies apply regardless of whether the building is new or existing.

The requirements listed in this book are a guideline only. It is important to refer to the actual code when determining requirements for a specific project.

New Assembly Occupancies
A fire alarm system is required to be installed for occupant loads greater than 300, theaters with two or more viewing rooms, and occupancies which are protected as part of a mixed assembly.

Mixed occupancies may have a common fire alarm system as long as the system requirements for all occupancies are met.

New Assembly Occupancies continued

Initiation of the fire alarm system must be by manual means and the system shall be provided with an emergency power source (generator complying with article 700 of the NEC®) unless the fire alarm system includes one of the following:

1. Automatic detection throughout OR…
2. Operation of an approved automatic sprinkler system
3. An annunciator which provides indication of signals shall be located at a constantly attended location
4. For occupant loads of greater than 300, automatic detection shall be provided in all hazardous areas that are not continuously occupied. If unoccupied hazardous areas are protected with approved supervised automatic sprinkler systems, then automatic detectors shall not be required.

Notification must include an audible alarm in a constantly attended receiving station located within the building. Positive alarm sequence shall be permitted. Occupant notification must be by visible signals and voice announcements. If there is no constantly attended location then manual initiation shall be provided and automatic occupant notification is required to be provided by prerecorded evacuation instructions.

Extinguishing requirements: An approved supervised automatic sprinkler system is required for new assembly occupancies with an occupant load of greater than 300. The approved supervised automatic sprinkler system is not be required for the following:

1. Assemblies used for worship with fixed seating and not part of a mixed use occupancy.
2. Assemblies consisting of a multipurpose room less than 12,000 sq ft, not used for exhibition and not part of a mixed use occupancy.
3. Gyms, skating rinks and swimming pools used exclusively for sports with audience facilities for no more than 300.

Existing Assembly Occupancies
A fire alarm system is required for occupant loads greater than 300, theaters with two or more viewing rooms, and occupancies which are protected as part of a mixed assembly. For mixed assembly occupancies a common fire alarm system shall be permitted as long as the system requirements for all occupancies are met.

Special Note. Where in the judgment of the AHJ, adequate alternative provisions exist or are provided for the discovery of a fire and for alerting occupants promptly, a fire alarm system is not be required.

Initiation of the fire alarm system is required by manual means and the system must be provided with an emergency power source (generator which complies with article 700 of NEC®) unless the fire alarm system includes automatic detection or an approved automatic sprinkler system is located in the building.

Existing Assembly Occupancies continued

An annunciator which provides indication of signals is required to be located at a constantly attended location.

For occupant loads of greater than 300, automatic detection must be provided in all hazardous areas that are not continuously occupied. If unoccupied hazardous areas are protected with approved supervised automatic sprinkler systems, then automatic detectors are not be required.

Notification must include an audible alarm in a constantly attended receiving station located within the building. This is for the purpose of initiating emergency action. Positive alarm sequence is permitted. Occupant notification must be by visible signals and voice announcements. Where the AHJ determines that a constantly attended location is impractical, manual initiation must be provided and automatic occupant notification is required to be provided by prerecorded evacuation instructions.

Extinguishing requirements: An approved supervised automatic sprinkler system is required for existing assembly occupancies with an occupant load of greater than 300. The approved supervised automatic sprinkler system is not be required for the following:

1. Assemblies used for worship with fixed seating and not part of a mixed use occupancy.
2. Assemblies consisting of a multipurpose room less than 12,000 sq ft, not used for exhibition and not part of a mixed use occupancy.
3. Gyms, skating rinks and swimming pools used exclusively for sports with audience facilities for no more than 300.

New Educational Occupancies
A fire alarm system is required for new educational occupancies.

A fire alarm system is not required for those occupancies where the area of the building is 1,000 sq ft or less, the building contains only one classroom and the building is located not less than 50 ft from another building.

Initiation of the fire alarm system is required to be by manual means. Pull stations may be eliminated when all of the following conditions are met:

1. Interior corridors are protected by smoke detectors using alarm verification.
2. Auditoriums, gyms, cafeterias etc are protected by heat detectors or other approved detection devices.
3. Shops and laboratories are protected by heat detectors or other approved detection devices.
4. Provision is made at a central location to manually activate the evacuation signal, or to evacuate only the affected areas.

New Educational Occupancies continued

The pull stations may be eliminated when all of the following conditions are met:

1. The building is protected throughout by an approved supervised automatic sprinkler system.
2. Provision is made at a central location to manually activate the evacuation signal, or evacuate only the affected areas.

In buildings provided with an automatic sprinkler system, the operation of the sprinkler system must activate the fire alarm system.

Occupant notification is required to occur automatically with audible and visible devices. Positive alarm sequence can be used with the permission of the AHJ. Where permitted by the AHJ, the fire alarm system can be used for other purposes. Fire alarm signals shall take precedence over any other signals though.

The recall signal must be distinctive so that children are not returned to a burning building. If the recall signal is electric, the key must be properly secured by the principal or a designated representative.

Emergency forces notification. Fire dept notification is required for new educational occupancies.

Extinguishing systems: Every portion of the educational facility below the level of exit discharge must be provided with an approved supervised automatic sprinkler system. Buildings with an unprotected communicating space, shall be provided throughout with an approved supervised automatic sprinkler system.

Existing Educational Occupancies
A fire alarm system is required for existing educational occupancies.

A fire alarm system is not be required for those occupancies where the area of the building is 1,000 sq ft or less, the building contains only one classroom and the building is located not less than 50 ft from another building.

Initiation of the fire alarm system is required to be by manual means. Pull stations may be eliminated when all of the following conditions are met:

1. Interior corridors are protected by smoke detectors using alarm verification.
2. Auditoriums, gyms, cafeterias etc are protected by heat detectors or other approved detection devices.
3. Shops and laboratories are protected by heat detectors or other approved detection devices.
4. Provision is made at a central location to manually activate the evacuation signal, or to evacuate only the affected areas.

Existing Educational Occupancies continued

The pull stations may be eliminated when all of the following conditions are met:

1. The building is protected throughout by an approved supervised automatic sprinkler system.
2. Provision is made at a central location to manually activate the evacuation signal, or evacuate only the affected areas.

In buildings provided with an automatic sprinkler system, the operation of the sprinkler system shall activate the fire alarm system.

Occupant notification is required to occur automatically with audible and visible devices. Positive alarm sequence can be used with the permission of the AHJ. Where permitted by the AHJ, the fire alarm system can be used for other purposes. Fire alarm signals must take precedence over any other signals though. The recall signal must be distinctive so that children are not returned to a burning building. If the recall signal is electric, the key must be properly secured by the principal or a designated representative.

Emergency forces notification.
Whenever any school authorities determine that an actual fire exists, they are required to immediately call the local fire dept using the public fire alarm system or other available facilities.

Extinguishing systems:
Where student occupancy exits below the level of exit discharge, every portion of the educational facility below the level of exit discharge must be provided with an approved automatic sprinkler system. If student occupancy does not exist below the level of exit discharge, it requires a 1 hour fire rated separation or be protected with an approved automatic sprinkler system. Buildings with an unprotected communicating space, must be provided throughout with an approved supervised automatic sprinkler system.

New Day Care Occupancies
A fire alarm system is required in all new day care occupancies other than day care occupancies housed in one room.

Initiation of the required fire alarm system is required to be by manual means and by the smoke detection system. Smoke detection is required on each story in front of the doors to stairways and in the corridors of all floors occupied by the day care occupancy. Detectors are also required in all lounges, recreation areas, and sleeping rooms in the day care occupancy.

Occupant notification must include audible and visible devices. Positive alarm sequence can be used with the permission of the AHJ. The private operating mode may be used in the occupied rooms and corridors.

New Day Care Occupancies continued

Emergency forces notification (the fire dept) is required.

Extinguishing requirements. No sprinkler system is required in new day care occupancies. If the building has an unprotected communicating space, then an approved supervised automatic sprinkler system is required.

Existing Day Care Occupancies
A fire alarm system is required in all existing day care occupancies other than day care occupancies housed in one room.

Initiation of the required fire alarm system is required to be by manual means and by the smoke detection system. Smoke detection is required on each story in front of the doors to stairways and in the corridors of all floors occupied by the day care occupancy. Detectors are also required in all lounges, recreation areas, and sleeping rooms in the day care occupancy.

Occupant notification must include audible and visible devices. Positive alarm sequence can be used with the permission of the AHJ. Where occupant notification appliances are provided in all occupied rooms and corridors, the private operating mode may be used in the occupied rooms and corridors.

Emergency forces notification (the fire dept) is required.

Extinguishing requirements. No sprinkler system is required in new day care occupancies. If the building has an unprotected communicating space, then an approved supervised automatic sprinkler system is required.

New Health Care Occupancies
A fire alarm system is required for new health care occupancies.

Initiation of the fire alarm system is required by manual means, waterflow devices, or automatic detection devices. Automatic smoke detection is required in spaces open to corridors and the corridors require smoke detectors or quick response sprinklers. Smoke detectors are also required in multipurpose areas, limited care facilities and group meeting rooms. Nursing homes require smoke detectors in the corridors and throughout smoke compartments containing patient sleeping rooms.

Pull stations are required at all nurse's control stations or other continuously occupied staff locations and located throughout all floors of the building so travel distance to pull stations does not exceed 200 feet. Pull stations are required to be visible and continuously accessible.

New Health Care Occupancies continued

Occupant notification needs to be accomplished automatically with audible and visible devices. Automatic detectors which are used for door release must activate the building evacuation alarm. In lieu of audible alarm signals, visible alarm indicating appliances shall be permitted to be used in critical care areas.

Emergency forces notification. Fire dept notification is required for new health care occupancies. Smoke detection systems using alarm verification are not be required to automatically notify the fire dept unless the signal is verified within 120 seconds.

Alarm annunciation is required to be both audible and visible. Each floor of the building is required to be a separate zone. Any single zone cannot exceed 22,500 square feet. Zones are not allowed to exceed a length of 300 feet. If a sprinkler system is installed, fire alarm zones should coincide with sprinkler systems. Extinguishing systems may be annunciated as a single zone on the fire alarm system. Separate buildings are required to be annunciated separately. Trouble signals require both audible and visible annunciation.

Emergency control. Devices designed to perform fire safety functions (elevator recall, fan shutdown, smoke relief) require such functions to be initiated automatically.

Extinguishment requirements. New health care occupancies require protection throughout by an approved supervised automatic sprinkler system. If the AHJ prohibits the use of sprinklers, Type I and Type II construction, alternative protection measures are required. Listed quick response or listed residential sprinklers are required throughout smoke compartments containing patient sleeping rooms.

Existing Health Care Occupancies
A fire alarm system is required for existing health care occupancies.

Initiation of the fire alarm system is required by manual means, waterflow devices, or automatic detection devices. Automatic smoke detection is required in spaces open to corridors and the corridors require smoke detectors or quick response sprinklers. Smoke detectors are also required in multipurpose areas, limited care facilities and group meeting rooms.

Limited care facilities require corridor smoke detectors unless each patient sleeping room is equipped with a smoke detection system and a smoke detector is located at each smoke barrier and horizontal exit. If the facility is protected throughout by an approved supervised automatic sprinkler system, then corridor smoke detectors are not required.

Pull stations are required at all nurse's control stations or other continuously occupied staff locations and located throughout all floors of the building so travel distance to pull stations does not exceed 200 feet. Pull stations are required to be visible and continuously accessible.

Existing Health Care Occupancies continued

Extinguishing systems which are used to protect commercial cooking equipment in sprinklered kitchens do not have to be connected to the fire alarm system.

Occupant notification needs to be accomplished automatically with audible and visible devices. Automatic detectors which are used for door release must activate the building evacuation alarm. In lieu of audible alarm signals, visible alarm indicating appliances shall be permitted to be used in critical care areas.

Emergency forces notification. Fire department notification is required for existing health care occupancies. Smoke detection systems using alarm verification are not required to automatically notify the fire department unless the signal is verified within 120 seconds.

Alarm annunciation is required to be both audible and visible. Each floor of the building is required to be a separate zone. Any single zone cannot exceed 22,500 square feet. Zones are not allowed to exceed a length of 300 feet. If a sprinkler system is installed, fire alarm zones should coincide with sprinkler systems. Extinguishing systems may be annunciated as a single zone on the fire alarm system. Separate buildings are required to be annunciated separately. Trouble signals require both audible and visible annunciation.

Emergency control. Devices designed to perform fire safety functions (elevator recall, fan shutdown, smoke relief) require such functions to be initiated automatically.

Extinguishment requirements. Existing health care occupancies require protection throughout by an approved supervised automatic sprinkler system. If the AHJ prohibits the use of sprinklers, Type I and Type II construction, alternative protection measures are required. Listed quick response or listed residential sprinklers are required throughout smoke compartments containing patient sleeping rooms.

New Ambulatory Health Care Occupancies
A fire alarm system is required for new ambulatory health care occupancies.

Initiation is required by pull stations. No automatic detection system is specifically required by NFPA 101®.

Occupant notification is required automatically and without delay upon activation of any fire alarm initiating device.

Emergency forces notification. Notification to the fire department is required. Smoke detection systems using alarm verification are not required to automatically notify the fire department unless the signal is verified within 120 seconds.

Emergency control. Devices designed to perform fire safety functions (elevator recall, fan shutdown, smoke relief) require such functions to be initiated automatically.

New Ambulatory Health Care Occupancies continued

Extinguishing requirements. Portable fire extinguishers are required. For isolated hazardous areas, a sprinkler system with piping serving not more than 6 sprinklers is permitted to be connected to the domestic water supply system. For new installations where more than 2 sprinklers are installed in a single area, waterflow devices are required.

Existing Ambulatory Health Care Occupancies
A fire alarm system is required for existing ambulatory health care occupancies.

Initiation is required by pull stations. No automatic detection system is specifically required by NFPA 101®.

Occupant notification is required automatically and without delay upon activation of any fire alarm initiating device.

Emergency forces notification. Notification to the fire department is required. Smoke detection systems using alarm verification are not required to automatically notify the fire department unless the signal is verified within 120 seconds.

Emergency control. Devices designed to perform fire safety functions (elevator recall, fan shutdown, smoke relief) require such functions to be initiated automatically.

Extinguishing requirements. Portable fire extinguishers are required. For isolated hazardous areas, a sprinkler system with piping serving not more than 6 sprinklers is permitted to be connected to the domestic water supply system. For new installations where more than 2 sprinklers are installed in a single area, waterflow devices are required.

New Detention and Correctional Occupancies
A fire alarm system is required for new detention and correctional occupancies.

A secondary power supply is required. The secondary power supply is an Emergency System which is an engine driven generator. The requirements for this secondary power supply are listed in NFPA 72® National Fire Alarm Code® and the NEC® Article 700.

Initiation of the fire alarm system is required by pull stations. The pull stations are permitted to be locked provided the staff have keys when the area is occupied. The pull stations are permitted to be located in a staff location as long as the location is attended when the building is occupied and the attendant has direct supervision of the sleeping areas.

New Detention and Correctional Occupancy continued

Initiation of the fire alarm system is also required by an approved automatic smoke detection system. Detectors are required throughout all resident sleeping areas and adjacent day rooms, activity rooms or contiguous common spaces. Smoke detectors are not required in sleeping rooms with 4 or fewer occupants. Where acceptable to the AHJ, alternate positioning of detectors is permitted to prevent damage or tampering. Locating devices in exhaust ducts behind grilles or other locations is acceptable. Smoke detectors are not required in Use Condition II open dormitories where staff persons are present during occupied times.

Initiation of the fire alarm system by waterflow is required.

Automatic occupant notification is required. Positive alarm sequence is permitted. Smoke detectors are permitted to alarm at a constantly attended location only and are not required to provide occupant notification.

Emergency forces notification. Fire department notification is required. Smoke detectors are not required to transmit a signal to the fire department. Fire department notification is not required when staff is provided at a constantly attended location, and the fire plan for the building includes procedures for logging of alarms and fire department notification. In addition, the facility must be capable of promptly notifying the fire department and have communications with a control room. The control room requires direct access to the fire department.

Extinguishing requirements. All buildings classified as Use Condition II – V are required to be provided throughout with an approved supervised automatic sprinkler system.

Existing Detention and Correctional Occupancies
A fire alarm system is required for existing detention and correctional occupancies. Existing systems lacking the monitoring of wiring shall be permitted where the building is protected by a complete automatic extinguishing system.

A secondary power supply is required. The secondary power supply is an Emergency System which is an engine driven generator. The requirements for this secondary power supply are listed in NFPA 72® National Fire Alarm Code® and the NEC® Article 700.

Initiation of the fire alarm system is required by pull stations. The pull stations are permitted to be locked provided the staff have keys when the area is occupied. The pull stations are permitted to be located in a staff location as long as the location is attended when the building is occupied and the attendant has direct supervision of the sleeping areas.

Existing Detention and Correctional Occupancies continued

Initiation of the fire alarm system is also required by an approved automatic smoke detection system. Detectors are required throughout all resident sleeping areas and adjacent day rooms, activity rooms or contiguous common spaces. Smoke detectors are not required in sleeping rooms with 4 or fewer occupants. Where acceptable to the AHJ, alternate positioning of detectors is permitted to prevent damage or tampering. Locating devices in exhaust ducts behind grilles or other locations is acceptable. Smoke detectors are not required in Use Condition II open dormitories where staff persons are present during occupied times and an approved sprinkler system is installed. Smoke detectors are required in corridors and sleeping rooms with more than 4 occupants. Smoke detectors are not required in smoke compartments protected throughout by an approved automatic sprinkler system.

Initiation of the fire alarm system by waterflow is required.

Automatic occupant notification is required. Positive alarm sequence is permitted. Smoke detectors are permitted to alarm at a constantly attended location only and are not required to provide occupant notification.

Emergency forces notification. Fire department notification is required. Smoke detectors are not required to transmit a signal to the fire department. Fire department notification is not required when staff is provided at a constantly attended location, and the fire plan for the building includes procedures for logging of alarms and fire department notification. In addition, the facility must be capable of promptly notifying the fire department and have communications with a control room. The control room requires direct access to the fire department.

Extinguishing requirements. All buildings classified as Use Condition II – V are required to be provided throughout with an approved supervised automatic sprinkler system.

One and Two Family Dwellings

Smoke alarms or a smoke detection system are required for one and two family dwellings. Smoke alarms are required to be installed in all sleeping rooms (not required in existing one and two family occupancies). Smoke alarms are required outside of each separate sleeping area in the immediate vicinity of the sleeping rooms. Smoke alarms are required on each floor of the dwelling unit including basements.

Dwelling units require protection by an approved smoke detection system (smoke alarms or a fire alarm system with smoke detectors) and equipped with an approved means for occupant notification.

In existing one and two family dwellings, approved smoke alarms powered by batteries are acceptable

Extinguishing requirements. None.

Lodging or Rooming Houses
A fire alarm system is required for lodging and rooming houses. Existing lodging or rooming houses with approved smoke alarms installed in every sleeping room do not require a fire alarm system.

Initiation of the fire alarm system is required by manual means or waterflow in buildings with an approved automatic sprinkler systems. Approved smoke alarms are required every sleeping room. Smoke alarms are not required to be interconnected. Existing battery operated smoke alarms, rather than electric powered smoke alarms are permitted where the facility has demonstrated to the AHJ that the testing maintenance and battery replacement programs will ensure reliability of power to the smoke alarms.

Extinguishing requirements. All new lodging or rooming houses require protection throughout by an approved automatic sprinkler system. An automatic sprinkler system is not be required where every sleeping room has a door leading to the directly to the outside.

New Hotel and Dormitory Occupancies
A fire alarm system is required to be provided for new hotel and dormitory occupancies.

Initiation of the fire alarm system is required by pull stations located throughout the building. A pull station is required at the hotel desk or other central control point under continuous supervision by a responsible person. Operation of the sprinkler system is required to initiate a fire alarm signal. A corridor smoke detection system is required in buildings which do not have an approved supervised automatic sprinkler system.

Smoke alarms are required in every guest room and every living area and sleeping area within a guest suite. Smoke alarms are not required to be connected to the building fire alarm system.

Occupant notification is required to be automatic. Positive alarm sequence can be used with the permission of the AHJ. Visible notification is required in guest rooms which are designated for the hearing impaired. Visible appliances are required throughout the building except in guest rooms and suites which are not designated for the hearing impaired.

Annunciation is required in buildings which exceed 2 stories or buildings with more than 50 guest rooms. Annunciation is required at a central control point which is under continuous supervision

Emergency forces notification is required. Provisions are required to immediately notify the fire department.

Extinguishment. All buildings require protection throughout by an approved supervised automatic sprinkler system.

New Hotel and Dormitory Occupancies continued

Buildings where all guest rooms and suites have a door opening directly to the street or grade level do not require sprinkler systems. Building which are no more than 3 stories in height above grade level and all guest rooms provide exit access to grade level do not require sprinkler systems

Existing Hotel and Dormitory Occupancies
A fire alarm system is required for existing hotel and dormitory occupancies.

Initiation. The fire alarm system is required to have a pull station at the hotel desk or other central control point under continuous supervision. Additionally, the system is required to have initiation form any one of the following:

1. Pull stations located throughout the building
2. Any automatic sprinkler system.
3. Any required automatic detection system other than sleeping room smoke detectors.

An approved single station smoke alarm is required in every guest room and every living area and sleeping room within a guest suite. Interconnection of guest room smoke alarms is not required. A secondary power source for the smoke alarms is not required.

Notification. Occupant notification is required to be automatic. Positive alarm sequence and presignal systems are permitted with the permission of the AHJ. Visible notification is required in guest rooms which are designated for the hearing impaired. Visible appliances are required throughout the building except in guest rooms and suites which are not designated for the hearing impaired.

Annunciation is required in buildings which exceed 2 stories or buildings with more than 50 guest rooms. Annunciation is required at a central control point which is under continuous supervision

Emergency forces notification is required. Provisions are required to immediately notify the fire department.

Extinguishment. All high rise buildings require the installation of an approved supervised automatic sprinkler system.

New Apartment Buildings
A fire alarm system shall be provided for apartment buildings with more than 3 stories or more than 11 dwelling units.

A fire alarm system is not required when each dwelling unit is separated from other contiguous units by fire barriers having a fire resistance rating of not less than 1 hour and each dwelling unit has its own exit or stairway discharging at grade.

New Apartment Buildings continued

A fire alarm system is not required when the building is protected throughout by an approved automatic sprinkler system, does not exceed 4 stories, and does not contain more than 16 dwelling units.

Initiation. The fire alarm system requires initiation by pull stations. If the building does not exceed 4 stories the pull stations are not required. If the building does not contain more than 16 dwelling units the pull stations are not required. If the building is protected throughout by an approved automatic sprinkler system the pull stations are not required.

In buildings protected throughout by an approved supervised automatic sprinkler system, waterflow is required to initiate an alarm signal.

Approved single station smoke alarms are required outside every sleeping room and on all levels of the dwelling unit including basements. All dwelling units require approved single station smoke alarms inside every sleeping room or the building is required to be protected throughout by an approved supervised automatic sprinkler system.

Notification. Occupant notification is required to be automatic. Positive alarm sequence is permitted with the approval of the AHJ. Visible signals are required in units designated for the hearing impaired.

Alarm annunciation is required to be both audible and visible. Each floor of the building is required to be a separate zone. Any single zone cannot exceed 22,500 square feet. Zones are not allowed to exceed a length of 300 feet. If a sprinkler system is installed, fire alarm zones should coincide with sprinkler systems. Extinguishing systems may be annunciated as a single zone on the fire alarm system. Separate buildings are required to be annunciated separately. Supervisory and trouble signals require both audible and visible annunciation.

Annunciation is not required if the building does not exceed 2 stories and has no more than 50 rooms. Annunciation is not required if the building is protected throughout by an approved automatic sprinkler system, does not exceed more than 4 floors and does not contain more than 16 dwelling units.

Emergency forces notification. Fire department notification is required.

Extinguishing requirements. New apartment buildings are required to be protected throughout by an approved supervised automatic sprinkler system.

An approved supervised automatic sprinkler system is not required when every dwelling unit has an exit door opening directly to the street or yard at ground level.

New Apartment Buildings continued

An approved supervised automatic sprinkler system is not required when every dwelling unit has direct access to an outside stair which serves a maximum of 2 units both located on the same floor.

An approved supervised automatic sprinkler system is not required when every dwelling unit has direct access to an interior stair serving only that unit and separated from all other portions of the building by fire barriers having a 1 hour fire resistance rating with no openings.

Existing Apartment Buildings
Existing Apartment Buildings are classified by one of the following options:

Option 1	Buildings without fire suppression or automatic detection systems.
Option 2	Buildings provided with a complete automatic fire detection and notification system.
Option 3	Buildings provided with automatic sprinkler protection in selected areas.
Option 4	Buildings protected throughout with an approved automatic sprinkler system.

A fire alarm system is required for existing apartment buildings with more than 3 stories or more than 11 dwelling units.

A fire alarm system is not required when each dwelling unit is separated from other contiguous units by fire barriers having a fire resistance rating of not less than 1 hour and each dwelling unit has its own exit or stairway discharging at grade.

A fire alarm system is not required when the building is protected throughout by an approved automatic sprinkler system, does not exceed 4 stories, and does not contain more than 16 dwelling units.

Initiation. The fire alarm system requires initiation by pull stations. If the building does not exceed 4 stories the pull stations are not required. If the building does not contain more than 16 dwelling units the pull stations are not required. If the building is protected throughout by an approved automatic sprinkler system the pull stations are not required.

In buildings using Option 2, initiation of the fire alarm system is required by pull stations located throughout the building and by automatic detection.

In buildings using Options 3 and 4, initiation of the fire alarm system is required by pull stations located throughout the building and waterflow. Additionally approved single station smoke alarms are required outside every sleeping room and on all levels of the dwelling unit including basements. Smoke alarms without a secondary power source are permitted.

Existing Apartment Buildings continued

Notification. Occupant notification is required to be automatic. Positive alarm sequence and presignal systems are permitted with the approval of the AHJ. Visible signals are required in units designated for the hearing impaired.

Alarm annunciation is required to be both audible and visible. Each floor of the building is required to be a separate zone. Any single zone cannot exceed 22,500 square feet. Zones are not allowed to exceed a length of 300 feet. If a sprinkler system is installed, fire alarm zones should coincide with sprinkler systems. Extinguishing systems may be annunciated as a single zone on the fire alarm system. Separate buildings are required to be annunciated separately. Supervisory and trouble signals require both audible and visible annunciation.

Annunciation is not required if the building does not exceed 2 stories and has no more than 50 rooms. Annunciation is not required if the building is protected throughout by an approved automatic sprinkler system, does not exceed more than 4 floors and does not contain more than 16 dwelling units.

Emergency forces notification. Fire department notification is required.

Extinguishing requirements. Buildings using Option 3 require automatic sprinklers in the corridors along the ceiling, and within any dwelling unit that has a door opening to the corridor. The sprinkler in the dwelling unit is required to be positioned over the center of the door unless the door has a fire protection rating of at least 20 minutes and is self closing.

Buildings using Option 4 are required to be protected throughout by an approved automatic sprinkler system. The automatic sprinkler system is not required where every dwelling unit has exterior access. The automatic sprinkler system is not required for buildings with an approved engineered life safety system.

New Residential Board and Care Occupancies
A fire alarm system is must be provided for new residential board and care occupancies.

Initiation. The fire alarm system is required to be initiated by pull stations located throughout the building. A pull station is required to be located at a constantly attended location. Waterflow is required to initiate the fire alarm system. Smoke detectors are required to initiate the fire alarm system.

Smoke detection is required in corridors and spaces open to corridors. Additionally, the smoke detectors are required to be arranged in such a way that audible notification appliances sound all sleeping rooms.

Approved smoke alarms are required in every sleeping room, outside each sleeping area and on all levels of the residential unit.

New Residential Board and Care Occupancies continued

Annunciators are required to be located as determined by the AHJ.

Occupant notification is required to be automatic and without delay. High rise buildings shall be provided with a voice communication system.

Emergency forces notification. Fire department notification is be required. Smoke detection systems using alarm verification are not be required to immediately provide notification to the fire dept unless the alarm condition is reconfirmed within 120 seconds.

Extinguishing systems. All buildings are required to be protected throughout by an approved automatic sprinkler system and provided with quick response or residential sprinklers throughout.

Existing Residential Board and Care Occupancies
A fire alarm system is required for existing residential board and care occupancies unless each sleeping room has exterior access and the building is not more than 3 stories.

Initiation. The fire alarm system is required to be initiated by pull stations located throughout the building. If the building has a complete automatic sprinkler system or a complete automatic detection system, then the pull stations are not required. A pull station is required at a constantly attended location.

Smoke detectors are required in corridors and all living areas. If the living areas are protected with an automatic sprinkler system, the smoke detectors are not required.
Approved smoke alarms powered by the building electrical service are required in every sleeping area. Battery operated smoke alarms are permitted providing that the building owner can demonstrate to the AHJ's satisfaction that an adequate battery replacement and testing program is in place.

Occupant notification is required to be automatic and without delay by audible alarm.

Emergency forces notification. Fire department notification is be required.

Extinguishing systems. Optional.

Classes of Mercantile Occupancies
Class A Mercantile. Mercantiles which have an aggregate gross area of more than 30,000 sq feet or occupying more than 3 stories for sales purposes.
Class B Mercantile. Mercantiles of more than 3,000 sq feet up to 30,000 sq feet and occupying no more than 3 stories for sales purposes.
Class C Mercantile. Mercantiles of no more than 3,000 sq feet occupying 1 story only.

New Mercantile Occupancies
A fire alarm system is required to be provided for Class A Mercantiles.

Initiation. The fire alarm system is required to be initiated by pull stations located throughout the facility. Automatic detectors are required throughout the building. Waterflow from the approved automatic sprinkler systems shall initiate the fire alarm system.

Occupant notification. At all times when the building is occupied the fire alarm system is required to activate an alarm throughout the occupancy. Positive alarm sequence is permitted with the approval of the AHJ. It is also acceptable to configure the fire alarm system to activate an alarm signal at a continuously attended location for the purpose of initiating emergency action. This emergency action is the initiation of live voice public address system announcements from the constantly attended location.

Emergency forces notification. Fire department notification is required. Additionally notification is required to the local emergency organization.

Extinguishment requirements. Mercantile occupancies which are 3 or more stories require an approved automatic sprinkler system. If a mercantile occupancy exceeds 12,000 square feet an approved automatic sprinkler system is required. The area of mercantile occupancies below the level of exit discharge which exceeds 2,500 square feet require protection throughout by an approved automatic sprinkler systems. An approved automatic sprinkler system is required in mixed occupancies where any of these conditions apply.

Class A mercantile occupancies are required to be protected throughout by an approved supervised automatic sprinkler system.

New Mercantile Occupancies (Malls)
A fire alarm system is required for new mercantile occupancies which are malls.

Initiation. The fire alarm system shall be initiated by the operation of the automatic sprinkler system (waterflow).

Occupant notification. During all times that the mall is occupied, initiation of the fire alarm system is required to activate a general alarm throughout the mall. Positive alarm sequence is permitted with the approval of the AHJ. Instead of the general alarm, it is acceptable for initiation of the fire alarm system to activate an alarm signal at a constantly attended location for the purpose of emergency action. The emergency action is required to provide live voice announcements.

Emergency forces notification. Fire department notification is required. Additionally, notification is required to be made to the local emergency organization.

New Mercantile Occupancies (Malls) continued

Emergency control. The fire alarm system is required to automatically actuate smoke management or smoke control systems.

New Mercantile Occupancies (Bulk merchandising retail buildings)
A fire alarm system is required for bulk merchandising retail buildings.

Initiation. The fire alarm system is required to be initiated by waterflow.

Occupant notification. During all times that the building is occupied, initiation of the fire alarm system is required to activate a general alarm throughout the building. Positive alarm sequence is permitted with the approval of the AHJ. Instead of the general alarm, it is acceptable for initiation of the fire alarm system to activate an alarm signal at a constantly attended location for the purpose of emergency action. The emergency action is required to provide live voice announcements.

Emergency forces notification. Fire department notification is required. Additionally, notification is required to be made to the local emergency organization.

Extinguishing requirements. Bulk merchandising retail buildings are required to be protected throughout by an approved supervised automatic sprinkler system.

Existing Mercantile Occupancies
A fire alarm system is required to be provided for Class A Mercantiles.

Initiation. The fire alarm system is required to be initiated by pull stations located throughout the facility. If automatic detectors are installed throughout the building, pull stations are not required throughout the building. If an approved automatic sprinkler system is installed throughout the building, the pull stations are not required throughout the building.

Occupant notification. During all times that the building is occupied, initiation of the fire alarm system is required to activate a general alarm throughout the building. Positive alarm sequence is permitted with the approval of the AHJ. Presignal systems are permitted with the approval of the AHJ. Instead of the general alarm, it is acceptable for initiation of the fire alarm system to activate an alarm signal at a constantly attended location for the purpose of emergency action. The emergency action is required to provide live voice announcements.

Emergency forces notification. Fire department notification is required. Additionally, notification is required to be made to the local emergency organization.

Existing Mercantile Occupancies continued

Extinguishment requirements.
Mercantile occupancies where any level of the building exceeds 15,000 square feet require an approved automatic sprinkler system. If a mercantile occupancy exceeds 30,000 square feet an approved automatic sprinkler system is requried. The area of mercantile occupancies below the level of exit discharge which exceeds 2,500 square feet require protection throughout by an approved automatic sprinkler systems. An approved automatic sprinkler system is required in mixed occupancies where any of these conditions apply.

Existing Mercantile Occupancies (Malls)
A fire alarm system is required to be provided.

Initiation. The fire alarm system is required to be initiated by the operation of the automatic sprinkler system.

Occupant notification. During all times that the mall is occupied, initiation of the fire alarm system is required to activate a general alarm throughout the mall. Positive alarm sequence is permitted with the approval of the AHJ. Instead of the general alarm, it is acceptable for initiation of the fire alarm system to activate an alarm signal at a constantly attended location for the purpose of emergency action. The emergency action is required to provide live voice announcements.

Emergency forces notification. Fire department notification is required. Additionally, notification is required to be made to the local emergency organization.

Emergency control. The fire alarm system is required to automatically actuate smoke management or smoke control systems.

Existing Mercantile Occupancies (Bulk merchandising retail buildings)
A fire alarm system is required for existing bulk merchandising retail buildings.

Initiation. The fire alarm system is required to be initiated by waterflow from the approved automatic sprinkler system.

Occupant notification. During all times that the building is occupied, initiation of the fire alarm system is required to activate a general alarm throughout the occupancy. Positive alarm sequence is permitted with the approval of the AHJ. Instead of the general alarm, it is acceptable for initiation of the fire alarm system to activate an alarm signal at a constantly attended location for the purpose of emergency action. The emergency action is required to provide live voice announcements.

Emergency forces notification. Fire department notification is required. Additionally, notification is required to be made to the local emergency organization.

Existing Mercantile Occupancies (Bulk merchandising retail buildings) continued

Extinguishing requirements. Bulk merchandising retail buildings are required to be protected throughout by an approved supervised automatic sprinkler system.

New Business Occupancies
A fire alarm system is required in a new business occupancy when the building is 2 or more stories in height above the level of exit discharge.

A fire alarm system is required in a new business occupancy when there are 50 or more occupants above or below the level of exit discharge.

A fire alarm system is required in a new business occupancy when the building has 300 or more total occupants.

Initiation. The fire alarm system is required to be initiated by pull stations located throughout the facility. If the building has an approved automatic fire detection system throughout the pull stations are not required. If the building has an approved automatic sprinkler system throughout the pull stations are not required.

Occupant notification. During all times that the building is occupied, initiation of the fire alarm system is required to activate a general alarm throughout the occupancy. Positive alarm sequence is permitted with the approval of the AHJ. Instead of the general alarm, it is acceptable for initiation of the fire alarm system to activate an alarm signal at a constantly attended location for the purpose of emergency action. The emergency action is required to provide live voice announcements.

Extinguishing requirements. Portable fire extinguishers.

Existing Business Occupancies
A fire alarm system is required in a new business occupancy when the building is 2 or more stories in height above the level of exit discharge.

A fire alarm system is required in a new business occupancy when there are 100 or more occupants above or below the level of exit discharge.

A fire alarm system is required in a new business occupancy when the building has 1,000 or more total occupants.

Initiation. The fire alarm system is required to be initiated by pull stations located throughout the facility. If the building has an approved automatic fire detection system throughout the pull stations are not required. If the building has an approved automatic sprinkler system throughout the pull stations are not required.

Existing Business Occupancies continued

Occupant notification. During all times that the building is occupied, initiation of the fire alarm system is required to activate a general alarm throughout the occupancy. Positive alarm sequence is permitted with the approval of the AHJ. Presignal systems are permitted with the approval of the AHJ. Instead of the general alarm, it is acceptable for initiation of the fire alarm system to activate an alarm signal at a constantly attended location for the purpose of emergency action. The emergency action is required to provide live voice announcements.

Extinguishing requirements. Portable fire extinguishers.

Industrial Occupancies
A fire alarm system is required for industrial occupancies. When the building has less than 100 persons with less than 25 above or below the level of exit discharge a fire alarm system is not required.

Initiation. The fire alarm system is required to be initiated by pull stations located throughout the facility. If the building has an approved automatic fire detection system throughout the pull stations are not required. If the building has an approved automatic sprinkler system throughout the pull stations are not required.

Occupant notification. The fire alarm system is required to provide audible and visible notification. Additionally an audible and visible signal is required at a constantly attended location for the purpose of initiating emergency action. Positive alarm sequence is permitted with the approval of the AHJ. Existing presignal systems are permitted with the approval of the AHJ. In high hazard industrial occupancies the fire alarm system is required to automatically initiate an occupant evacuation signal.

Storage Occupancies
A fire alarm system is required for storage occupancies. If the storage occupancy is limited to low hazard contents, a fire alarm system is not required. If the storage occupancy has an aggregate floor area of 100,000 square feet or less, a fire alarm system is not required. If the storage occupancy is protected throughout by an approved automatic sprinkler system, a fire alarm system is not required.

Initiation. The fire alarm system is required to be initiated by pull stations located throughout the facility. If the building has an approved automatic fire detection system throughout the pull stations are not required. If the building has an approved automatic sprinkler system throughout the pull stations are not required.

Storage Occupancies continued

Occupant notification. The fire alarm system is required to provide audible and visible notification. Additionally an audible and visible signal is required at a constantly attended location for the purpose of initiating emergency action. Positive alarm sequence is permitted with the approval of the AHJ. Existing presignal systems are permitted with the approval of the AHJ. In high hazard industrial occupancies the fire alarm system is required to automatically initiate an occupant evacuation signal.

Summary

The International Building Code ® and the Life Safety Code® play a critical role in the design of fire alarm systems. All fire alarm professionals should understand that these codes detail the fire protection requirements based on the type or occupancy of the building. The first reference in fire alarm system design should be the building or Life Safety Code®.

Chapter 4

Types of Fire Alarm Systems

All modern fire alarm system equipment is required to be appropriately listed for its intended use. In addition to this, there are several options available to increase the reliability and performance of fire alarm systems. These options include the following:

1. Connection of the system to a remote monitoring station or a listed central station.
2. Runner service.
3. Guards tour supervisory service.
4. Listed installation (third party verification).

The type of fire alarm system is determined based on these reliability options. The options the fire alarm system employs will identify which type of fire alarm system it is.

The Fire Alarm Code (NFPA 72®) specifies requirements for 5 types of commercial fire alarm systems. These types are:

1. Protected Premise Fire Alarm Systems
2. Remote Station Fire Alarm Systems
3. Central Station Fire Alarm Systems
4. Proprietary Station Fire Alarm Systems
5. Auxiliary Fire Alarm Systems

NFPA 72® has a separate chapter which details the requirements for residential or household fire alarm systems and equipment.

It is important to remember, the fire alarm code has been in development since 1899. The language used throughout the code reflects our language as it has developed over that entire period. Some wording and phrases are difficult for today's professional to understand due to this old language. The detailed explanations of these systems are on the following pages.

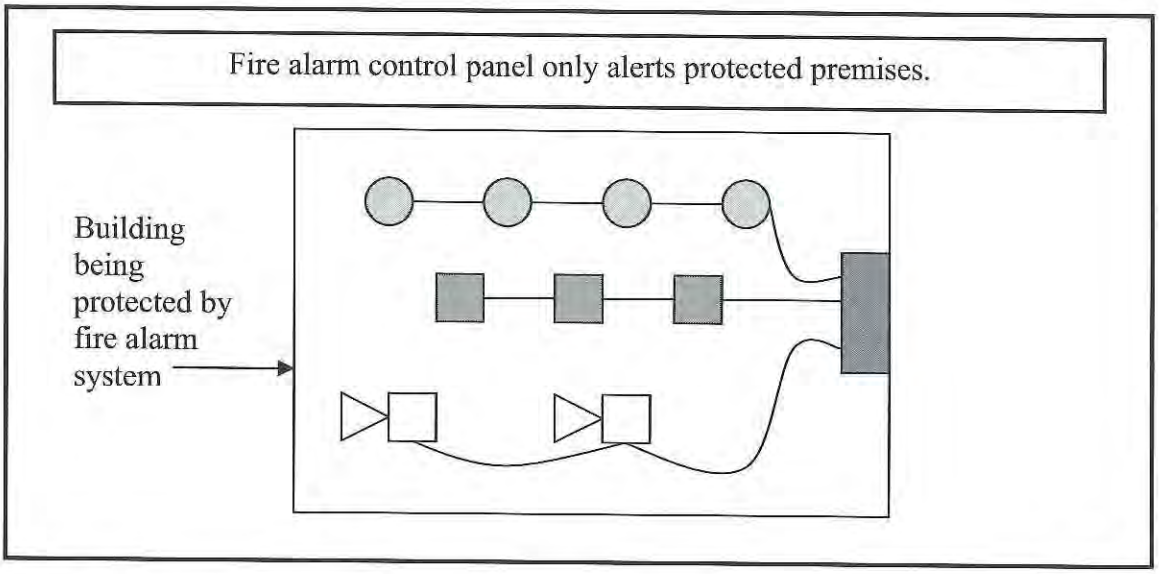
Fire Alarm System Origins

The damage, destruction and death caused by fire has been a problem for all human societies. Today, we are much better at early detection and suppression than our ancestors. For centuries, cities depended on people to detect and somehow report a fire. In the mid 1800's technology was developed to speed this process. Populated areas started to install wiring throughout the city. These circuits started at a fire station house. They attached this wiring to large fire alarm boxes located at key street corners.

Photo courtesy of NTC, p4.1

Each box used wind up code wheels with small teeth. Certain teeth on the code wheels were broken off. The exact number (or location of the box) could be identified by which teeth were broken. When a citizen detected a fire, they could go to the nearest box and pull the handle. This would release the wind up code wheels and the teeth would tap out a Morse code (the number of the box). The fire station then would respond to that particular box to extinguish the fire. The city owned the communications wiring and the street boxes. These types of municipal communications systems are called public fire alarm systems, and are discussed later in this chapter.

Protected Premise Fire Alarm Systems



Diagram, NTC, d4.1

In our industry protected premise fire alarm systems are called local fire alarm systems. These systems are very common. They are characterized by having no communications ability with a monitoring facility. Local fire alarm systems include all of the fire alarm equipment at the protected building including the following items:

1. Fire Alarm Control Panel.
2. Initiating devices including smoke/heat detectors, pull stations.
3. Notification appliances.
4. Power supplies.
5. Emergency voice evacuation systems.
6. Fire safety equipment (elevator recall/shutdown, HVAC detectors, door release).

All types of fire alarm systems share one thing. They all have to meet the requirements of a local system. The distinguishing characteristics between the five types of fire alarm systems are primarily communications. All types of fire alarm systems must meet the code requirements identified for protected premise fire alarm systems. New technology in the manufacture of fire alarm systems has brought to the forefront two important aspects of protected premise fire alarm systems.

1. Interconnection of multiple fire alarm control units.
2. The combination of fire alarm control units with other systems.

Until recently, the interconnection of fire alarm control units was permitted in a conventional way. This means a fire alarm control panel was permitted to trip another fire alarm control panel. NFPA 72® now recognizes a "systems integration" approach to this interconnection. Major fire alarm control panel manufacturer's now have the capability of integrating multiple fire alarm control units with networked facility computer systems. This approach allows for multiple fire alarm control units to be initially installed and/or added at a later date to the computer network. A user on the network can have access to all of the fire alarm information processed by the control, including type of signal, point identification, and environmental conditions (analog systems).

Photo courtesy of Honeywell, p4.2

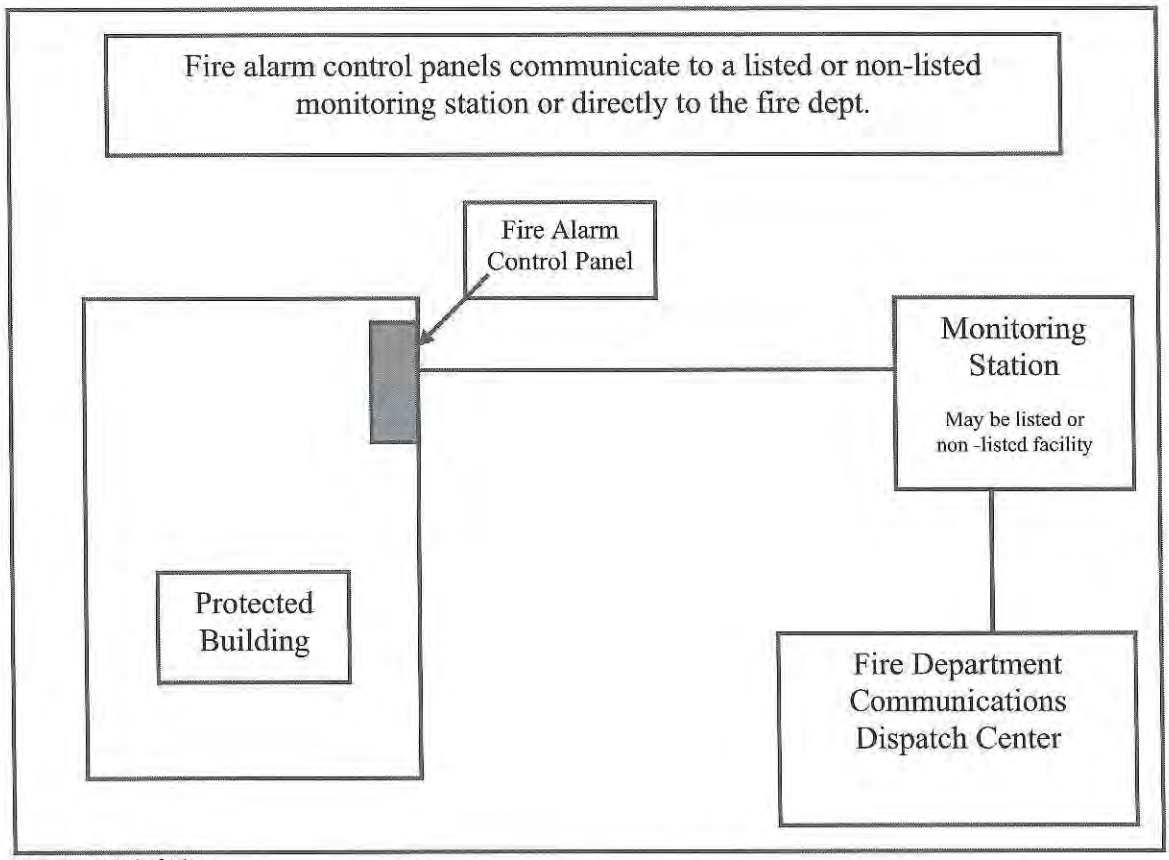
Photo courtesy of Honeywell, p4.3

The amount of fire alarm system information available to the user and first responders has never been greater. The code permits this systems integration approach, but there are stipulations. The gateway (method of interconnection to the computer network) is required to be listed. Additionally there is a concern for maintaining the integrity of fire alarm system signals. The code requires all installation conductors be supervised (monitored for integrity). The pathways used for the transmission of fire alarm signals on the computer network are expected to meet a similar requirement. Losing fire alarm signals or information is not permitted.

Combining the control functions of a fire alarm system with other building systems just makes sense. NFPA 72® allows for combination systems. In fact, there are no limitations as to what types of other systems may be combined with fire alarm systems. There are limitations on how such combined systems may function. It is critical, that the primary function of combination systems remains fire detection and signaling. Fire alarm system functions shall take precedence over any other function. Any malfunction from the nonfire system must not be permitted to affect the fire alarm system. Additionally, if any devices serve more than just a fire alarm system function, they must be set up for the fire alarm system and they shall not be permitted to be otherwise adjusted. An example of this is a combination fire alarm system and paging system. The speakers used for the fire alarm system may also be used for the paging system. The speakers are required to be located according to the fire alarm system requirements and must meet the audibility

requirements for fire alarm system use. The speaker volume may not be reduced for use with the paging system.

Remote Station Fire Alarm Systems



Diagram, NTC, d4.2

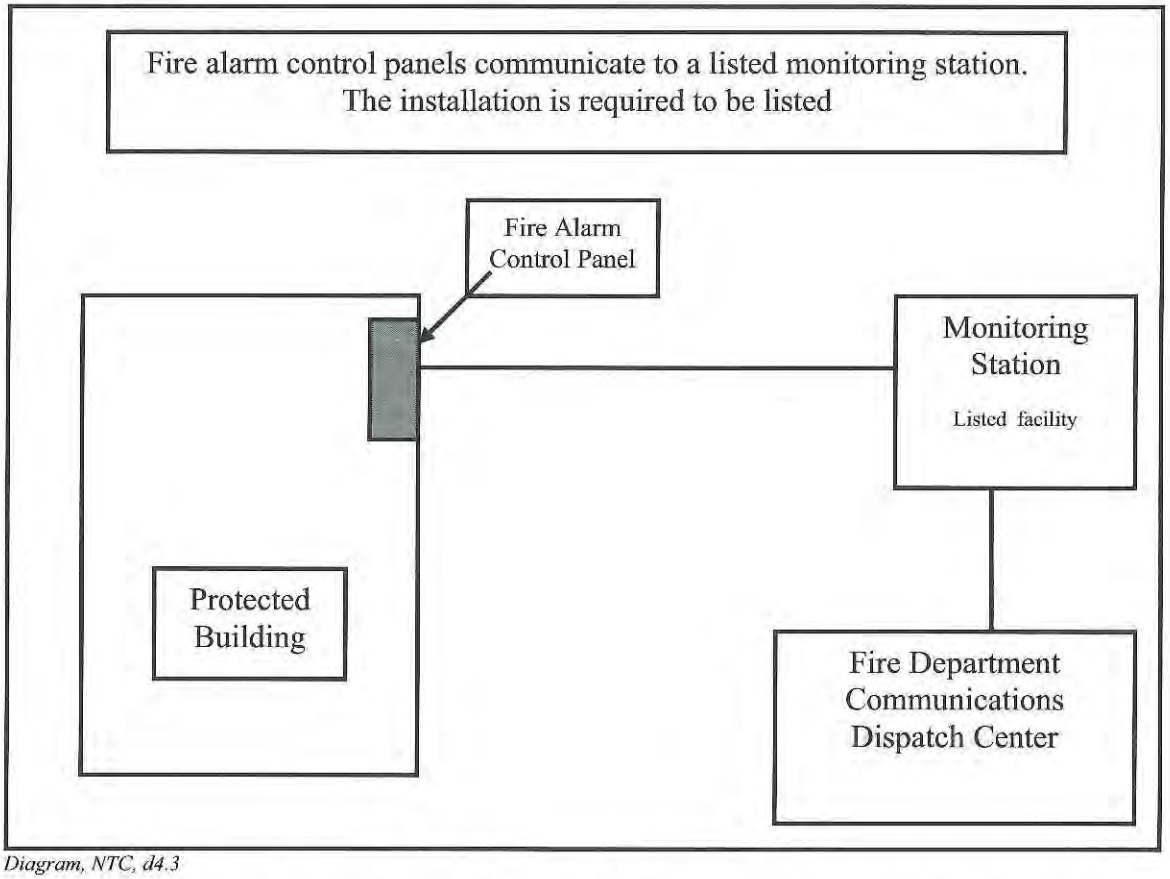
Remote station fire alarm systems are the most common of all communicating fire alarm systems. This is the type of fire alarm system most industry professionals work with on a daily basis. Most fire alarm systems which are sold, designed, installed and maintained fall into this category.

Remote Station fire alarm systems are characterized by using a communicator or radio system to transmit signals to a Listed Central Station or Non-Listed monitoring facility. Remote station systems, like all systems, have to meet the code requirements for protected premise fire alarm systems. They also have to meet the supervising station requirements detailed in NFPA 72®. The installation itself is not required to be listed. The monitoring facility must be approved by the authority having jurisdiction. The monitoring facility is not required to be listed. Remote station fire alarm systems do not require runner service.

From the 1950's thru the early 1990's, it was common for remote station fire alarm systems to transmit signals using a dialer or communicator directly to a public communications center, who would then dispatch the fire department to the protected

premise location. Due to staffing concerns, financial concerns, and false alarms this practice has been stopped in most states. Most commonly today, remote station fire alarm systems transmit signals to a listed central station.

Central Station Fire Alarm Systems



Diagram, NTC, d4.3

Insurance authorities normally dictate when the very highest level of fire alarm system performance is required. Central station fire alarm systems provide the most reliable and effective systems available. The key factors which describe a Central Station Fire Alarm System are:

1. Appropriately listed commercial fire alarm equipment.
2. The installation must be listed.
3. The monitoring station be a listed Central Station.
4. Central Station Service elements must be provided:
    a. Installation of fire alarm systems.
    b. Signal monitoring.
    c. Retransmission of signals.
    d. Associated record keeping and reporting.
    e. Testing and maintenance.
    f. Runner service.
5. Appropriate contract arrangements.

a. Subscriber contracts with a listed central station. The actual installation of the system may be conducted by a listed installation company or subcontracted to a non listed company.
b. Subscriber contracts with a listed installation company. The listed installation company shall then subcontract the monitoring of signals to a listed central station.

A very small percentage of all fire alarm system installations are central station fire alarm systems. These are highly specialized systems intended primarily for higher risk facilities. No code requires the higher protection and service elements provided by central station fire alarm systems. Insurance companies normally are the driving force behind the installation of central station fire alarm systems.

Central station fire alarm systems are also required to have a certificate and a placard within 3 feet of the control unit. The certificate must be issued by the certifying agency that certifies the central station and must state that the system meets all the requirements. The placard must identify the central station by name and telephone number.

Starting in 1899, insurance companies began publishing fire alarm system requirements. The insurance companies maintained control of publishing the requirements for fire alarm system installations until 1950. The government did not regulate the industry, the insurance companies did.

The insurance companies underwrote policies for buildings and facilities and they had a vested interest in making sure appropriate standards were in place. In 1950, the National Fire Protection Association (NFPA) took charge of these requirements. Today, the enforcement of NFPA 72®, the National Fire Alarm Code® falls under the control of local, state and federal governments.

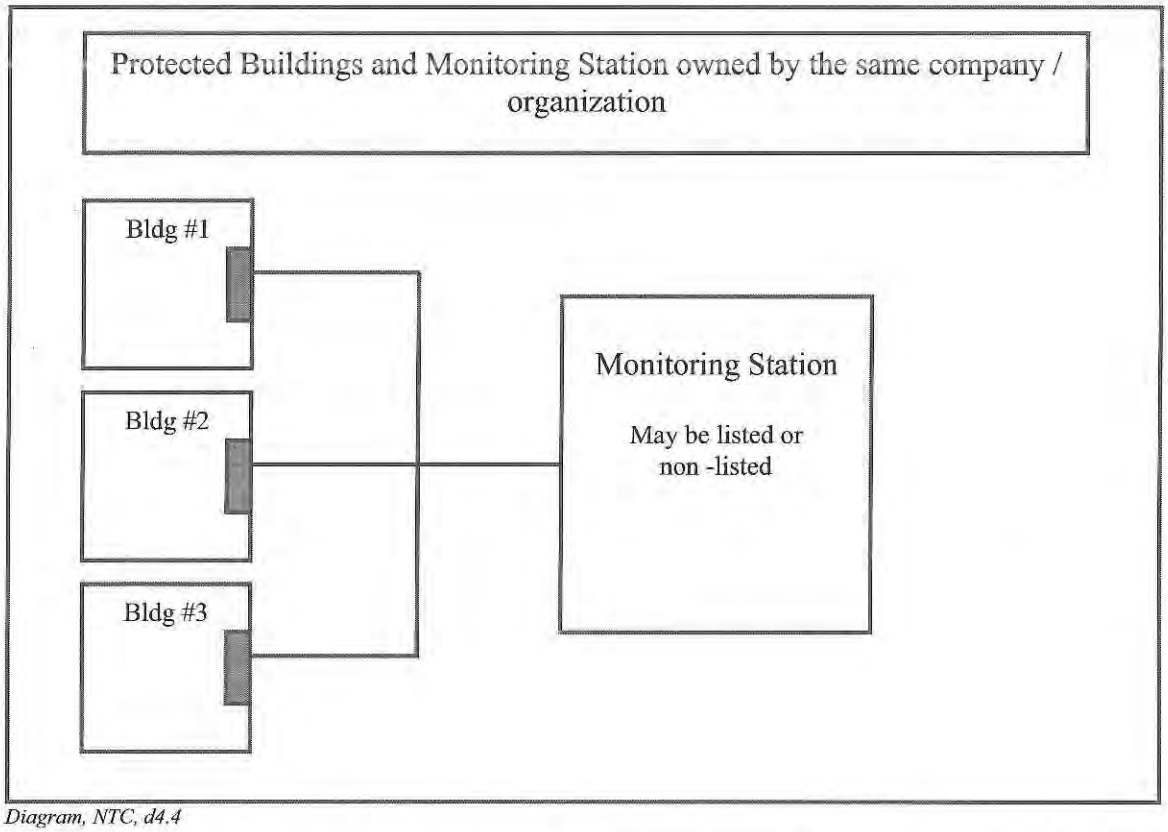
Normally, insurance authorities dictate when a central station system is required to be installed. Recently though, some local and / or state governments are requiring the installation of central station fire alarm systems to the exclusion of all other systems.

Central station fire alarm systems require the installation to be listed. This higher standard requires the installation to be certified by a listing agency and rigorously inspected.

The installation is subject to unannounced annual inspections by the listing agency. Some jurisdictions and AHJ's view this 3rd party verification as a way of relieving their responsibility for plans review and inspection.

Ultimately it increases the cost to the end user. Check with your local jurisdiction to find out information about their requirements.

Proprietary Station Fire Alarm Systems



Diagram, NTC, d4.4

Proprietary Station Fire Alarm systems are characterized by one ownership. The protected buildings and the monitoring facility are both under the same ownership. The reasons an organization would install a proprietary station fire alarm system are:

1. Increased control for the organization.
2. Higher reliability.

Proprietary station fire alarm systems are commonly used for college campuses, airports, multi-building manufacturing facilities, military bases, and some large corporations (e.g., Wal-Mart). Normally these systems are specified by the organization or possibly by the insurance authority. A proprietary station fire alarm system has several advantages over a remote station fire alarm system.

1. The organization has total control over the monitoring facility.
2. Runner service provides higher degree of liability.
3. Increased level of operator site specific knowledge.

Proprietary station fire alarm systems are required to use appropriately listed fire alarm equipment, however the installation is not required to be listed. The monitoring facility is not required to be listed. Runner service is required and this provides a higher level of reliability than remote station systems which do not require runner service. The proprietary monitoring facility shall provide runner service for fire alarm system signals.

1. Alarm signals, runner response to the protected building within 2 hours.
2. Supervisory signals, runner response to the protected building within 2 hours.
3. Trouble signals, runner response to the protected building within 4 hours.
4. Guards tour supervisory, runner response within 30 minutes.

The monitoring facility for proprietary station systems also has additional requirements. There is a requirement for two trained operators to be on duty at all times. 1 of the operators can serve as a runner.

Frequently, proprietary station fire alarm systems also monitor and control facility guard service. Specific guard tour stations are installed throughout the buildings/facilities.

As the guards patrol the premises, they are required to activate each station in a specific sequence. Failure of a guard to activate a station in the proper sequence or at the designated time will result in a guard's tour supervisory signal.

A runner response is required for these delinquency signals.

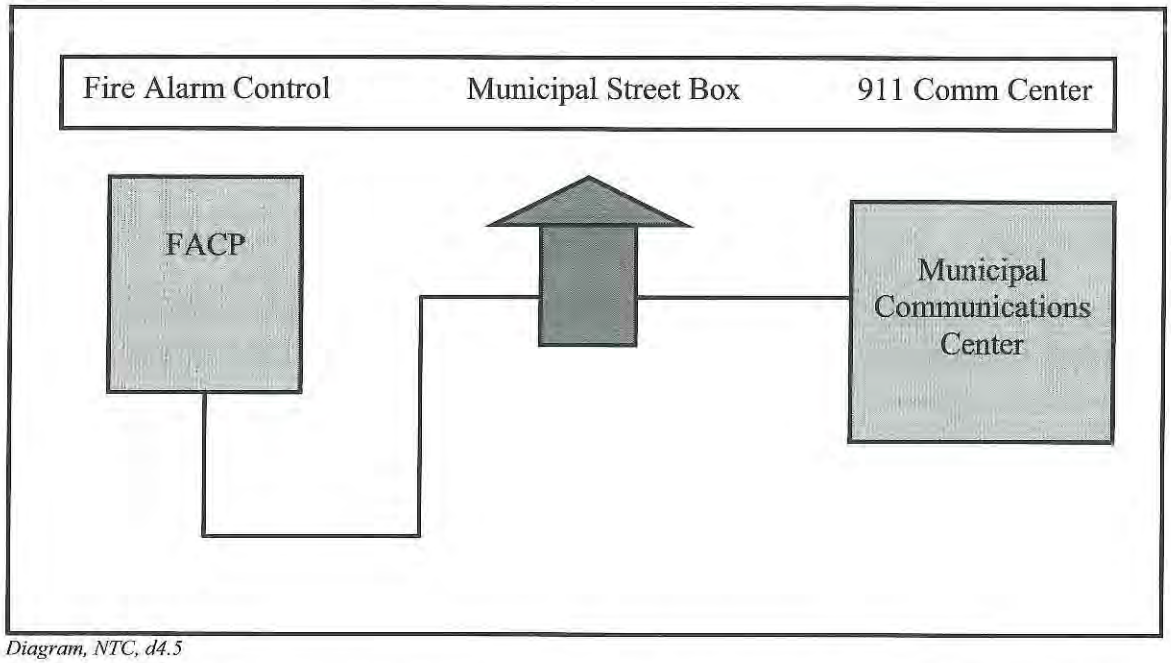
The guard service commonly associated with proprietary station fire alarm systems originates in the history of fire alarm systems. In fact, guard service (formerly known as fire watch) arguably served as the first fire detectors.

The primary job of these guards in days gone by was the early detection of fire for life safety and facility protection.

Proprietary station fire alarm systems are not frequently installed. They do provide more control for the organization.

They also provide a higher degree of reliability with additional monitoring station requirements, runner service requirements and guards tour supervision.

Auxiliary Fire Alarm Systems



Diagram, NTC, d4.5

Auxiliary fire alarm systems are characterized by the use of municipal street boxes. These systems use the municipally owned fire alarm communications system in order to communicate signals to the fire department or public communications center. There are two important aspects to auxiliary fire alarm systems:

1. The fire alarm equipment at the protected building.
2. The method of connection to the municipal communications network.

The fire alarm equipment used at the protected building is exactly the same as any other fire alarm equipment used today. These systems may be conventional or addressable. The panels, detectors, notification appliances etc are all the same equipment normally installed today. The difference is in how this equipment transmits signals to the fire department. Auxiliary fire alarm systems do not use communicators or radios to send their signals. They use the municipal (public) communications network.

Connection to the municipal communications network.
The one thing that separates auxiliary fire alarm systems from any other type of system is its connection directly to the municipal communications network. The fire alarm system at the protected building is capable of generating alarm, supervisory and trouble signals just like all of the systems we install today. The municipal communications network is only capable of transmitting an alarm signal, or a trouble signal. The auxiliary fire alarm system can annunciate a supervisory signal locally at the panel or remote annunciator.

The interconnecting circuit between the fire alarm panel and the municipal street box is the critical link for auxiliary fire alarm systems. The code requires the use of 14 AWG

wire for this interconnection. The length of the circuit is also limited to no more than 750 feet and it is required to be run in conduit. Each conductor of the circuit is required to be run in a separate conduit. Also, using a normally closed relay to trip the municipal street box is not allowed. The reason for this is due to the fact that a fault on the interconnecting circuit would then generate an alarm signal on the municipal communications network.

Summary

There are five types of fire alarm systems. The most common fire alarm systems which are installed today are:

1. Local Fire Alarm Systems
2. Remote Station Fire Alarm Systems

The other three types are installed less frequently in most areas. They are all very specialized types of fire alarm systems. These less frequently used systems are as follows:

1. Central Station Fire Alarm Systems
2. Proprietary Fire Alarm Systems
3. Auxiliary Fire Alarm Systems

Each of these systems have a place in our industry or in the history of our industry. All of these systems shall meet the requirements of NFPA 72® The National Fire Alarm Code®. Always check with the code to determine the specific requirements for the system you are installing.

Chapter 5

Initiating Devices

Initiating devices on a fire alarm system generate signals (alarm or supervisory) to be processed by the fire alarm control unit. These devices may generate signals by manual activation, automatically when they detect heat or smoke, or when triggered by another system or device. The type of signal sent to the control, and the response of the control, depends upon the device itself and how the zone is programmed to respond.

Photo courtesy Edwards, p5.1

Photo courtesy Edwards, p5.2

Photo courtesy Edwards, p5.3

Manual Fire Alarm Boxes

Manual fire alarm boxes, more commonly known as pull stations, are manually activated by a person who wishes to initiate a fire alarm signal. Depending upon the configuration of the system, activation of the device immediately causes a general alarm throughout the building.

Photo courtesy Edwards, p5.4

Photo courtesy Edwards, p5.50

Photo courtesy Firelite, p5.6

Some systems are configured to send the alarm signal to a constantly attended location first. This provides time for investigation of the signal (positive alarm sequence or

presignal systems). General alarm applications are considerably more popular. Presignal systems and positive alarm sequence require special circumstances and AHJ approval.

Breakglass and Nonbreakglass

The term "breakglass" refers to manual stations that require the breaking of glass (or other easily breakable material) rods or covers in order to activate the manual station. The intent is to help prevent false alarms, and to meet the requirement that special tools be required to reset the manual station after activation. The glass may be internal or external to the station itself, and should only be replaced with manufacturer approved replacement materials. Manual stations without this feature are referred to as "nonbreakglass."

Photo courtesy Edwards, p5.7

Single and Dual Action

This refers to the number of physical actions required to activate a manual station. A single action manual station only requires a single physical action to activate it. This action is typically pulling a lever. A dual action requires two physical actions to activate it. The actions may be pushing in a door, breaking glass, or lifting a cover to gain access to the second device to activate the alarm.

Dual action
(push in and pull down)

Photo courtesy Firelite, p5.8

Single action
(pull down only)

Photo courtesy Firelite, p5.9

Noncoded or Coded

Noncoded manual stations provide a maintained contact closure until the manual station is reset. Some older systems used coded stations, which contained a mechanical or electrical motor that would turn a wheel with teeth. As the wheel turned, the teeth caused a contact to open and close. The contact would sound the fire alarm control's audibles each time it closed. The location of the alarm could be determined by counting the code as it sounded out.

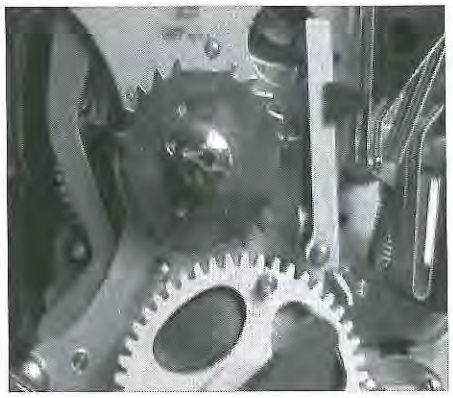
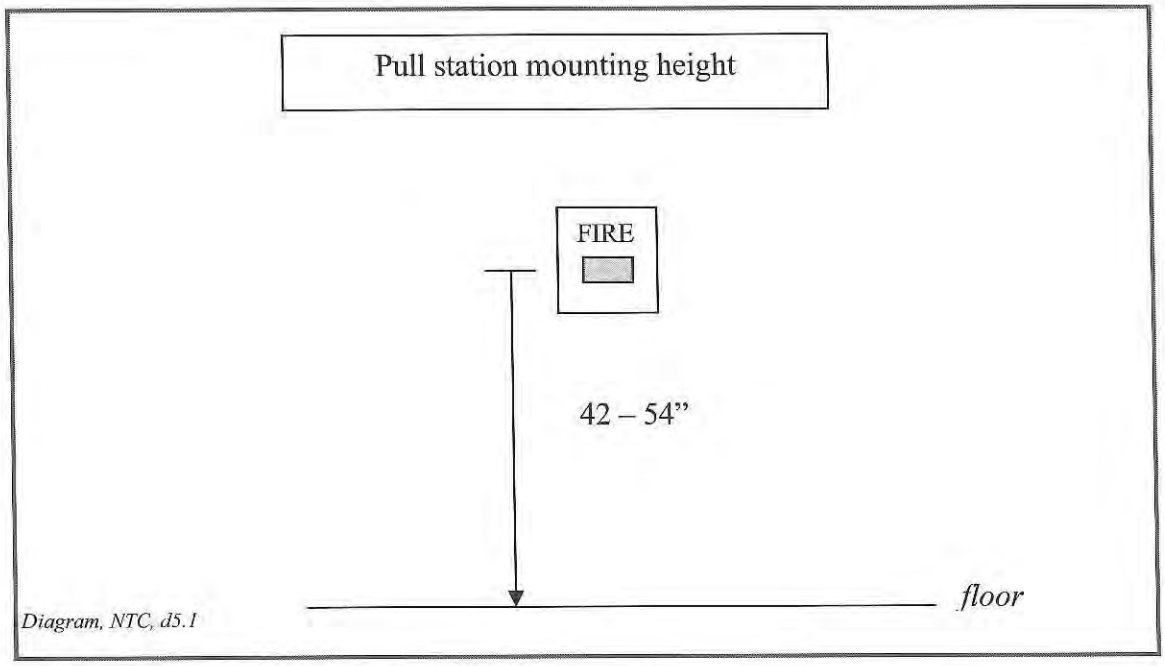


Photo courtesy NTC, p5.10

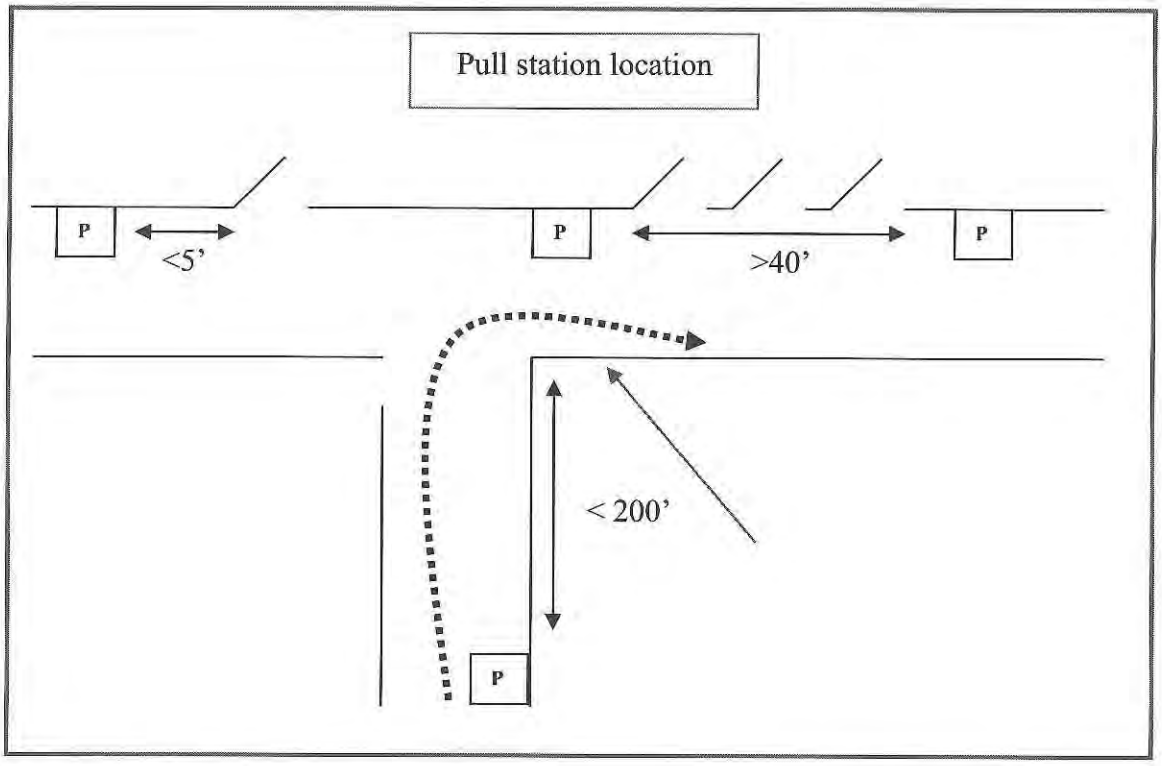
Location and Spacing

Manual stations are required to mounted so that the operable part of the station (actuator) is between 3-1/2 and 4-1/2 feet off the floor. Mounting at this height allows easy access by a standing person or a handicapped person in a wheelchair.



Diagram, NTC, d5.1

Manual stations need to be located throughout the protected area in locations where they are easily accessible and along the normal path of exit from an area. At least one manual station must be provided on each floor and at least one must be located within 5 feet of each exit door on a floor. Additional units must also be provided within 200 feet horizontal travel distance on the floor. Grouped openings over 40 feet wide should have a pull station within 5 feet of either side.



Diagram, NTC, d5.2

If they are subject to abuse, a mechanical guard may be used to protect them.

Photo courtesy Safety Technology International, p5.11

Automatic Fire Detectors

Automatic fire detectors are designed to provide early detection of fires and protection in buildings. They can provide detection in unoccupied areas. Automatic detectors are designed to detect common signatures of combustion at an early stage before the fire gets out of hand. Heat, smoke, gas, and light (radiation) are the most common means of early detection. Proper detector selection requires consideration of local environmental factors that can produce or mimic these signatures. It is best to use detectors that are immune to those environmental factors, yet provide the fastest possible response.

Automatic detectors are classified as spot type or other type (line type). Spot type detectors are most common. Spot type detectors have the detection element concentrated in a single location.

Photo courtesy System Sensor, p5.12

Photo courtesy System Sensor, p5.13

Other types (beam smoke detector, line type heat detectors) have their detection element(s) spread out over an area.

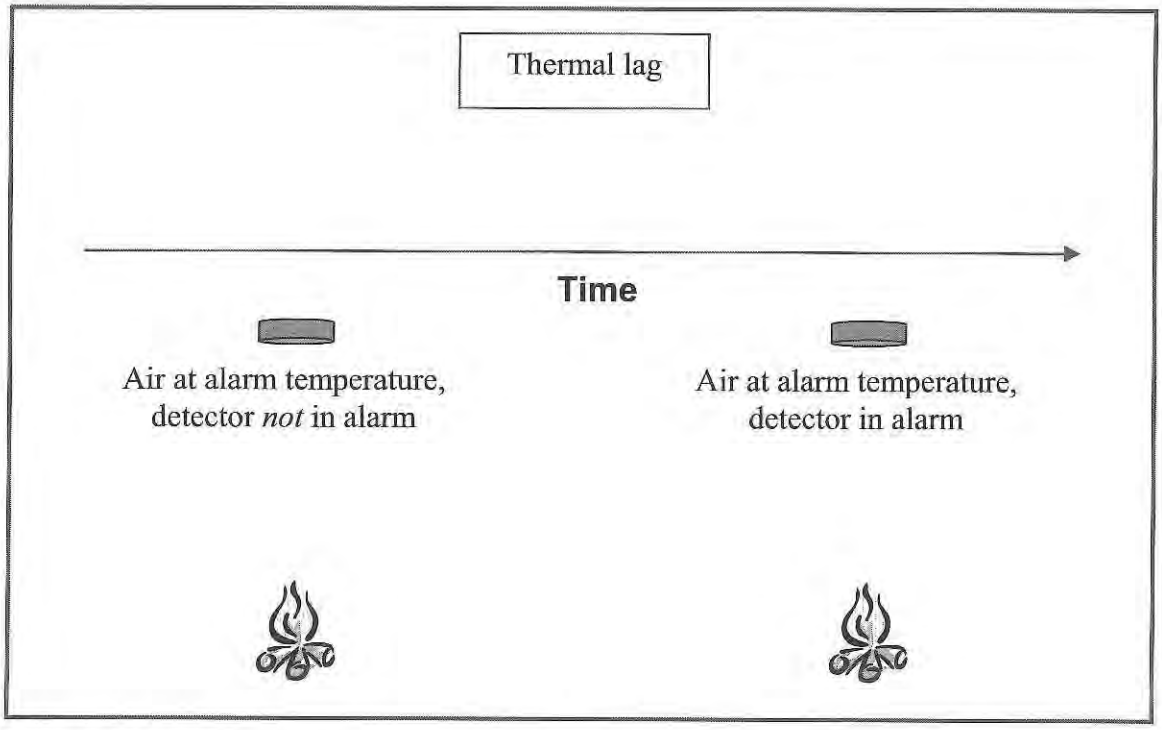
Photo courtesy System Sensor, p5.14

Photo courtesy Protectowire, p5.15

Heat detectors are the oldest type of automatic fire detector. Heat detectors are generally mounted on or near the ceiling and are designed to detect the thermal energy from a fire. They are the least expensive and most reliable of all the automatic detectors, but they are also the slowest to respond. Heat detectors can operate under several different operating principles, but all generally respond to a specific physical change to the detection material (melting or expanding).

Thermal Lag

Thermal lag is the delay between the time at which the air surrounding the heat detector reaches the alarm operating temperature and the time at which the detector goes into alarm. This delay results in the delayed response of a heat detector to a fire situation.



Diagram, NTC, d5.3

Fixed Temperature Heat Detectors

Fixed temperature heat detectors respond when the temperature at the detector itself reaches a predetermined, specific level. This type of detector is extremely slow to respond due to the time it takes the detector to reach the temperature of the surrounding air (thermal lag). Fixed temperature detectors are available that can be used in areas with high ambient temperatures (above 100° F). The detectors are marked with a color code to designate the temperate range of the unit. Some manufacturers use large print numerical temperature ratings on the detector for identification.

Heat Detector Temperature Range

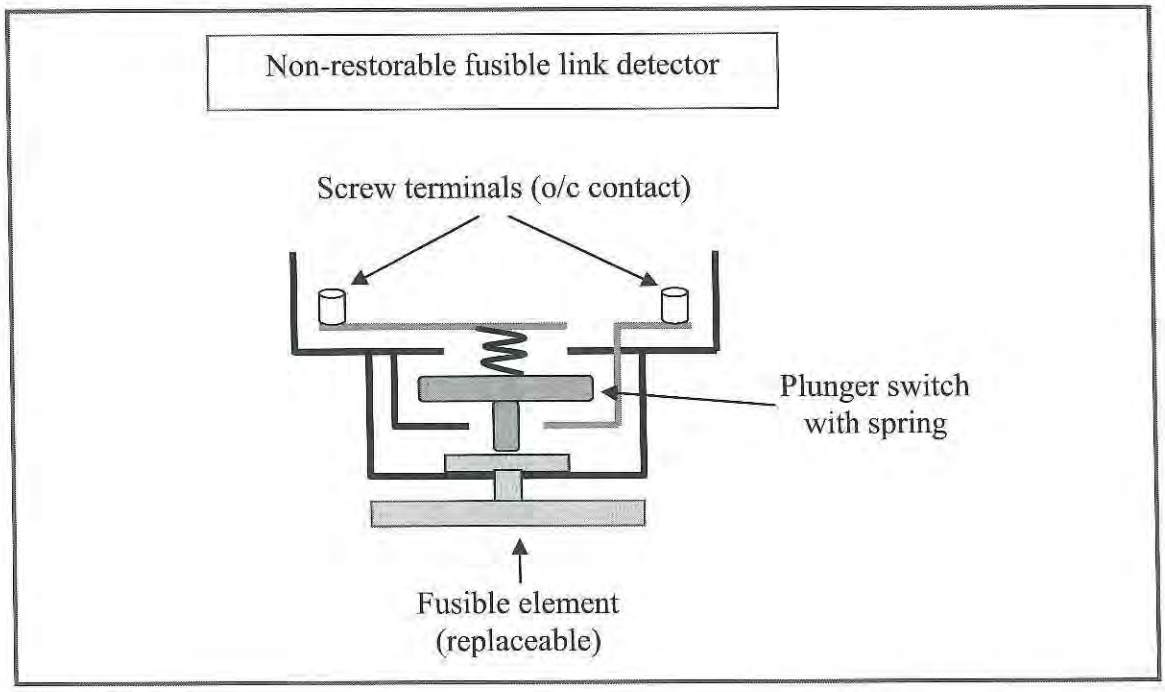
Temperature Classification	Temperature Range °C	°F	Maximum Ceiling Temperature °C	°F	Color Code
Low	39-57	100-134	28	80	Uncolored
Ordinary	58-79	135-174	47	115	Uncolored
Intermediate	80-121	175-249	69	155	White
High	122-162	250-324	111	230	Blue
Extra high	163-204	325-399	152	305	Red
Very extra high	205-259	400-499	194	380	Green
Ultra high	260-302	500-575	249	480	Orange

Diagram, NTC, d5.4

Fixed Temperature Heat Detectors

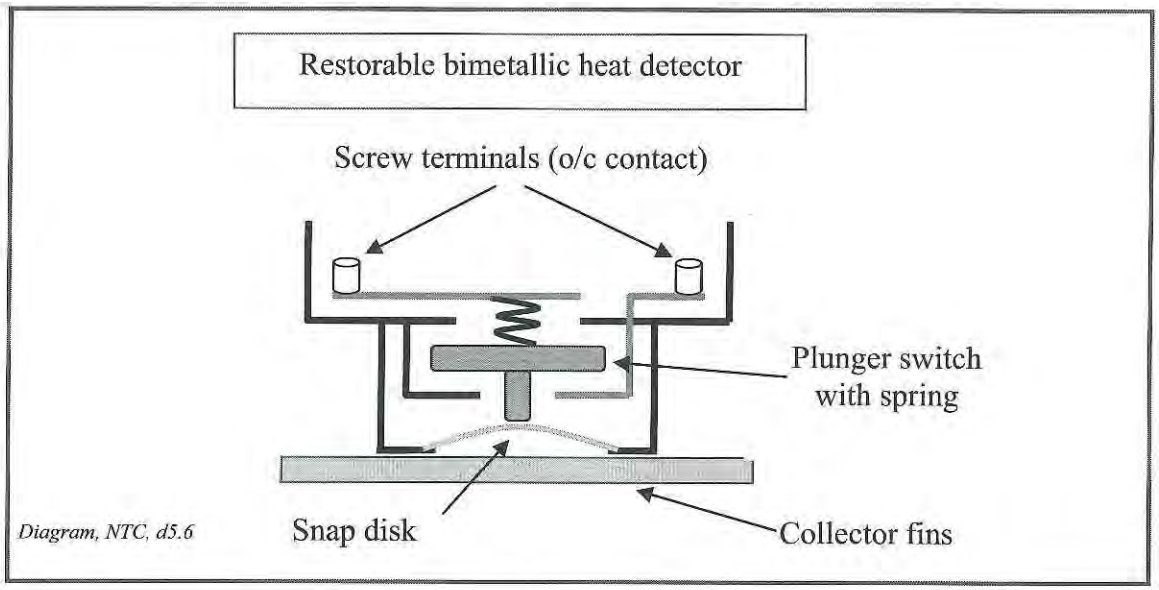
Fixed temperature detectors are available in restorable and non-restorable types. Non-restorable type detectors must have their detector element or the entire detector replaced when they have been activated. Restorable detectors automatically reset themselves once the heat level has dropped below its operating range.

Non-restorable fusible link type detectors use a eutectic metal (melts rapidly at predetermined temperature) to hold back a switch. When the metal melts, the switch activates and initiates an alarm since the detector is non-restorable the detector itself or its detection element must be replaced after operation.



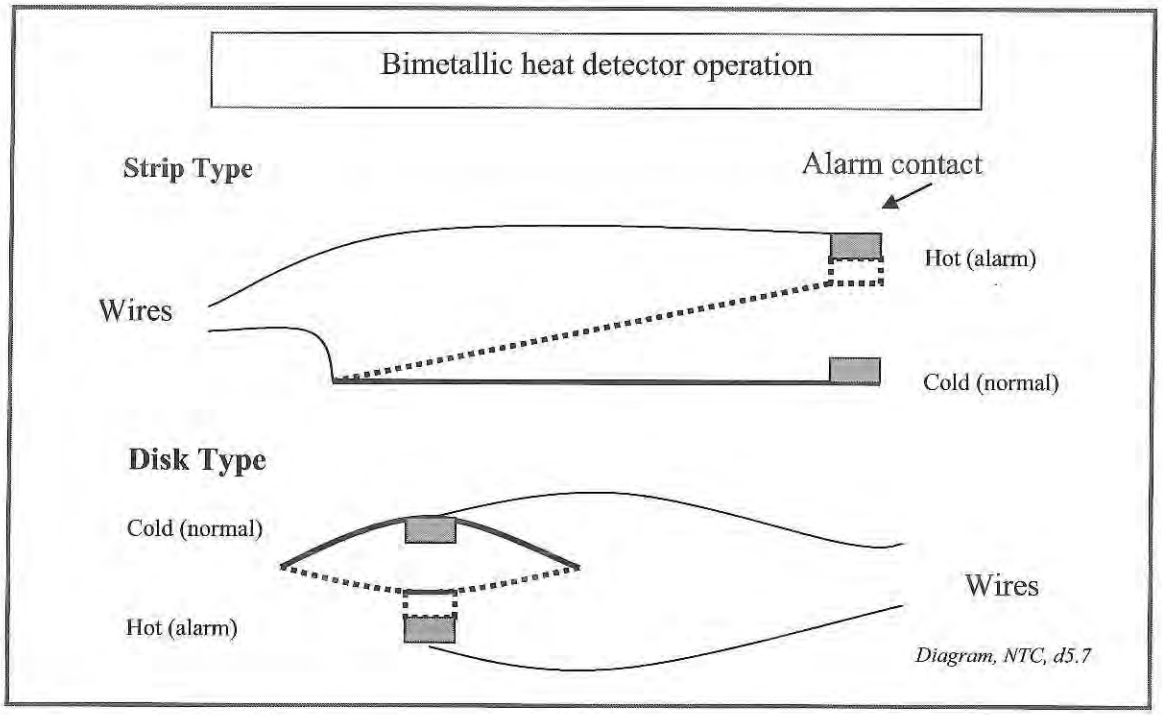
Diagram, NTC,d5.5

Restorable bimetallic type heat detectors have sensors with two different metals each having a different thermal expansion coefficient. When the sensor is heated it bends toward the metal with the lower expansion rate. Invar ™ (an alloy of nickel and iron) is commonly used as the low expansion metal. Alloys of manganese-copper-nickel, nickel-chromium-iron, or stainless steel may be used for the high expansion side.



Diagram, NTC, d5.6

The sensing element is typically a disk or strip, oriented so that when it is heated the high expansion side will push it towards a contact point to complete the electrical connection. The strip type lifts towards the contact point, the disk type changes from a concave to convex shape to make contact. The detector typically has collector fins attached to the detector to speed reaction time.

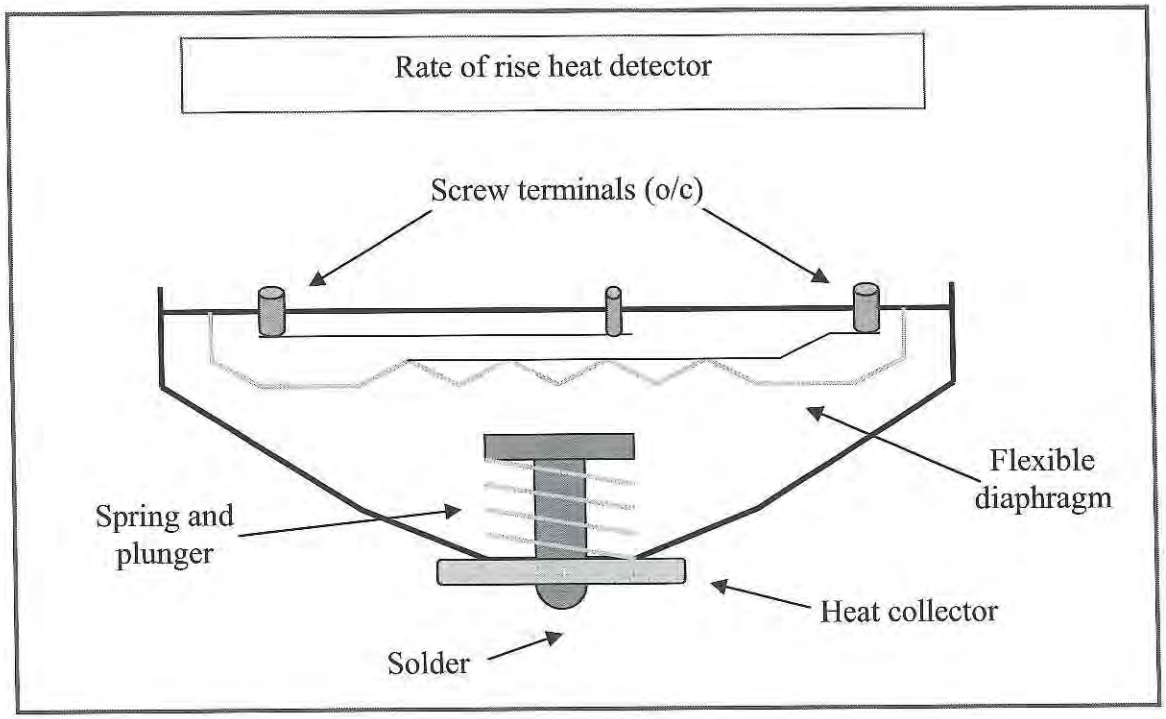


Diagram, NTC, d5.7

Rate-of-Rise Heat Detectors

Rate of rise detectors respond when the temperature of the detector rises more than 15° per minute. An air chamber in the detector is covered by a flexible metal diaphragm. A rapid rise in temperature expands the air in the chamber and pushes the diaphragm up against contacts. The detector itself restores after activation. An air vent allows the detector to compensate for slow temperature changes.

Photo courtesy Edwards, p5.16



Diagram, NTC, d5.8

This type of detector usually also employs a fixed temperature element as well. A low temperature alloy holds a spring in place. If the temperature of the detector gets high enough to melt the alloy the spring is released. The spring pushes the diaphragm into the contacts causing an alarm condition. Once operated in this mode, the detector must be replaced.

Rate Compensation Heat Detectors

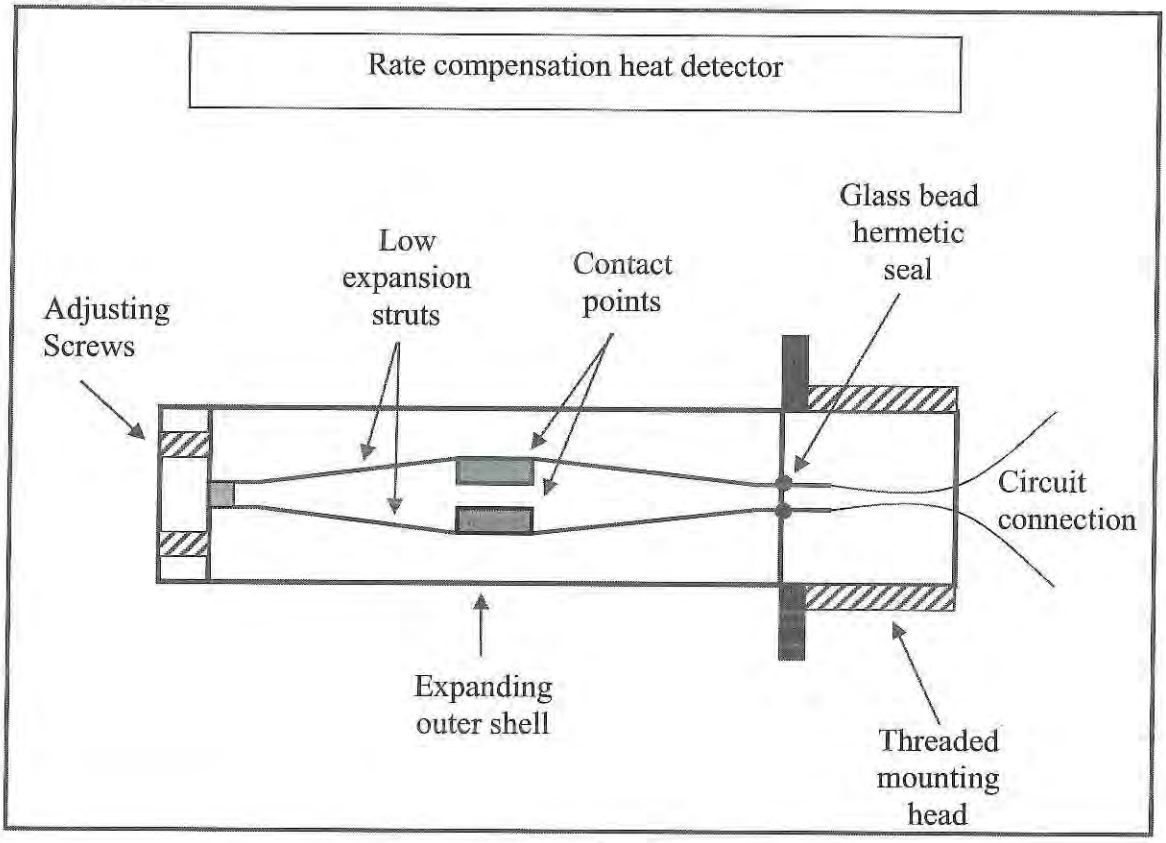
Photo courtesy Thermotech, p5.17

Photo courtesy Thermotech, p5.18

Rate compensation heat detectors respond to a preset temperature of the surrounding air no matter how matter fast or slow the temperature rises. The detector has a tubular metal case that extends lengthwise when it is heated. This extension pulls on a set of contacts allowing them to close. A second metallic element in the tube exerts force in the opposite direction to keep the contacts open.

The entire unit must reach the target temperature to be activated. The detector is balanced so that a slow temperature rise takes longer to heat the inner contacts. A fast temperature rise causes the tube to expand quicker and defeat the force holding the internal contacts open. This helps compensate for thermal lag. Once the ambient temperature drops far enough below the detectors alarm point the unit resets.

Diagram, NTC, d5.9



Thermoelectric Effect Detectors

Thermoelectric effect detectors utilize sensing elements that produce an increase in voltage in response to a temperature rise. The element, typically a thermocouple or thermopile, is monitored by signal processing equipment that looks for rapid voltage increases.

Thermopile detection devices use two sets of thermocouples. One is the detection element; the other is a reference element (protected from environmental changes). The units are connected in series. When the sensing element is activated by heat it generates a net voltage, which activates the alarm circuit.

Thermistor Heat Detector

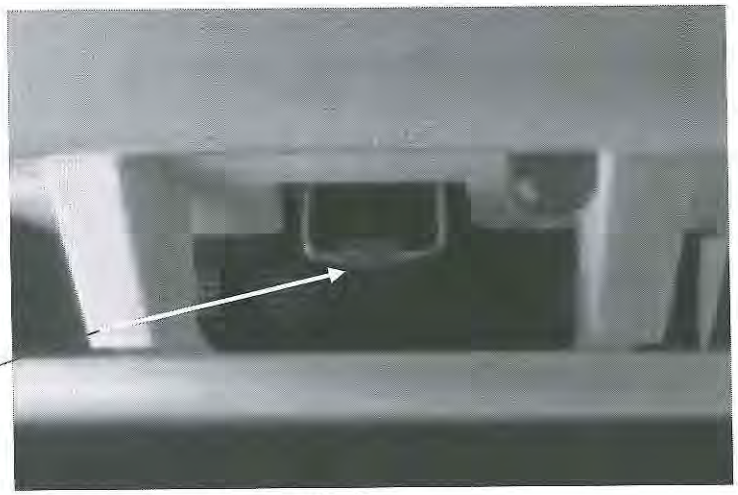


Photo courtesy System Sensor, p5.19

Thermistor heat detectors have a sensing element that increases electrical resistance in response to increasing temperature. The detector element is supported by electronic circuitry, which allows them to respond like a fixed temperature or rate of rise heat detector (or both). The circuitry can even send actual temperature data to the fire panel as well.

Thermistor heat detectors are often incorporated into smoke detectors. The thermistor detection circuit is arranged with the smoke detection circuit so that activation of either detection technology will activate the detector's relay. Some models are available with separate outputs for the heat and smoke detector. This feature is referred to as isolated heat detector.

Line Type Heat Detectors

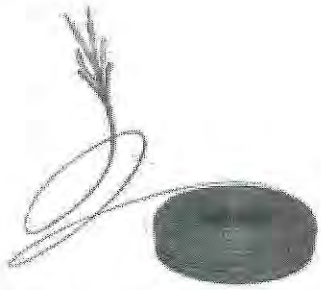
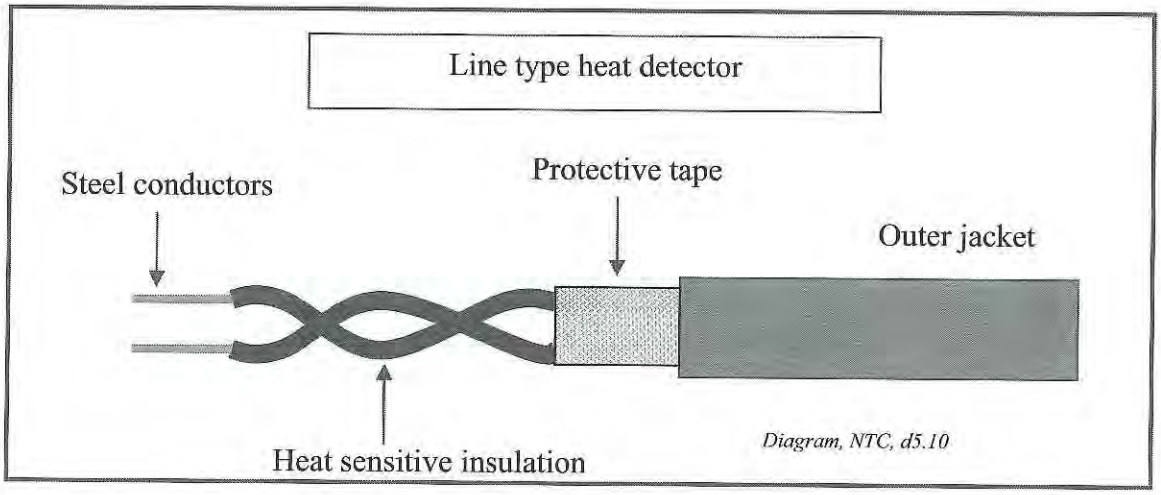


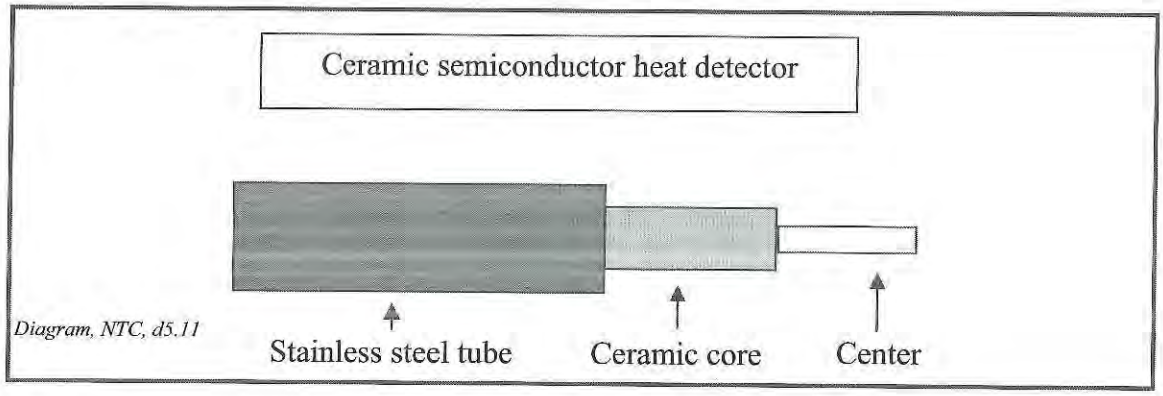
Photo courtesy Protectowire, p5.20

Line type heat detectors detect along a linear path. Various types of linear heat detectors are available. Heat sensitive cable, sold under the trade name of Protectowire™, has two conductor twisted to impose spring pressure and separated by heat sensitive insulation. When the detection temperature is reach the insulation melts and the wire come into contact with each other. After an alarm, the fused section of cable must be located and replaced. The cable is available with special jackets for weather resistance, and with messenger wire for unsupported aerial applications.



Diagram, NTC, d5.10

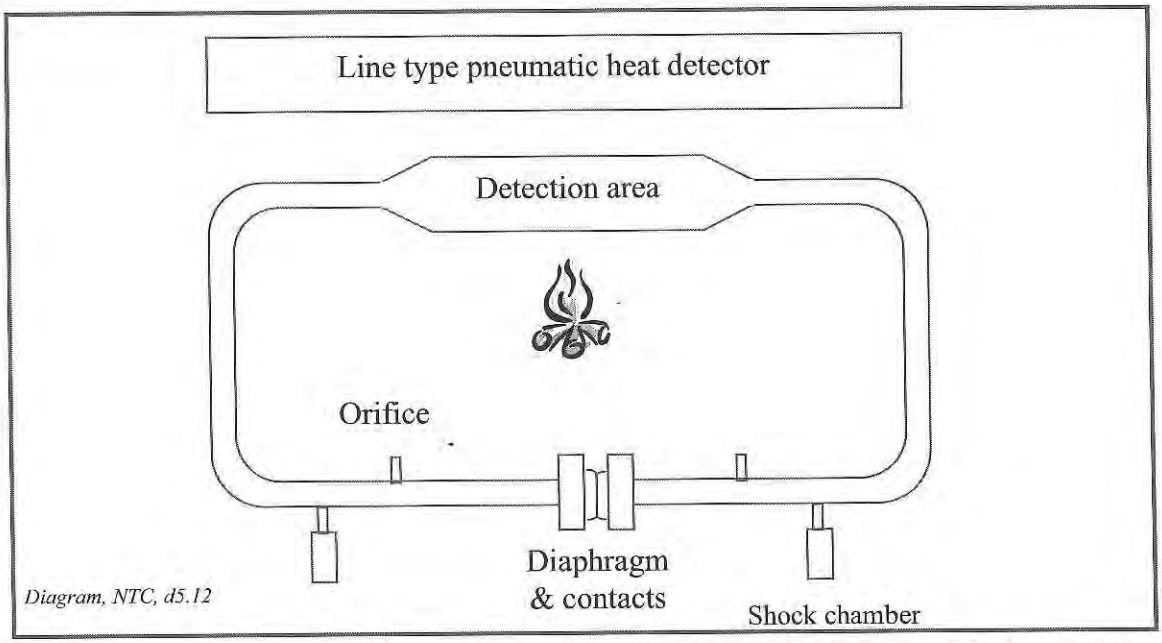
Another type of line type heat detector features a stainless steel tube with a center conductor surrounded by a temperature sensitive ceramic semiconductor material. As the semiconductor is heated its resistance decreases allowing an increase current flow from the center to the tubing.



Diagram, NTC, d5.11

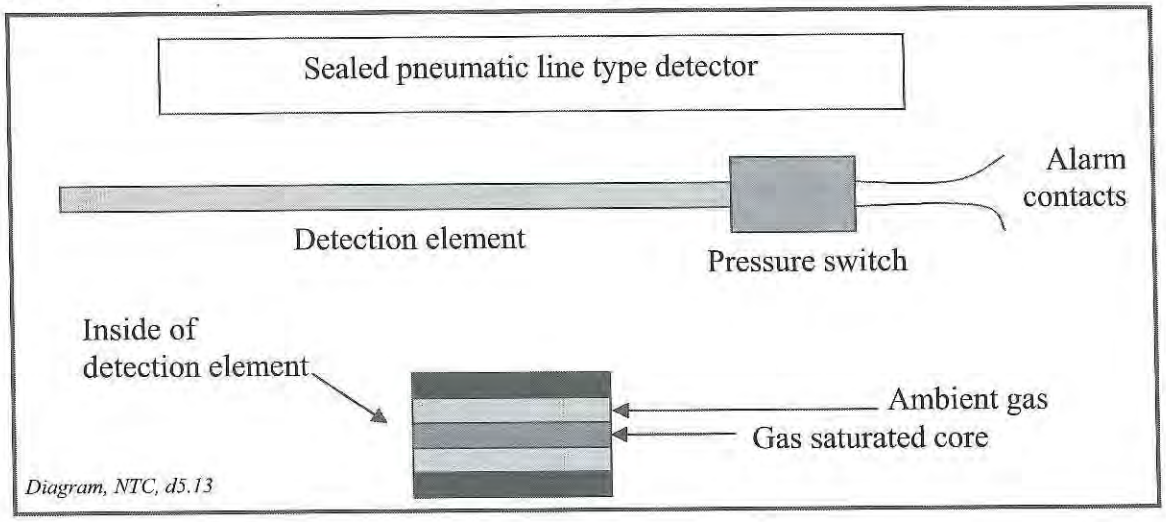
Line Type Pneumatic Heat Detectors

Line type pneumatic heat detectors feature a loop of metallic tubing running through the protected area. The tubing contains air which presses against a diaphragm. Sudden sustained rises in temperature push the diaphragm into contacts which create a closed circuit for alarm. The tubing must be no more than 15 feet from the walls and no more than 30 feet apart, with maximum distance of 1000 feet. A minimum of 5% of the tube circuit or 25 feet of the tube itself, which ever is greater must be in each protected area. Shock chambers compensate for sudden, short term temperature changes, and orifices compensate for gradual changes in pressure.



Diagram, NTC, d5.12

Sealed pneumatic line type detectors consist of a tube containing a special chemical that is saturated with hydrogen gas. When a section of the tube is heated, hydrogen gas is released, increasing the pressure in the tube. The tube pressure is monitored by a pressure switch, which monitors the tube for high and low pressure conditions.



Diagram, NTC, d5.13

Smoke Detectors

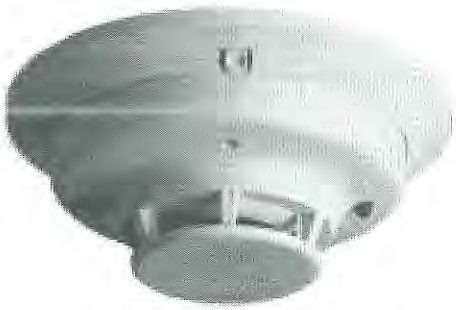


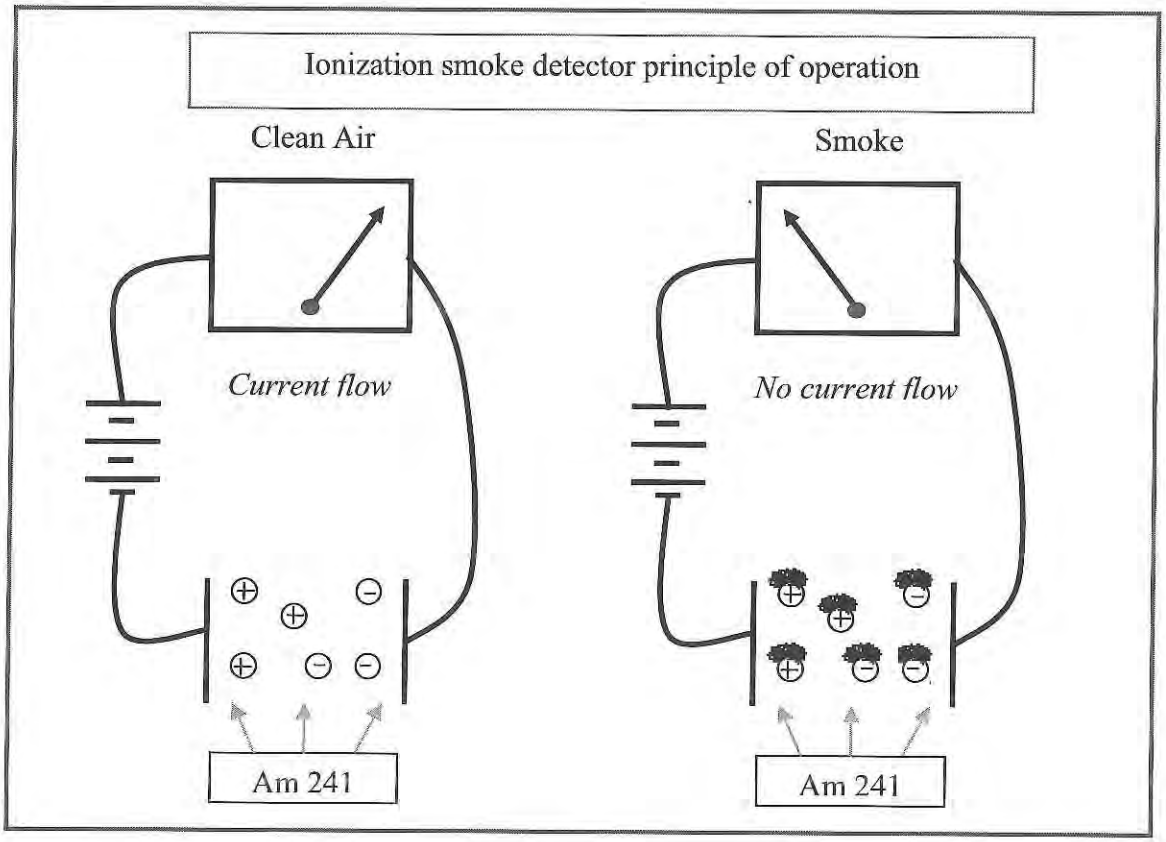
Photo courtesy System Sensor, p5.21

Smoke detectors provide a more rapid response to fire than heat detectors. Fires will typically produce detectable amounts of smoke long before they produce detectable amounts of heat. Since smoke detectors respond to smoke, they are more prone to false alarm than heat detectors. Many benign environmental factors can look like smoke to a smoke detector, but heat is more difficult to imitate.

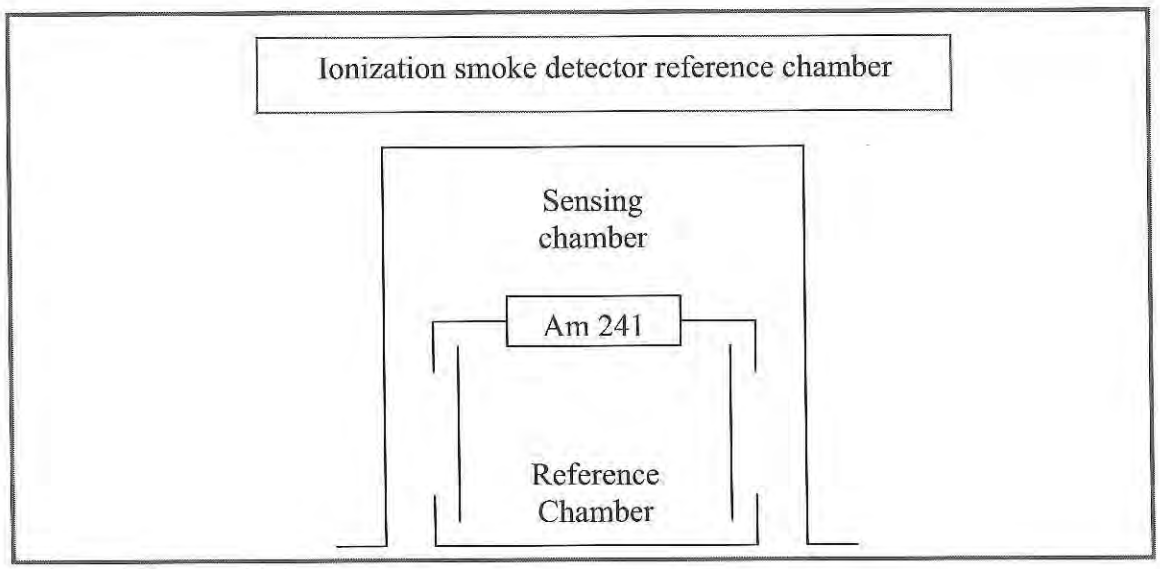
Ionization Smoke Detectors

Ionization smoke detectors use a small amount of radioactive material (typically Americium-241), which emits alpha particles to ionize air in a sensing chamber. The ionized air allows current flow between two charged plates and the detector monitors this current flow using a galvanometer. When smoke enters the chamber, it attaches to the ionized particles and reduces the current flow between the two plates. If the current flow drops low enough the detector goes into alarm.

Diagram, NTC, d5.14



Modern ionization detectors are dual chamber, which increase their stability. The second chamber is a reference chamber. It is protected from the entry of smoke particles, but can sense changes in humidity and pressure. These changes in humidity and pressure can affect detector performance. The detector monitors both chambers and only alarms if there is a large imbalance between the reference and the detection chamber.



Diagram, NTC, d5.15

The government strictly regulates the use of radioactive materials, so there is virtually no risk of irradiation from an ionization smoke detector. One gram of Americium-241 is enough to build 5,000 smoke detectors. Additionally, the radiation from the material only travels about one inch before it picks up a free electron and becomes harmless.

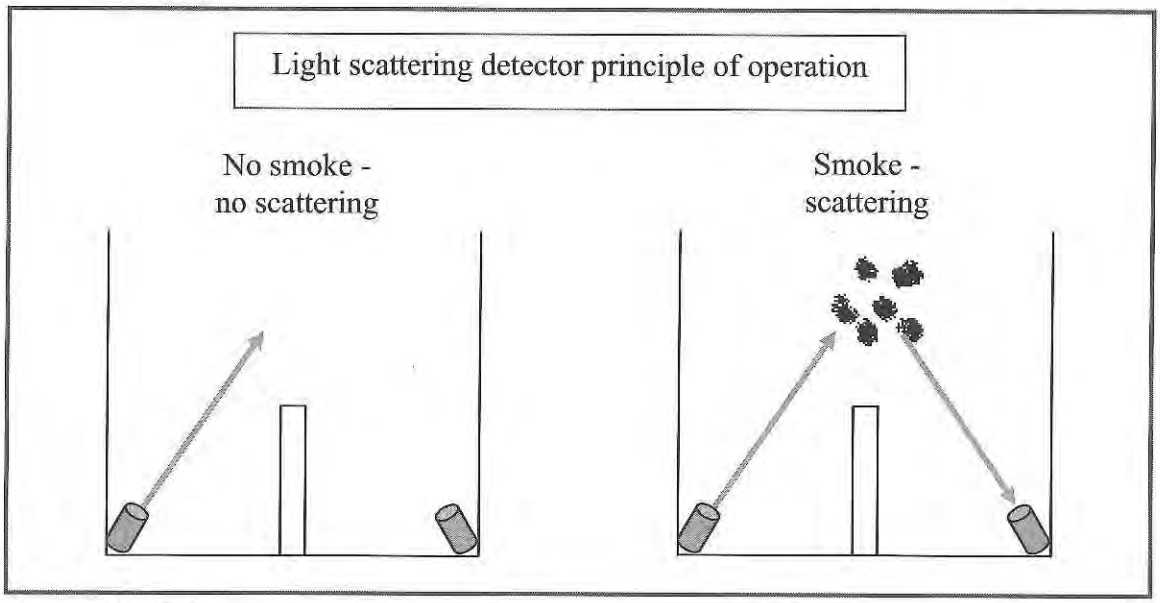
Ionization smoke detectors will detect a fire in the incipient stage before other types of smoke detectors. Altitude can affect the performance of ionization smoke detectors. For those areas with an altitude of 3,000 feet or greater will influence the ability of the smoke detector to perform its job.

Photoelectric Smoke Detectors

Photoelectric smoke detectors detect smoke based on how it affects a projected light beam. There are two methods of detection for this type of detector. Light scattering detects light scattered or refracted into a sensor by the presence of smoke. Light obscuration detects when light received by a sensor is reduced by the presence of smoke.

Light Scattering Detectors

Light scattering detection is most commonly used in spot type smoke detectors. The light source and the sensor are arranged so that the sensor cannot normally "see" the light source. When smoke enters the detector, it refracts (scatters) light onto a light sensitive element. When sufficient light is reflected into the sensor it goes into alarm condition.



Diagram, NTC, d5.16

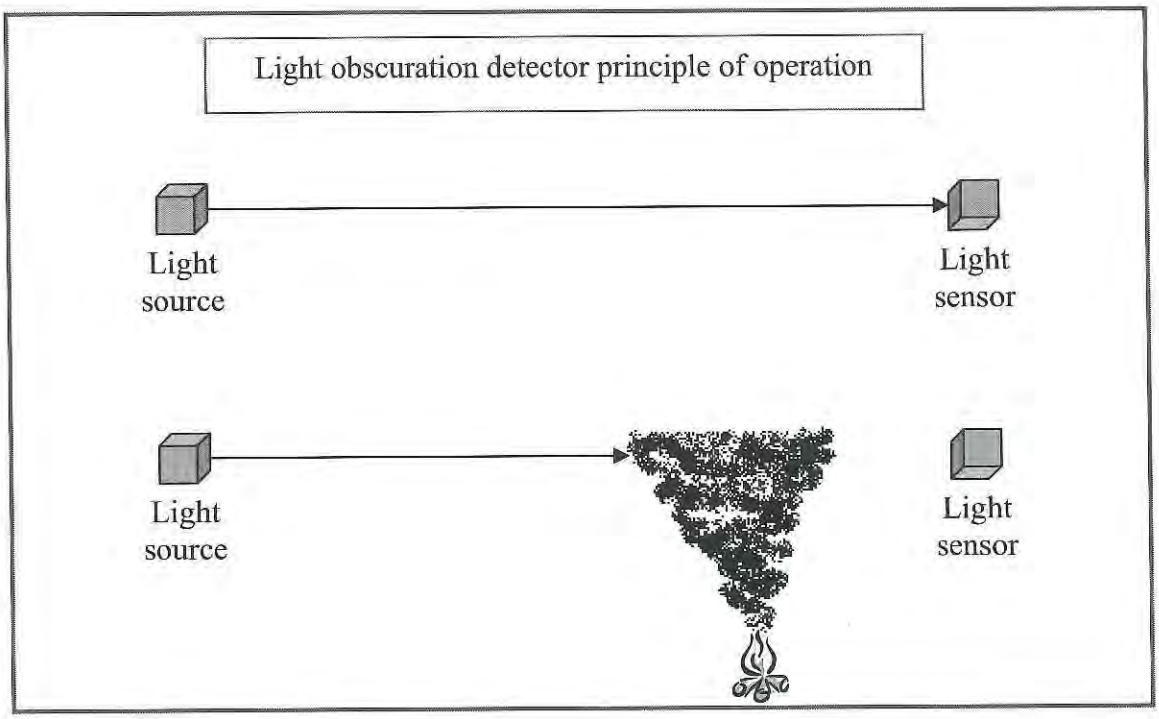
Light Obscuration Detectors

Light obscuration detection is common with projected beam detectors. Projected beam smoke detectors have light transmitter and sensing element (receiver) as physically separate units. Some units house both the transmitter and receiver together. They use a reflector to return the signal. Light is projected from the transmitter to the receiver, and as long as the receiver can see the transmitter, the receiver is in a non-alarm condition. If the receiver loses sight of the transmitter within a short period of time, it goes into alarm. If it loses the signal from the transmitter over a long period of time (from dust or dirt build up) it causes a trouble signal rather than an alarm. If it suddenly loses the signal (from objects obstructing the path) it also causes a trouble.

Projected Beam Smoke Detectors

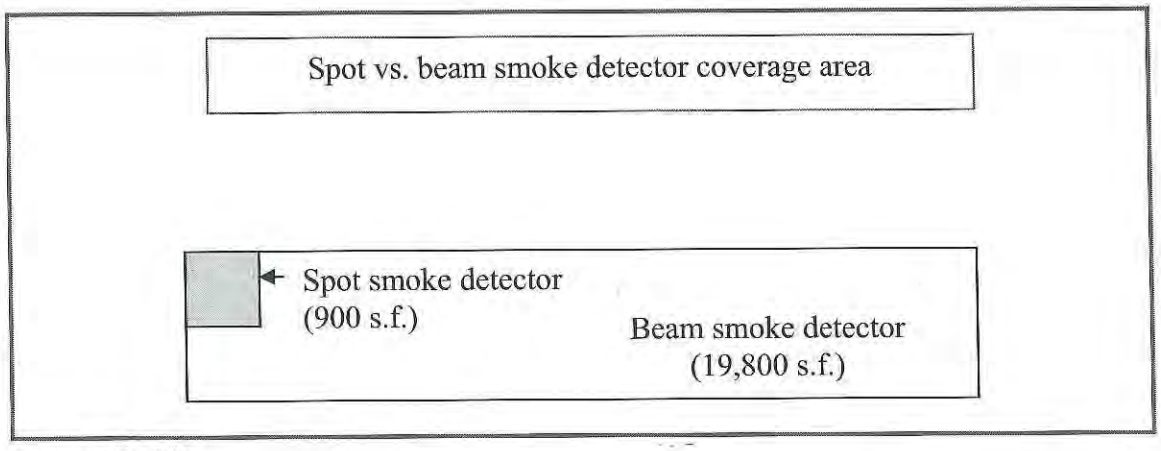
Photo courtesy System Sensor, p5.22

Photo courtesy System Sensor, p5.23



Diagram, NTC, d5.16

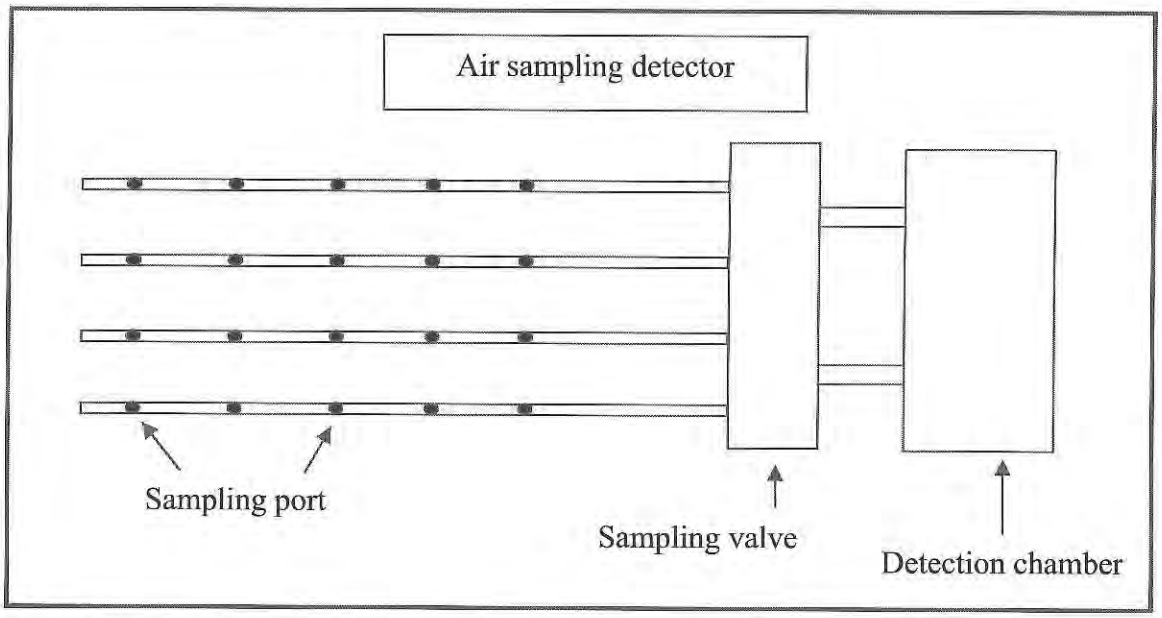
Projected beam detectors are commonly used to cover large open spaces, such as auditoriums or gymnasiums. A single detector can be used to protect an area 330 feet long and 60 feet wide. The large coverage area of projected beam smoke detectors allows them to be used in place of multiple spot type smoke detectors. Because of their large coverage area, projected beam detectors can be used to replace spot type smoke detectors. A single spot smoke detector can cover up to 900 square feet, and single beam detector can cover 19,800 square feet. On a smooth, flat ceiling a single beam smoke detector can replace 22 smoke detectors. The equipment and labor savings realized with this type of detector makes it popular for large, open area applications.



Diagram, NTC, 5.17

Air Sampling Smoke Detectors

Air sampling smoke detectors draw air from a protected area using perforated piping. The air is transported to a detection chamber. The means of detecting smoke is most commonly a laser or high intensity strobe. Older air sampling systems, called cloud chamber smoke detectors, used a humidification process. Air sampling smoke detectors are very fast acting because they can detect very small amounts of smoke. They can detect smoke minutes or even hours before conventional smoke detectors.



Diagram, NTC, d5.18

Optical Air Sampling Smoke Detectors

Optical air sampling detectors pass air in front of a laser or high intensity strobe, and any smoke particles in the air scatter light into an extremely sensitive receiver. The control unit generates an analog signal of the amount of smoke detected and sends it to the control panel for an alarm/no alarm decision. The detection system, available under the trade names Vesda™ and AnaLASER™, have three advantages. It can protect large areas (up to 20,000 square feet), it can provide very early detection of fire (in the incipient stage), and it can be used in high air flow environments. The disadvantage of this type of system is that it cannot identify the source of the fire.

Cloud Chamber Smoke Detector

Cloud chamber smoke detectors draw air from the protected area. Piping extending into the protected area draws air into the system via mechanical valves and switches. The system may have up to 4 detection zones, with up to 10 sampling heads per zone. Each zone is sampled once per second for 15 seconds, allowing four zones to be sampled each minute. Air drawn into the system is sent to a humidifier. Once in the humidifier, the air is brought to 100% humidity. The air is then passed to an expansion chamber where the pressure is reduced, causing water droplets to attach to the particles. A light beam projected through the cloud measures the concentration droplets formed. If sufficient levels are present indicating smoke, the system initiates an alarm signal.

Duct Smoke Detectors

The primary purpose of duct smoke detectors is to prevent the spread of smoke via the HVAC system. The detector is designed to detect fire within the HVAC system, or to detect smoke drawn in by the systems from rooms connected to it. It is not designed to be a replacement for primary fire detection in the building.

Duct Detector With Sampling Tube

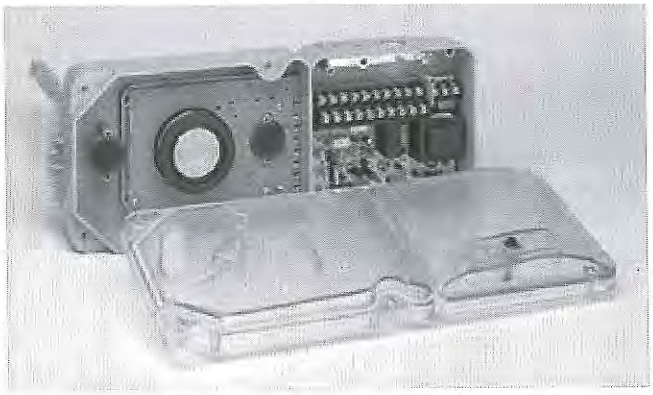


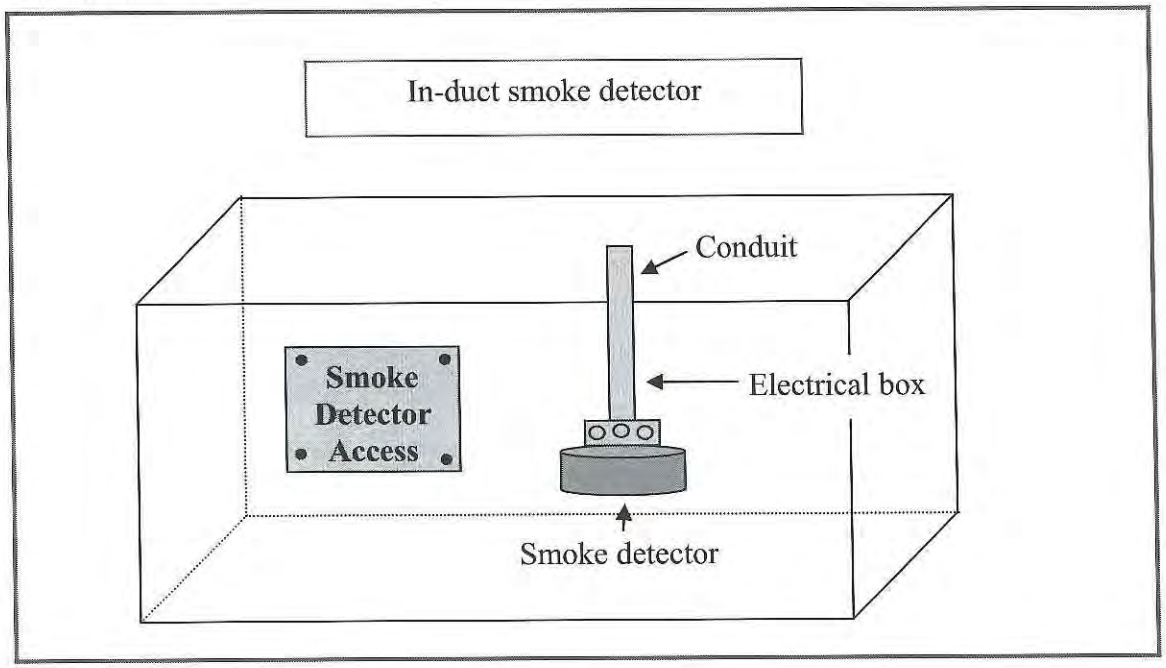
Photo courtesy System Sensor, p5.24

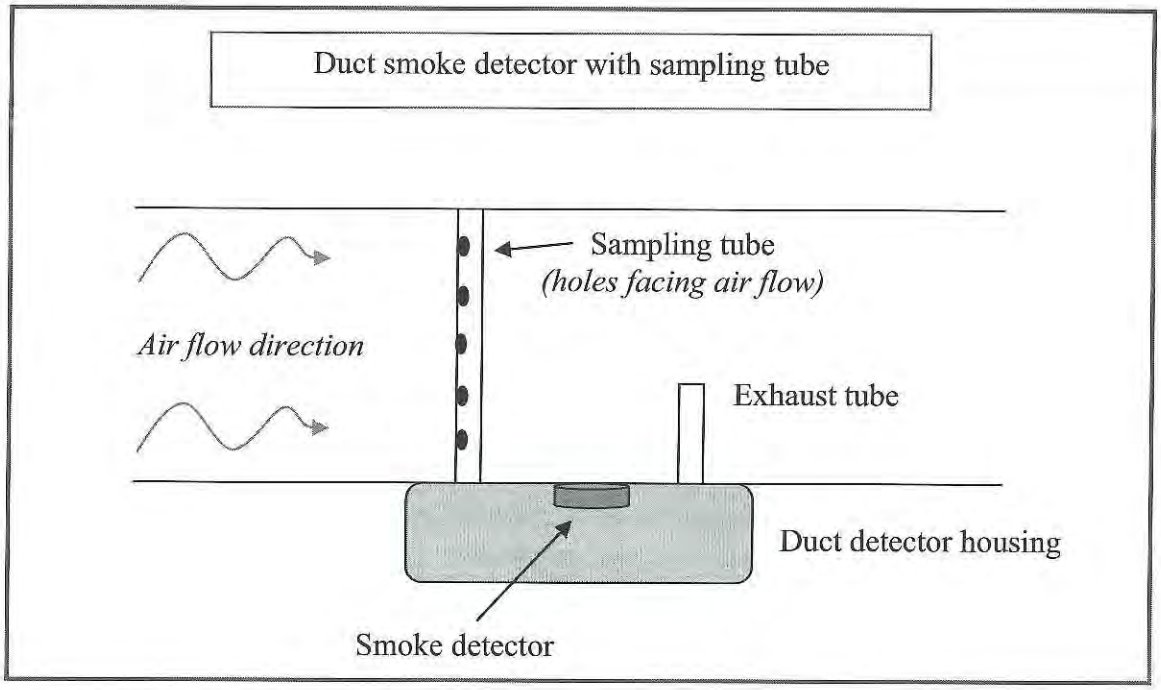
In Duct Smoke Detector

Photo courtesy System Sensor p5.25

Duct detectors can be mounted in the duct, but are typically mounted outside the duct with sampling tubes penetrating the duct. Detectors mounted in the duct must be rated to handle the air velocity in the duct. The detectors in either application must be listed for use as duct smoke detectors. They must sample air passing the sensor or the sampling tube at a high volume and be able to detect smoke in it.

Diagram, NTC, d5.19





Diagram, NTC, d5.20

Gas Detectors

Gas detectors detect toxic gases resulting from combustion (like carbon monoxide) and flammable gases capable of combustion (like propane and butane). This type of detector is designed to detect the presence of gases before they reach fatal or explosive levels. Depending on the application, gas detectors may sound a local alarm, activate a general alarm, shutdown the gas source, or turn on ventilation equipment.

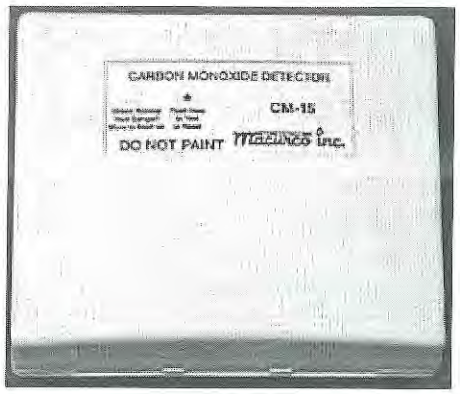


Photo courtesy Macurco, p5.26

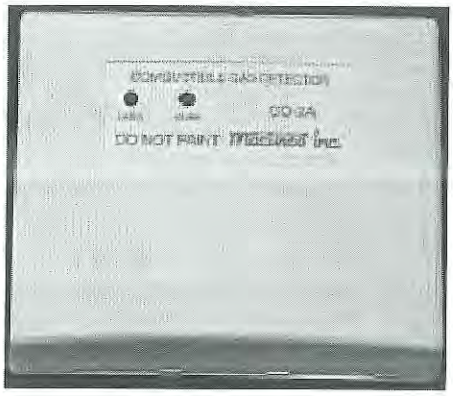
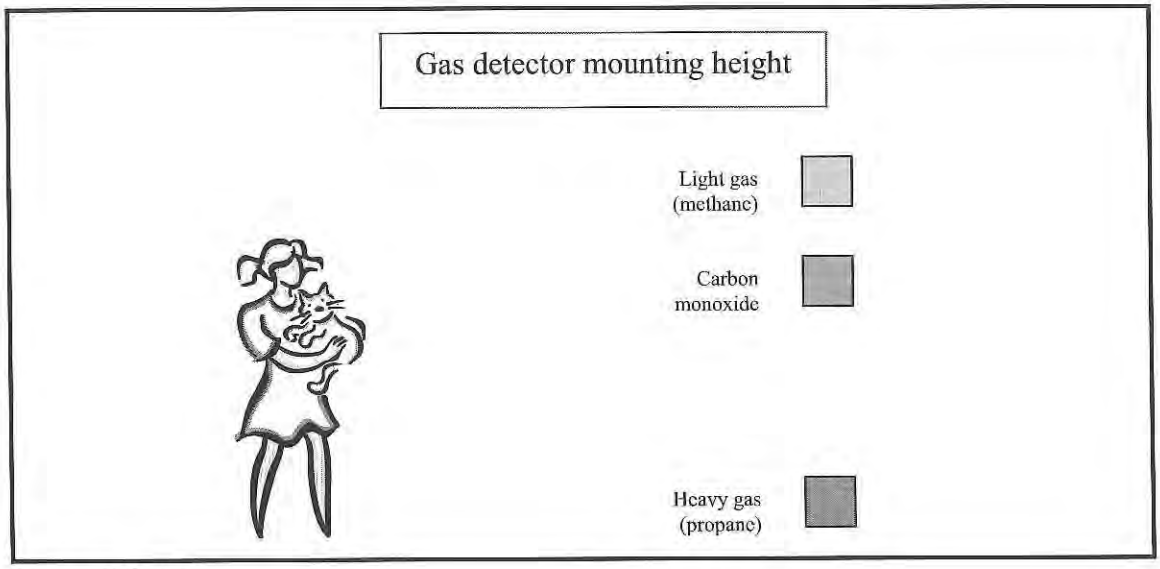


Photo courtesy Macurco, p5.27

Carbon monoxide (CO) is a colorless, odorless, and tasteless gas that can be fatal with extended exposure. CO depletes the amount of oxygen in the air, and when inhaled, it binds to blood cells and prevents them from carrying oxygen throughout the body. CO detectors are becoming very popular in residential applications, and are even being required by some local codes. Fireplaces, wood stoves, gas heating appliances, and

automobiles can produce carbon monoxide. CO detectors are typically wall mounted at 5 feet above the floor.

Cooking and heating gases (methane, propane, etc) present an explosion concern if they reach sufficient levels. Combustible gas detectors are designed to detect these gases in concentrations well below their lower explosive limits. The mounting height of the detector depends on the type of gas being detected. Lighter than air gases (such as methane) require the detector to be mounted close to the ceiling. Heavier than air gases (such as propane) require the detector to be mounted close to the floor.



Diagram, NTC, d5.21

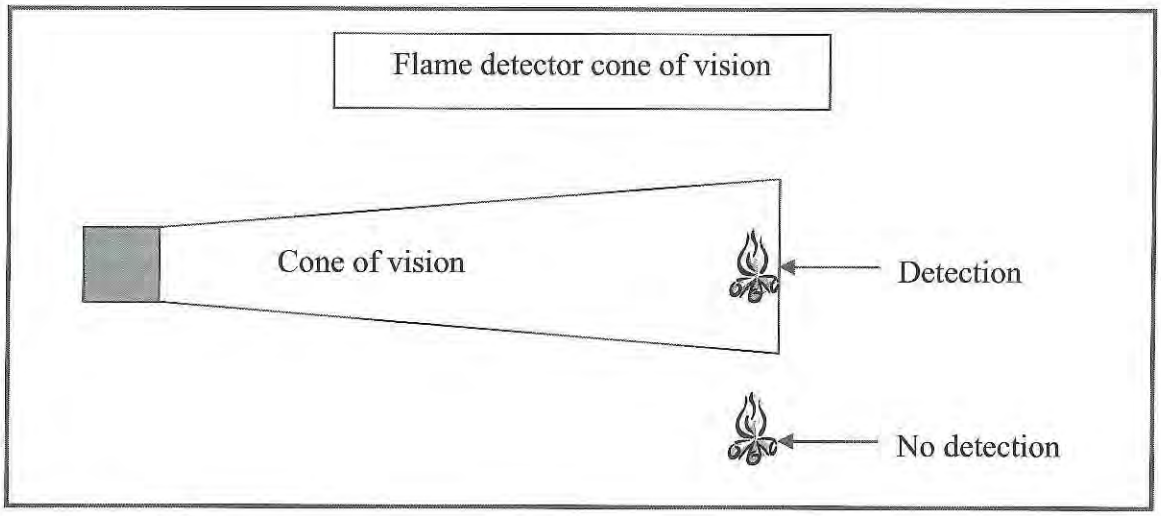
Gas Sensing Fire Detectors

Gas sensing fire detectors are designed to detect products of combustion that are normally present in high levels. The detectors are typically designed to detect gases from specific materials. Various detection elements are available, ranging from semiconductors or catalytic elements, to nondispersive infrared absorption or electrochemical cells. Detectors using semiconductors respond to electrical changes in the semiconductor in the presence of specific gases. Catalytic detectors accelerate oxidation of combustible gases, then, sense the resulting temperature rise.

Flame Detectors

Flame detectors respond to visible or invisible light produced by a fire. Flame detectors are extremely sensitive (they can see glowing embers) and have a fast response time. Due to their high sensitivity and rapid response they are typically used in hazardous areas like fuel areas, hyperbaric chambers, and any other areas a small flame or ember can quickly result in an explosion or rapid fire. Flame detectors are available in infrared (IR), ultraviolet (UV), and combination IR/UV. The actual detector type used depends upon the environment and the type of flame or ember to be detected.

Flame detectors have a "cone of vision," or viewing angle, similar to the human eye. IR flame detectors can detect reflected infrared energy. The best detection still occurs when the detector has a direct, centered view of the flame. The detector is less sensitive to flame which is off of the center axis of the detector.



Diagram, NTC, d5.22

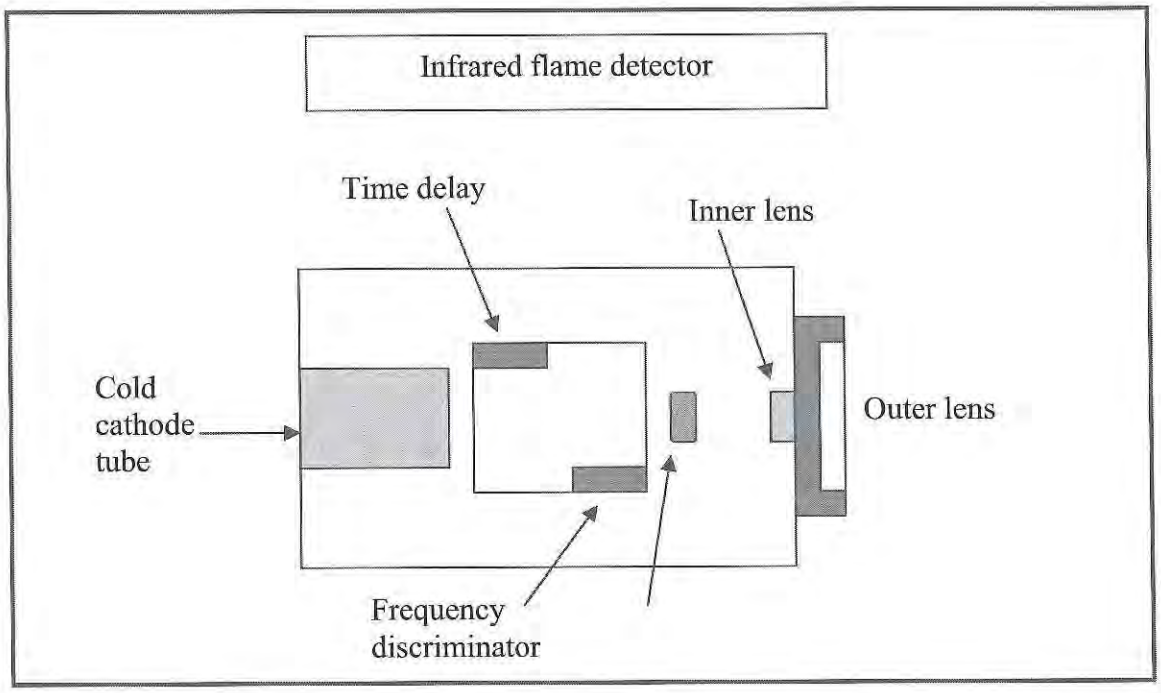
IR Flame Detector

IR flame detectors use a photovoltaic or photoresistive cell which is sensitive to IR (infrared) energy. The sensor responds to infrared energy in specific wavelengths (typically 2.5 – 2.8 and 4.2 – 4.5 micrometer range), and is protected by filters that screen out other IR energy wavelengths. The detector responds to the total infrared component of a flame alone, or to the flame energy and the flame flicker in the 5 - 30 Hz range. The flicker requirement helps minimize false alarms when viewing a surface that is normally hot but does not have a flame.

Photo courtesy Detronics, p5.28

IR flame detectors respond best to hydrocarbon fires. Fires from burning metals, ammonia, hydrogen, and sulfur typically do not emit enough energy in the 4.4 micrometer range to be effectively detected by IR flame detectors. Ice and water build up

on the detector window will greatly reduce the sensitivity of the detectors. It is important to keep the window clean and free of such build up.



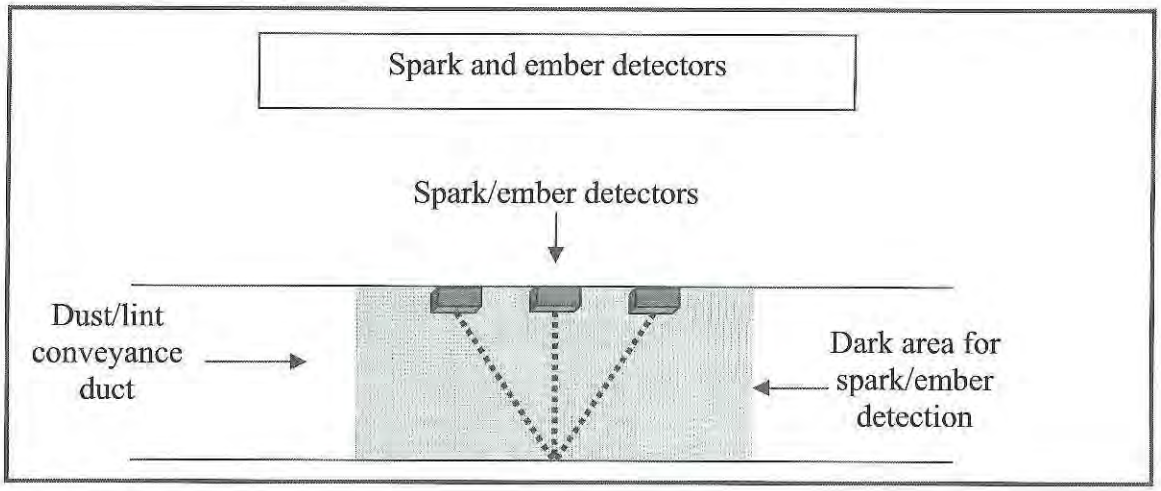
Diagram, NTC, d5.23

IR flame detectors in outdoor applications are subject to interference from sunlight. This interference can be reduced by using filters that block out all infrared energy except emissions in 2.5 to 2.8 and 4.2 to 4.5 micrometer range. Energy in these ranges is typically absorbed by moisture and CO_2 in the atmosphere. Another method used to reduce nuisance alarms from outdoor detectors is the use of two detection circuits that respond to different frequencies. One responds to sunlight (0.6 – 1 micrometer) the other responds to flame frequencies (2 – 5 micrometer). If the first detector is activated, it shunts the second. Flame flicker circuitry also makes a detector more immune to false alarms from sunlight. Flame flicker circuitry watches for the alternating signal of a flickering flame. However, this alternating signal can be produced by reflected sunlight on water.

Flame detectors can have fixed or scanning detection. Fixed units "see" in a conical pattern ranging from 15° to 170°. Scanning units use a mirror that rotates above the sensor to detect in a 360° pattern around the unit. If it senses a flame, the mirror stops to verify the signal before producing an alarm.

Spark and Ember Detectors

Spark and ember detectors respond to passing sparks or embers. These detectors are often used in textile mills and other applications where fine dust and lint are produced and carried away by duct or conveyor systems. A section of the duct or conveyor usually must pass through a dark area where the detector is located (darkness makes detection easier). The detectors must be positioned so that all points within a cross section of the duct or chute are in the view of at least one detector. This type of detector typically controls a water spray that extinguishes the ember before it can develop into a flame.



Diagram, NTC, p5.24

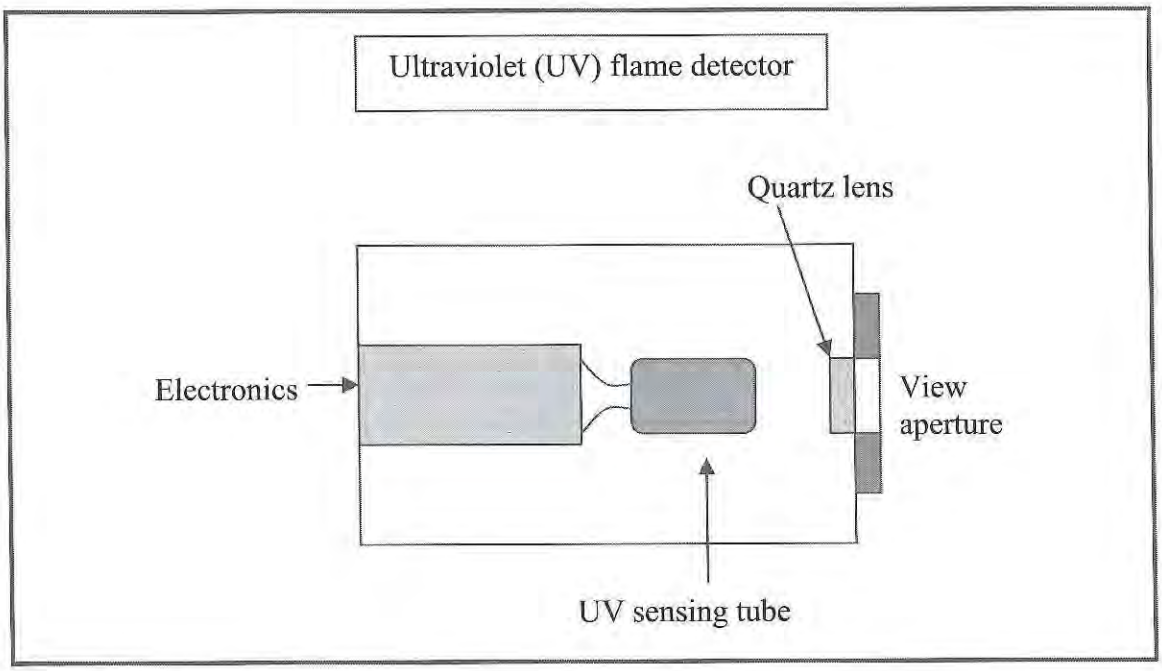
UV Flame Detectors

UV (ultraviolet) flame detectors use a solid-state sensor (such as silicone carbide or aluminum nitride) or a gas-filled tube as a sensing element. UV (ultraviolet) flame detectors detect energy in the 0.17 to 0.30 micrometer range, making them basically immune to sunlight and artificial light problems. The sun puts out radiation in this band, but it is absorbed by the Earth's atmosphere, making the detectors "solar blind" and generally suitable for outdoor applications.

Photo courtesy Detronics, p5.29

UV detectors respond well to most fires, including hydrocarbons, metals, sulfur, hydrogen, hydrazine, and ammonia. They are prone to false alarms from arc welding, electrical arcs, lightning, X-rays, and radioactive materials. UV-absorbing gases will reduce the sensitivity of the detector, and the presence of oil mist in the air or oil film on the viewing window has the same effect.

The viewing window itself must be quartz, since ordinary glass will not pass UV. Detectors are often unintentionally disabled by replacing a broken quartz window with a glass one. The units typically have a viewing angle of 90° - 180°.



Diagram, NTC, d5.25

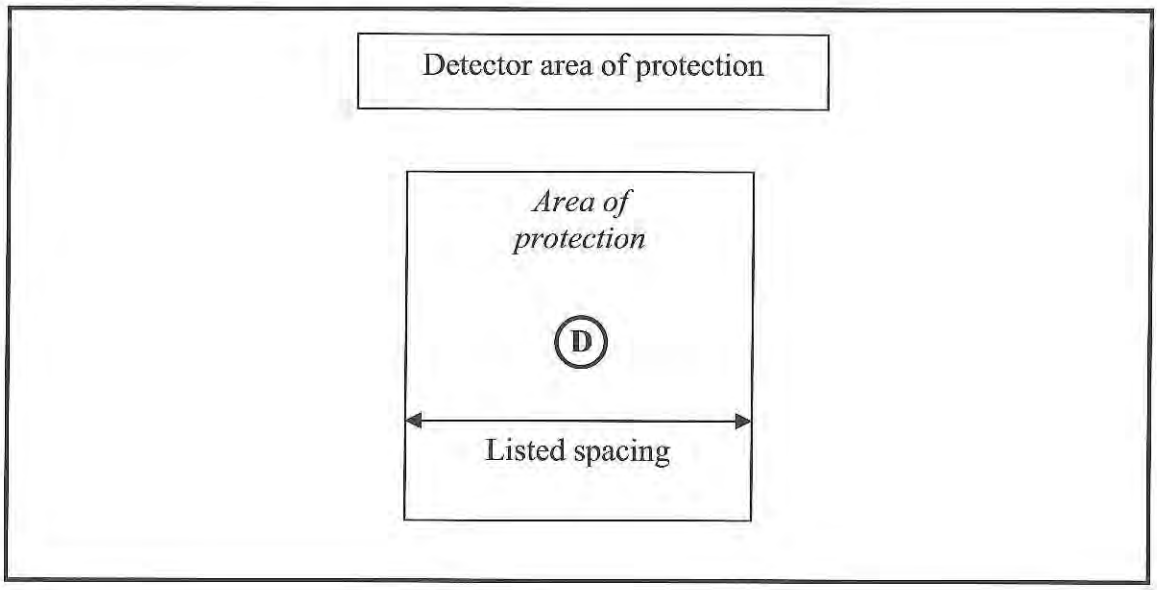
Combination IR/UV Detectors

Combination IR/UV detectors pair two sensing technologies together in a single unit. The sensors process their signals independently, but additional circuitry is used to compare the signals and only produces an alarm when both sensing technologies detect a fire. The unit is typically more stable than single technology units, but it is also subject to the limitations of both sensor technologies.

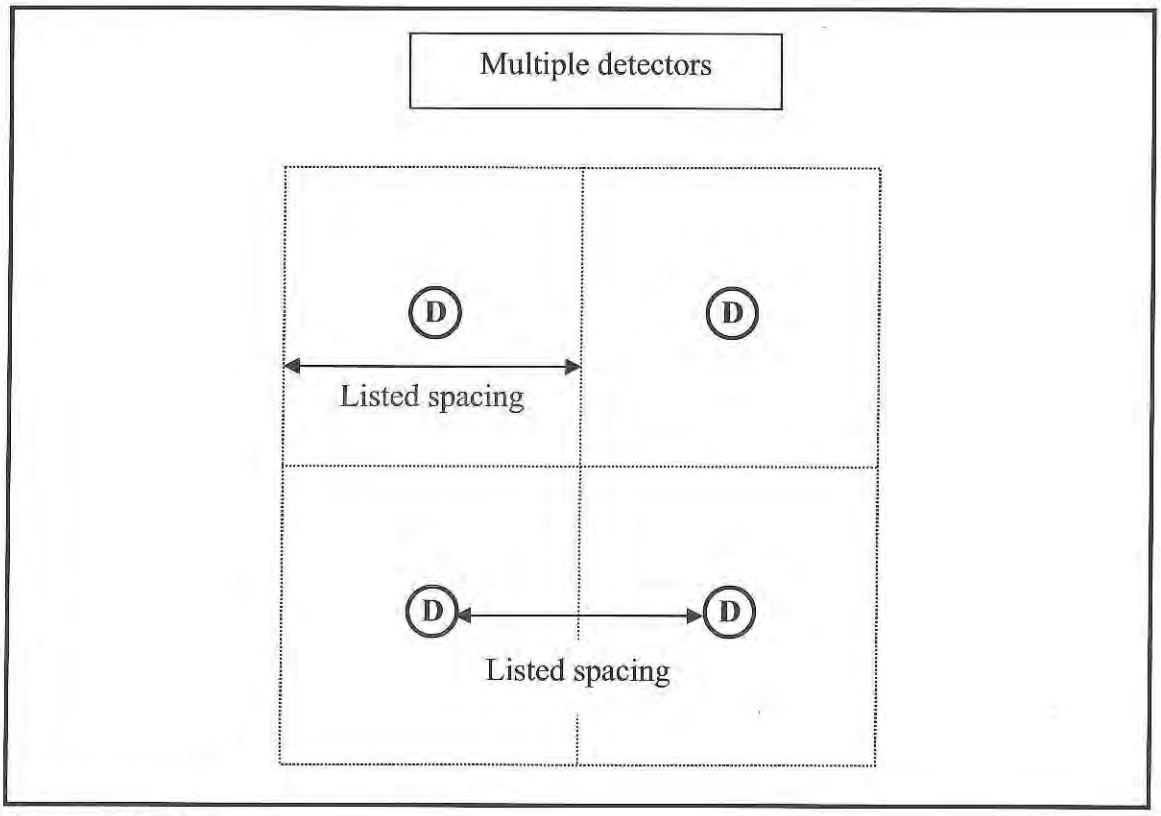
Detector Spacing

Heat detectors have a listed spacing (maximum distance between detectors), as determined by a listing agency. Smoke detectors do not have a listed spacing, but are allowed to be spaced 30 feet apart by NFPA 72®. The spacing is determined by testing the device and making sure it meets a minimum set of standards. Spot type heat detectors are typically listed for 50 foot spacing (this can vary depending upon the

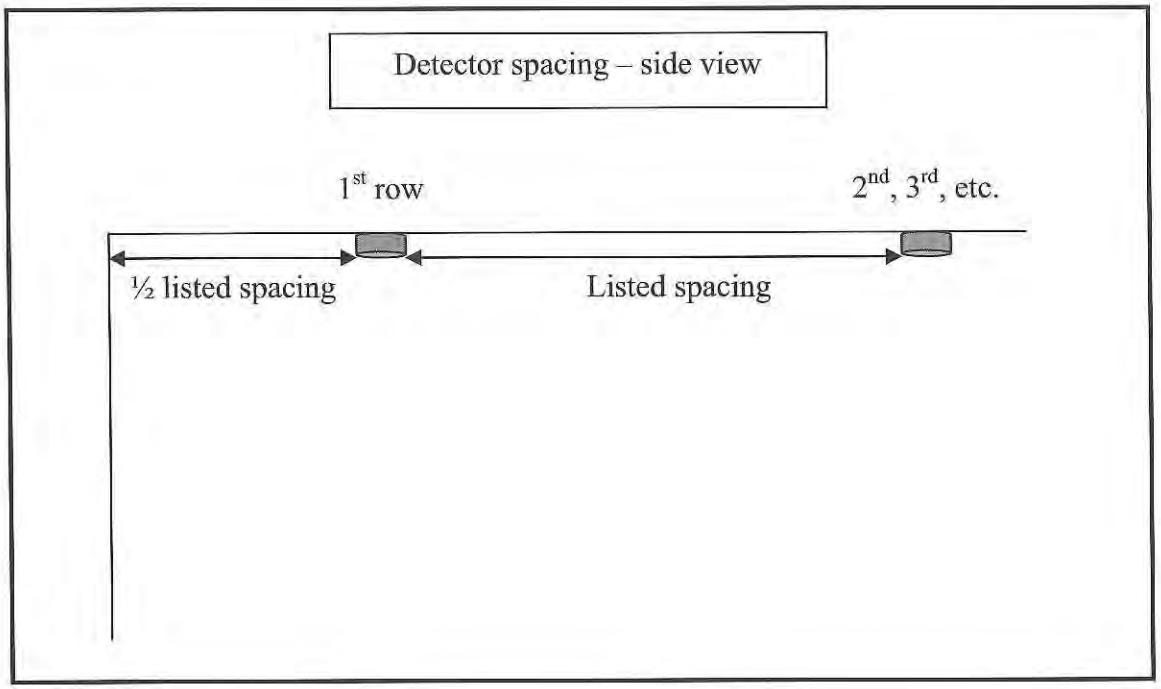
detection technology used). The listed spacing represents the maximum distance between detectors. The first detectors are spaced ½ the listed spacing from wall.



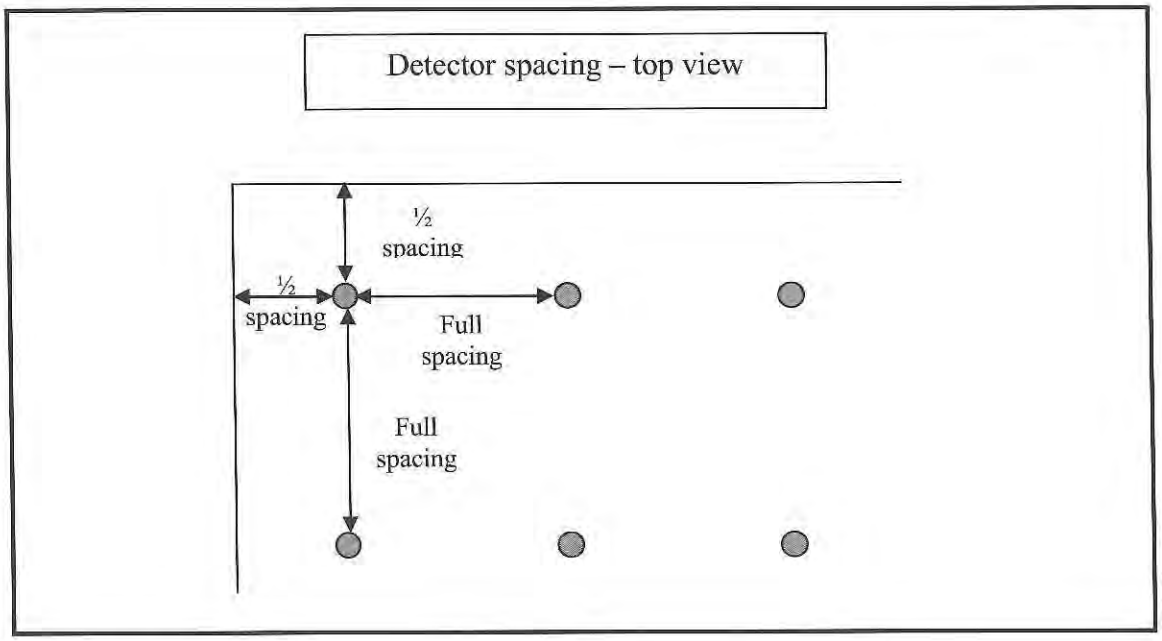
Diagram, NTC, d5.26



Diagram, NTC, d5.27



Diagram, NTC, d5.28

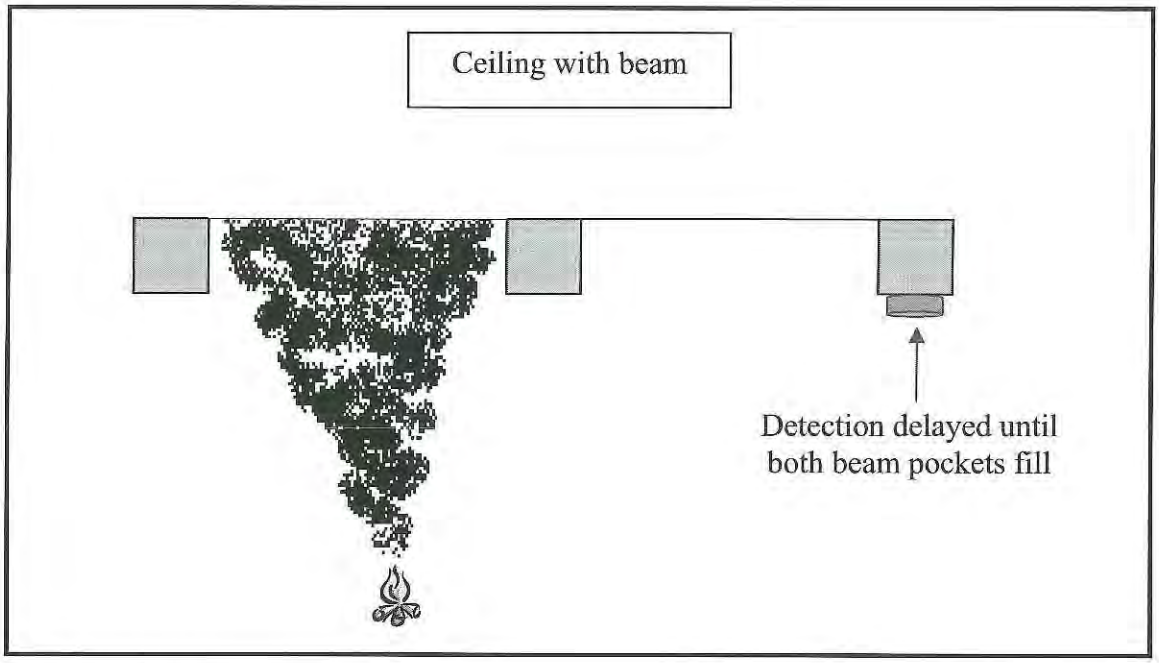


Diagram, NTC, d5.29

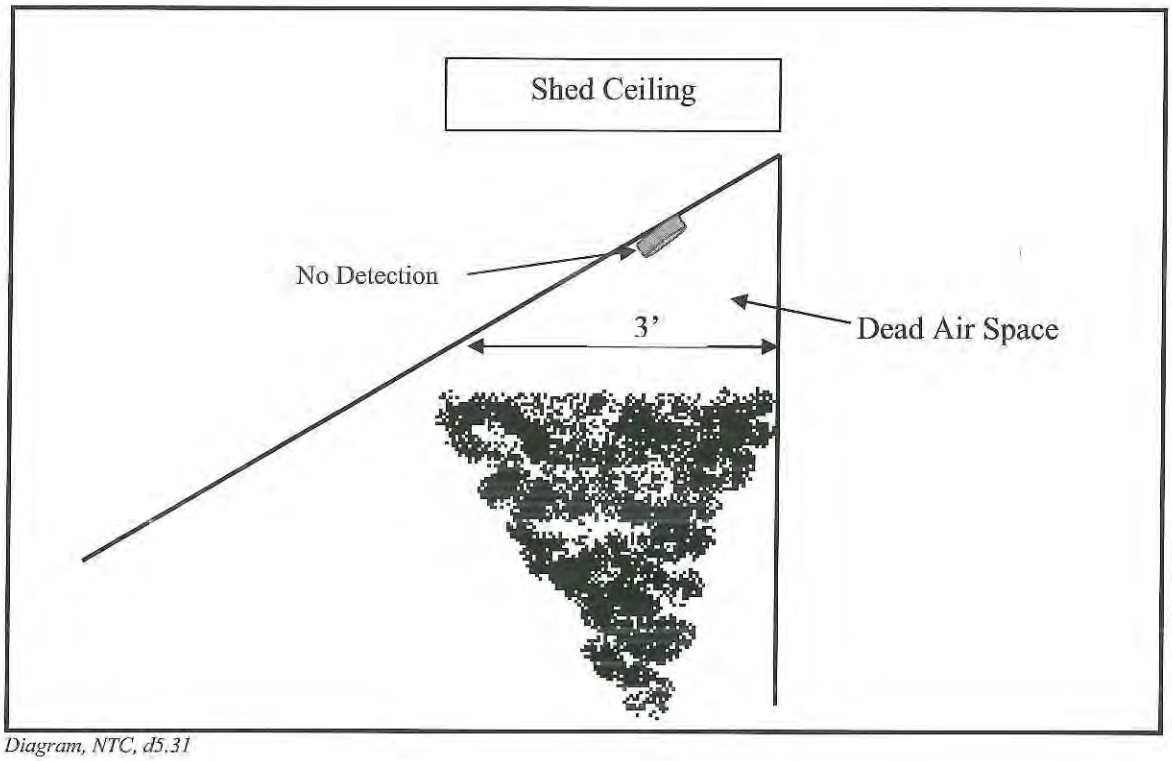
Irregular Ceilings Affect Detection

Ceiling features such has beams, joists, sheds, and peaks can affect the speed at which a fire can be detected. Pockets between beams and joists can collect smoke and heated air and delay its movement to a detector. Sheds and peaks can have dead air space near the peak which will prevent proper detection if a detector is located there. Testing agencies

have thoroughly tested detector operation in all of these scenarios and determined how they affect detector spacing requirements



Diagram, NTC, d5.30



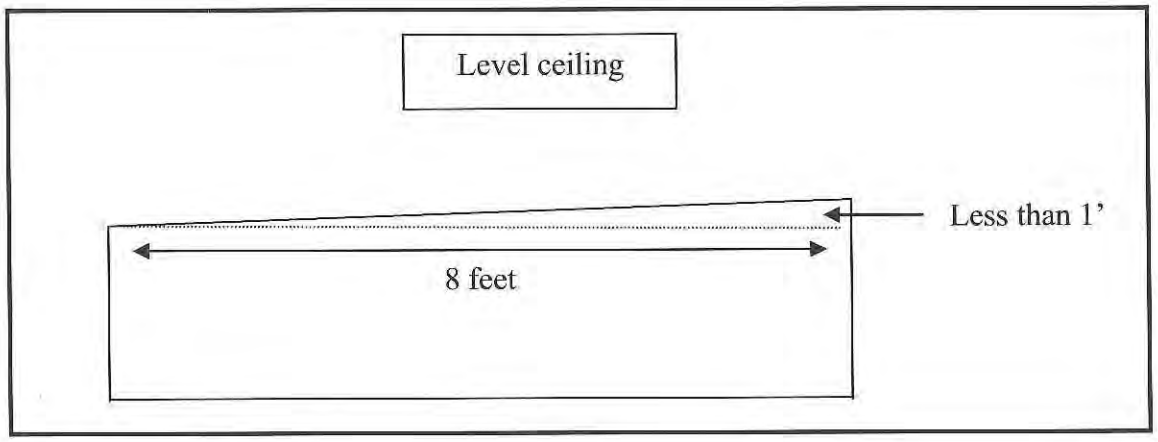
Diagram, NTC, d5.31

Ceiling Affect On Detector Spacing

NFPA 72® gives spacing guidelines for automatic detectors based on specific ceiling attribubes. Ceiling height, shape, and construction can affect the spacing and location of heat and smoke detectors. To understand how ceiling features affect detector spacing, you must first understand the NFPA 72® definition of these ceiling attributes:

Level Ceiling

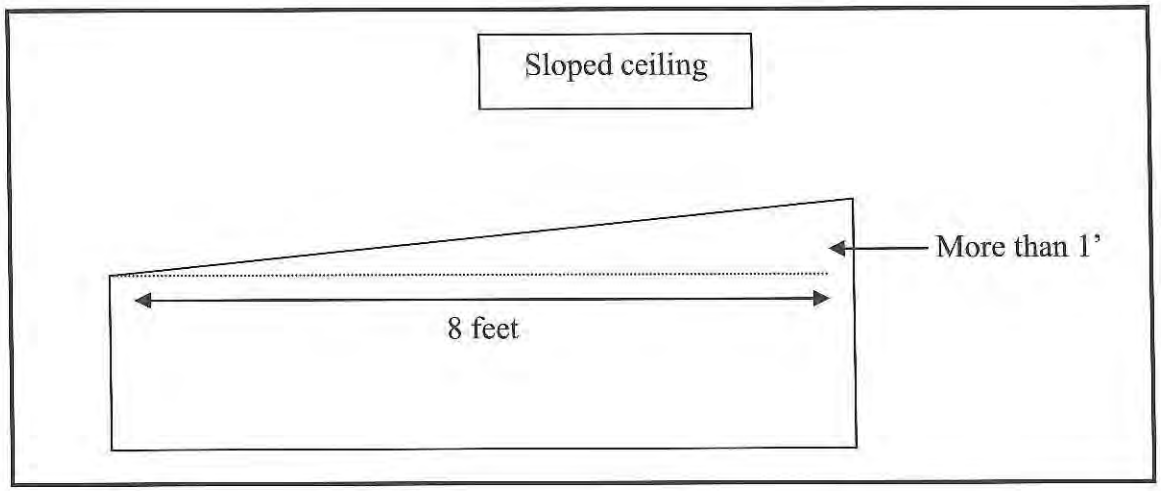
A ceiling with a slope of *less than* or equal to 1 foot rise or fall in every 8 feet of distance.



Diagram, NTC, d5.32

Sloped Ceiling

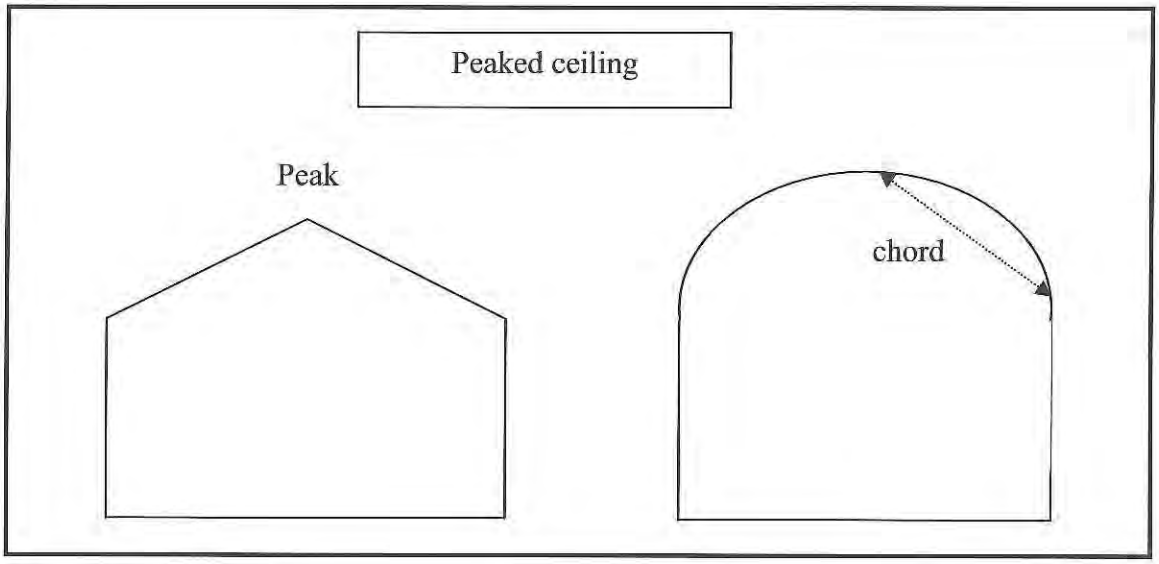
A ceiling with a slope of *more than* 1 foot rise or fall in every 8 feet of distance.



Diagram, NTC, d5.33

Peaked Ceiling

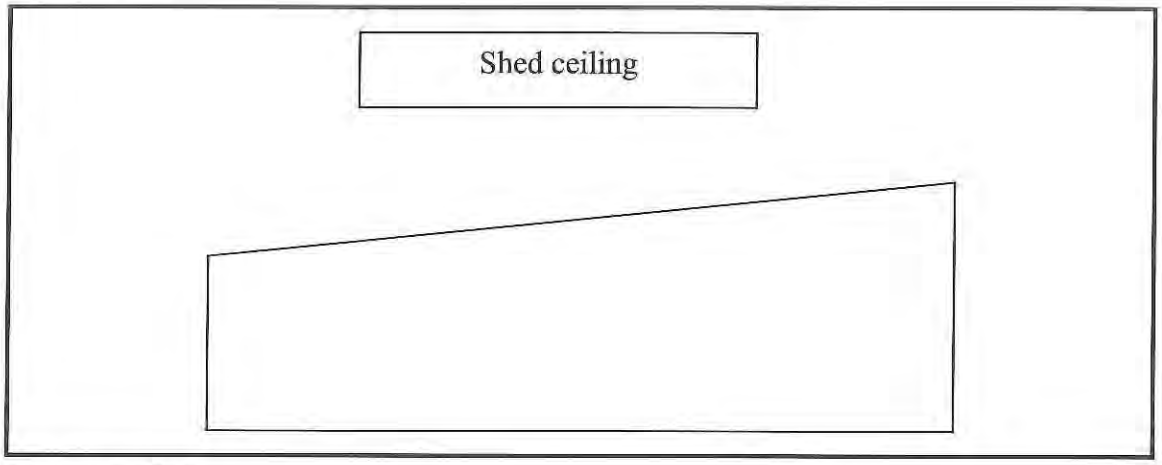
A ceiling with slopes in more than one direction from the highest point is a peaked ceiling. Curved or dome ceilings are considered peaked, with the slope figured as a chord from the highest to lowest point.



Diagram, NTC, d5.34

Shed Ceiling

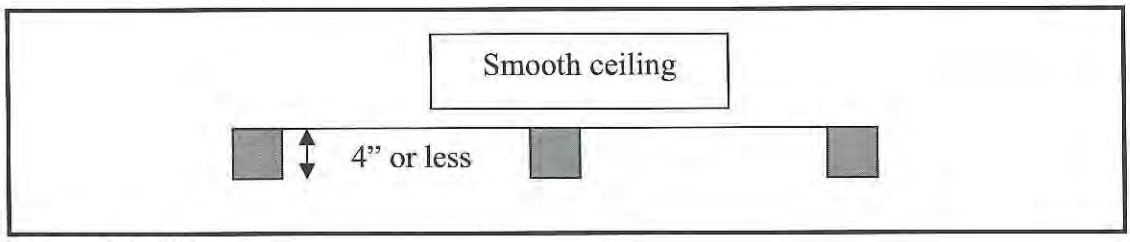
A shed ceiling slopes in only one direction. A shed ceiling has a high side, a peak, and a low side.



Diagram, NTC, d5.35

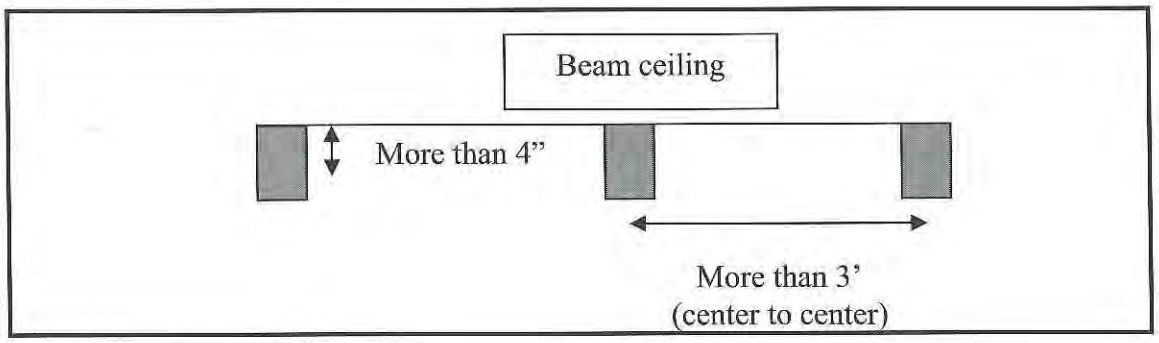
Detector spacing is also affected by the shape of the ceiling surface. NFPA 72® provides a definition for several different ceiling surfaces:

Smooth Ceiling
A ceiling without any solid projections down from the surface more than 4 inches high.



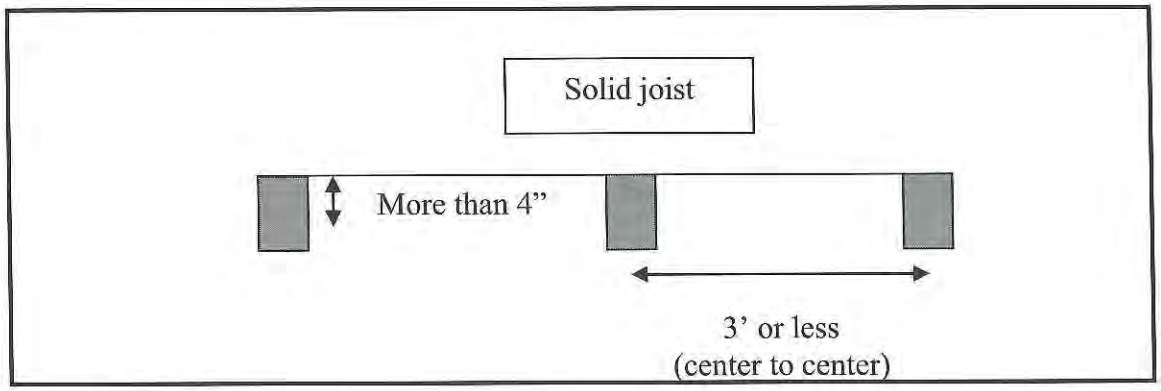
Diagram, NTC, d5.36

Beam
Beam ceilings have solid projections down from the surface more than 4 inches *and* more than 3 feet apart center to center.



Diagram, NTC, d5.37

Solid Joist
Solid joist ceilings have solid projections down from the surface more than 4 inches *and* 3 feet or less apart center to center.

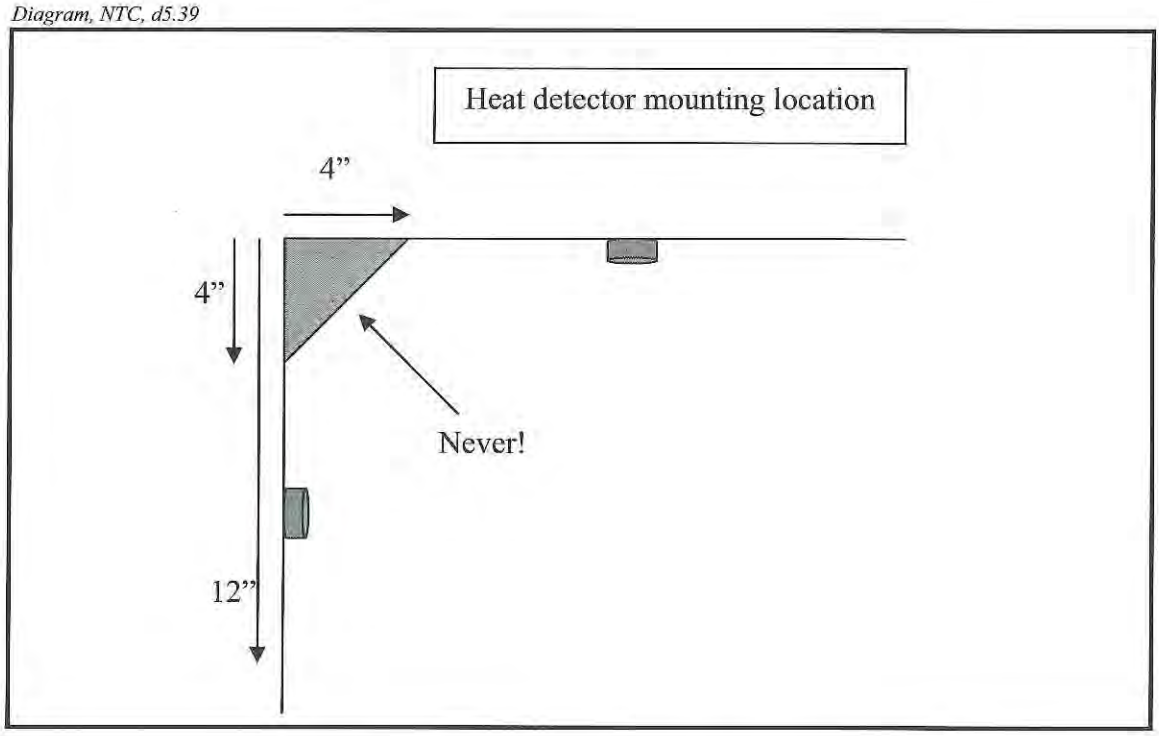


Diagram, NTC, d5.38

Spot Type Heat Detector Mounting & Spacing

Spot type heat detectors can be ceiling or wall mounted (although ceiling mounting is considerably more popular). If they are wall mounted, they must be mounted more than 4" down from the ceiling and some part of the detector must be within 12" of the ceiling. If they are ceiling mounted, they can be no closer than 4 inches to the wall. These provisions keep the detector out of the dead air space where the ceiling meets the wall. Testing has shown that heat and smoke takes much longer to penetrate this area, resulting in delayed response by the detector.

Diagram, NTC, d5.39



Heat Detector Spacing

Heat detector listed spacing is based on a smooth, flat ceiling of 10 feet high or less. If the ceiling is greater than 10 feet, or the ceiling is not flat and smooth the spacing is reduced based on the ceiling's attributes. Ceiling height for example can have a major affect on the time it takes for heat to travel from the fire to the detector. Consider a ceiling which is 10 feet high compared to a ceiling which is 30 feet high. It is obvious that heat will take much longer to travel to a detector on a 30 foot high ceiling. Therefore the spacing of detectors on high ceilings must be reduced.

Ceiling Height

Ceiling heights of 10.1 feet to 30 feet require a reduction in heat detector spacing. The spacing is reduced by multiplying the listed spacing by the factor listed in the table below

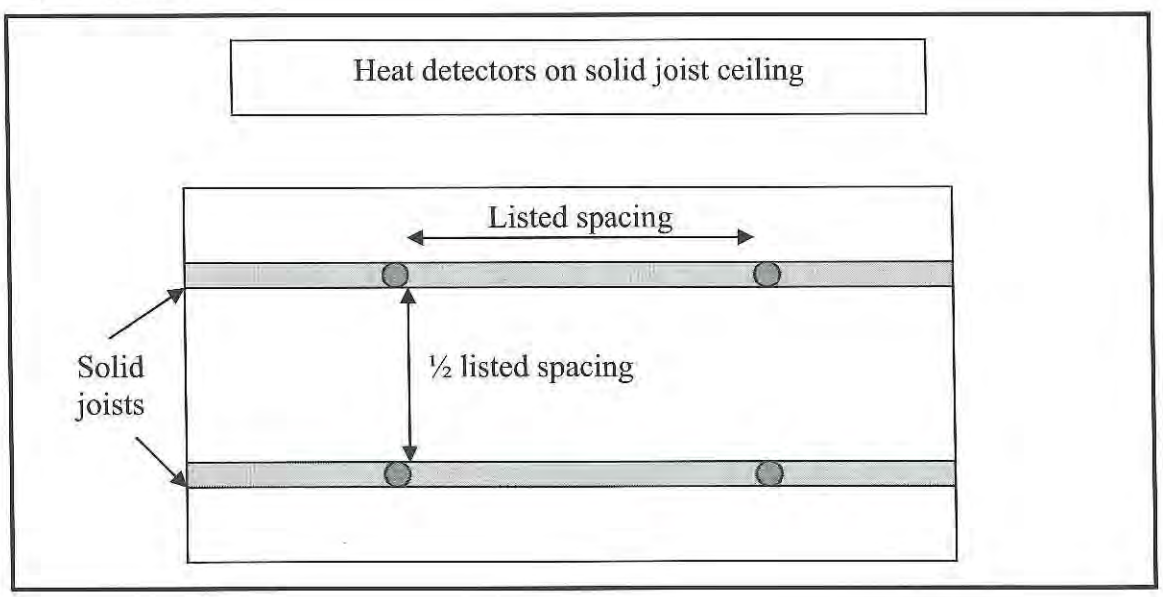
(diagram d5.40). The spacing reduction for ceiling height must be applied prior to any additional reductions based on beams, joists, slopes, or peaks.

Ceiling Height Above		Up to and Including		Multiply Listed Spacing by
Meters (m)	Feet (ft)	Meters (m)	Feet (ft)	
0	0	3.05	10	1.00
3.05	10	3.66	12	0.91
3.66	12	4.27	14	0.84
4.27	14	4.88	16	0.77
4.8	16	5.49	18	0.71
5.49	18	6.10	20	0.64
6.10	20	6.71	22	0.58
6.71	22	7.32	24	0.52
7.32	24	7.93	26	0.46
7.93	26	8.54	28	0.40
8.54	28	9.14	30	0.34

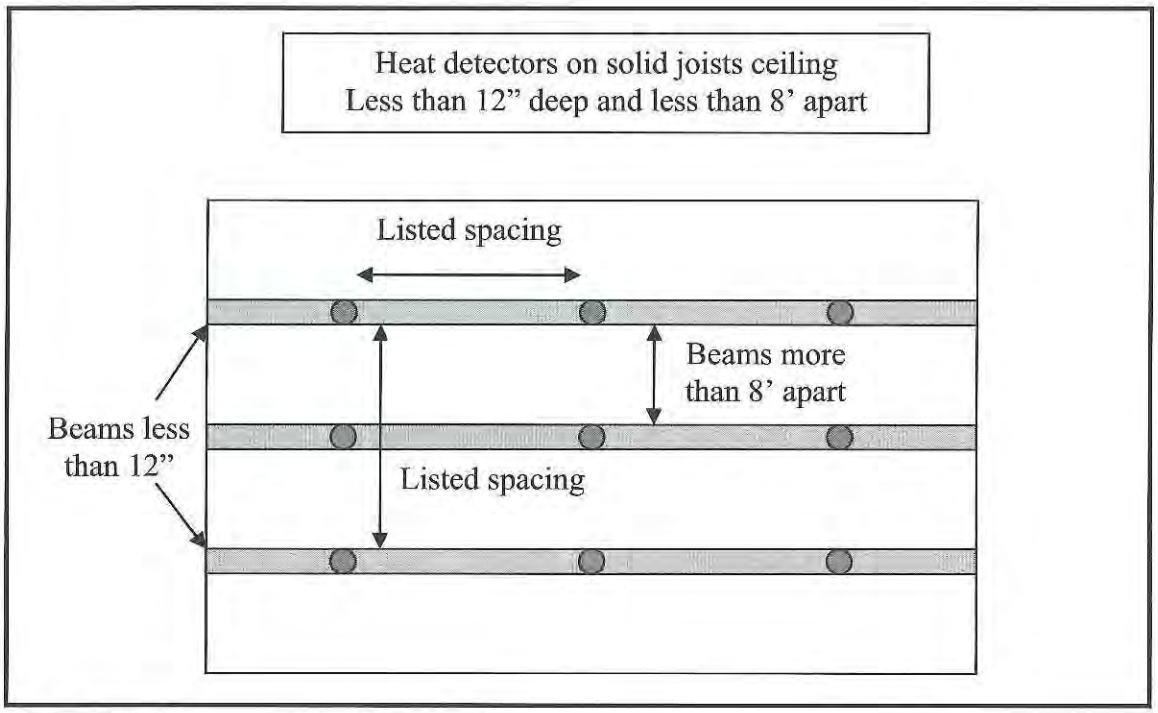
Diagram, NTC, d5.40

A ceiling with solid joist construction requires the heat detector spacing be reduced by ½ measured perpendicular to the joists. The spacing parallel to the joist is not affected.

Diagram, NTC, d5.40

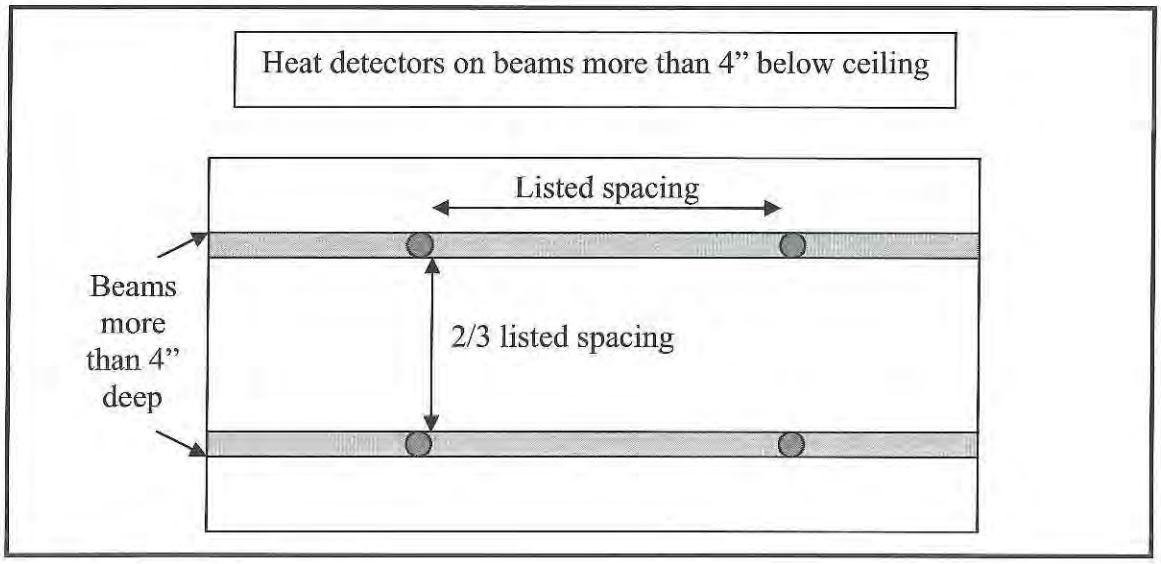


A ceiling with solid joist construction requires the detectors to be mounted to the bottom of the joists. For ceilings with beam construction, where the beams are *less* than 12 inches deep and *less* than 8 feet apart, the detectors must be mounted on the bottom of the beams.



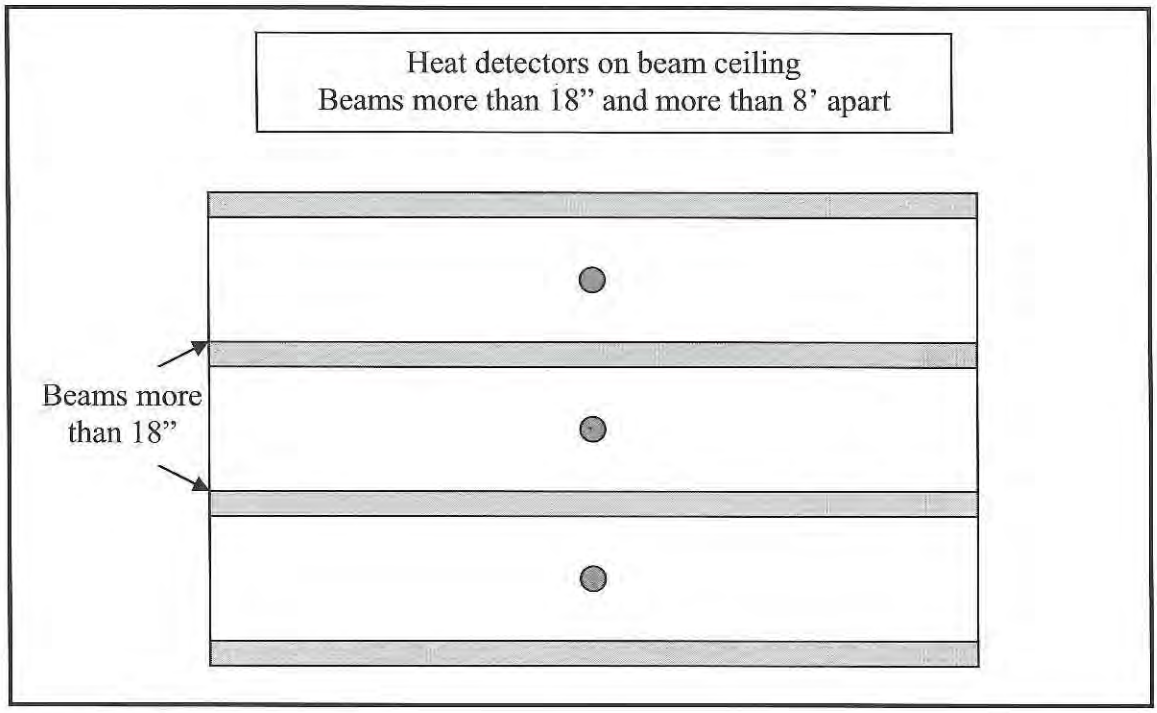
Diagram, NTC, d5.41

Beam construction requires heat detector spacing to be reduced by 2/3 the listed spacing measured perpendicular to the beams.



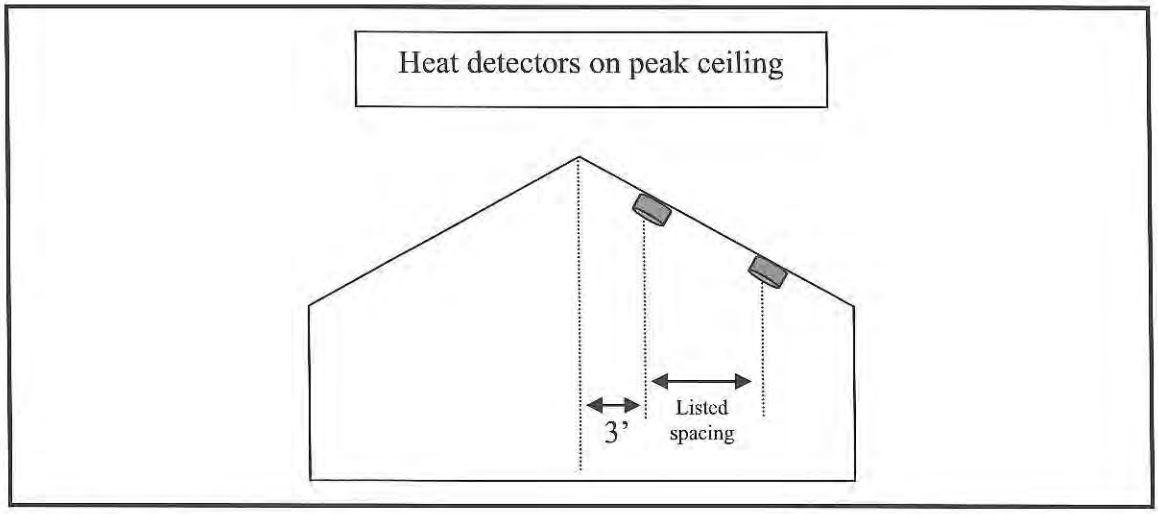
Diagram, NTC, d5.42

Beam construction that extends *more* than 18 inches below the ceiling, and has beams *more* than 8 feet apart requires that each bay formed by the beams be treated as a separate area.



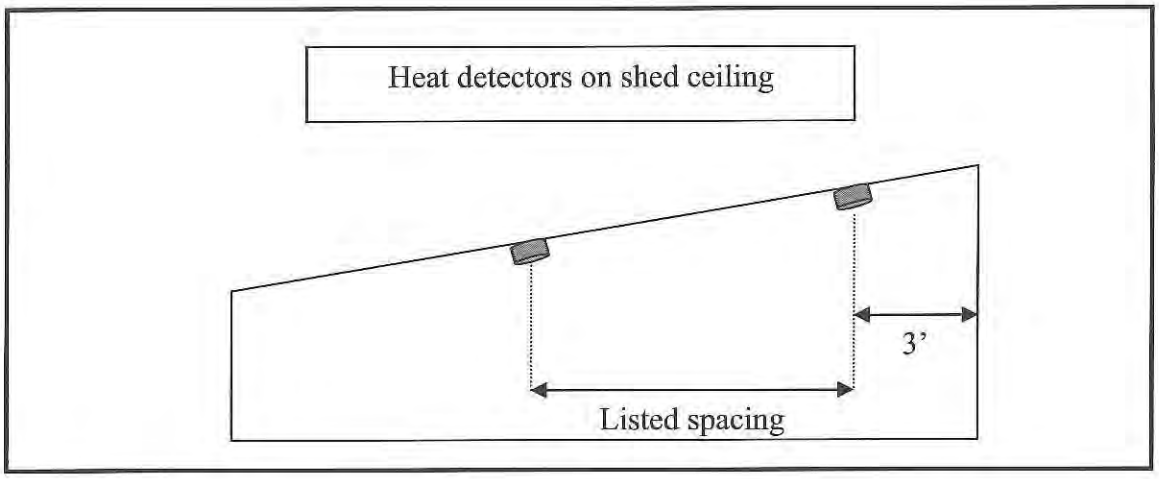
Diagram, NTC, d5.43

Peaked ceilings require a row of detectors be placed within 3 feet of the peak. Additional detectors must be spaced according to the horizontal distance of the ceiling and the ceiling construction.



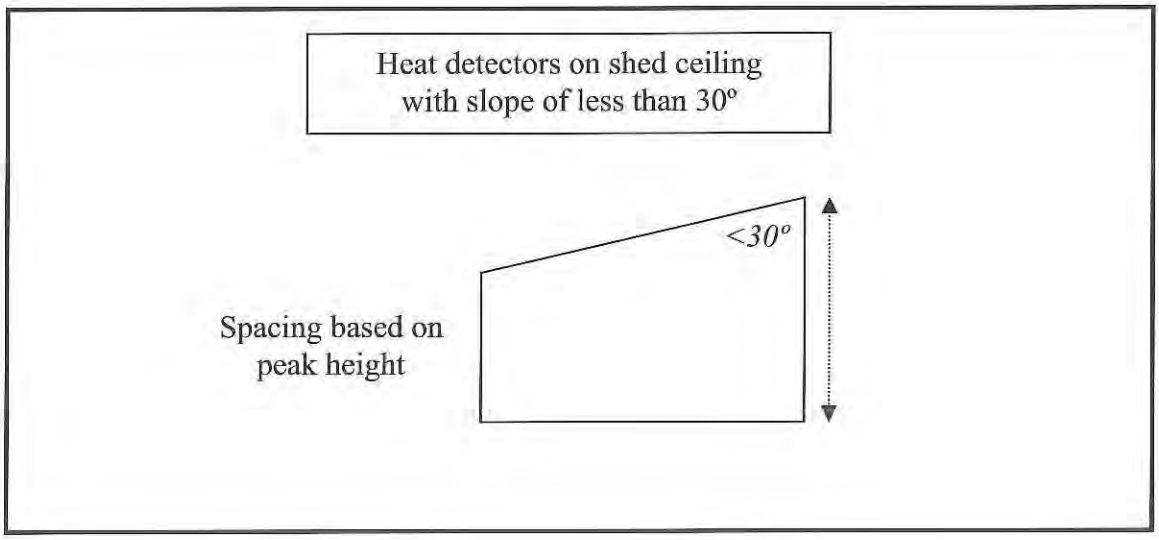
Diagram, NTC, d5.44

Shed ceilings require a row of detectors be placed with 3 feet of the high side. Additional detectors must be spaced according to the horizontal distance of the ceiling and the ceiling construction.

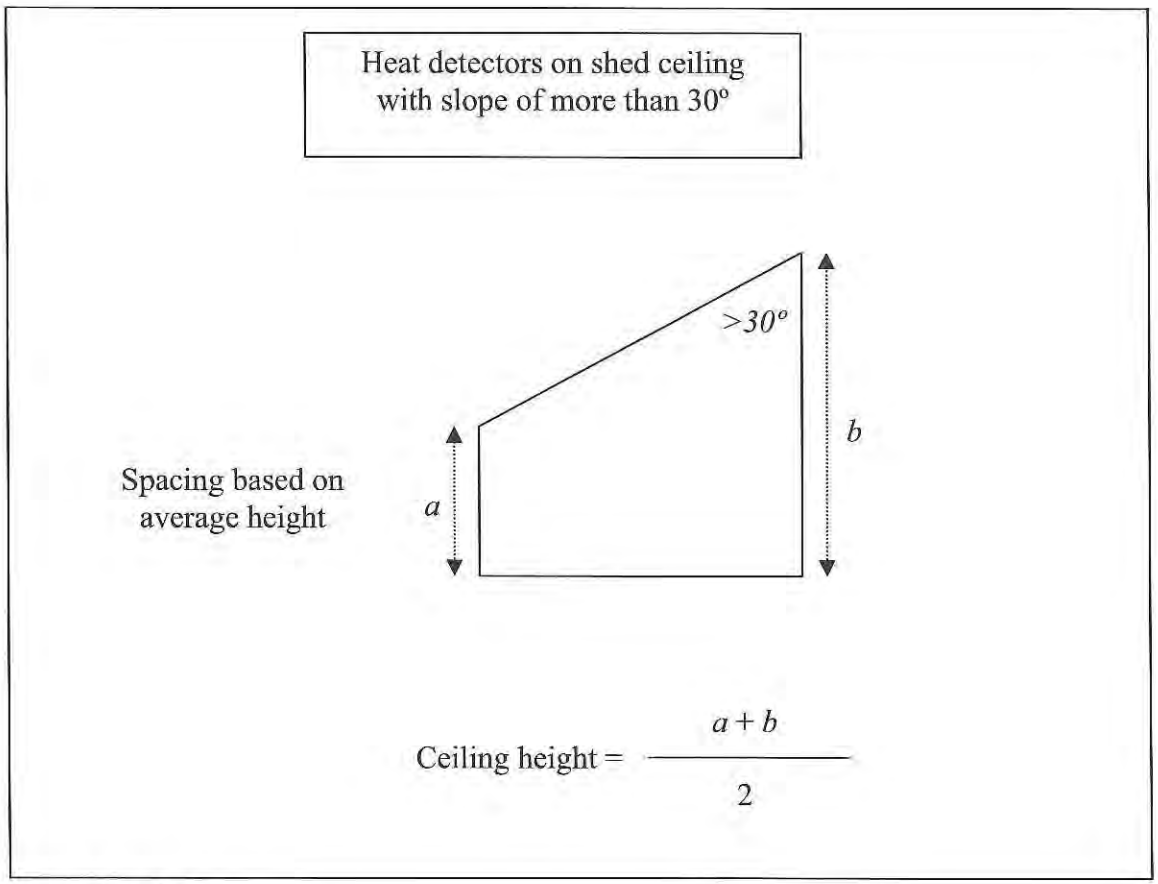


Diagram, NTC, d5.45

Sloped roofs with a slope of *less* than 30°
The detectors must be spaced based on the height at ceiling peak. For roofs with a slope of more than 30°, the detectors must be spaced based on the average roof height. Adding the highest and lowest point and dividing it by 2 determine the average height.



Diagram, NTC, d5.46

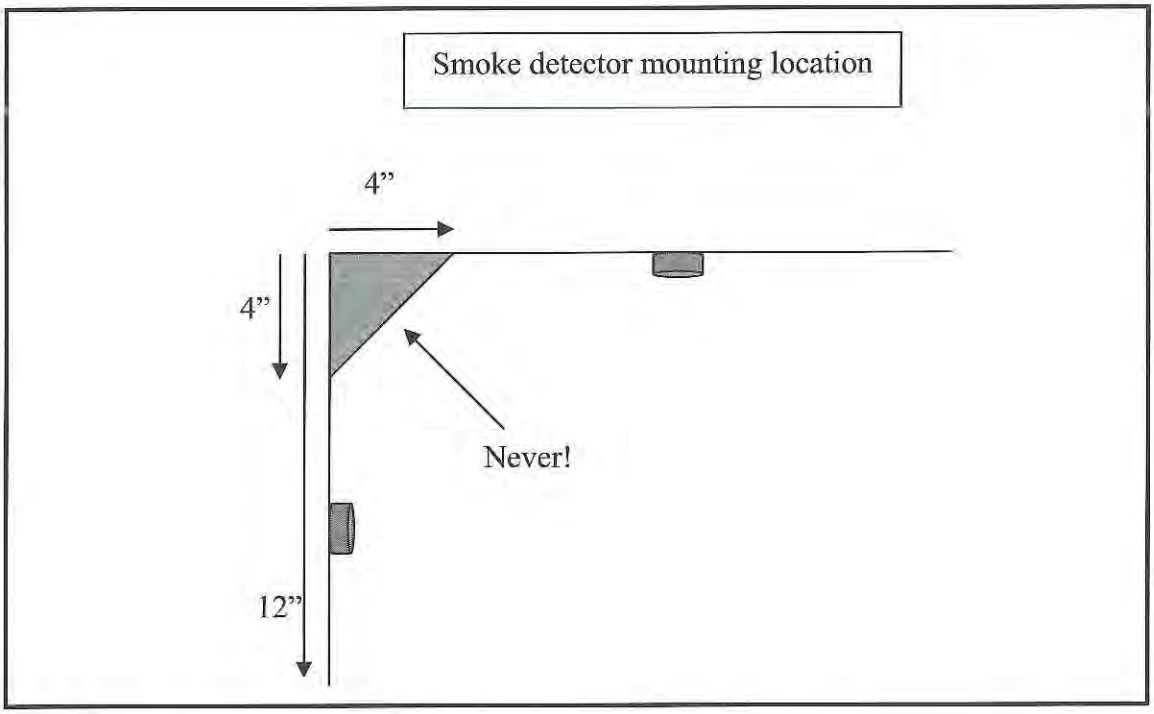


Diagram, NTC, d5.47

Smoke Detector Mounting and Spacing

Smoke detectors are designed to be used in environmentally protected areas. Smoke detectors are not suited to harsh environmental conditions. Unlike heat detectors, smoke detector mounting must take into account environmental factors such as humidity and air velocity. Additionally, possible sources of false alarms (steam, dust, fumes) must also be considered. Detectors must be placed so that smoke can readily enter the detector, and not be redirected by HVAC vents or other sources of air movement.

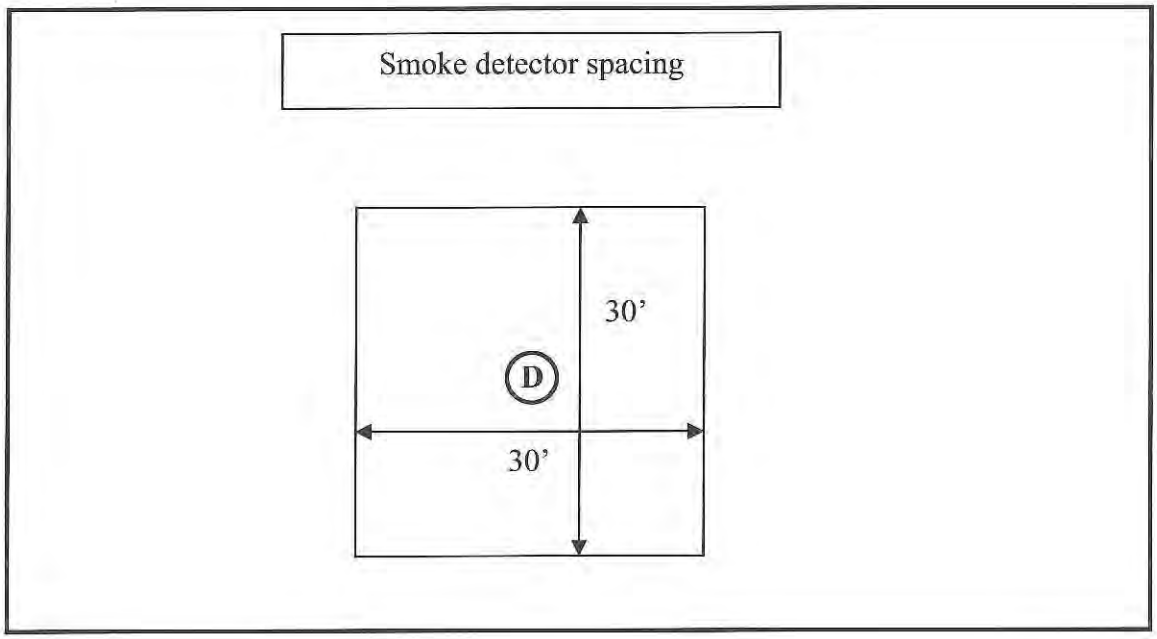
Like heat detectors, spot type smoke detectors can be ceiling or wall mounted (although ceiling mounted is considerably more popular). If they are wall mounted the smoke detector must be at least 4' down from the ceiling. Additionally some portion of the detector must be located within 12" of the ceiling. If they are ceiling mounted, they can be no closer than 4 inches to the wall. These provisions keep the detector out of the dead air space where the ceiling meets the wall. Testing has shown that smoke takes much longer to penetrate this area, resulting in delayed response by the detector.



Diagram, NTC, d5.48

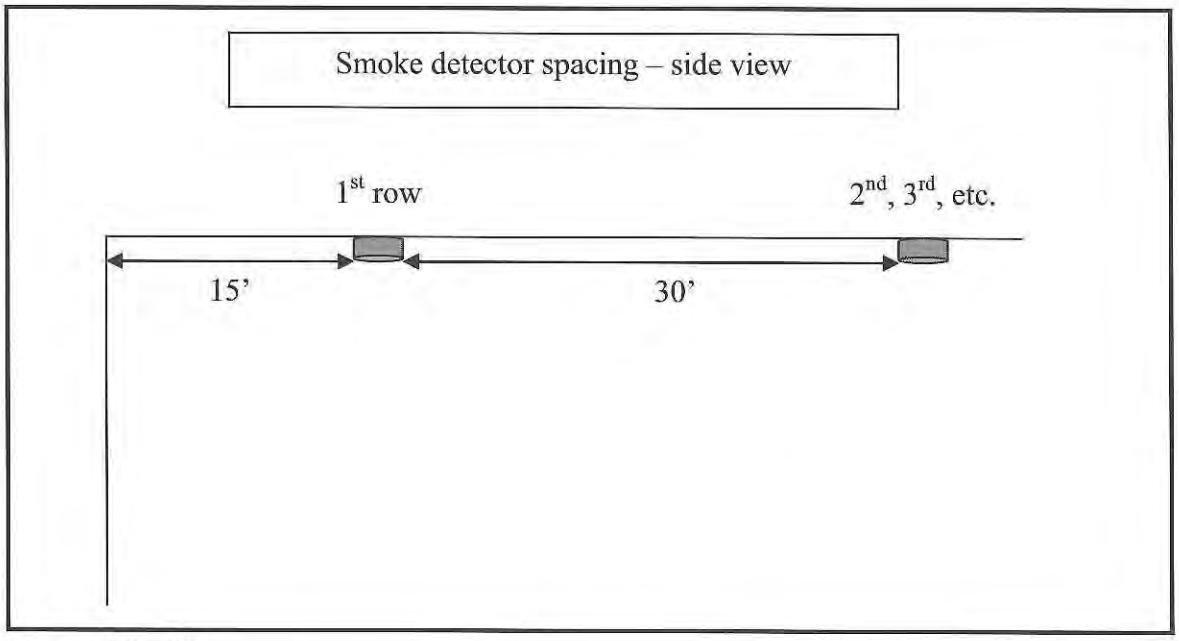
Spot Type Smoke Detector Spacing

On smooth flat ceilings, smoke detectors can be spaced on 30 foot centers (unless the manufacturer's instructions specify differently). Non-smooth flat ceiling have an affect on smoke detector spacing similar to their affect on heat detector spacing. Unlike heat detectors, though, beams and joists are considered to be the same for spacing guidelines

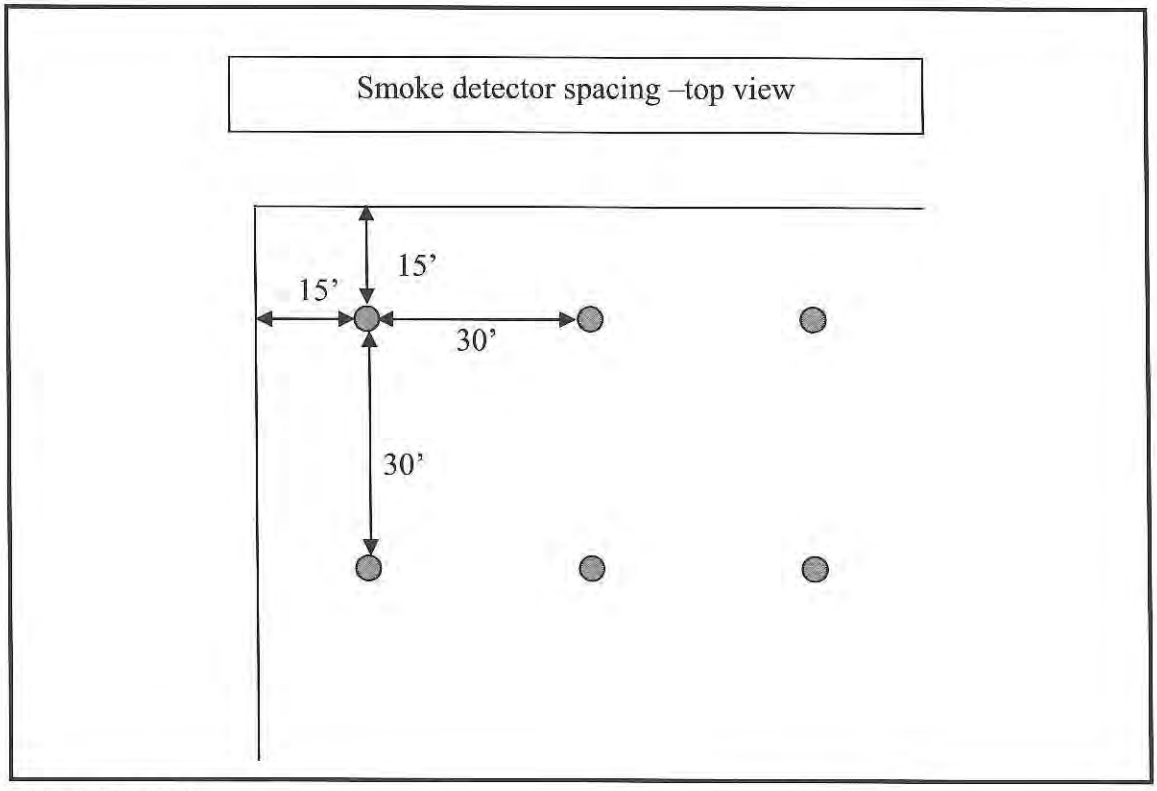


Diagram, NTC, d5.49

On smooth flat ceilings, the first row of smoke detectors must be located within ½ the spacing of the sidewall. Each consecutive row is located based on the spacing.



Diagram, NTC, d5.50

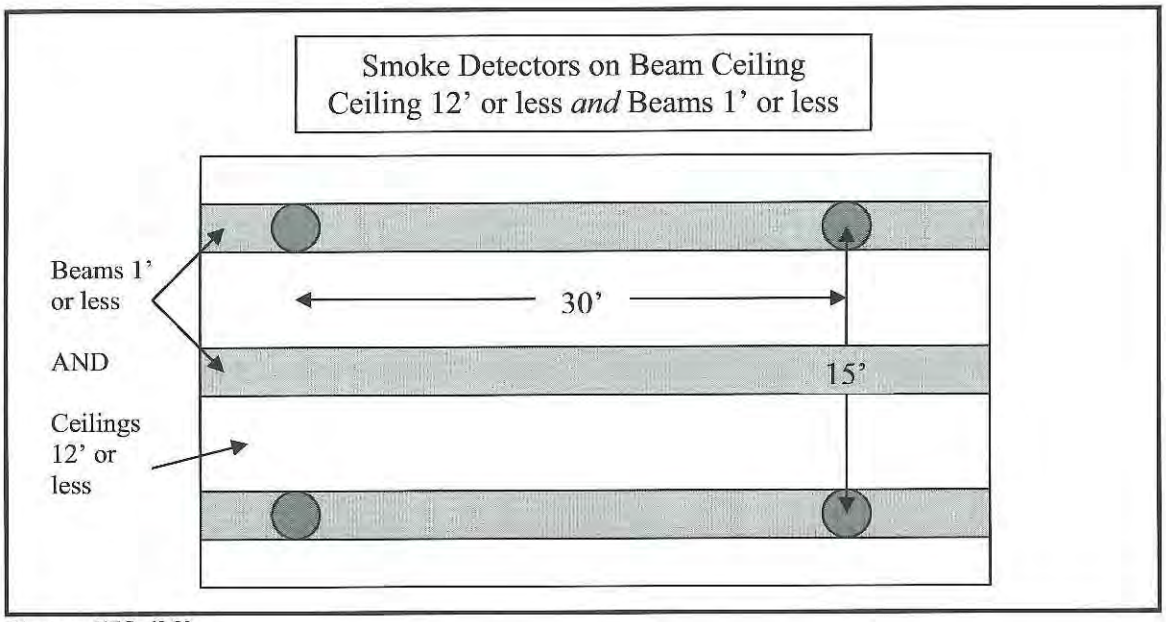


Diagram, NTC, d5.51

For ceiling heights which exceed 28 feet, an engineering study is recommended to determine proper detector spacing and locations.

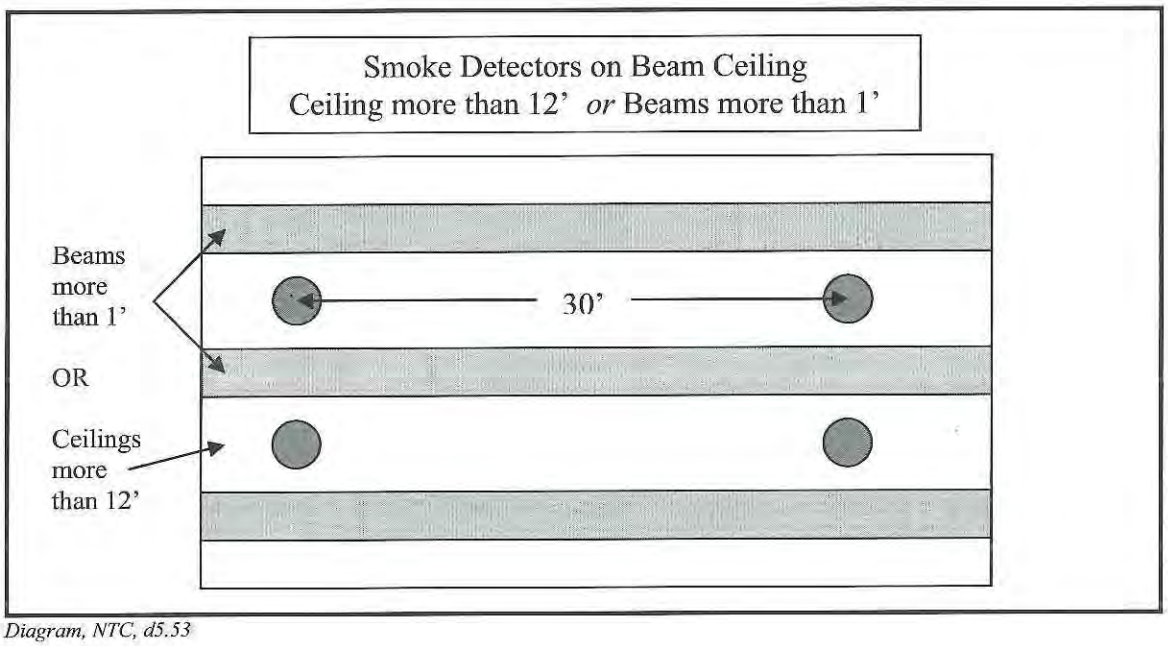
Beam Ceilings

Normal 30' spacing can be used in the direction parallel to the beams provided the ceiling is 12' or less and the beam depth is 1' or less. Spacing must be reduced by ½ in the direction perpendicular to the beams.



Diagram, NTC, d5.52

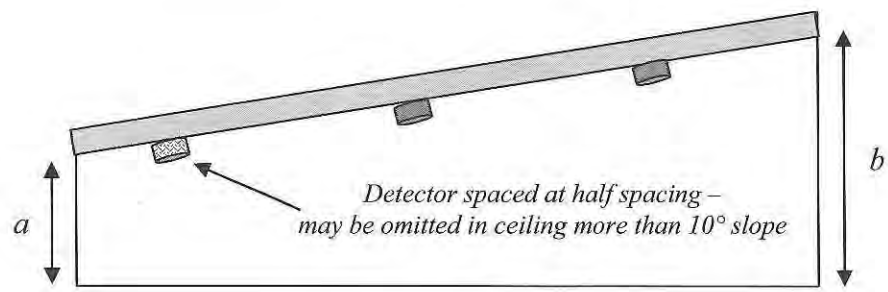
When ceiling heights exceed 12' or beam depths exceed 1', detectors are required to be mounted on the ceiling in every beam pocket. This will require a lot more detectors.



Diagram, NTC, d5.53

Sloped ceilings with beams running parallel to the slope (up) allow the beam considerations above to be used. The average height (sum of highest and lowest point divided by 2) is used to determine the ceiling height for the above calculation. Spacing must be measured along a horizontal projection of the ceiling. For slopes more than 10°, the detectors located at ½ the required spacing at the lower end are not required.

Smoke detectors on sloped ceilings with beams running parallel to slope)

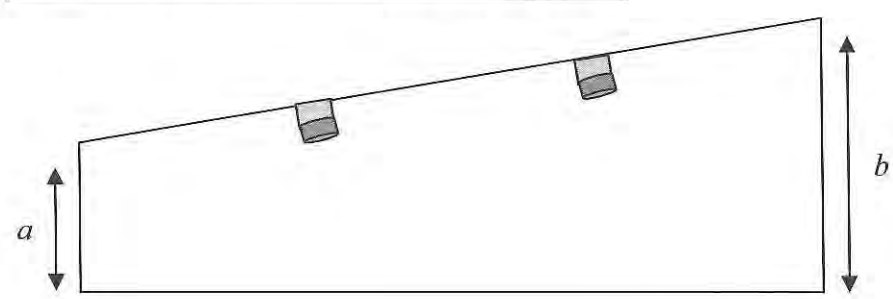


Diagram, NTC, d5.54

$$\text{Ceiling height} = \frac{a + b}{2}$$

Sloped ceilings with the beams running perpendicular to the slope (across) require the beams to be considered in detector spacing as well. They also require that the average ceiling height be used.

Smoke detectors on sloped ceiling with beams running perpendicular to slope



Diagram, NTC, d5.55

$$\text{Ceiling height} = \frac{a + b}{2}$$

Solid Joist

Solid joists are considered equivalent to beams for smoke detector spacing considerations. For all sloped ceiling with solid joists the detectors must be mounted on the bottom of the joist.

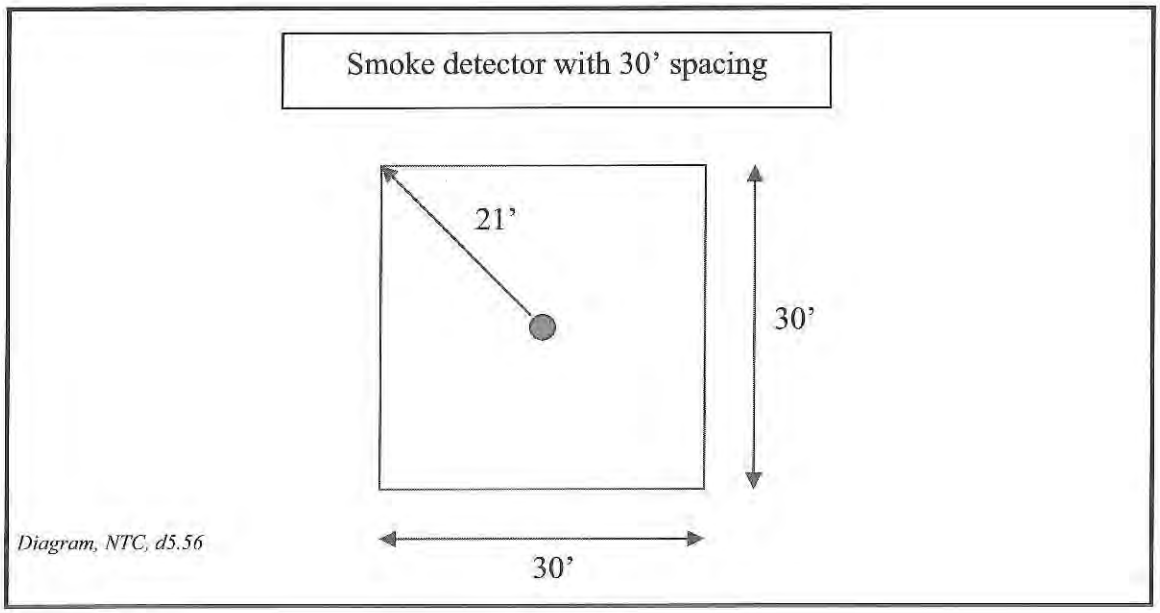
Shed and peaked ceilings for spot type smoke detectors are not specifically addressed in NFPA 72®. Generally, smoke detectors in shed and peaked ceilings should be spacing on 30 foot center, based on a horizontal projection (as the AHJ would walk across the floor). The first row of detectors should start 3 feet from the peak or high side of the shed.

The 0.7 Rule

Detectors are required to be spaced so that no point on the ceiling is more that 0.7 times the listed spacing from a detector. This rule, commonly called the 0.7 Rule, has practical application in corridors. Because the corridor is narrow, NFPA 72® The National Fire Alarm Code® permits extended spacing of automatic detectors. Here are some typical examples of the extended spacing allowed by code for smoke detectors:

10 foot wide corridor	Extended spacing: 41 feet
15 foot wide corridor	Extended spacing: 39 feet
20 foot wide corridor	Extended spacing: 37 feet
25 foot wide corridor	Extended spacing: 34 feet

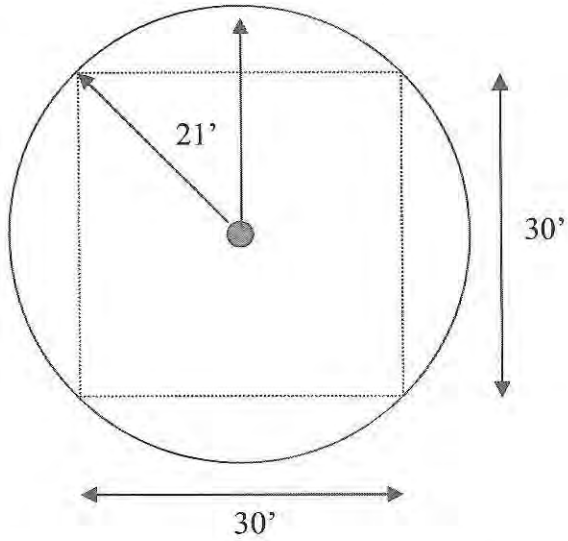
Standard smoke detector spacing is permitted to be 30 feet between detectors. One smoke detector is permitted to protect a room which is 30' x 30'. The smoke detector is located in the center of the room 15 feet from each side wall. Since every point in the 30' x 30' room is protected (even the corners) the detector is effectively protecting areas as much as 21 feet away.



Diagram, NTC, d5.56

The code recognizes that a smoke detector can therefore protect areas as much as 21 feet away. So the area of protection is actually a circle, which encompasses all points within 21 feet of the detector as depicted below:

Smoke detector circle of protection

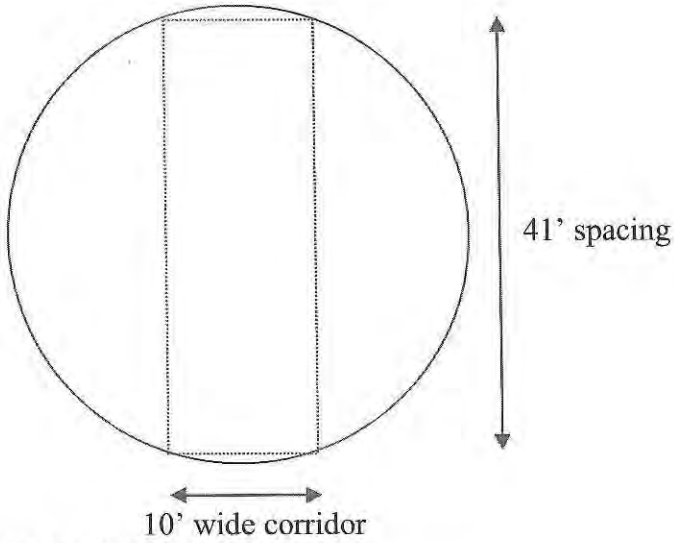


Diagram, NTC, d5.57

Since a corridor is narrow, the end to end distance (spacing) is greater. In a 10' wide corridor the end to end distance is 41'. The entire corridor is within the circle of protection.

Diagram, NTC, d5.58

Smoke detector in 10' wide corridor



This principle allows extended spacing as the corridor becomes narrower.

Calculation: Determining the total number of detectors for a corridor can be calculated using the following formula:

Corridor Length ÷ Corridor Spacing

For example, calculate the total number of detectors for a corridor, which is 41' long and 10' wide. From the information above, we know that a 10' wide corridor can use an extended spacing of 41' between detectors.

Corridor Length = 41'
Corridor Spacing = 41'

Using the formula Corridor Length ÷ Corridor Spacing,

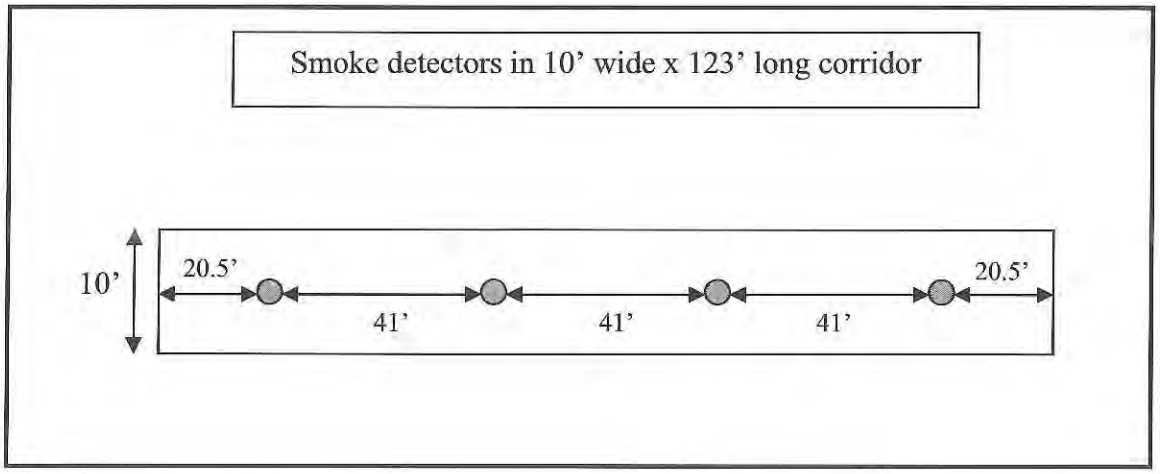
41 ÷ 41 = 1 detector

This formula works for any length of corridor. The width of the corridor must be known so the spacing can be determined. Below is an example of a 10' x 123' corridor.

Corridor Length = 123'
Corridor Spacing = 41'

Using the formula Corridor Length ÷ Corridor Spacing,

123 ÷ 41 = 3 detectors



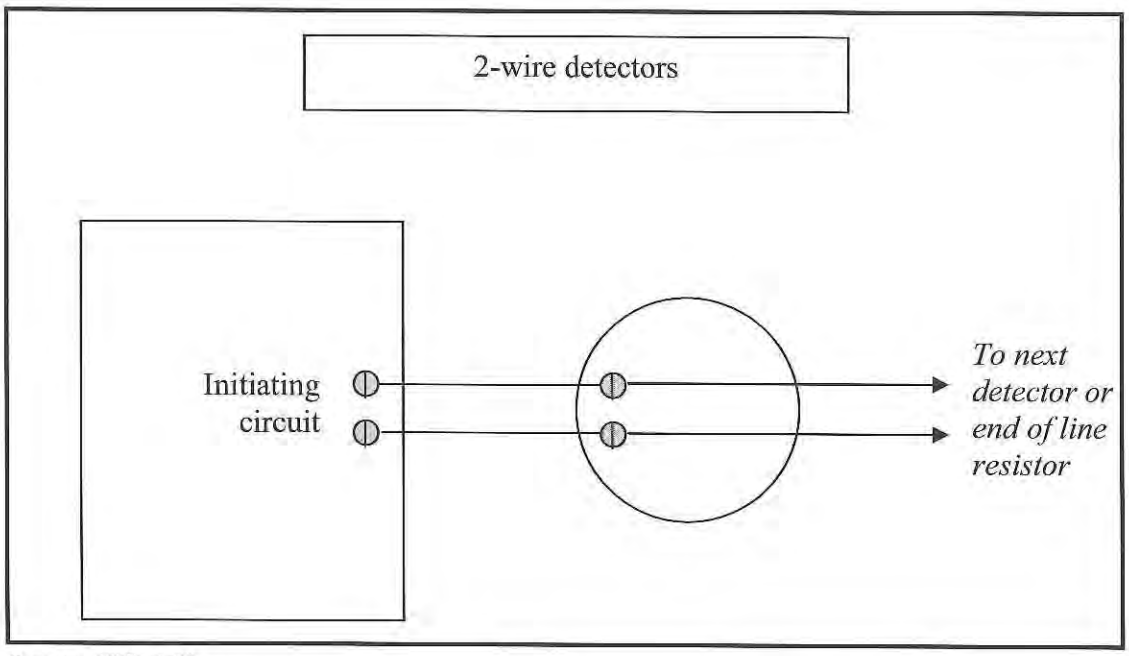
Diagram, NTC, d5.59

The width of the corridor determines the spacing used.

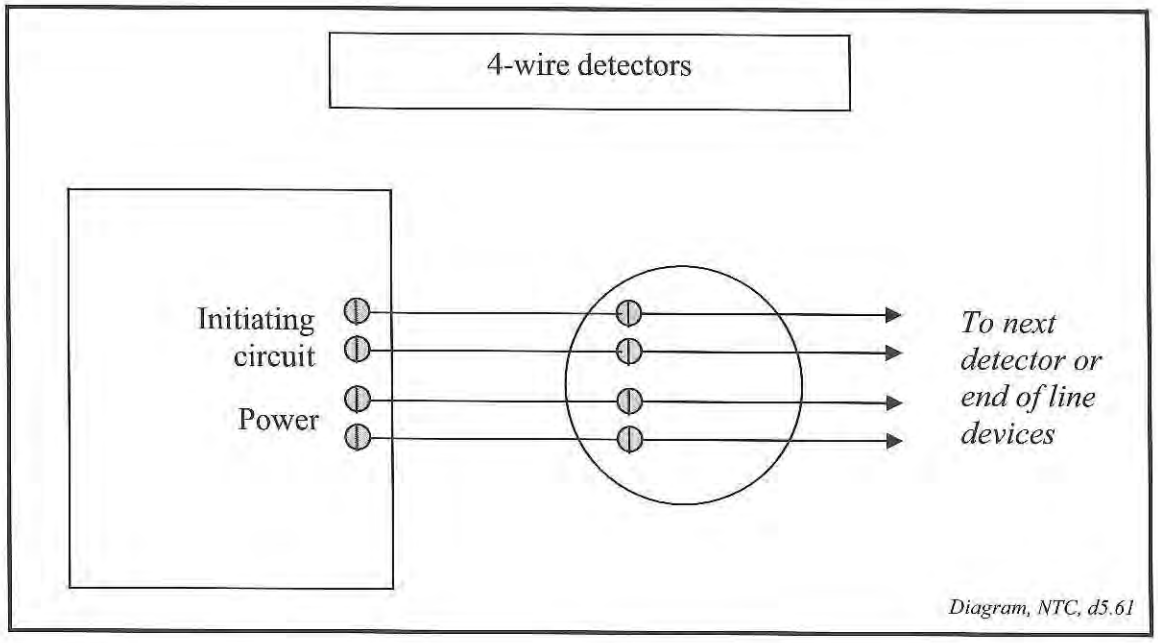
Corridor width, 10'	Spacing = 41'
Corridor width, 15'	Spacing = 39'
Corridor width, 20'	Spacing = 37'
Corridor width, 25'	Spacing = 34'

Spot Type Smoke Detector Features / Options

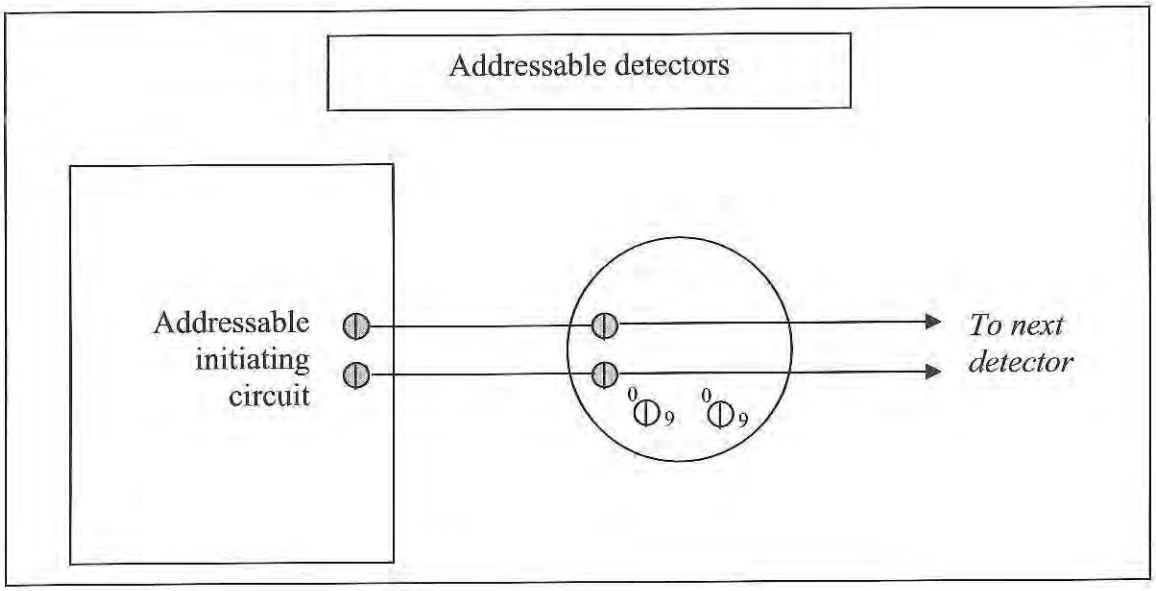
Smoke detectors are available as 2-wire, 4-wire, and addressable models. 2-wire detectors are powered by the initiating device circuit and are required to be compatibility listed with the fire alarm control. 4-wire detectors receive power on a separate pair of wires from the initiating circuit. Addressable detectors receive their power for the device and/or the interface module from the fire alarm control's signaling line circuit (SLC). The configuration is similar to 2-wire detector operation, except that device annunciates individually at the control panel.



Diagram, NTC, d5.60



Diagram, NTC, d5.61



Diagram, NTC, d5.62

2-Wire Detectors

2-wire detectors have a compatibility cross listing (available from the device manufacturer) that lists the control panels the detector is compatible with. This list will usually state the maximum number of devices that can be used on an individual initiating device circuit. Compatibility information is also available in the fire alarm control's installation manual. Using incompatible detectors may result in false alarms, or worse, lack of detection.

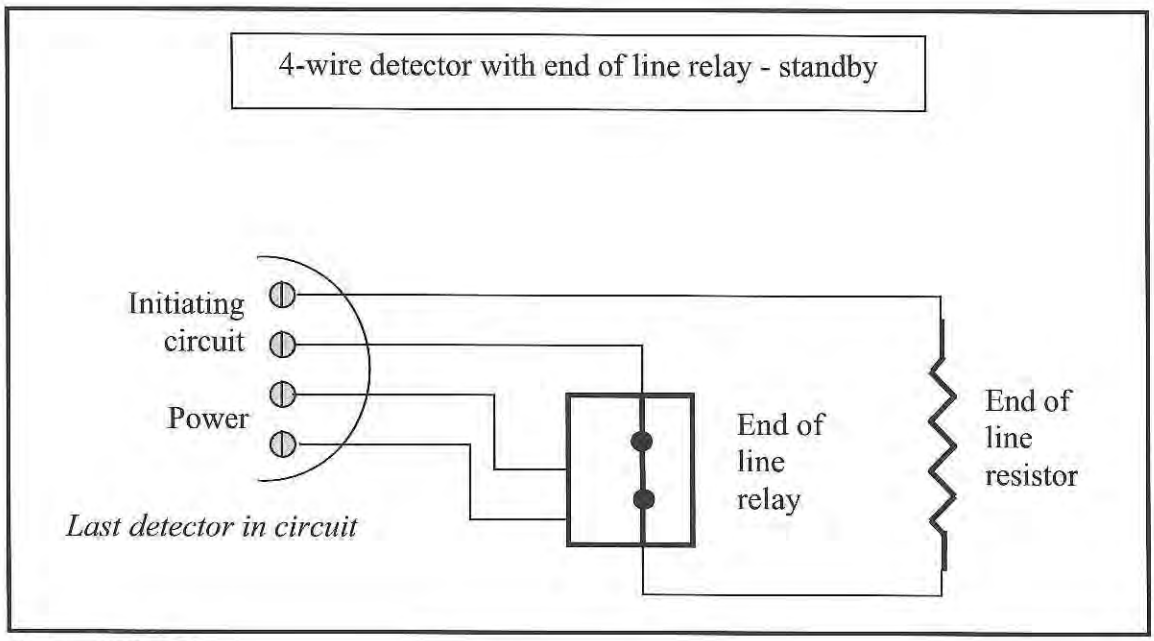
Panel Mfg.	Panel Model	Detector Model	Max. Det. Per Zone	Zone Model
ABC	123	DET1, DET2	20	ZM1
ABC	123	DET3, DET4	15	ZM2
XYZ	987	DET1	12	n/a
XYZ	987-2	DET3	20	n/a

Diagram, NTC, d5.63

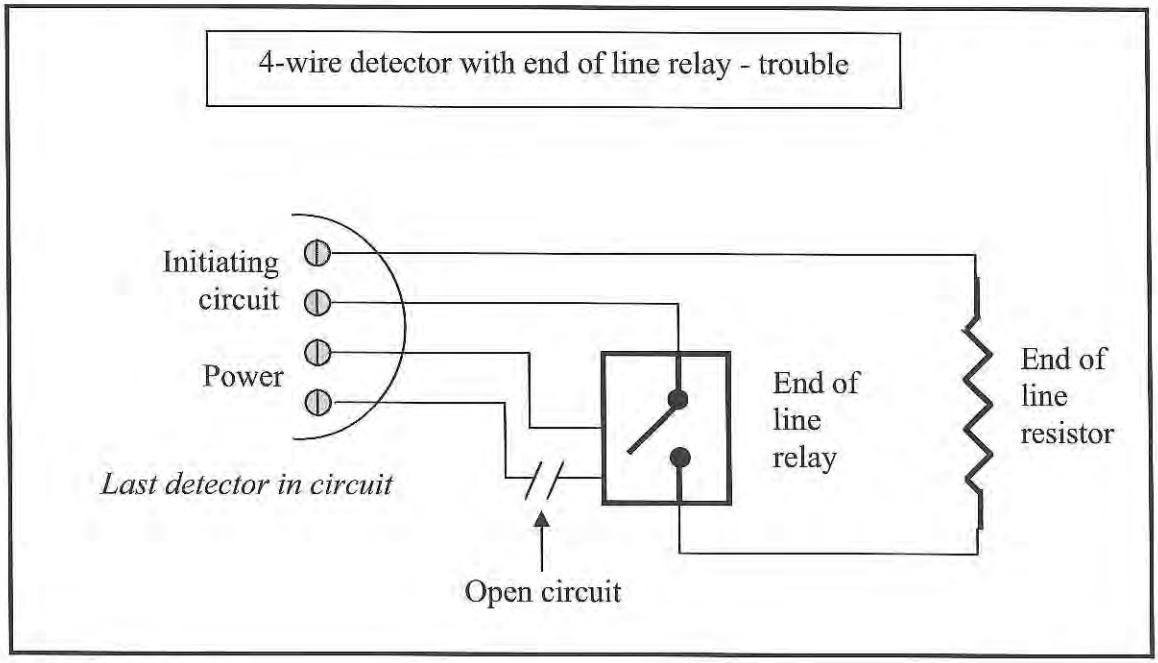
4-Wire Detectors

4-wire detectors only need to be electrically compatible with the fire alarm control. They must operate at the same voltage as the auxiliary power output which powers them. 4-wire detectors should be connected to the auxiliary power connection designated for this type of detector. The detectors latch in alarm condition and require their power to be momentarily interrupted to reset them. Connecting them to this circuit assures that the detector power will be reset when the panel is reset.

4-wire detectors require that their power circuit be supervised with an end of line relay (EOLR). The relay connects to the power circuit after the last detector. If the power is interrupted to the circuit, the relay provides an open on the initiating detector circuit to alert the control panel of the trouble condition.



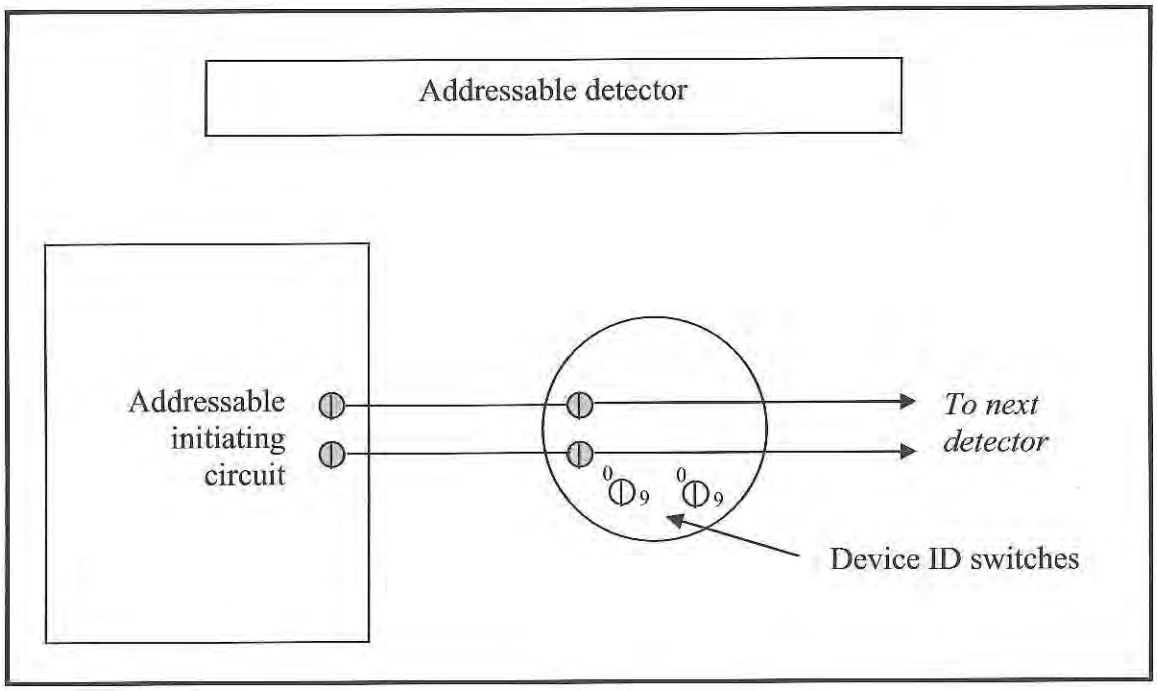
Diagram, NTC, d5.64



Diagram, NTC, d5.65

Addressable Detectors

Addressable detectors must be listed for use with the fire alarm control they are being used with. The control panel provides power for the addressable interface module and the detector (if it requires power) over the signaling line circuit (SLC). Addressable detectors are typically proprietary, and vendors generally cannot be mixed. Addressable detectors are individually monitored by the control panel. An end of line resistor or relay for supervision is typically not required.

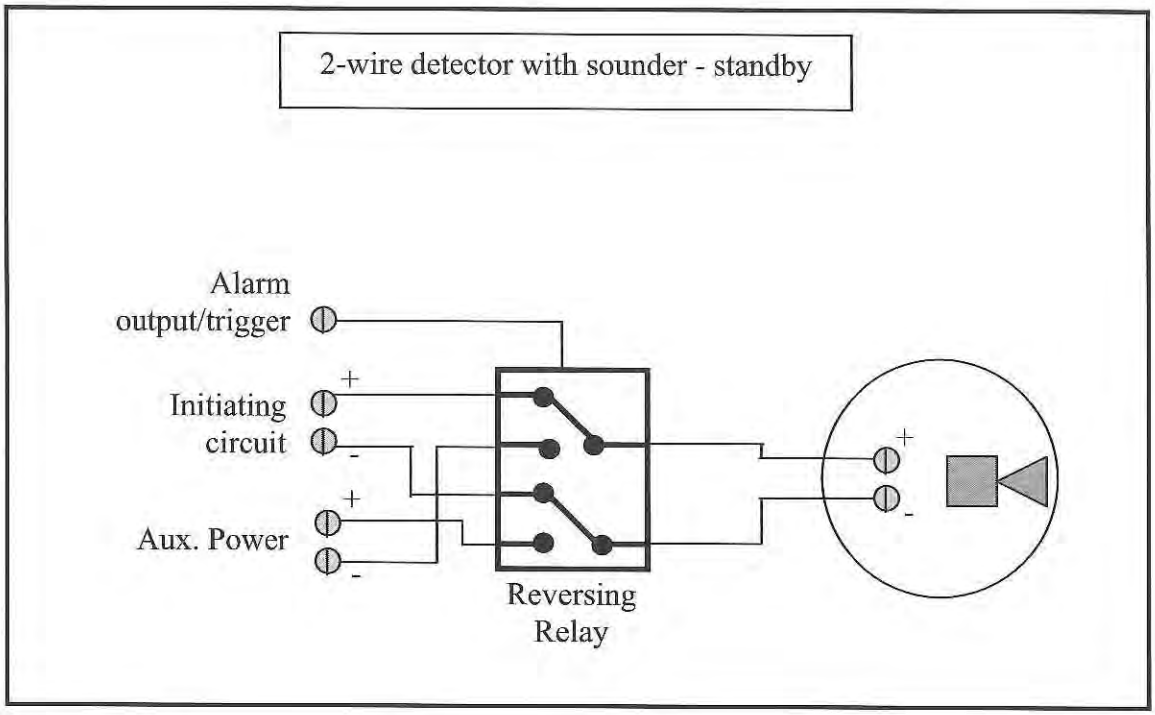


Diagram, NTC, d5.66

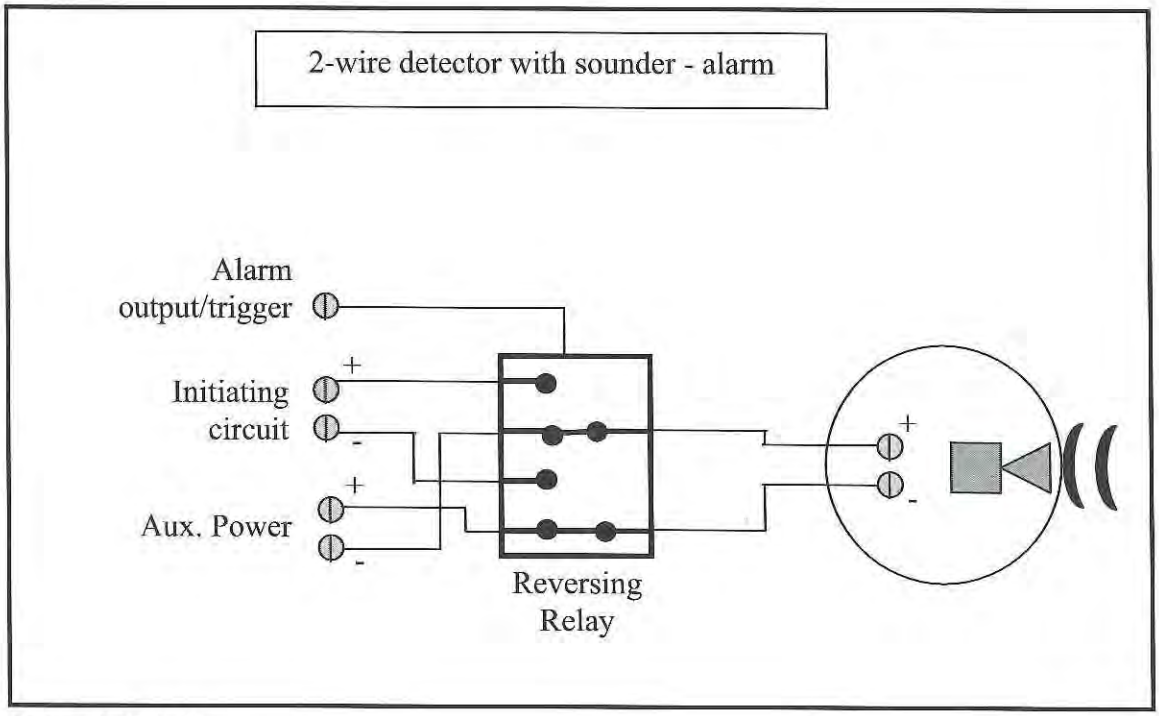
Smoke Detectors with Sounder

Spot type smoke detectors are available with built in sounders. The sounder is activated when the detector goes into an alarm condition. In some applications, all the detectors are required to sound when in a single detector goes into alarm. This is accomplished by using a reversing relay in the control panel. The relay reverses polarity on the detector power which causes all the detectors on the circuit to alarm simultaneously. The relay can also drive 2-wire units with sounders by switching auxiliary power voltage to the detectors (in reverse polarity) after an alarm is detected.

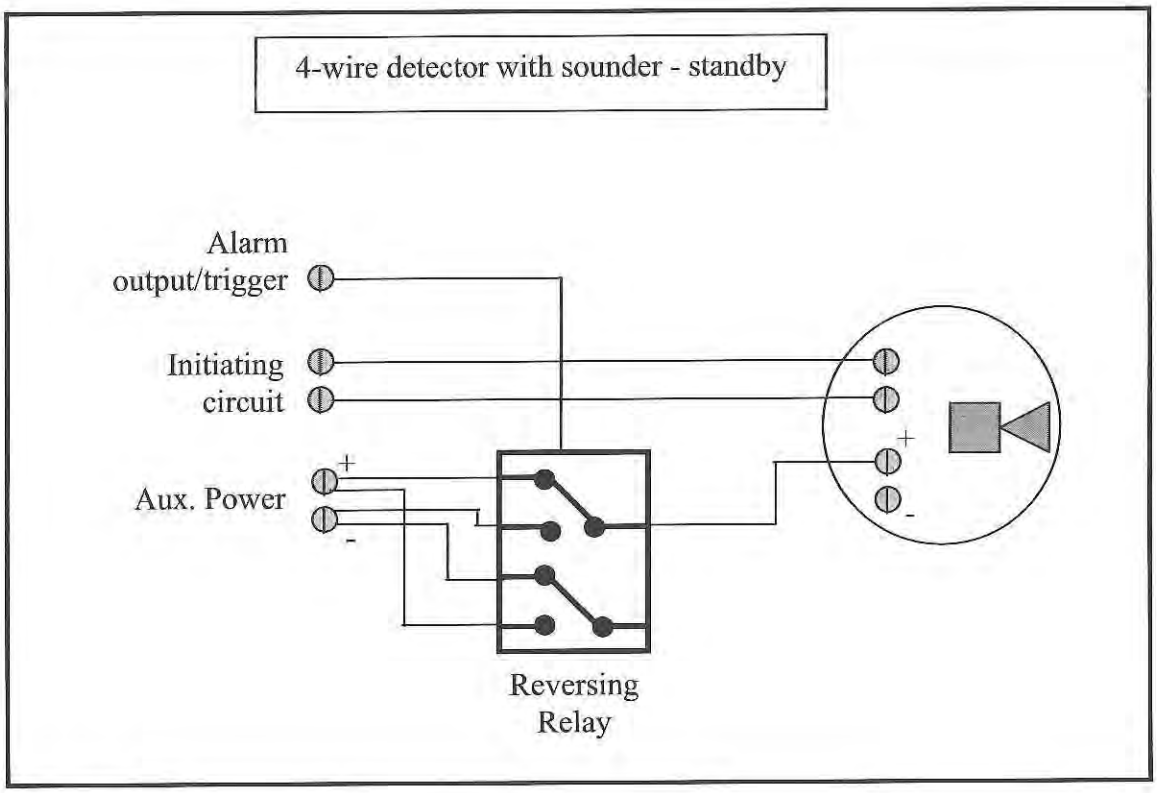
These detectors are commonly used in residential applications. Such applications may include hotel rooms, dormitory rooms and apartments. It is always important to consult the state and / or local code requirements for the use of this type of detector. The following diagrams show how these devices operate.



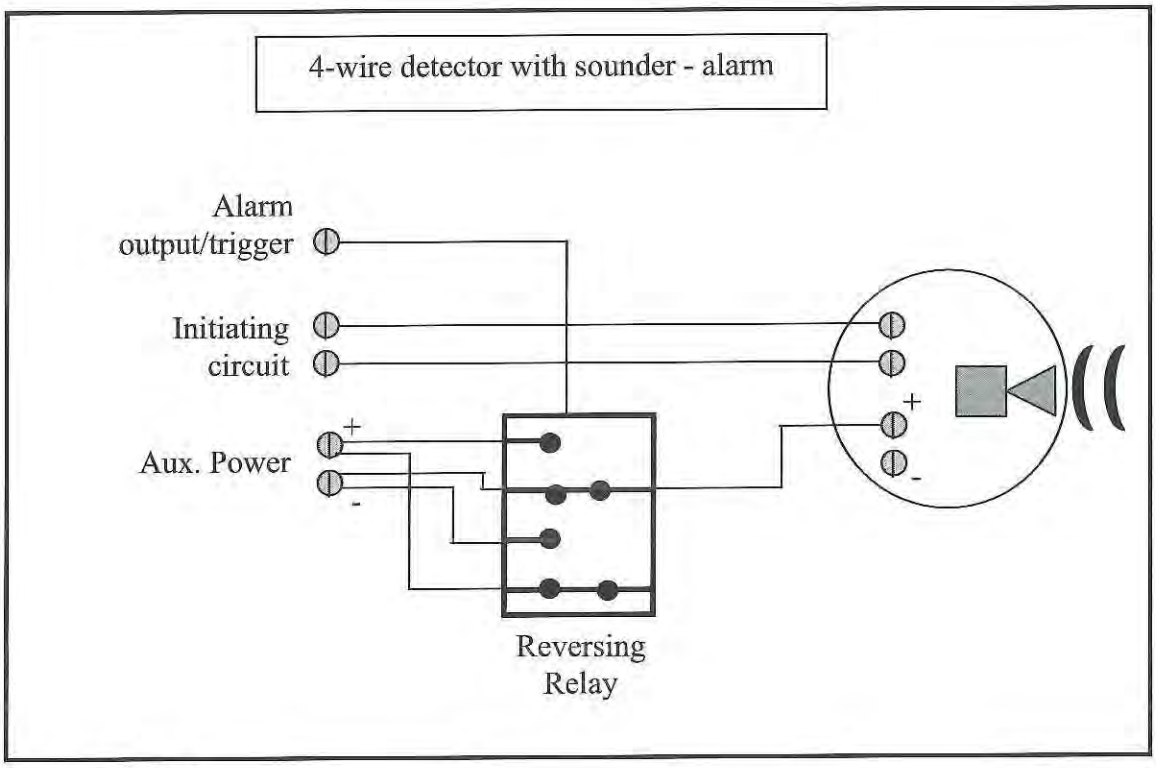
Diagram, NTC, d5.67



Diagram, NTC, d5.68



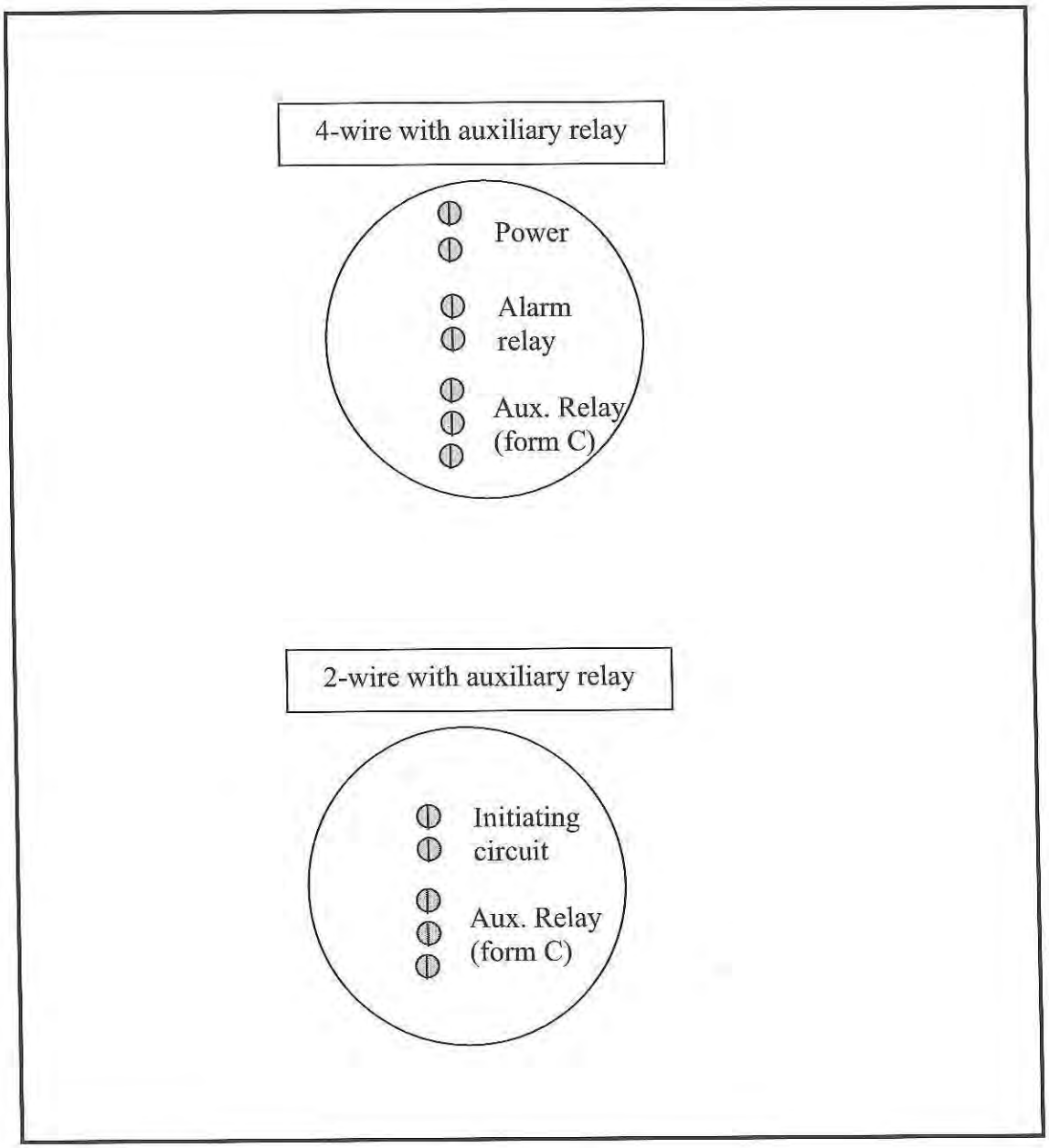
Diagram, NTC, d5.69



Diagram, NTC, d5.70

Smoke Detector with Auxiliary Relay

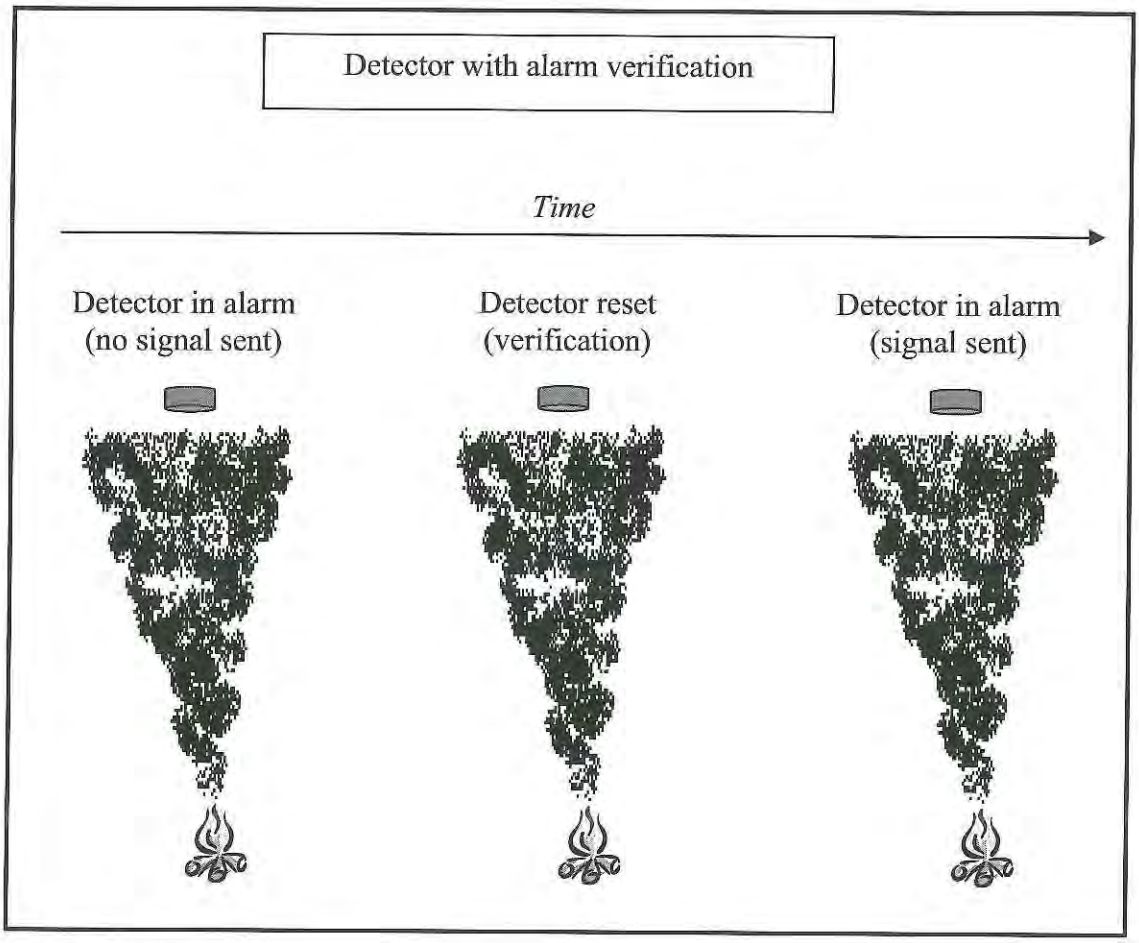
Spot type smoke detectors are available with auxiliary relays. The relay activates when the detector goes into alarm condition. 2-wire detectors with auxiliary relays must be cross listed with the fire alarm control they are used with. When two or more detectors with auxiliary relays are connected to a single circuit the circuit may only be capable of supporting at least one detector in alarm operation. If the detectors are used to operate critical building safety functions (elevator control, fan shutdown, etc.) the detectors should be on separate circuits.



Diagram, NTC, d5.71

Alarm Verification

Alarm verification helps reduce false alarms. Alarm verification provides a method for checking to make sure the alarm condition persists. Most conditions which cause nuisance alarms are temporary. Alarm verification can reduce nuisance alarms. When the detector goes into alarm, the detector is automatically reset. If it detects smoke again within a preset time window (normally 60 seconds) it goes into alarm as normal. If it does not detect smoke within its preset window, it resets its timer and goes back into normal operating mode.



Diagram, NTC, d5.72

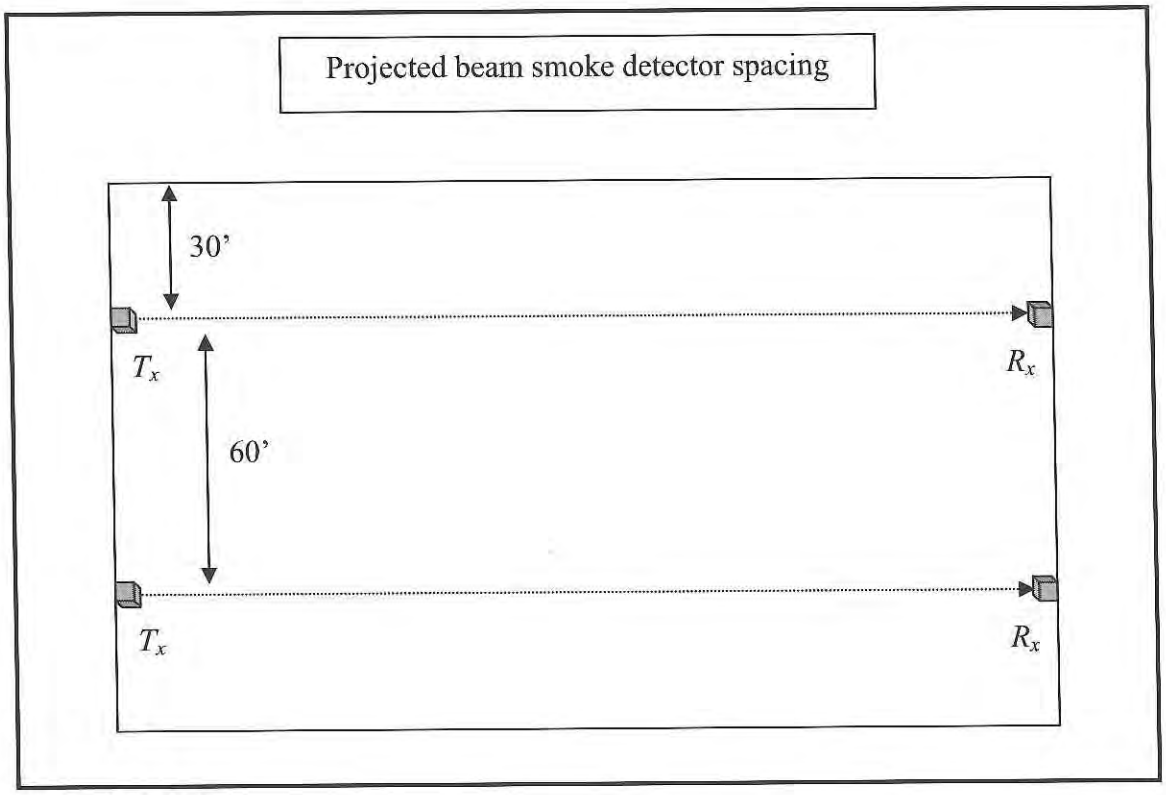
Alarm verification can be provided the by the detector or by the fire alarm control panel. The installer must be sure that only one of the alarm verification options is operating. If both operate at the same time the detector may never go into alarm. Alarm verification is not permitted to be used with presignal or positive alarm sequence systems.

Projected Beam Type Smoke Detector Spacing

Photo courtesy System Sensor, p5.30

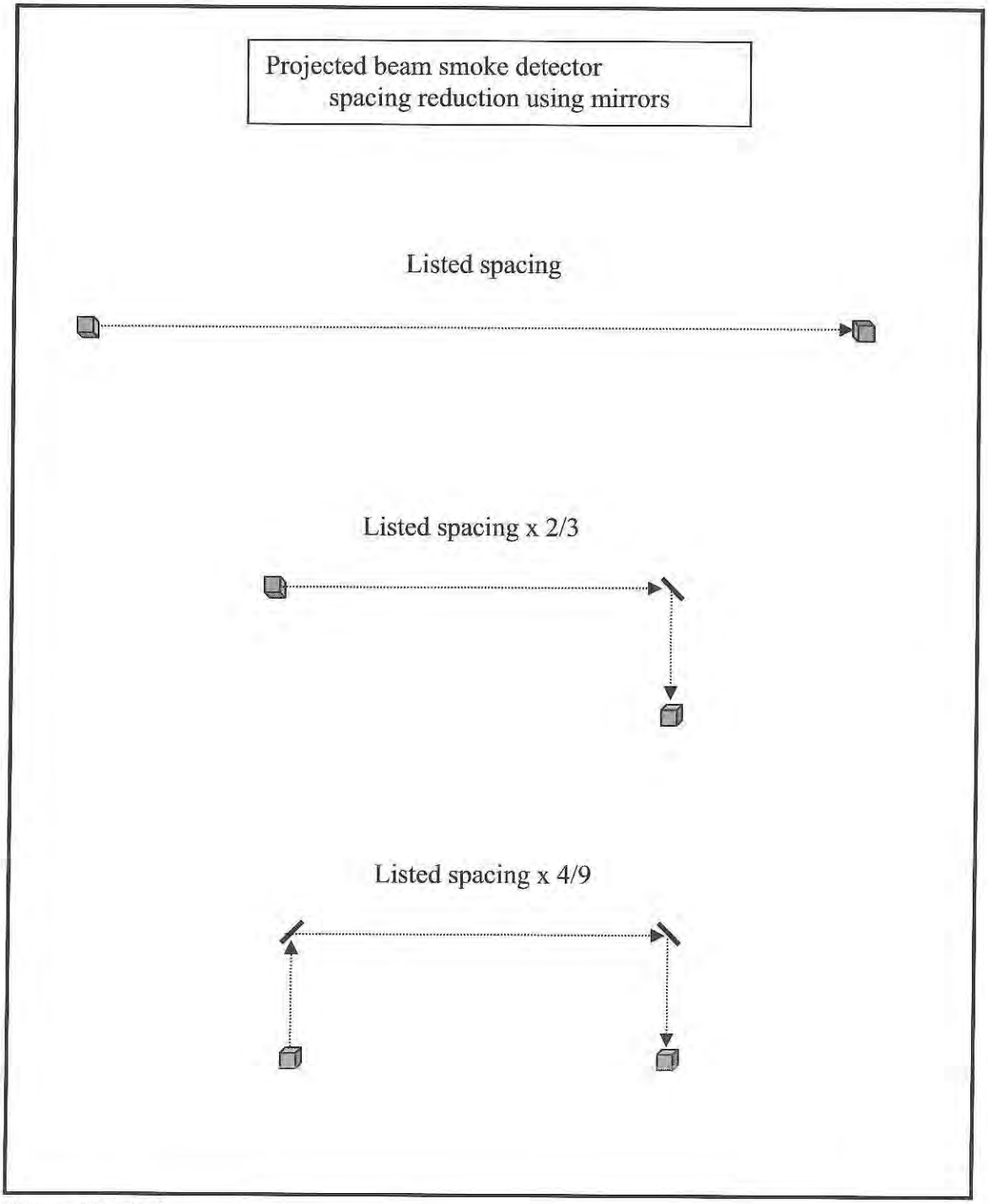
Photo courtesy System Sensor, p5.31

As with heat detectors and spot type smoke detectors, projected beam smoke detectors are affected by ceiling type as well. NFPA 72® only gives specific spacing instructions for peaked and shed ceiling. It refers to the manufacturer's instructions for any other applications. Typically, beam detector spacing is 60 feet between beams.



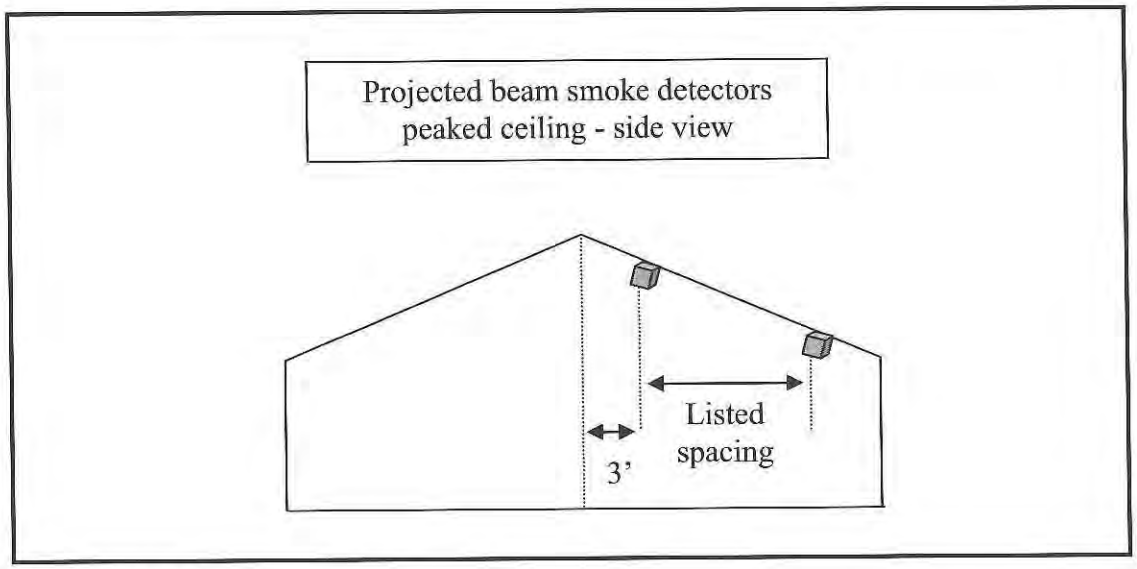
Diagram, NTC, d5.73

When mirrors are used, the manufacturer usually requires the distance of the beam to be decreased. Normally each mirror decreases the maximum distance by 1/3rd.

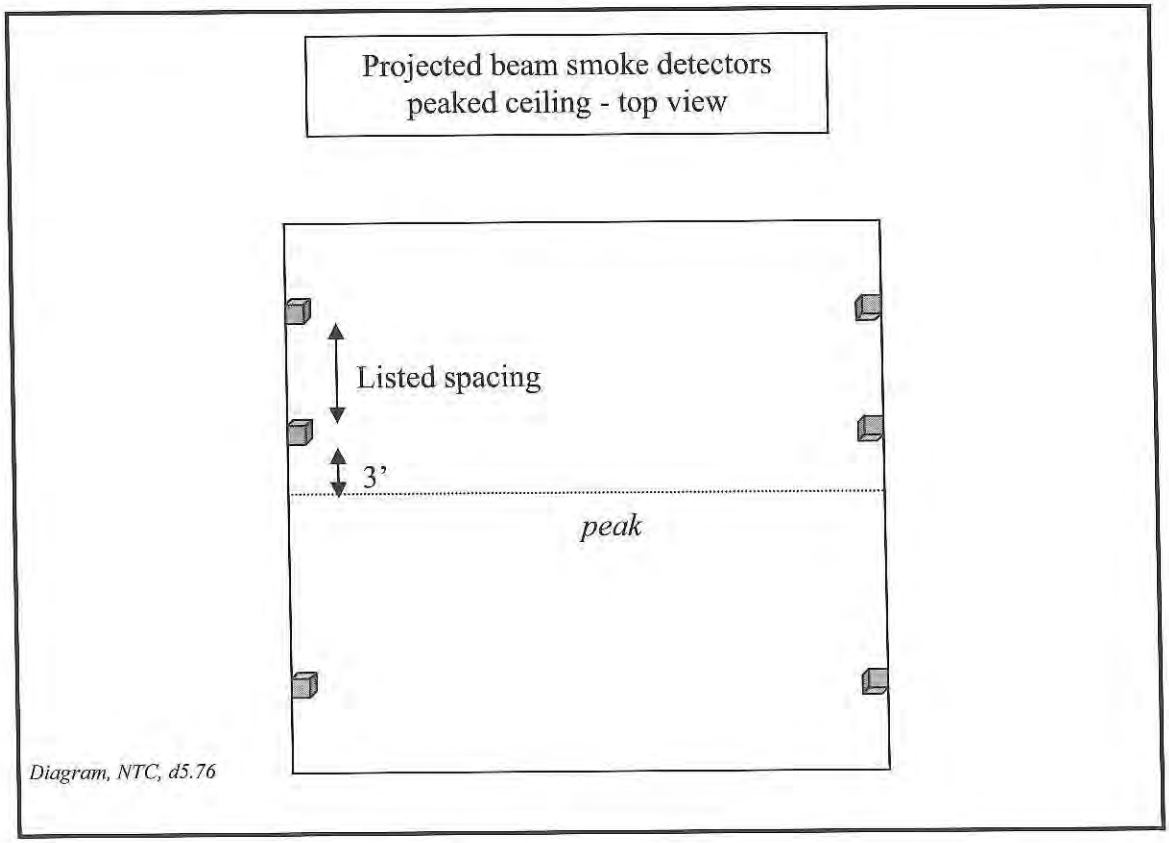


Diagram, NTC, d5.74

Peaked ceilings require that the detector be spaced and located within 3 feet of the peak. Shed ceilings also require the detector to be located within 3 feet of the high side of the ceiling. Any additional detectors (if required) must be spaced according to a horizontal projection of the ceiling (as it would be walked along a flat and level floor).



Diagram, NTC, d5.75



Diagram, NTC, d5.76

Air Sampling Smoke Detector Spacing

Air sampling type smoke detection systems are highly specialized and designed to detect smoke in very small quantities. These systems are typically used in clean rooms, electronic equipment rooms and computer rooms. They are quite expensive as well.

NFPA 72®, The National Fire Alarm Code® requires that each sampling port of an air sampling type smoke detector be treated as a spot type smoke detector for the purposes of location and spacing. The sampling tube must be airtight and permanently mounted. The tubing must be identified as "SMOKE DETECTOR SAMPLING TUBE – DO NOT DISTURB" at each change in direction or branch in piping, at each side of a barrier (wall, ceiling, floor) penetration, and where the pipe is visible at intervals of 20 feet or less.

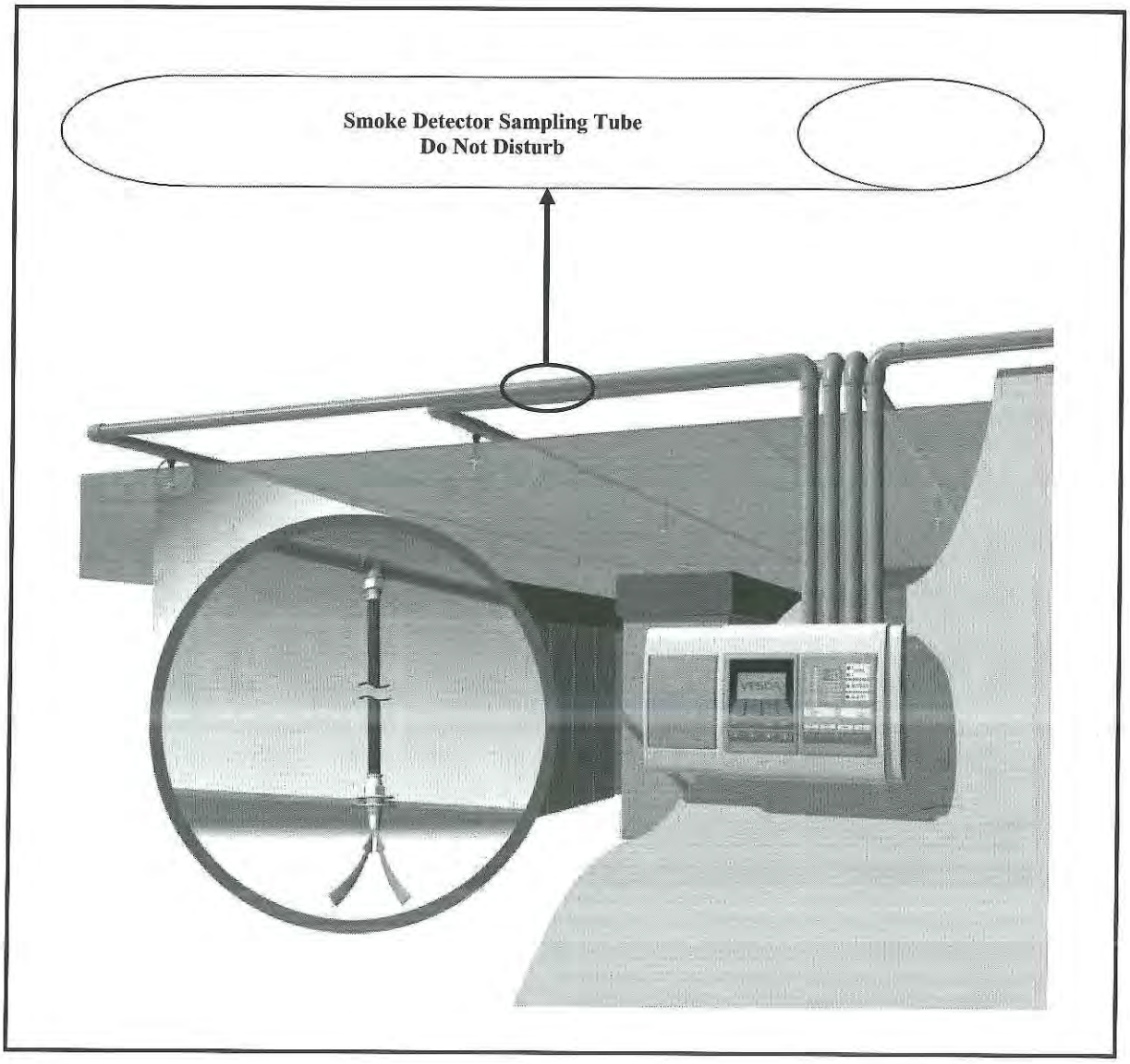
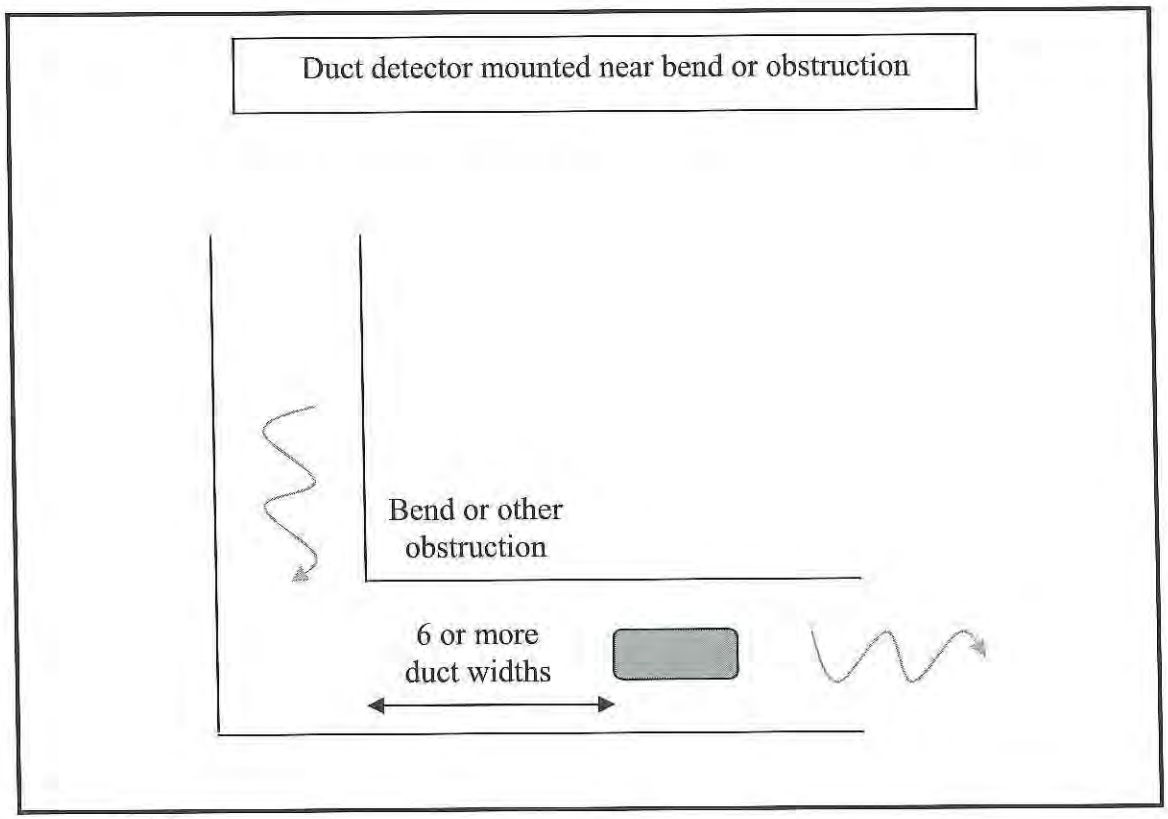


Diagram courtesy of Vision Systems (VESDA), d5.77

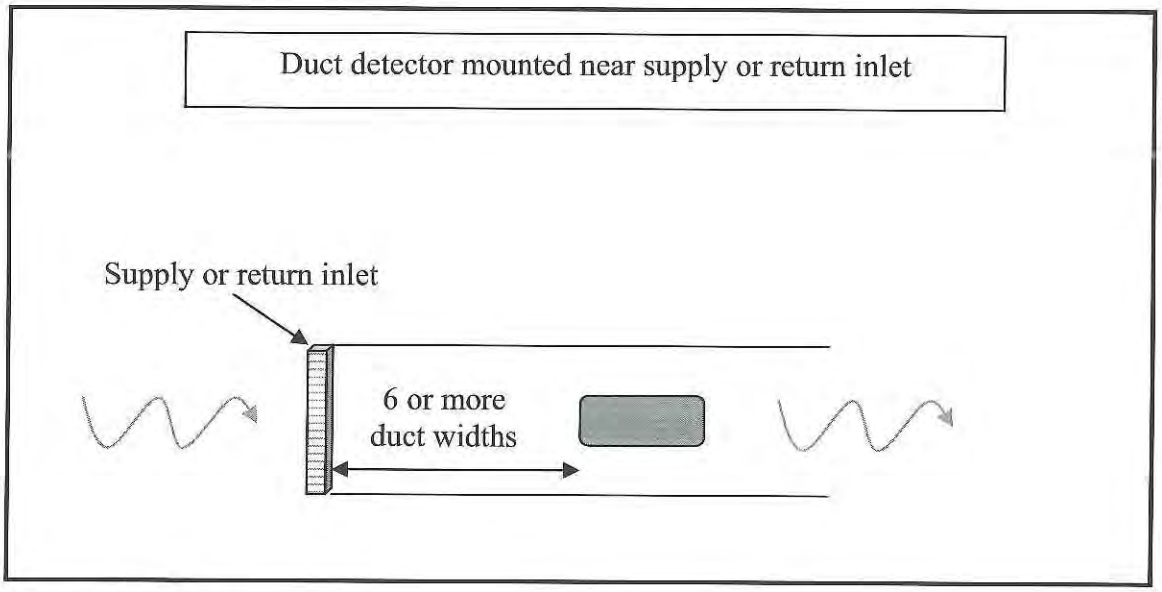
Duct Detector Spacing

NFPA 72® and NFPA 90A® (Standard for Air Conditioning and Ventilation System) cover the spacing and application requirements for duct smoke detectors. NFPA 90A® requires that duct smoke detectors be installed on air systems greater than 2,000 CFM, and that the detectors be installed downstream of any air filters and ahead of any branch connections. Additionally, NFPA 90A® requires that systems with a capacity of greater than 15,000 CFM and serving more than one story have a detector at each story, prior to connection to a common return or fresh air inlet. Return system detectors are not required if the entire space served by the system is protected by area smoke detectors.

Externally mounted duct smoke detectors use a sampling tube to sample the duct's airflow. The tube should be supported at the far side (away from the detector) in duct's larger than 3 feet. The detector itself should be mounted 6 or more duct widths from the return inlet, or from any bends or obstructions in the duct.



Diagram, NTC, d5.78



Diagram, NTC, d5.79

Duct detectors mounted more than 10 feet above the floor, or installed where the detector alarm and supervisory indicators are not visible, are required to have remote alarm and supervisory indicators in a location acceptable to the AHJ. The remote indicator must be labeled to indicate their function and which air handler they are associated with, unless the air handler is individually annunciated at the fire alarm control.

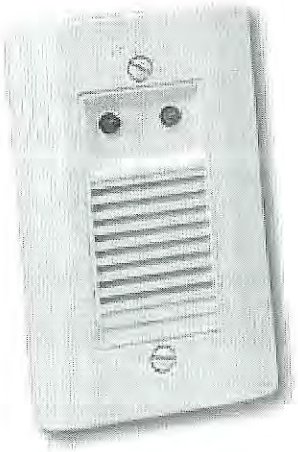


Photo courtesy System Sensor, p5.32

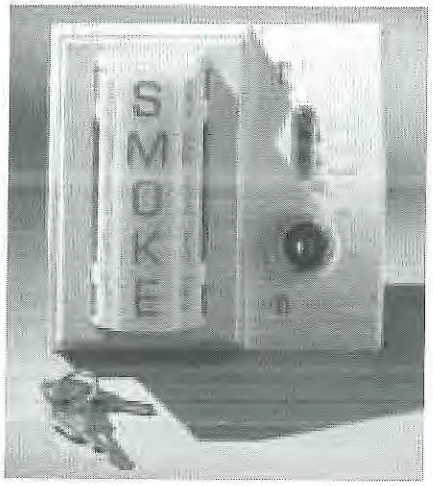


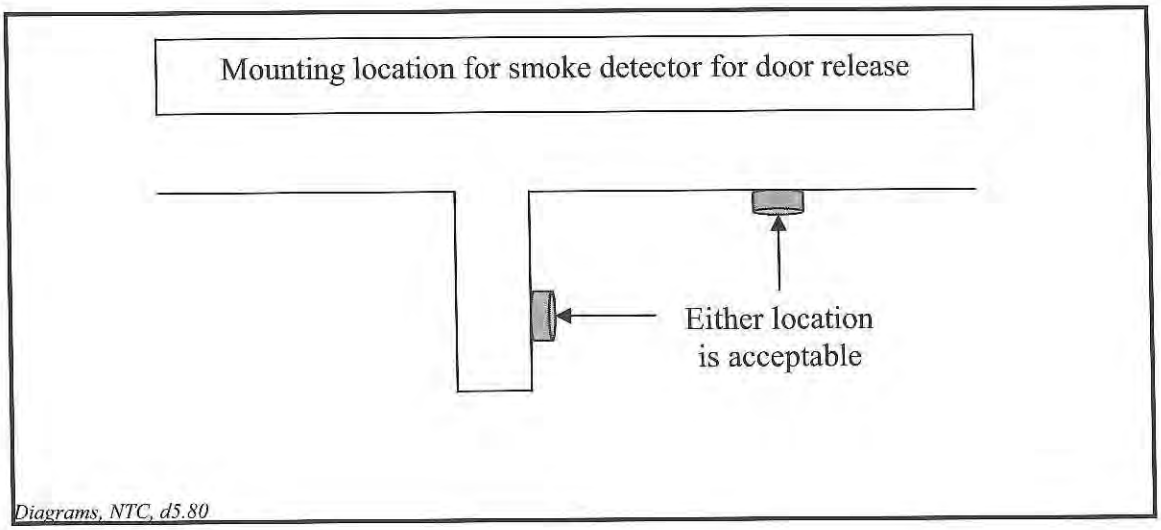
Photo courtesy System Sensor, p5.33

Smoke Detectors for Door Release

Smoke barrier doors are used to prevent smoke spread in the event of a fire. They are held open (typically via magnetic door holder) during non fire conditions and close automatically when released due to the detection of smoke, or they may be closed electromechanically. Smoke barrier doors are activated by smoke detectors. Smoke detectors used primarily for area protection on both sides of a smoke barrier door may be used to operate the smoke doors. Smoke detectors dedicated to operating the smoke doors may also be used, but they must release the door directly and they must be listed for that purpose.

Photo courtesy Edwards, p5.34

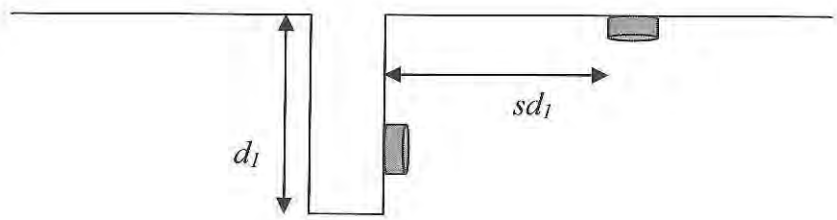
Smoke detectors used exclusively for door release service must be spaced according to the guidelines of the NFPA 72®. Detectors for door release service may be wall mounted above the door, or they may be ceiling mounted. If they are ceiling mounted, the depth of the wall section above the door determines the distance from the door.



Diagrams, NTC, d5.80

If the depth of the wall section above the door is 24 inches or less on both sides of the door, only one detector, mounted on either side of the door, is required. If ceiling mounted, the detector must be spaced no more 5 feet from the door, and no closer than the depth of the wall section. In any case, it cannot be located closer than 12 inches.

Detector mounting for 24" or less on both sides



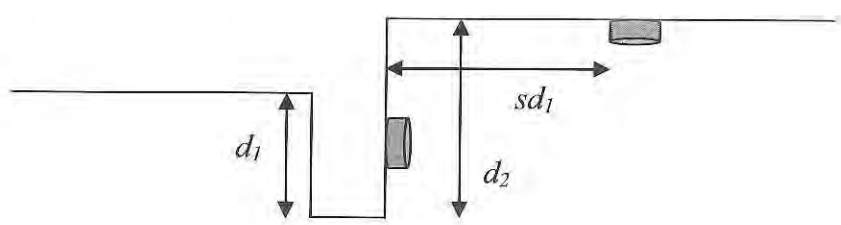
d_1 = 24" or less

sd_1 = d_2 or more, but less than 5',
no less than 12"

Diagram, NTC, d5.81

If the depth of the wall section above the door is more than 24 inches on one side of the door only, a detector is required on the higher side only. If ceiling mounted, the detector must be spaced no more than 5 feet from the door, and no closer than the depth of the deepest wall section.

Detector mounting for more than 24" on one side



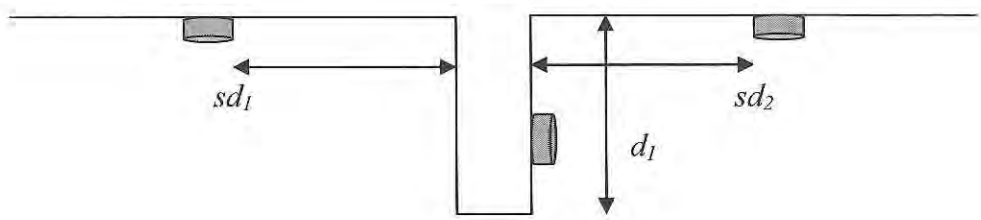
d_1 = 24" or less
d_2 = more than 24"

Diagram, NTC, d5.82

sd_1 = d_2 or more, but less than 5',
no less than 12"

If the depth of the wall section above the door is more than 24 inches on both sides of the door, a detector is required on both sides of the door. If ceiling mounted, the detector must be spaced no more than 5 feet from the door, and no closer than the depth of the deepest wall section.

Detector mounting for more than 24" on both sides



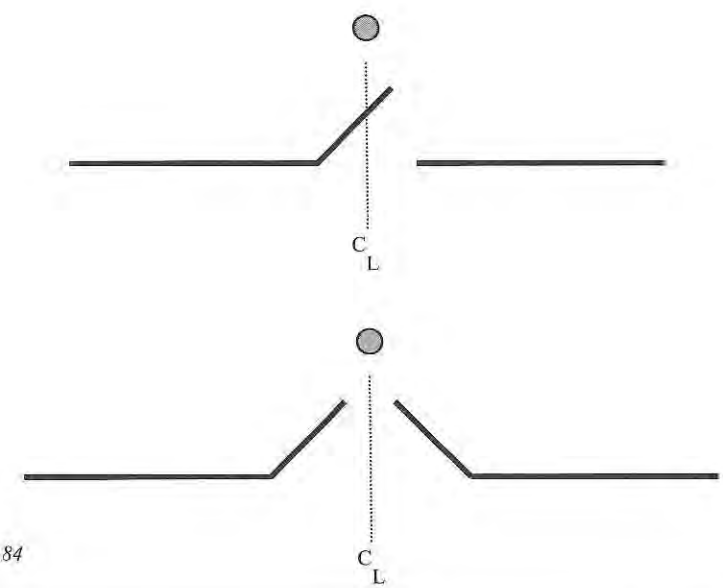
d_1 = more than 24"

sd_1 & sd_2 = d_1 or more,
but less than 5', no less than 12"

Diagram, NTC, d5.83

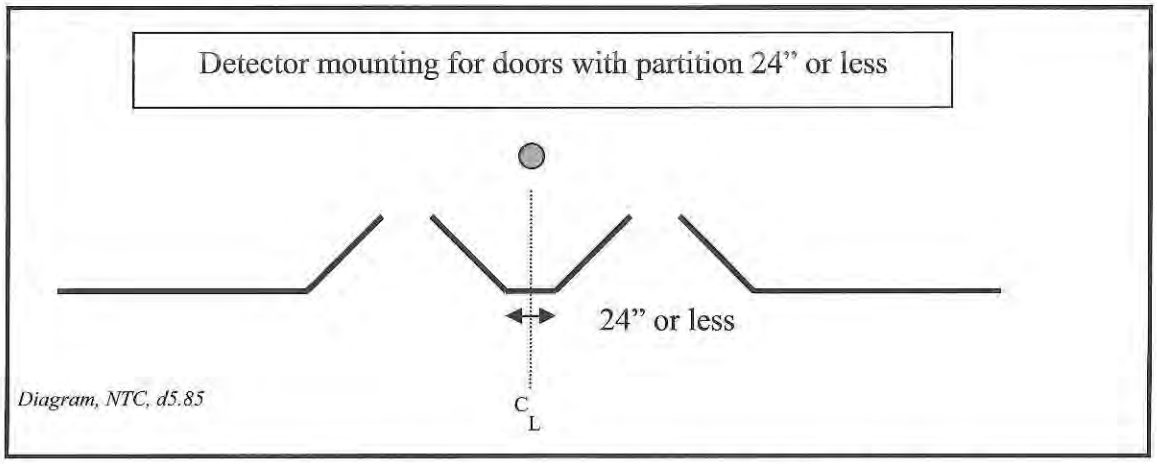
If there are multiple doorways, additional ceiling mounted detectors may be required. The detector must be mounted along the centerline of the doorway in single or two door applications.

Detector mounted along centerline of doorway



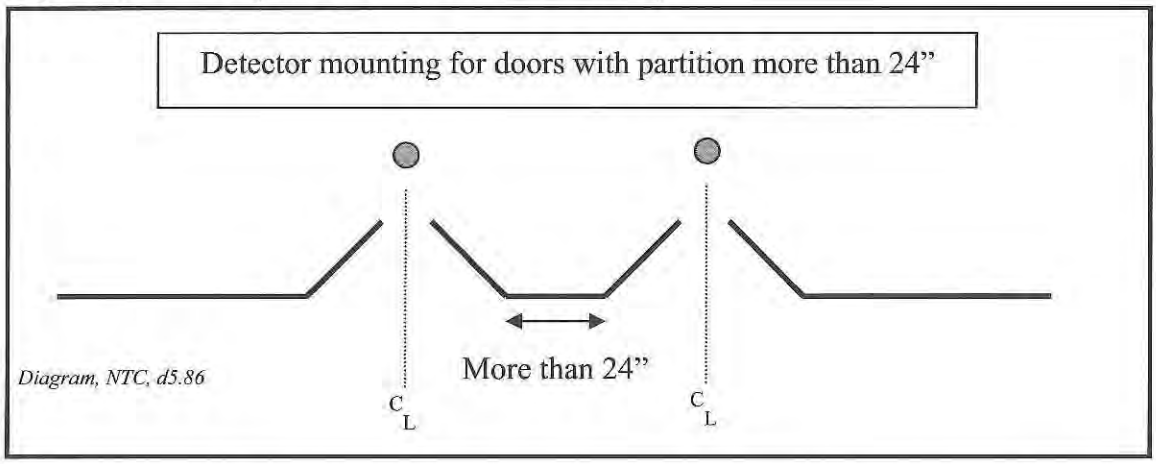
Diagram, NTC, d5.84

If the doors are separated by a partition 24 inches wide or less, the detector must be mounted along the centerline of the partition.



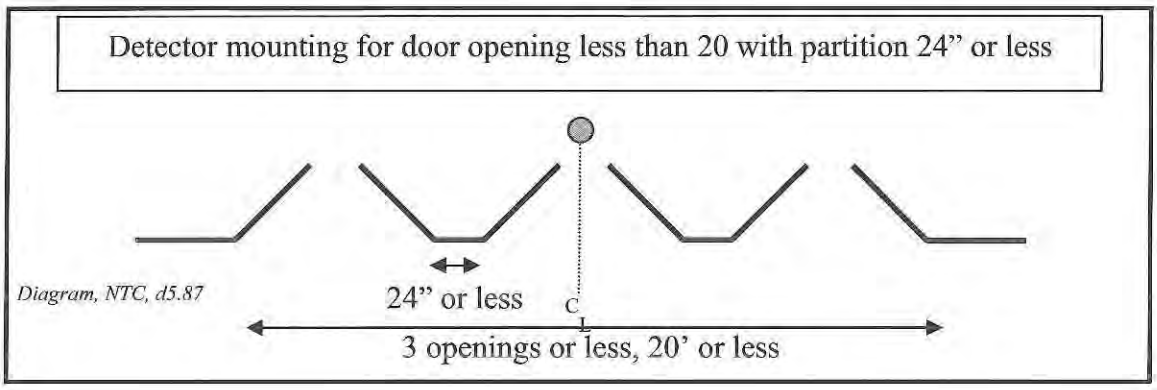
Diagram, NTC, d5.85

If the doors are separated by a partition more than 24 inches wide, two detectors are required, each along the centerline of each doorway.



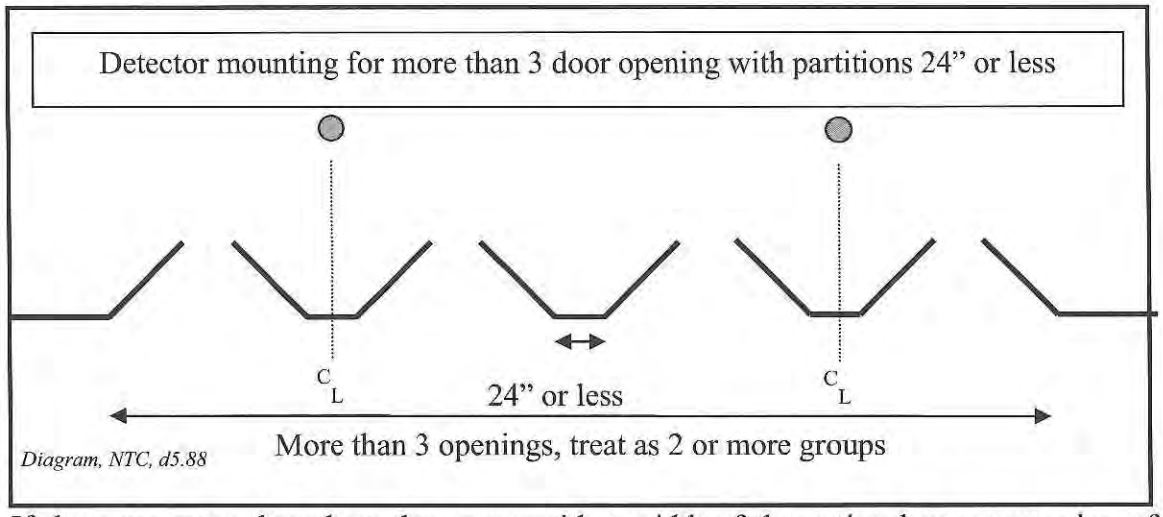
Diagram, NTC, d5.86

Applications with three or more doorways have additional requirements. If there are three doorways, with a width of the entire doorway opening of less than 20 feet, and the doors are separated by a partition 24 inches or less wide, single detection can be used along the centerline of the center opening.



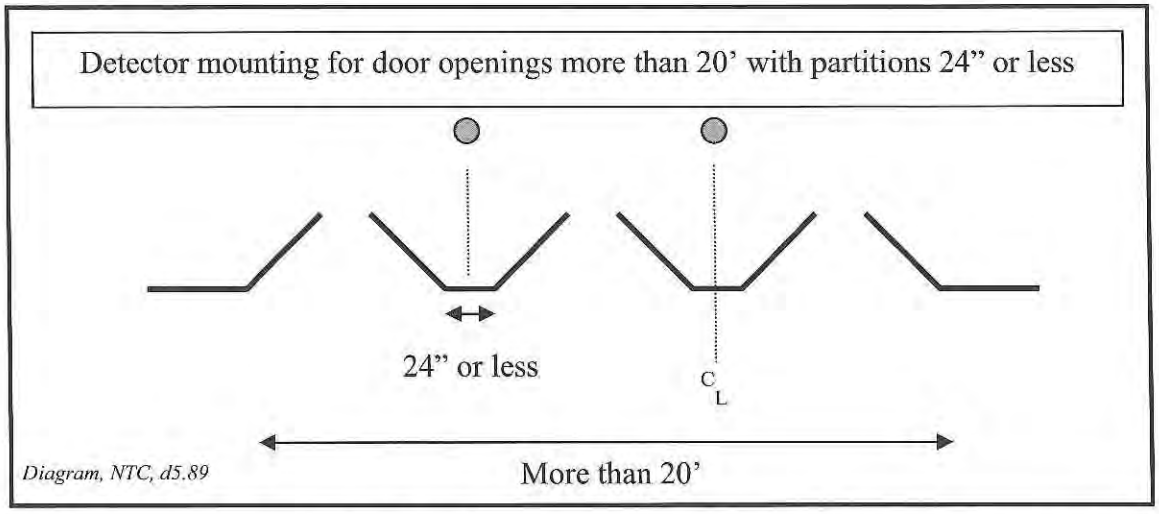
Diagram, NTC, d5.87

If there are more than three doorways, and the doors are separated by partitions of 24 inches or less wide, the doorways must be treated as two or more groups with detectors along the centerline of each partition.



Diagram, NTC, d5.88

If there are more than three doorways, with a width of the entire doorway opening of more than 20 feet and the doors are separated by a partition 24 inches or less wide, detectors are required along the centerline of each partition.



Diagram, NTC, d5.89

If the detector is listed for door frame mounting, or part of a door closer, only one detector is required. If there are multiple doorways, a detector or detector/door closer combination must be used in each single or double doorway.

Photo courtesy of Dorma USA
P5.35

Flame Detector Location and Spacing

The location and spacing of flame detectors and spark/ember detectors is required to be determined by an engineering evaluation. The engineering evaluation should review the following:

1) Size of fire or spark/ember to be detected
2) Fuel involved
3) Detector sensitivity
4) Detector field of view
5) Distance from fire to detector
6) Radiant energy absorption of the atmosphere
7) Possible extraneous sources of radiation (false alarm sources)
8) Purpose of the system
9) Response time required

The protected area must be in the optical detection axis (field of view) of the detector. If the fire to be detected could occur outside the optical axis of the detector the spacing must be reduced and additional detectors must be added. Since flame detectors are line of sight device there must be no obstructions between the detector and the protected area.

If the detection window is prone to get dirty, provisions must be made for keeping the detector's window clean between maintenance intervals. This may be accomplished by using an air purge device or lens clarity monitor.

If the detector is detecting a fuel different from the fuel used to get the device listed or approved, the spacing of the detector must be adjusted based on the fuel specificity of the detector stated by the manufacturer.

Spark and Ember Detector

Spark and ember detector system design must specify the size of spark or ember the system is designed to detect. The detectors must be positioned so that all points in a cross section of the conveyance duct, conveyor, or chute are within the field of view of a detector. The field of view is defined as a solid cone that extends out from the detector in which the effective sensitivity is at least 50% of its on-axis listed or approved sensitivity.

Detector spacing must be adjusted using the inverse square law, with modifications for atmospheric absorption and suspended particles. The inverse square law states the following: double the distance equals 50% of the energy. Every time the distance is doubled from the detector to the spark/ember, the radiant energy the detector is capable of detecting is reduced by 50%.

Detection Technology Considerations

Smoke and heat detector performance can be influenced by environmental factors. These factors, whether manmade or naturally occurring, can cause false alarms or worse, lack of detection. It is up to the fire alarm system designer and installer to judge the environmental factors on a project and recommend the appropriate detector for the application.

Heat Detector Considerations

Fixed temperature heat detectors rated 20° F above the expected maximum ceiling temperature should be used. Rate of rise detectors should not be used in applications where sudden, non-fire related temperature fluctuations are possible (i.e., over an oven, or a door leading to the outside). Heat detectors used outside or in explosive environments should be rated for such use.

Smoke Detector Considerations

Smoke detectors respond more rapidly than heat detectors, but they are also more prone to environmental problems. Factors such as vibration or shock, radiation, RF, bright light, lighting, and static discharge can cause false alarms. Air gusts or excessive air velocity can inhibit detector response. Air velocities above 300 feet per minute, altitudes above 3,000 feet, relative humidity above 93%, temperatures above 100° F and below 32° F, and the color of the smoke may all affect detector response.

Ionization detectors respond quickly to flaming fires (which produce invisible particles of combustion), but they respond equally well to other small particles. Aerosols and other fine particles can be ionized as easily as small smoke particles. Ionization detectors are also adversely affected by high humidity, high altitude, and high air velocity, low and high temperature extremes. Ionization detectors are not affected by the color of the smoke, but are more effective with smaller particles than with larger, more visible particles

Photoelectric spot type detectors respond quickly to smoking fire, where the particles are visible. However, they respond better to white or gray smoke than to black smoke. Black smoke does not scatter light as readily as lighter colored smoke. Photoelectric spot type detectors are sensitive to high humidity and temperature extremes, but are not sensitive to high air velocity or high altitude like ionization detectors.

Beam smoke detectors are adversely affected by high humidity and temperature extremes, but they are not adversely affected by smoke color like spot type (scattering) photoelectric detectors. They are not adversely affect by high air velocity (making them usable in large duct applications) or high altitude.

Air sampling detectors are not affected by air velocity, altitude, or smoke color, but are affected by humidity and temperature extremes.

Compare detector types based on environmental conditions using the following table.

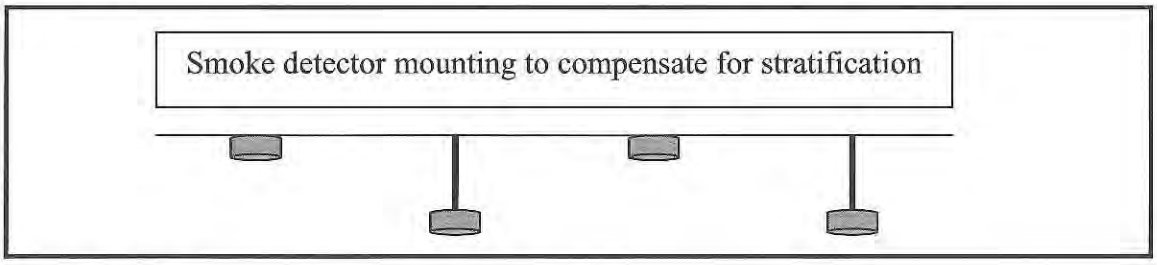
Environmental Conditions Affect on Detector Response

Detector Type	Air Velocity >300 ft/min	Altitude >3,000 ft	Humidity >93% RH	Temperature <32° / >100° F	Smoke Color
Ion	Yes	Yes	Yes	Yes	No
Photo	No	No	Yes	Yes	Yes
Beam	No	No	Yes	Yes	No
Air Sampling	No	No	Yes	Yes	No

Diagram, NTC, d5.90

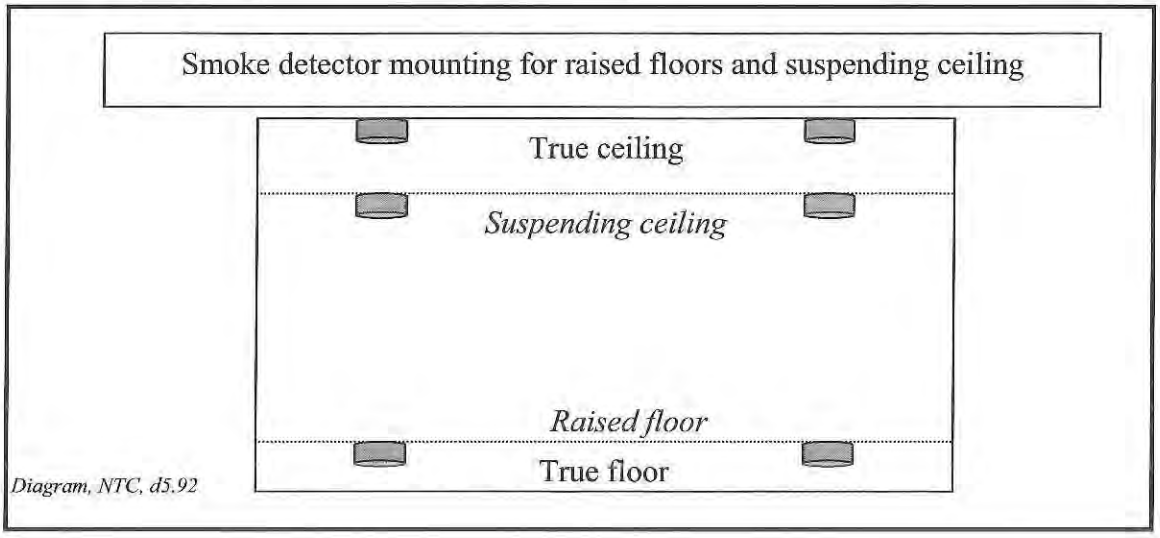
Stratification

Stratification occurs when heated air (smoke) rises and cools to the point of the surrounding air. The air is no longer lighter (less dense) than the surrounding air, so it is no longer able to rise. Stratification can hinder detection of smoke by smoke detectors, if the level of stratification is below the mounting of the detectors. If stratification is a concern, it is recommended to mount detectors at two levels. Mount half on the ceiling, and the other half at least 3 feet below the ceiling. In high ceiling applications, projected beam or air sampling detectors mounted at different levels are suggested.



Diagram, NTC, d5.91

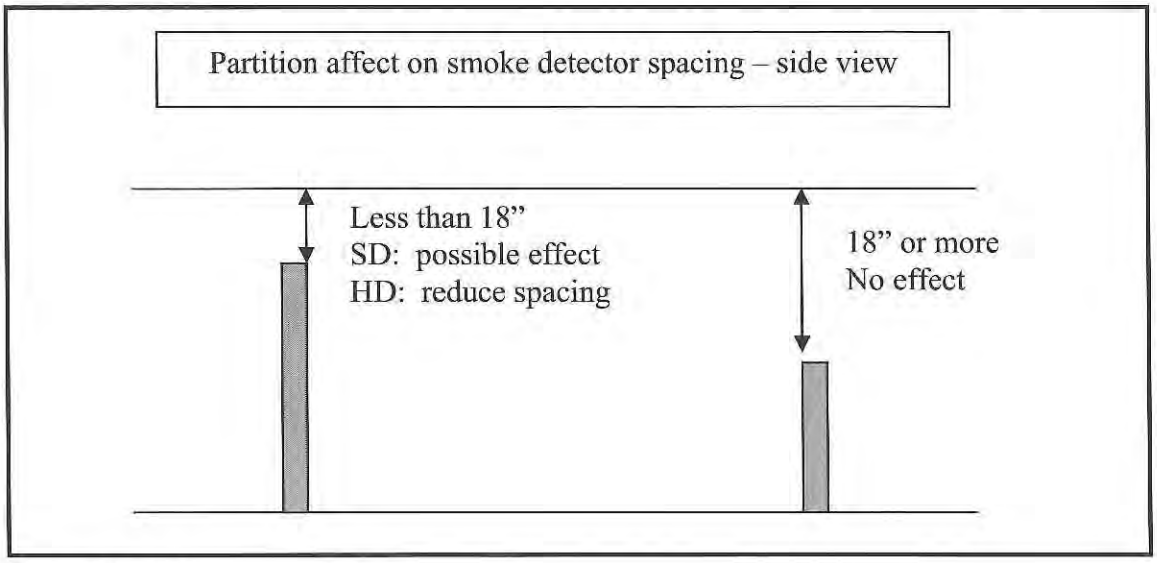
Spaces below raised floors (like computer rooms) and above suspended ceilings must be treated as separate rooms. The normal rules for spacing of detectors apply. The detectors must be mounted securely, and mounted in their normal ceiling or wall mount positions, not in inverted or angular positions. If the spaces are used for environmental air (HVAC), the detectors may need to be rated for high air velocity. In any case, detectors in these spaces are not substitutes for open area smoke detection.



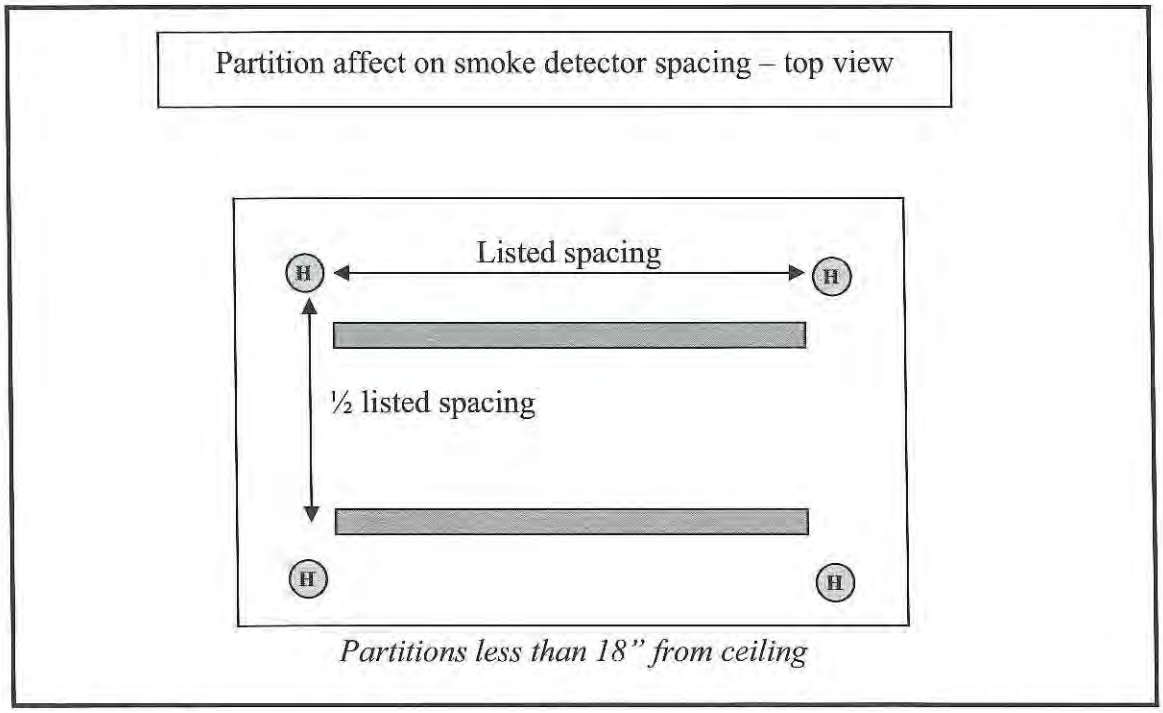
Diagram, NTC, d5.92

Partitions

Partitions that do not extend within 18 inches of the ceiling, do not affect detector spacing. Partitions closer than 18 inches to the ceiling may affect smoke travel and should be evaluated for reducing spacing. Heat detectors must be located within one-half (1/2) of their listed spacing perpendicular to walls or partitions that extend to within 18 inches from the ceiling.



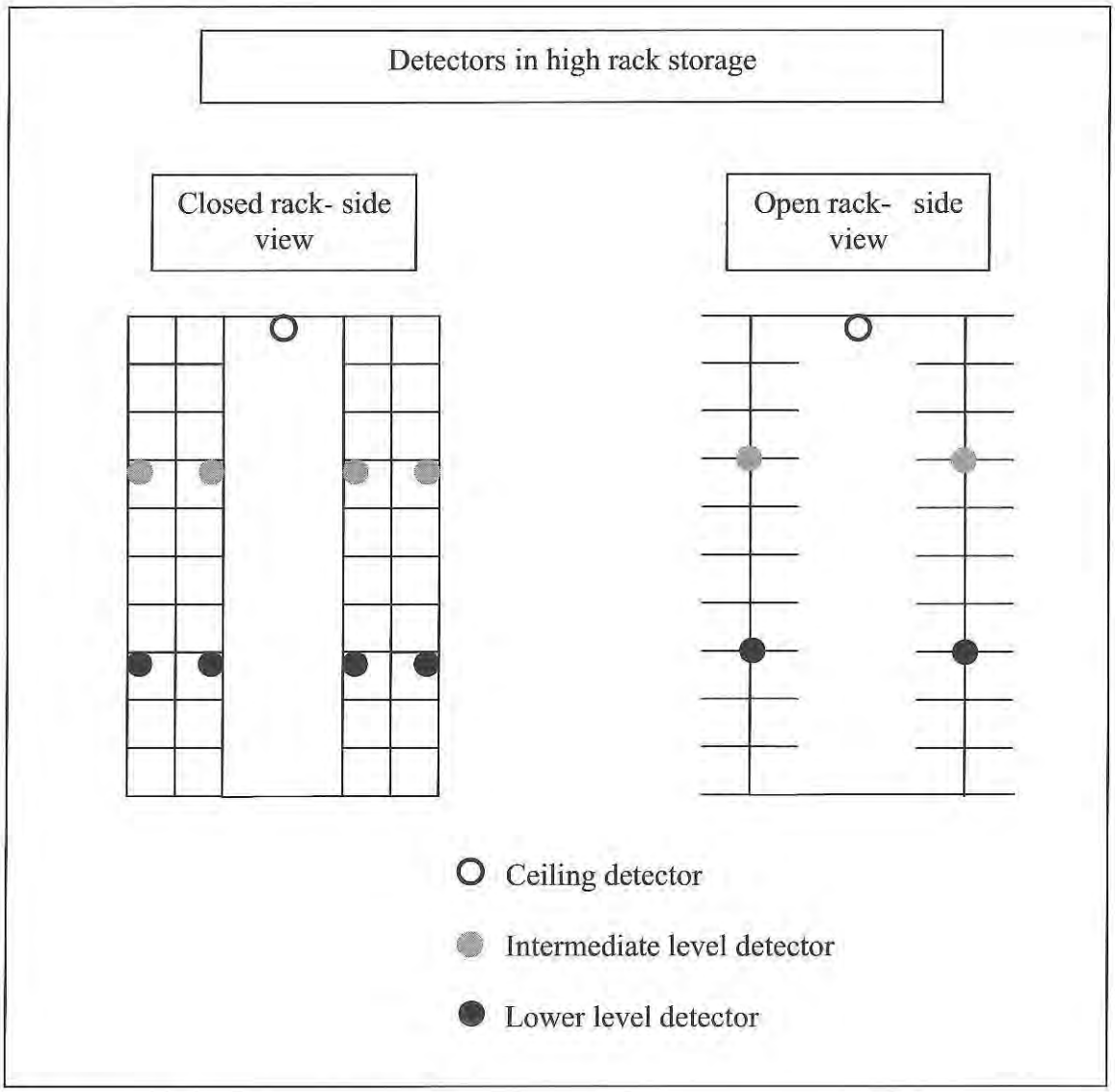
Diagram, NTC, d5.93



Diagram, NTC, d5.94

High Rack Storage

Detectors installed in high rack storage areas must be located on the ceiling and at intermediate levels in the rack. Projected beam or air sampling detectors can be used instead of single rows of spot detectors.



Diagram, NTC, d5.95

Smoke Detectors in High Air Movement Areas

Smoke detectors in high air movement areas need to have their spacing reduced based on the amount of air movement. HVAC mechanical rooms that are used as plenum air spaces are exempt from this spacing reduction.

Detectors should never be installed directly in the air stream of supply or return registers. Areas with more than 7.5 air changes per hour are considered high air movement areas and must have their spacing adjusted accordingly.

Smoke Detector Spacing in High Air Movement Areas

Minutes per Air Change	Air Changes per Hour	Spacing per Detector m^2	ft^2
1	60	11.61	125
2	30	23.23	250
3	20	34.84	375
4	15	46.45	500
5	12	58.06	625
6	10	69.68	750
7	8.6	81.29	875
8	7.5	83.61	900
9	6.7	83.61	900
10	6	83.61	900

Diagram, NTC, d5.96

Sprinkler Supervision and Alarm

If a building has a sprinkler system it may be required to be monitored by the fire alarm system. Sprinkler systems are typically monitored for alarm and supervisory conditions. NFPA 13® and NFPA 101® determine which sprinkler systems require monitoring and the location of supervisory devices for the sprinkler system.

Sprinkler alarm condition is usually initiated by a waterflow device. A waterflow device is attached to the sprinkler riser (main pipe entering the building) and detects when water flows through the pipe (when a sprinkler head has been activated.) Waterflow devices can be installed by the fire alarm contractor; however the drilling of the riser is involved in the installation of such devices. It is recommended to use a sprinkler contractor for this job.

Photo courtesy System Sensor, p5.36

Sprinkler supervisory conditions are usually initiated by sprinkler supervisory devices. These devices monitor control valves, air pressure, water temperature, and room temperature. These devices must annunciate separately at the control panel as a supervisory signal, rather than a trouble signal. Sprinkler alarm and supervisory devices are discussed in more detail in chapter 22 of this book.

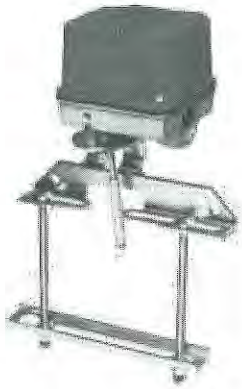


Photo courtesy System Sensor, p5.37

Photo courtesy System Sensor, p5.38

Guard Tour Supervisory Service

Guard service is used in larger applications as a security and fire prevention function. The guard provides a live person to observe the facility, and evaluate, report, and record any situations that may affect the facility's security or fire protection. Guard tour supervisory service is offered by some fire alarm controls as a mean of monitoring and recording the activity of a guard as he makes his rounds.

NFPA 601® Standard for Security Services in Fire Loss Prevention governs the requirements for guard tours and systems. NFPA 72® permits monitoring, recording, and reporting of guard tour activities by the fire alarm. The system monitors the guard's activities to make sure he checks in at all the required stations in the order required and within the time period required.

The reporting stations may standalone, or they may be combined with a manual station. In either case, they must be listed for their intended use. The stations must report back to the control where a permanent record must be kept of the activity.

Intermediate stations that do not transmit a signal must be capable of being operated only in a specific sequence. Signal transmitting stations with distinctive signals must be at the beginning and end of each tour using intermediate stations, with no more than 10 intermediate, non-transmitting stations in between them on the tour.

Exception reporting guard tour systems (suppressed signal systems) must report a start signal to the receiving location at the start and end of every tour. The system must transmit a delinquency signal within 15 minutes of the predetermined activation time for a particular station if the guard fails to operate a station as scheduled. These types of stations are not very common in modern fire alarm systems.

Summary

Understanding initiating device operating principles and applications are critical to the proper design and installation of fire alarm systems. Some of the detection technologies discussed in this chapter are no longer in common use, but they may be encountered in service work.

Ceiling types have a significant effect on detector spacing. It is the duty of the fire alarm system designer and the system installer to make sure the detectors are placed and installed correctly in non-flat ceiling applications. Failure to follow the guidelines set forth by NFPA 72® The National Fire Alarm Code® could result in delayed system response.

Chapter 6

Notification Appliances

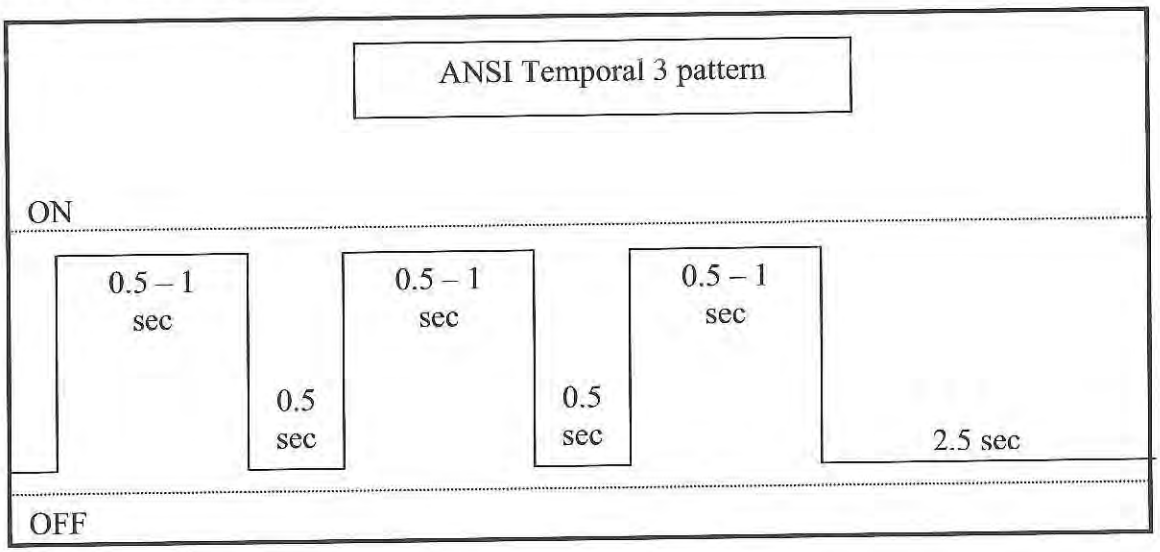
Photo courtesy Edward P6.1

Photos courtesy System Sensor, p6.2

The purpose of fire alarm notification appliances is to initiate evacuation or relocation of building occupants. Notification appliances are also used to alert the building staff so they may initiate the building emergency action plan. There are various types of notification appliances that can be used to achieve this purpose. The appliances fall into two main categories: audible and visual.

Temporal 3 (ANSI S3.41)
Fire alarm audio evacuation signals are required to be distinctive, so that they will not be confused with other sounds or signals that may be generated in an area. The recommended fire evacuation signal is Temporal 3. This consists of a pattern of ½ to 1 second on, ½ second off, ½ to 1 second on, ½ second off, ½ to 1 second on, and then 2 ½ seconds off before the process repeats. NFPA 72®, The National Fire Alarm Code®

refers to this signal as the ANSI S3.41 signal. The American National Standards Institute (ANSI) developed this Temporal 3 pattern for fire alarm system audible notification.



Diagram, NTC, d6.1

Types of Audible Notification Appliances

Bells

Bells generate sounds by striking a gong with a hammer. Vibrating bells are most common (sound continuously when power is applied). Single stroke bells, which sound once each time power is applied, are used in special applications.

Photo courtesy Potter, p6.3

Horns

Horns generate a buzz or electronic tone when power is applied. Horns are the most popular form of audible notification appliance due to low current requirements and competitive pricing. Most modern horns are electronic, and some are capable of

generating different tones (based on programming or switch settings). Some vendors still offer mechanical type horns.

Photo courtesy Edwards, p6.4

Chimes

Chimes generate a "soft", pleasant tone similar to a door bell chime. Chimes are generally used in applications where harsher tones like bells or horns would cause panic. Hospitals and mental health facilities often use chimes for evacuation signals.

Photo courtesy System Sensor, p6.5

Speakers

Speakers reproduce tones and voice signals from an amplifier. They can reproduce electronic tones and electronic voice evacuation instructions, or live instructions from a voice evacuation amplifier. Voice evacuation systems are discussed in more detail later in this chapter.

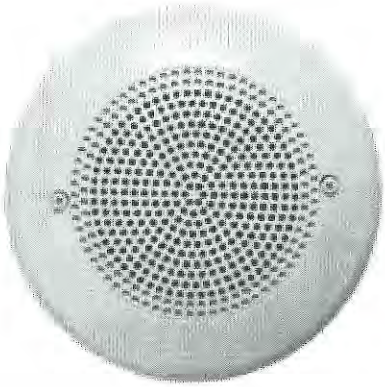


Photo courtesy System Sensor, p6.6

Photo courtesy System Sensor, p6..7

Types of Visible Notification Appliances

Strobes

Strobes serve as a visual means of notification. They flash regularly to draw attention to themselves and are usually labeled as fire alarm signals. They may be used by themselves or integrated with a horn, chime, or speaker.

Photo courtesy System Sensor, p6.8

Lamps and Beacons

Lamps provide a steady light indication; beacons provide a flashing or rotating light indication. Lamps and beacons are not required by NFPA 72®, but are sometimes used as auxiliary signaling device on the fire alarm system. They may be powered by the fire alarm notification circuit directly, or driven by an auxiliary power supply or circuit.

Photo courtesey Edwards, p6.9

Notification Appliance Requirements

Notification appliances are required to list their electrical requirements and audible and/or visual performance on their nameplate.

Photo courtesy System Sensor, p6.10

Appliances intended for special applications (outdoor, high or low temperature, hazardous locations) must be listed for their intended use.

Photo courtesy Edwards, p6.11

Photo courtesy Edwards, p6.12

Appliances subject to mechanical damage must be protected. If a guard or cover is used, it must be listed for use with the appliance.

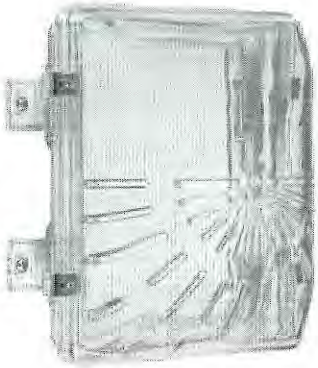
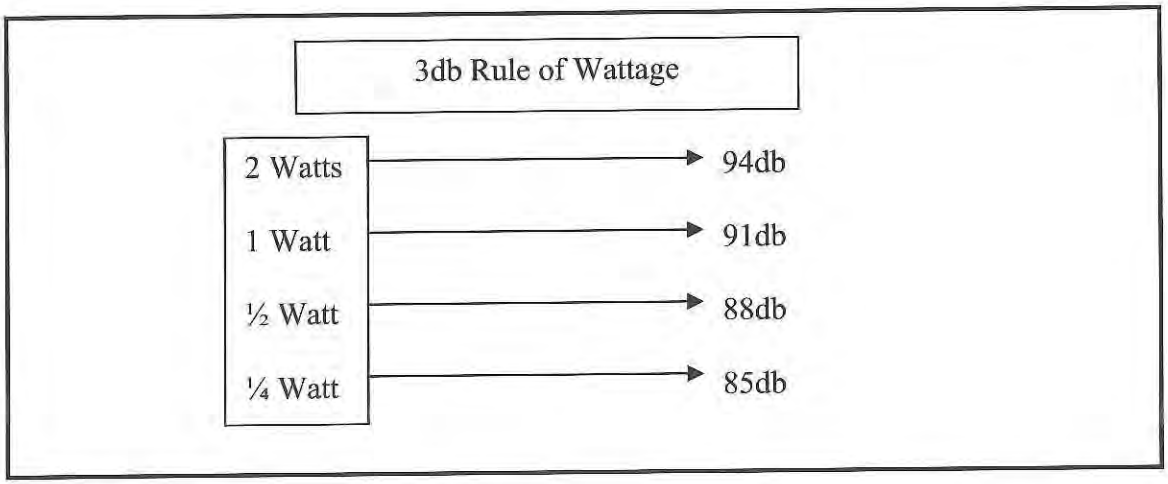


Photo courtesy STI, p6.13

3db Rule of Wattage

Every time the power (wattage) is doubled, the sound level will increase 3db. Inversely every time the power is cut in half the sound level will decrease by 3db.



Diagram, NTC, d6.2

Decibels

Average (ambient) sound levels and signal sound output levels are expressed in decibels (dB). A decibel is a measure of sound pressure level, or loudness. Decibels are expressed on logarithmic scale, so the progression is not linear.

Average Ambient Sound Levels for Guidance Purposes

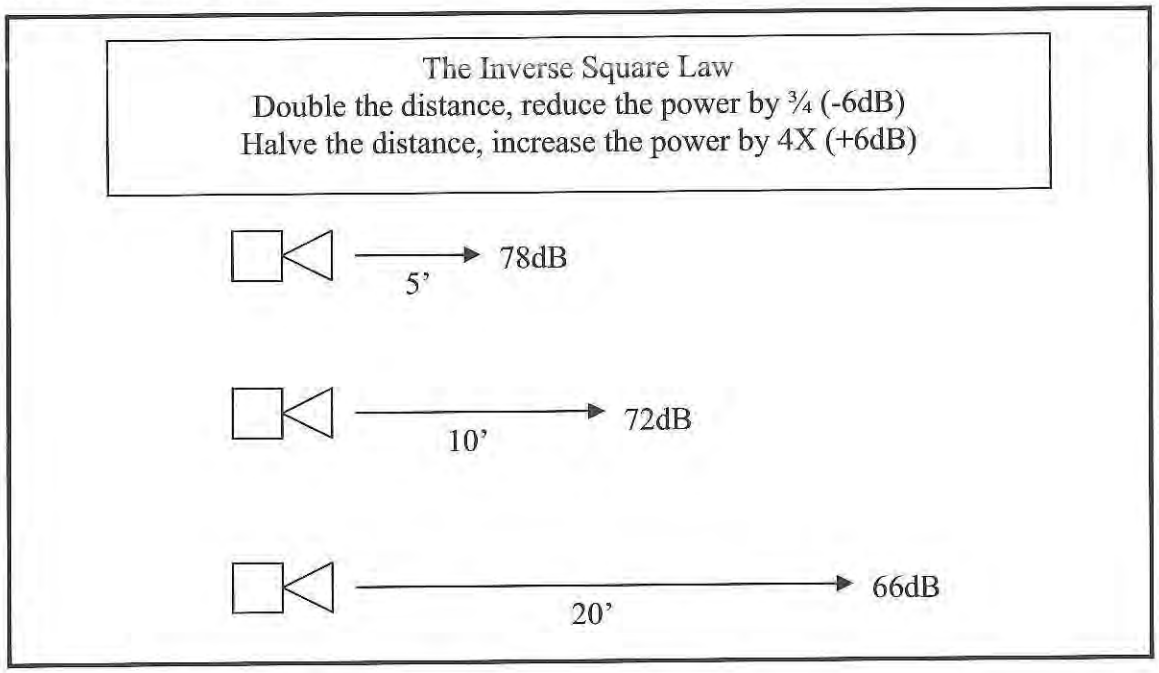
Location	Average Ambient Sound
Business Occupancy	55
Educational Occupancy	45
Industrial Occupancy	80
Institutional Occupancy	50
Mercantile Occupancy	40
Mechanical Rooms	85
Piers (bldgs near water)	40
Assembly Occupancy	55
Residential Occupancy	35
Storage Occupancy	30
Thoroughfares, Urban	70
Thoroughfares, Med Density	55
Thoroughfares, Rural	40
Tower Occupancy	35
Underground / Windowless bldg	40
Vehicles and Vessels	50

Diagram, NTC, d6.3

6db Rule of Distance

Sound level decreases (dB) as it travels. This loss is expressed as the inverse square law. Power loss (or gain) is inversely proportional to the square of the loss (or gain) in distance. When the distance from an audible device is doubled, the sound level

decreases by 6db. When the distance from an audible device is cut in half, the sound level increases by 6db.



Diagram, NTC, d6.4

Fire alarm audibility requirements are measured and expressed in the A-weighted scale. The A-weighted scale generally limits the sensitivity of the dB meter to sounds perceptible to human hearing; sounds in the 600Hz to 7,000Hz range.

Public vs. Private Mode

Public mode signals are intended to alert all building occupants that the fire alarm system has been activated and the building must be evacuated. Horns and strobes in public areas and voice evacuation systems are examples of public mode signaling applications.

Private mode signals are intended to alert only those people who are responsible for initiating evacuation and relocation during a fire alarm. Private mode signaling is used in applications where alerting the entire building population that there is a possible fire (i.e., hospitals, or prisons) is not desirable.

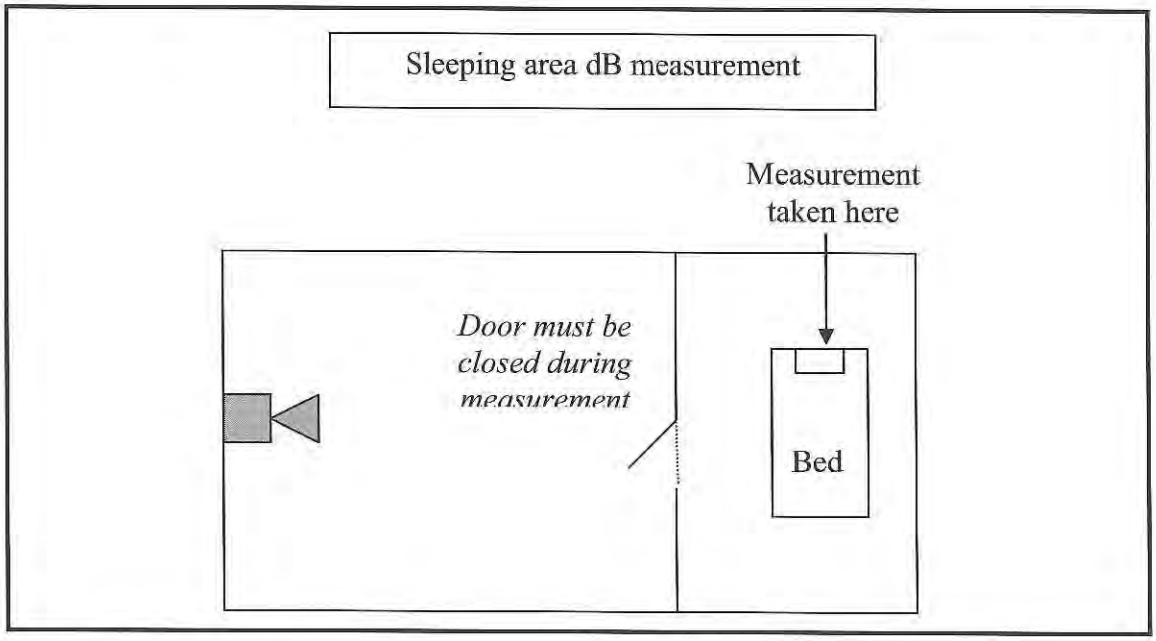
Private mode signals require lower levels of audibility and light intensity since they are not required for the general public. Positive alarm sequence and pre-signal systems are examples of private mode signaling applications.

Public Mode Audible Levels

Public mode audibles must have a sound level of at least 15dB (decibels) above the average ambient sound level, or 5dB above the maximum sound level having a duration of at least 60 seconds (whichever is greater) as measured 5 feet above the floor.

Private Mode Audible Levels
Private mode audibles must have a sound level of at least 45dBA at 10 feet. They must be at least 10dB above the average ambient sound level, or 5dB above the maximum sound level having a duration of at least 60 seconds (whichever is greater) as measured 5 feet above the floor.

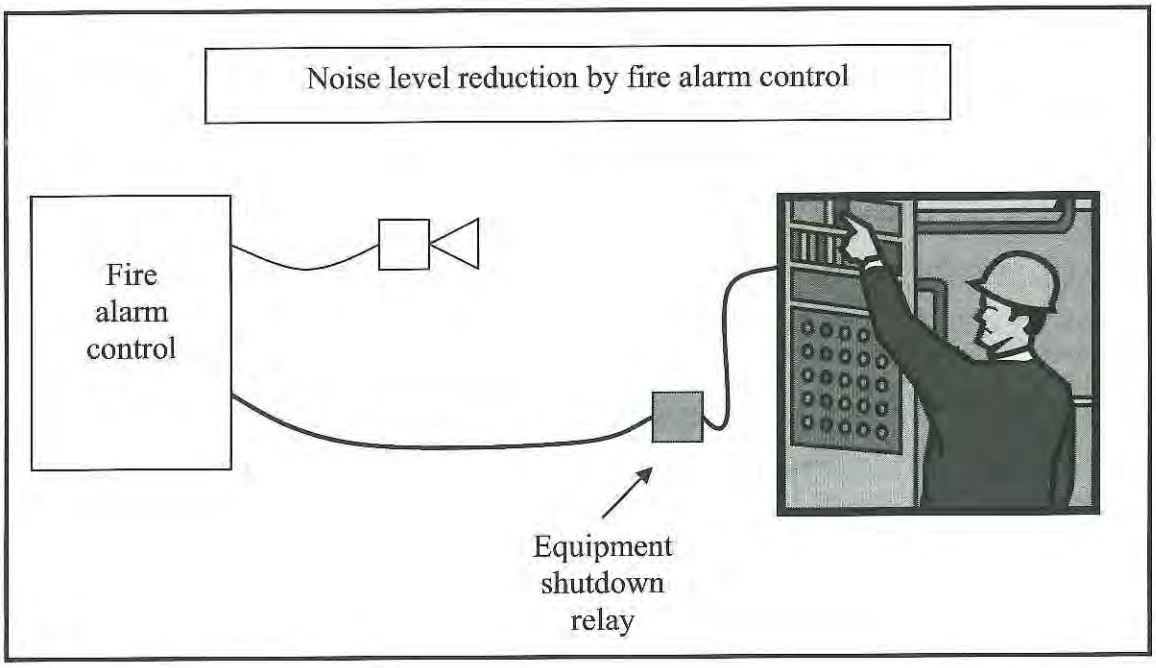
Sleeping Areas
Sleeping area audible level requirements are similar to those of public mode audibles. They must have a sound level of at least 15dB (decibels) above the average ambient sound level, or 5dB above the maximum sound level having a duration of at least 60 seconds or a sound level of at least 75dB, whichever is greater. The measurement must be taken with any barriers (curtain, door, etc) between the signal and the bed in place, and the measurement must be taken at the pillow.



Diagram, NTC, d6.5

Maximum Sound Level
The maximum sound level for fire alarm audibles is 120dbA. This requirement is in place because sound levels greater than 120dbA can cause physical damage to human beings.

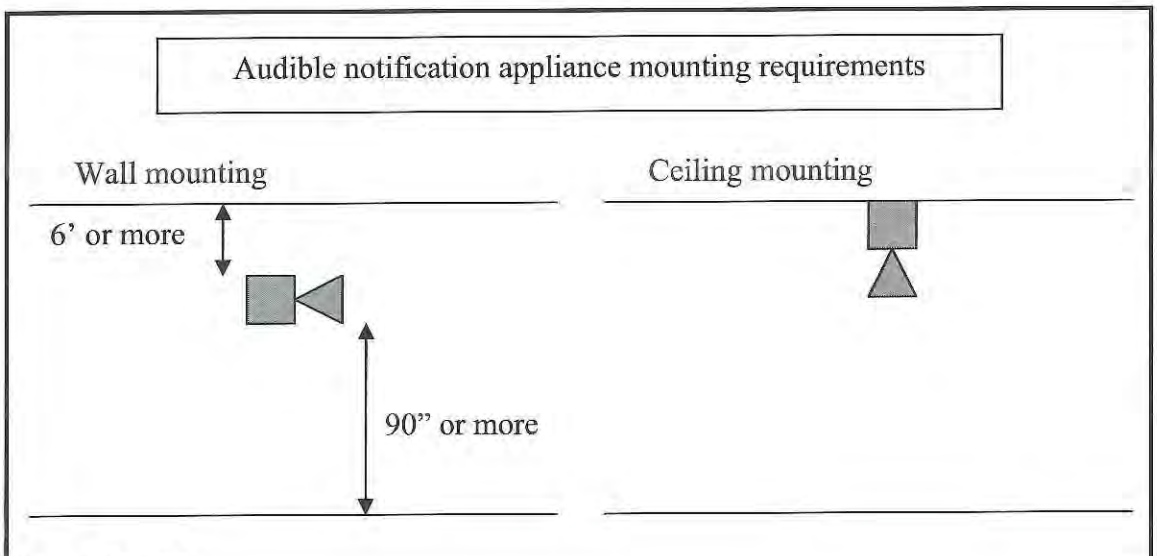
High Noise Areas
Areas with ambient sound levels more than 105dBA require a visual appliance in addition to the audible device. The maximum sound pressure level cannot exceed 120dBA anywhere in the occupied area. If acceptable to the AHJ, the fire alarm system can be used to stop or reduce the ambient noise level to reduce the number or sound level of the signals required. This is helpful in factory applications where the noise level from machinery pushes the ambient sound levels up.



Diagram, NTC, d6.6

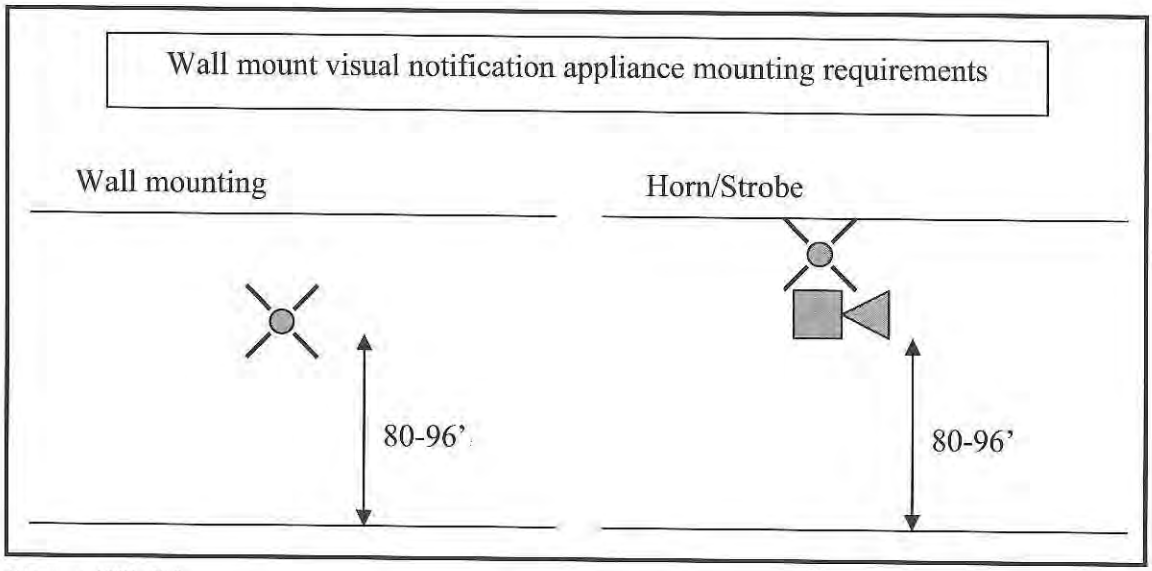
Elevators and Restrooms.
Since elevators and restroom areas are small and generally quiet in nature, private mode audible appliances are permitted.

Location and Mounting.
Wall mounted audibles must be mounted with the top of the device 90 inches or more above the floor, and 6 inches or more below the ceiling. Ceiling mounting is also permitted. The 6 inches below the ceiling takes precedence.



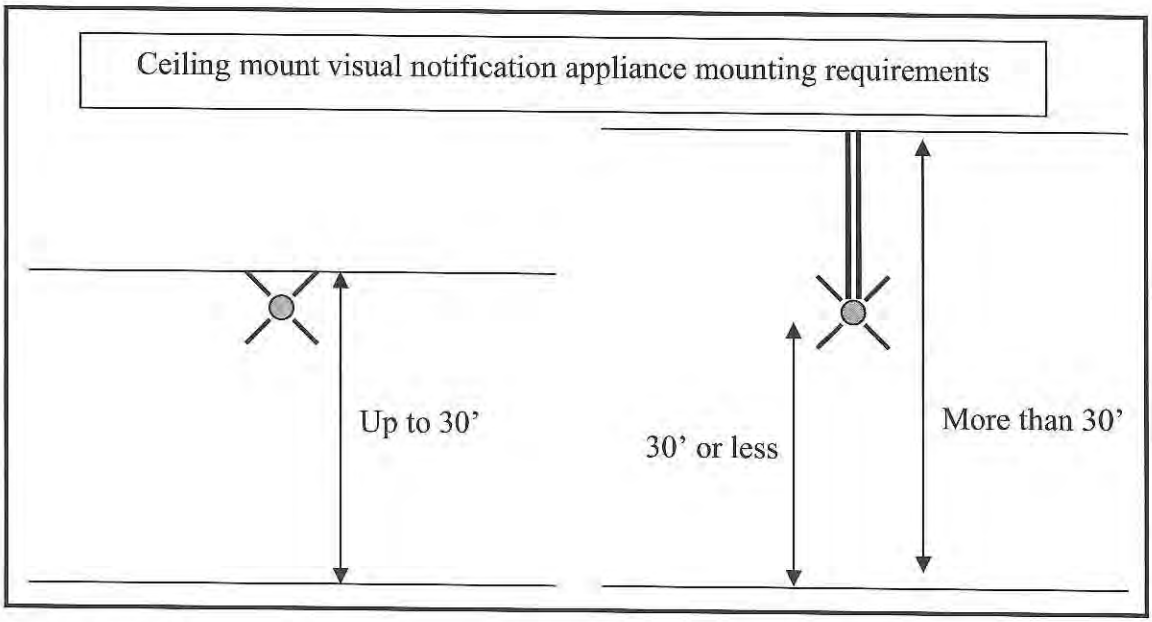
Diagram, NTC, d6.7

Wall mounted strobes must be located such that the entire lens is between 80 and 96 inches above the floor. Combination horn/strobe, chime/strobe, or speaker/strobe must be mounted to meet the strobe height requirement.



Diagram, NTC, d6.8

Ceiling mounting is also permitted, but they cannot be mounted any higher than 30 feet. If the ceiling is higher than 30 feet, the signals must be suspended at or below 30 feet.



Diagram, NTC, d6.9

Strobes are required to flash at least 1 time per second and not more than 2 times per second. Strobes are rated in intensity (brightness) stated in candelas (cd). The intensity required for strobes used in public mode is dependant upon the size of the area being signaled and the quantity of strobes being used. NFPA 72® determines the candela rating required based on the following tables.

Room Spacing for Wall Mounted Visual Appliances

Maximum Room Size		Minimum Required Light Output (Effective intensity, cd)		
m	ft	One Light per Room	Two Lights Per Room (opposite walls)	Four Lights per Room (one per wall)
6.10 x 6.10	20 x 20	15	NA	NA
8.53 x 8.53	28 x 28	30	Unknown	Unknown
9.14 x 9.14	30 x 30	34	15	NA
12.2 x 12.2	40 x 40	60	30	15
13.7 x 13.7	45 x 45	75	Unknown	Unknown
15.2 x 15.2	50 x 50	94	60	30
16.5 X 16.5	54 x 54	110	Unknown	Unknown
18.3 x 18.3	60 x 60	135	95	30
21.3 x 21.3	70 x 70	184	95	60
24.4 x 24.4	80 x 80	240	135	60
27.4 x 27.4	90 x 90	304	185	95
30.5 x 30.5	100 x 100	375	240	95
33.5 x 33.5	110 x 110	455	240	135
36.6 x 36.6	120 x 120	540	305	135
39.6 x 39.6	130 x 130	635	375	185

Diagram, NTC, d6.10

Room Spacing for Ceiling Mounted Visual Appliances

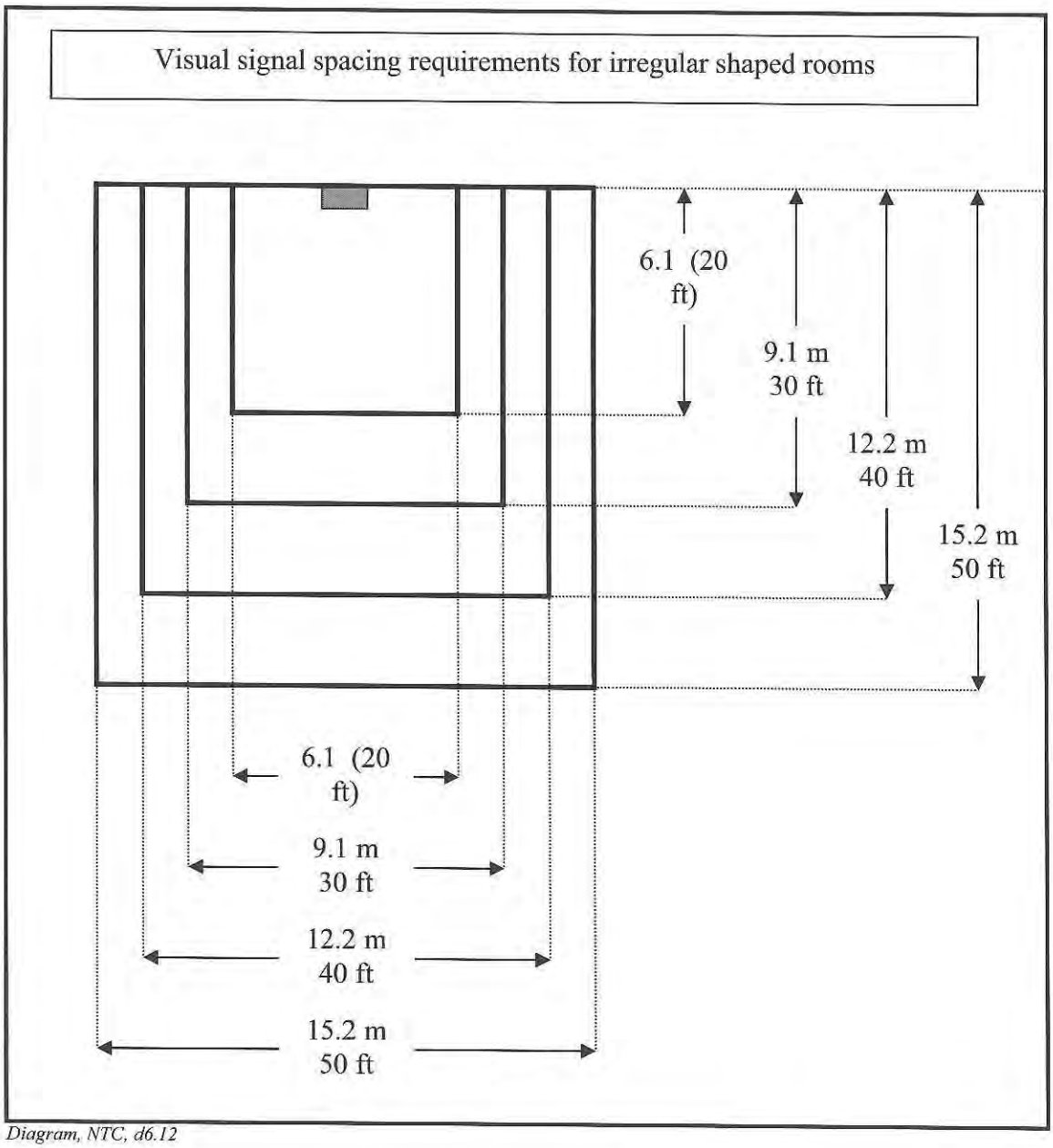
Maximum Room Size		Maximum Ceiling Height		Maximum required Light Output (effective intensity); one light (cd)
m	ft	m	ft	
6.10 x 6.10	20 x 20	3.05	10	15
9.14 x 9.14	30 x 30	3.05	10	30
12.2 x 12.2	40 x 40	3.05	10	60
15.2 x 15.2	50 x 50	3.05	10	95
6.10 x 6.10	20 x 20	6.1	20	30
9.14 x 9.14	30 x 30	6.1	20	45
12.2 x 12.2	40 x 40	6.1	20	80
15.2 x 15.2	50 x 50	6.1	20	115
6.10 x 6.10	20 x 20	9.14	30	55
9.14 x 9.14	30 x 30	9.14	30	75
12.2 x 12.2	40 x 40	9.14	30	115
15.2 x 15.2	50 x 50	9.14	30	150

Diagram, NTC, d6.11

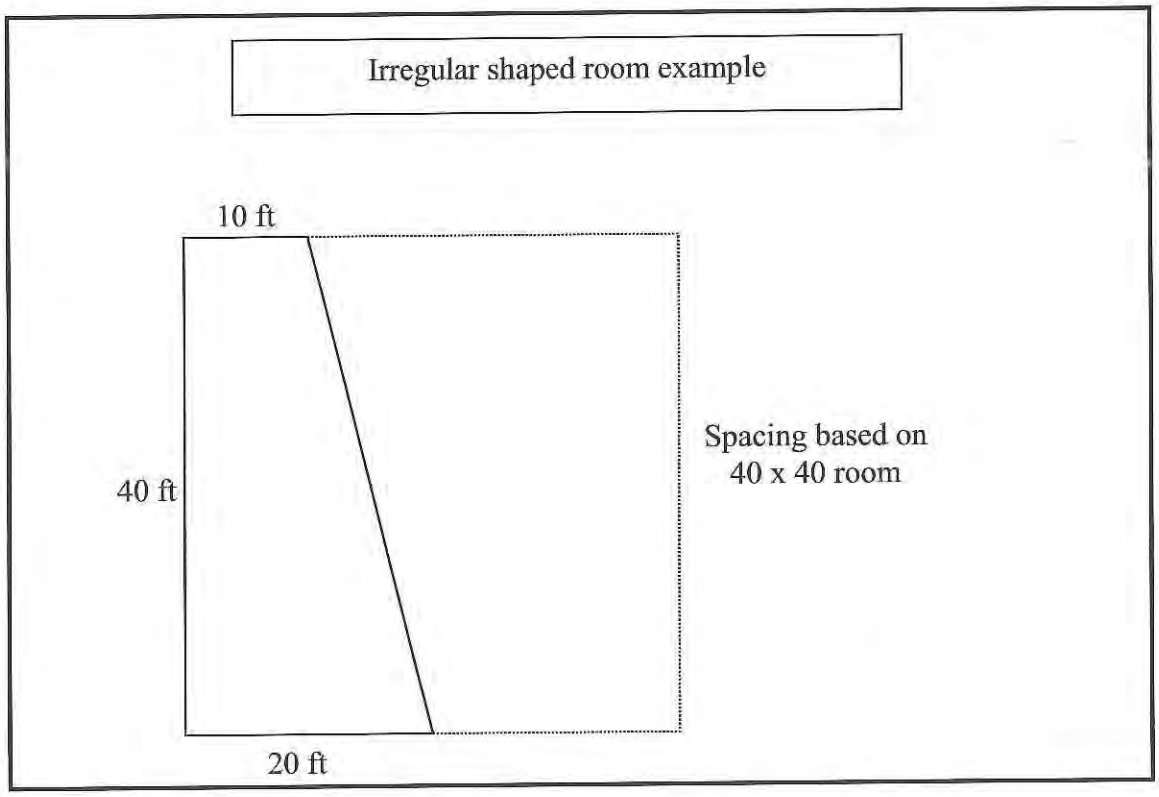
The tables in NFPA 72® are based on the strobe being mounted at the halfway point on the wall. If the strobe is not centered, or the room is not square, the required intensity must be determined by the maximum room size dimensions. These dimensions are determined by measuring the distance to the farthest wall, or doubling the distance to the farthest adjacent wall, which ever is greater.

Synchronization

When more than 2 strobes are located in any field of view the strobes are required to be synchronized. As a general industry practice, any strobes in the same field of view are synchronized.

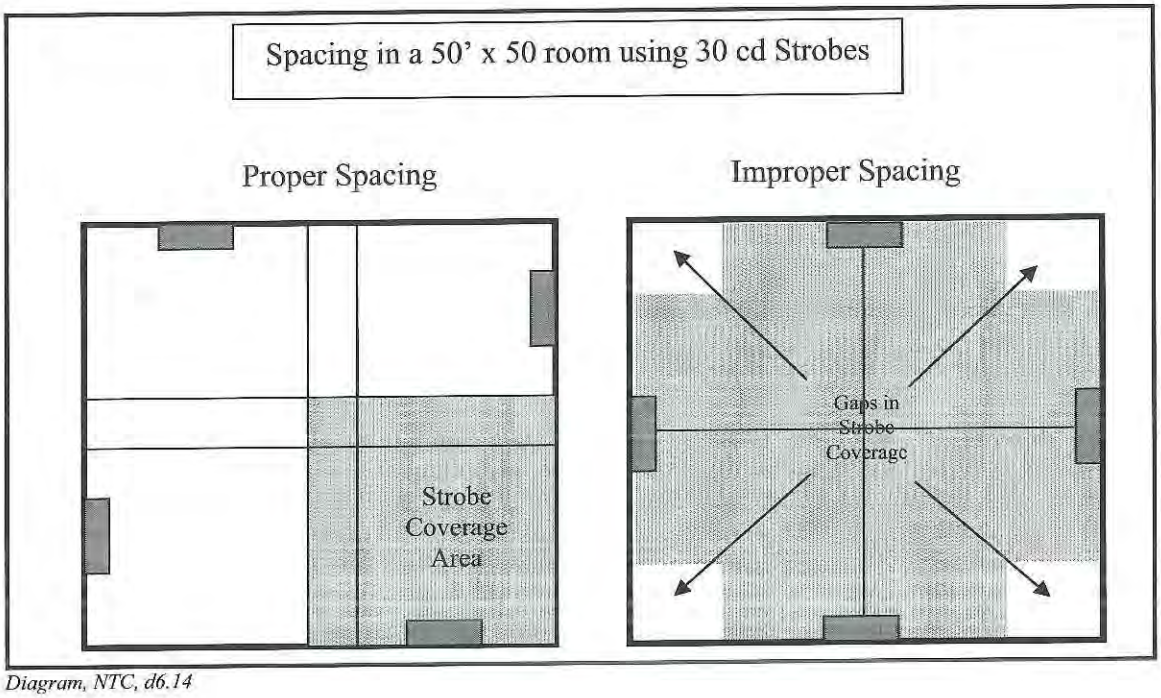


Diagram, NTC, d6.12



Diagram, NTC, d6.13

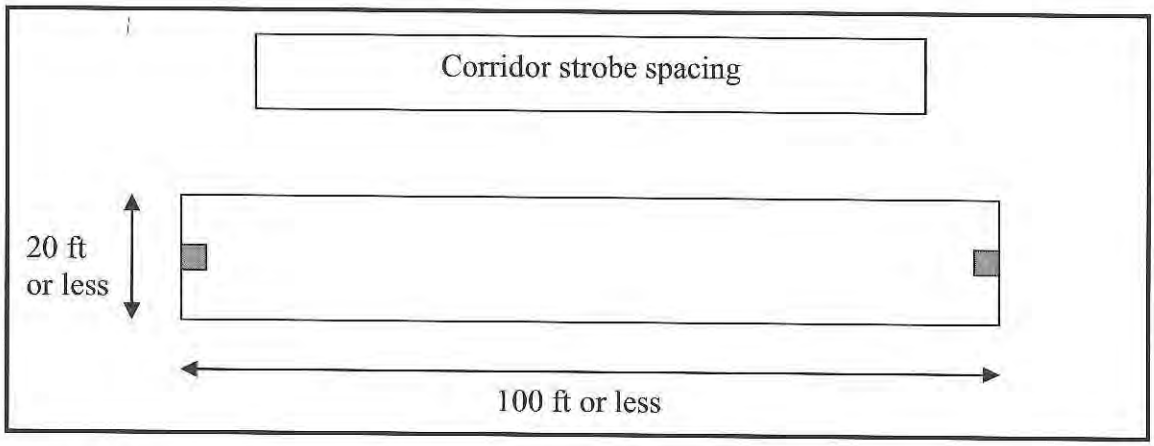
Areas exceeding the maximum room size on the charts, or requiring extremely high power strobe lights, may be broken into multiple squares to determine strobe requirements and placement. The strobes must be located in the center of the individual square they are covering, otherwise there will be gaps in coverage.



Diagram, NTC, d6.14

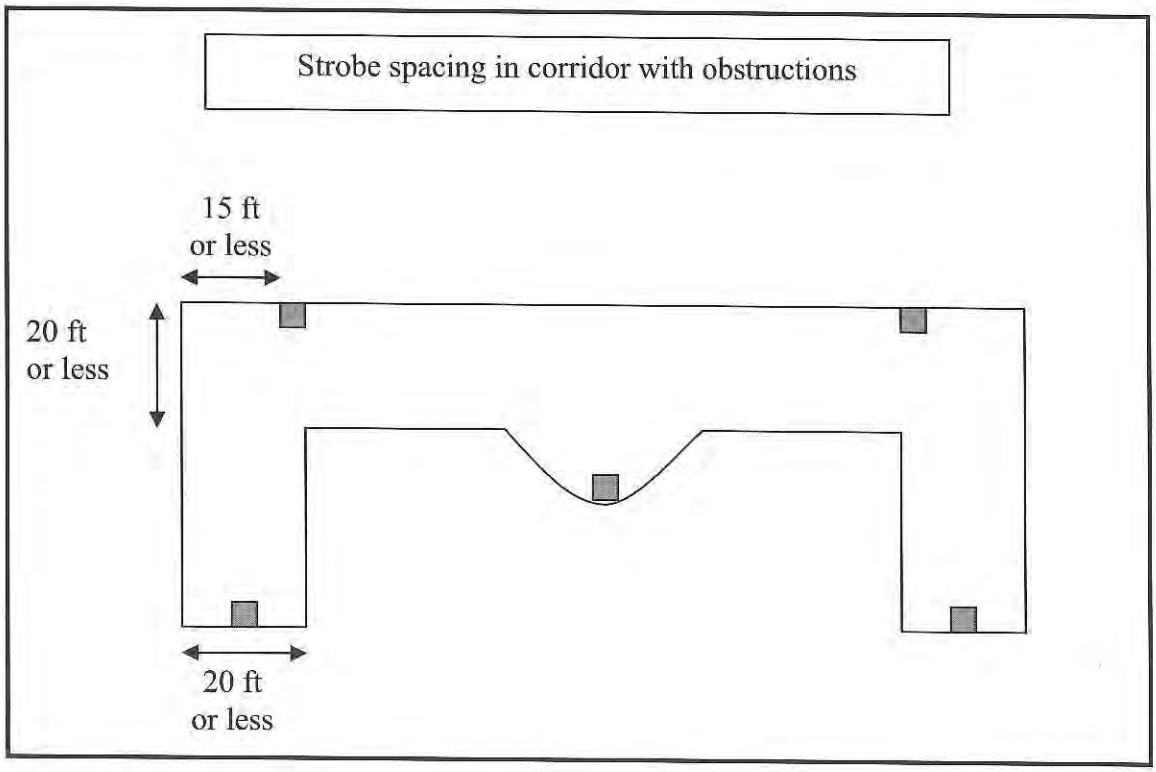
Corridors

Corridors 20 feet wide or less have special spacing requirements. Strobes can be 15cd, no more than 100 feet apart, and no more than 15 feet from the end of the corridor. The strobes can be mounted on either side of the corridor.



Diagram, NTC, d6.15

Any changes in elevation, or obstructions of view require the area to be treated as a separate corridor.

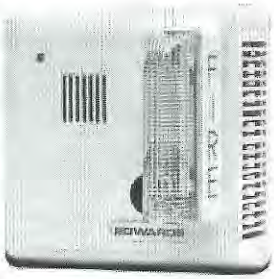


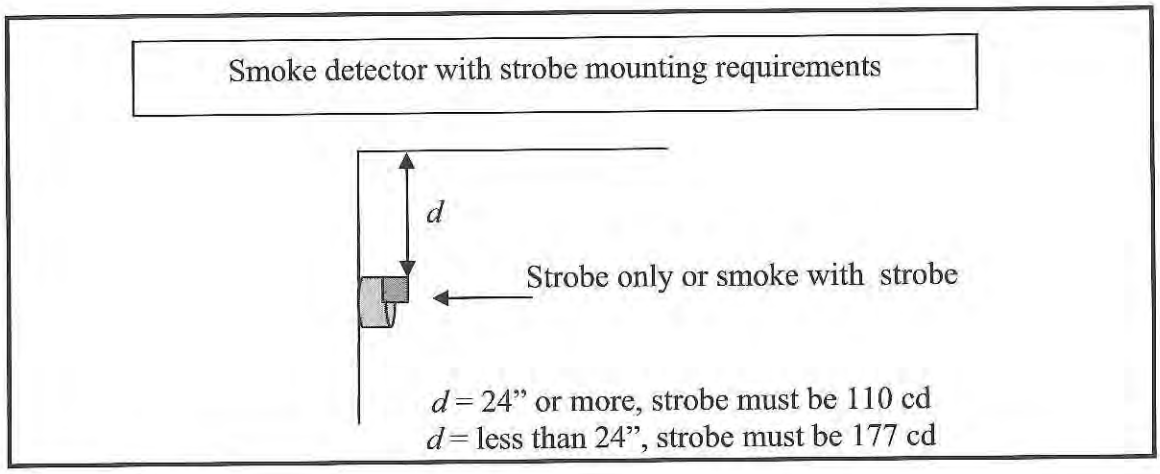
Diagram, NTC, d6.16

Sleeping Areas

NFPA 72® does not specifically require visual signals in sleeping areas, but does have specific requirements if they are used. Combination smoke detectors/alarms and visual signals are sometimes used to meet ADA requirements. The detector itself must be installed according to the smoke detector installation requirements of NFPA 72®. The intensity of the strobe light required depends upon how far down the lens of the strobe is from the ceiling (measured to the top of the lens).

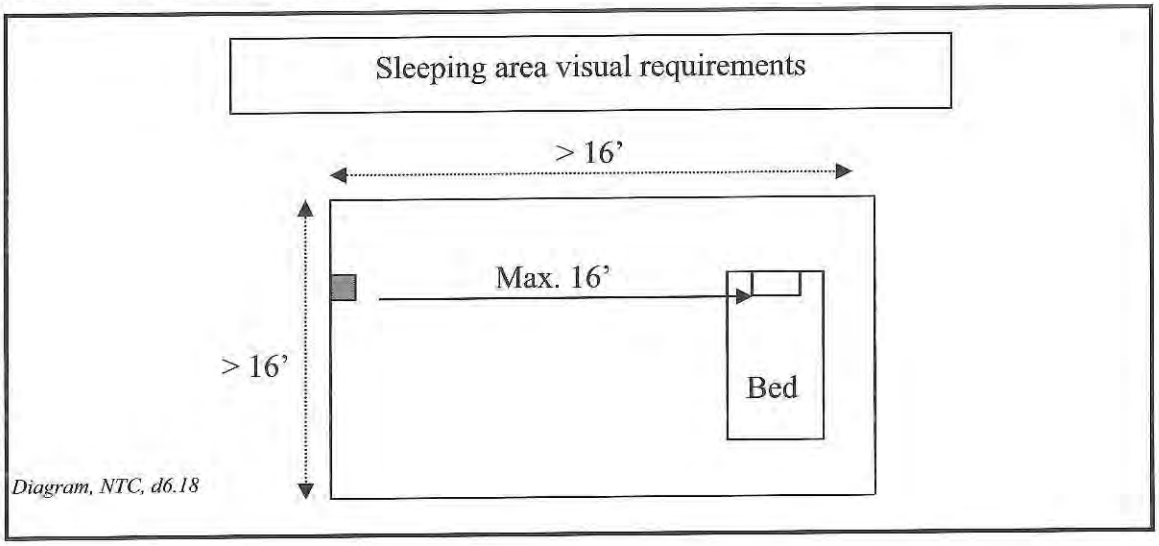
Photo courtesy Edwards, p6.14





Diagram, NTC, d6.17

Additionally, rooms greater than 16 feet in any dimension require a visual signal to be within 16 feet of the pillow.



Diagram, NTC, d6.18

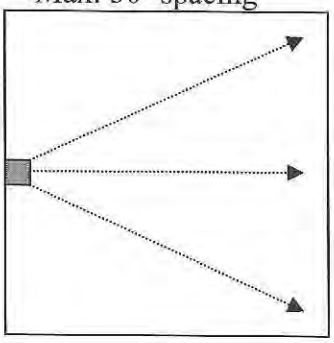
The Americans With Disabilities Act (ADA)
In 1990, the federal government passed the Americans with Disabilities Act. This law was passed to require easier access for handicapped individuals. The bulk of the law covers structural requirements of a building to make them more handicap friendly (wheelchair ramps, wide bathroom stalls, etc). A small part of the law covers audible and visual requirements for fire alarm systems.

The requirements of the law differ slightly from the requirements of NFPA 72®. Specifically, they require a minimum strobe intensity of 75 candela, that they be wall mounted only, and no more than 50 feet line of sight from anywhere in a normally occupied area to a strobe light. NFPA 72® requires strobes to be anywhere from 15 candela upward, depending upon the room size, allows strobes to be mounted on the wall or the ceiling, and allows strobes to be up to 100 feet apart. Fortunately, ADA allows "equivalent facilitation." Equivalent facilitation allows the intent of the ADA to be met by other equal or superior designs.

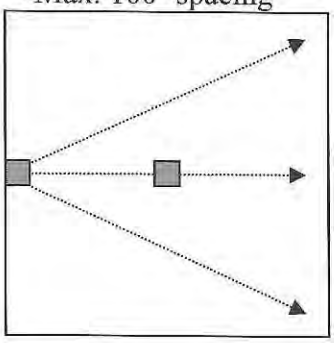
Diagram, NTC, d6.19

ADA vs. NFPA 72

ADA
-Minimum 75 cd
-Wall mount only
-Max. 50' spacing



NFPA 72®
-Minimum 15 cd
-Wall or ceiling mount only
-Max. 100' spacing



The ADA is a federal law, so it is typically not enforced by the local AHJ (although some areas have adopted it as a requirement). It is enforced by the US Department of Justice. More information on ADA requirements can be obtained from the following vendors websites, or from the Department of Justice.

System Sensor
800-736-7672
www.SystemSensor.com

Gentex
800-436-8391
www.Gentex.com

U.S. Department of Justice
ADA Laws (Title III, 28 CFR part 36)
800-514-0301
www.usdoj.gov/crt/ada

Notification Appliance Power

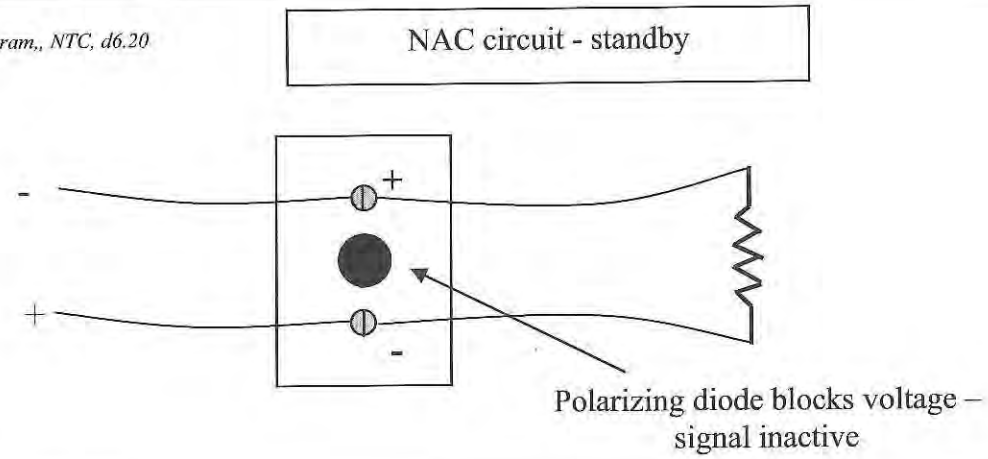
Fire alarm panels are capable of producing two types of power for notification appliances: regulated (DC) and unregulated (FWR). Regulated power supplies provide filtered and regulated DC power. Regulated power is compatible with all notification devices of the same operating voltage. Unregulated power provides rectified DC power that is not as clean as DC; it has spikes and peak voltages. Unregulated power is only compatible with notification appliances which are listed to work with unregulated power.

Notification Appliance Supervision

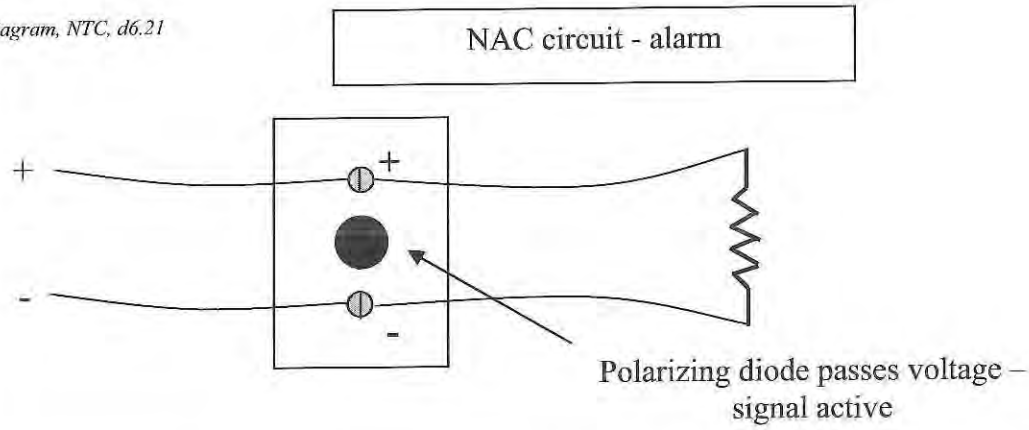
In the non-alarm condition, the fire alarm control panel puts out supervisory voltage in the opposite polarity of the operating voltage of the notification appliances. Notification devices have a polarizing diode that blocks this supervisory voltage from reaching the notification appliance. Since the load of the signal appliances is blocked, the panel only sees the end of line resistor.

In alarm condition, the fire alarm control panel reverses polarity to the operating polarity. The voltage is no longer blocked by the diode, and the signal sounds. Since electricity takes the path of least resistance, the EOLR is no longer a factor in the circuit.

Diagram,, NTC, d6.20



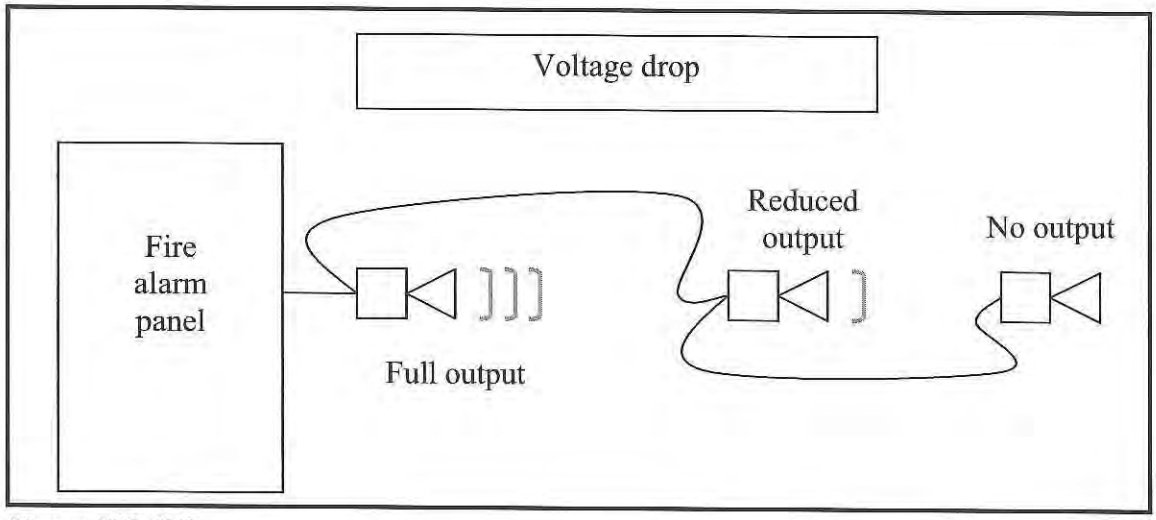
Diagram, NTC, d6.21



Voltage Drop

Voltage drop is the reduction in voltage from the source due to the resistance of the cable. The notification appliances and the NAC circuit wiring itself provide resistance to the voltage output from the fire alarm panel. This resistance reduces the voltage as it flows through the cable and each appliance.

Voltage drop is typically not an issue for the notification appliances closer to the fire alarm panel or NAC extender, but it can be an issue for devices toward the end of the line. A NAC which has too much voltage drop will see lower dB level output (or worse, no sound output) on the devices at the end of the circuit.



Diagram, NTC, d6.22

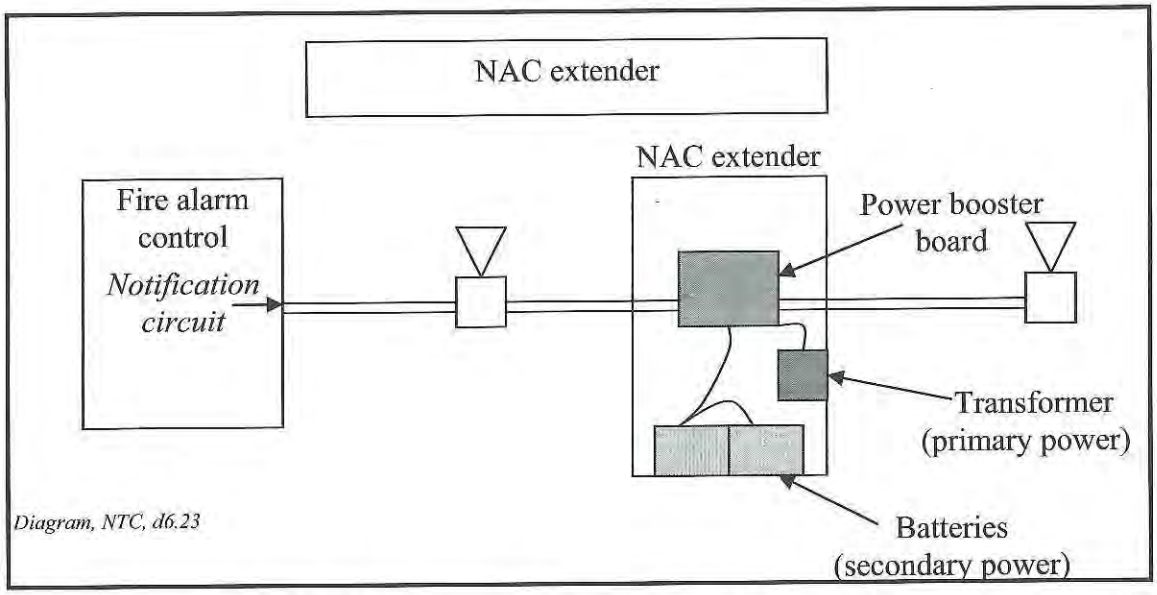
See Appendix B, Electronics for Fire Alarm Systems, for more information about and how to calculate voltage drop.

NAC Power Extenders

ADA brought about changes to the fire alarm code by requiring more strobes and higher intensity. These changes forced fire alarm manufacturers to re-engineer their products to meet the new requirements. The new signals required significantly more power, and ADA required more of them. The solution was the NAC extender.

Photo courtesy, Silent Knight, p6.15

A NAC extender is basically a power booster. It accepts signal input from the fire alarm control NAC circuit and produces a new signal on it's own circuit using it's own power supply. NAC extenders are used to extend the distance of NAC circuits, and to augment the power available from the fire alarm control.



Diagram, NTC, d6.23

The requirements for the NAC power source are similar to those for a fire alarm control's power supply. The unit must have primary and secondary power sources. It must be monitored for integrity and must generate a trouble signal when it loses one of its power sources.

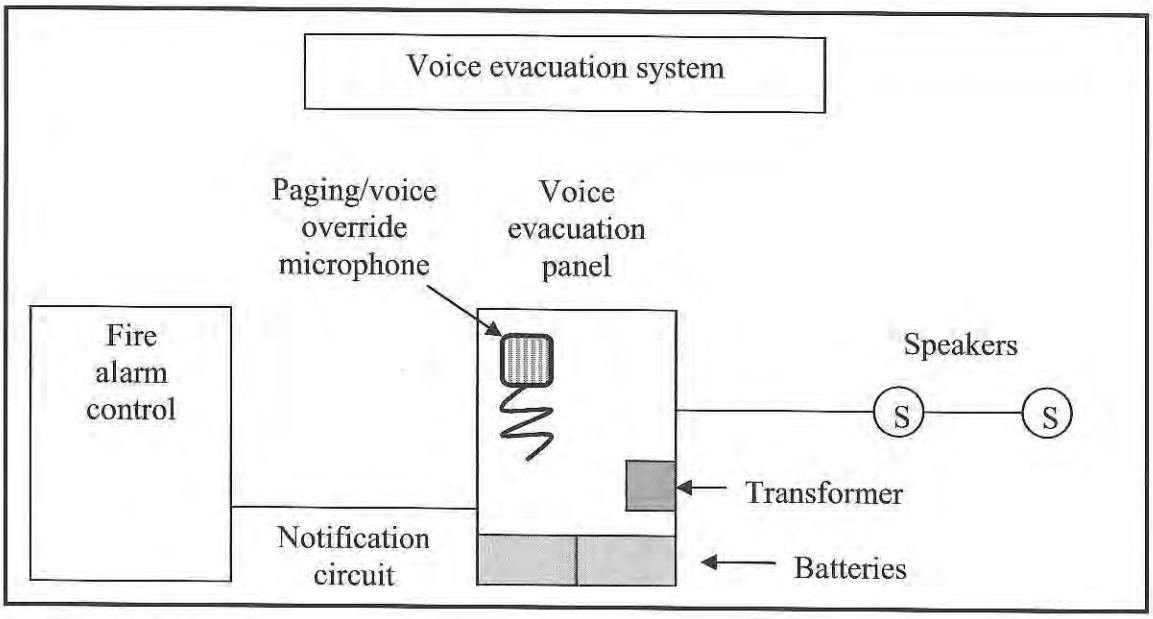
NAC power extenders are available in single input/output and multiple input/output models. Single input/output models accept a single input and provide a single output. Multiple input/output models accept multiple inputs (typically 2) and provide multiple, programmable outputs (up to 8). Multiple output models may also allow some outputs to be programmed as auxiliary power outputs (constant power) instead of NAC circuits.

Voice Evacuation Systems

Voice evacuation systems allow voice commands and instructions to be given to building occupants and emergency forces during a fire. A voice evacuation system can be used to evacuate a building in stages or redirect building occupants to safe areas.

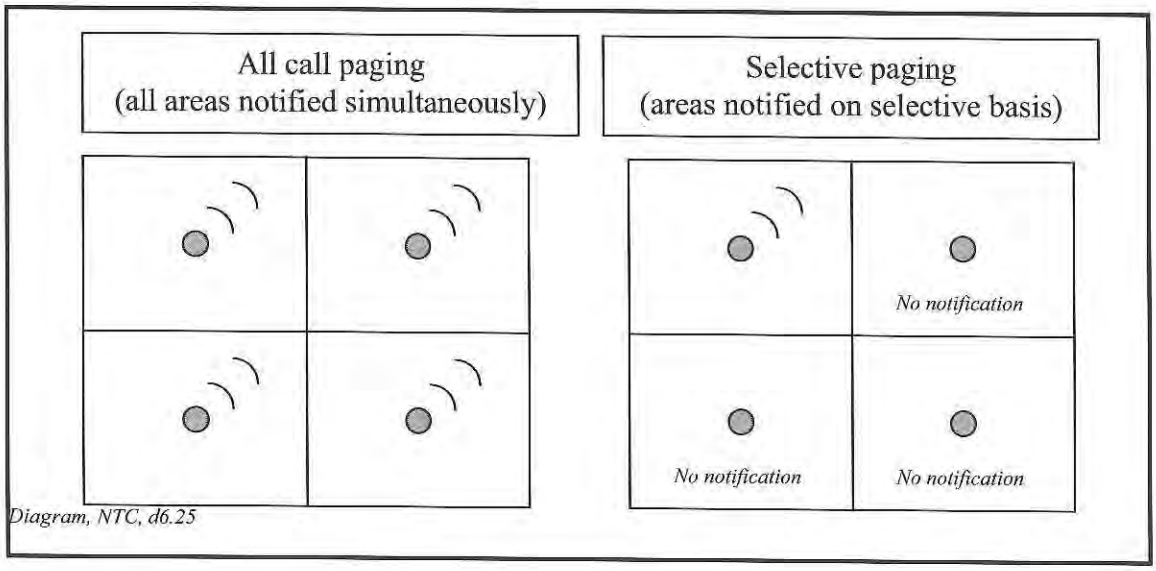
Photo courtesy Evax Systems, p6.16

Voice evacuation systems use a central amplifier (and sometimes remote amplifiers as well, depending on the system configuration). The amplifier generates an alert tone followed by voice instructions to alert the occupants of the fire. The system allows manual override of the tones and message by a microphone so that live voice instructions can be given as well. The amplifier may be a separate component connected to the alarm output of the fire alarm control, or it may be integrated with the control.



Diagram, NTC, d6.24

Systems may be all call or selective paging. All call systems broadcast message to all speakers on the system simultaneously. Selective call systems allow different areas (zones) to be communicated with separately. The building's evacuation plans and the AHJ determine which type of system is required. If all occupants can be safely evacuated at once an all call system is used. If evacuation must occur in stages due to capacity of exits then selective call systems are used. Selective call systems are common in high-rise buildings.



Diagram, NTC, d6.25

Voice communication systems are commonly required in assembly and high rise building occupancies. These systems may also be used for general purpose paging and other alert functions, if permitted by the AHJ. In any case, the fire alarm system must still have priority over the non-alarm paging functions

Speakers

Voice evacuation systems use speakers to reproduce the tones and voice instructions from the voice evacuation amplifier. The speakers may be ceiling or wall mounted, and must be listed for use as a voice evacuation speaker.

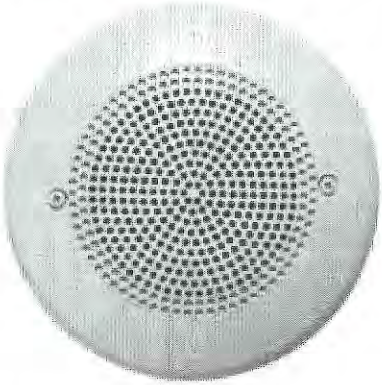


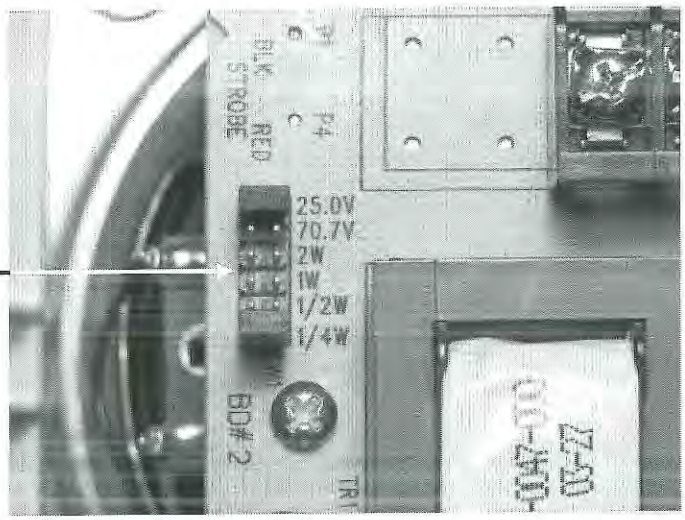
Photo courtesy System Sensor, p6.17

Photo courtesy System Sensor, p6.18

Speaker Load

Speaker load on an amplifier is expressed in watts (W) rather than milliamps. Speakers have multiple taps, or wattage settings, and amplifiers have a maximum rated wattage. Wattage of multiple speakers is additive. A 25 watt amplifier can support 25 speakers tapped at one watt each. Good design practice suggests that an amplifier never be loaded past 80% of its rated capacity to allow for additional speakers or higher wattages that may be required by the AHJ.

Photo courtesy System Sensor P6.19



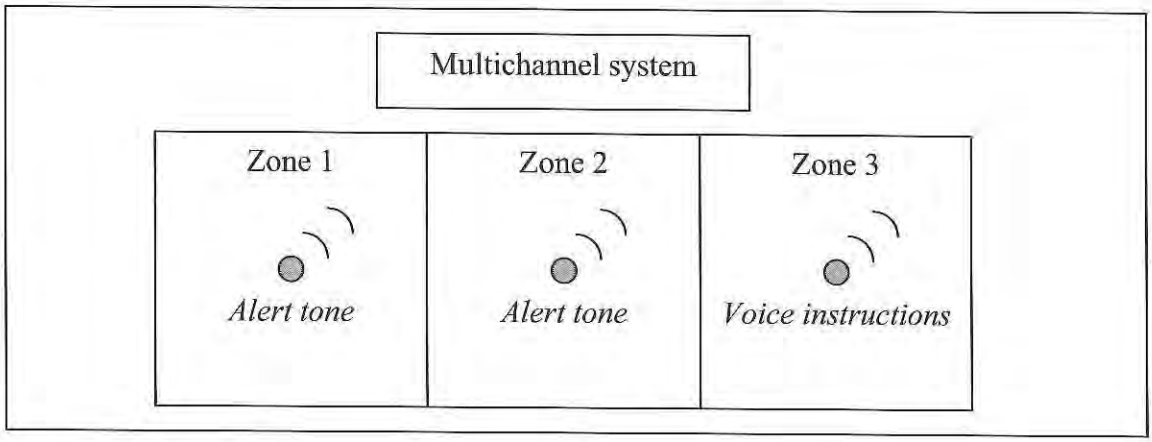
The ½ or 1 watt setting is most common for voice evacuation speakers in areas with average ambient sound levels. Noisy areas, such as boiler rooms or mechanical rooms, may require a 2 watt setting. High noise areas may require higher wattages or more speakers. Wall mount speakers provide more effective coverage than ceiling mount speakers. Speakers should be no closer than 20 feet from the voice evacuation microphone to avoid feedback.

Speakers

Speakers must be installed based on the audible notification appliance requirements of NFPA 72®. Each notification zone in the building must have at least two speakers. Enclosed stairwells may be required to have speakers on a separate notification zone for manual selective paging only. Speakers should be installed so they do not interfere with other fire communications systems.

Multichannel

Multichannel capability allows the evacuation signal be broadcast over one or more zones, while simultaneously being able to send voice signals over other zones. This feature may be required by the AHJ.



Diagram, NTC, d6.26

Fire Command Center

Control over the voice evacuation system, indication of system status, and control over fire safety functions must be provided at the fire command center. The fire command center is usually located near the building entrance and may be combined with other building operations and security centers. All controls for use by the fire department must be clearly marked.

Survivability

The system must be designed so that an attack by fire in an evacuation zone will not disable devices outside that zone. Circuits must be protected until they enter the evacuation zone they serve. They must be protected by a 2-hour rated cable or cable system, a 2-hour rated cable enclosure, or other alternatives allowed by the AHJ. The amplifiers, tone generators, and two-way telephone communications circuits must be monitored for integrity.

The secondary power supply for a voice evacuation system needs to be sized to operate the system in standby mode for 24 hours, and then operate at full load for 15 minutes. If the system evacuates all building occupants simultaneously, it is only required to operate for 5 minutes in alarm condition.

If the fire command center control equipment is remote from the central control equipment the interconnecting wiring must be installed to resist an attack by fire. The wiring must be protected by a 2-hour rated cable or cable system, a 2-hour rated cable enclosure, or other alternatives allowed by the AHJ.

Operation

The voice evacuation system must provide an automatic response to a fire alarm condition. Manual control and transmission of signals (evacuation tone, alert tone, and voice instructions) on a selective and all call basis after the alarm condition has been received may be required from the fire command center by the AHJ. Automatic operation is not required if the fire command center or remote monitoring location is constantly attended by trained operators who can acknowledge receipt of a fire alarm signal within 30 seconds.

Upon operation, the voice evacuation system must transmit two cycles of an approved evacuation tone, and then transmit a voice evacuation message. Where the system is used to send relocation or other non-evacuation messages, the system must send a continuous alert tone for 6 to 10 seconds followed by a message (or messages in multichannel systems) that is repeated at least three times. The evacuation signal sent must be in accordance with the building's fire evacuation plan. Transmission of the signals may be delayed or Positive Alarm Sequence may be used if permitted by the AHJ.

In applications where the voice evacuation message is generated and controlled separately from the evacuation signal, failure of the message must sound the evacuation signal automatically. Additionally, provisions for manual voice instructions or evacuation signal generation must be provided. Live voice instructions must override any other signals.

If the system notifies all building occupants automatically and simultaneously it is not required to have the ability to give voice instructions on a selective basis and is not required to have a manual means of initiating the voice instructions. The application of this exception requires AHJ approval and must meet with building fire evacuation plan.

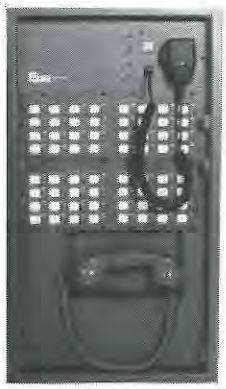
Zoning

Undivided smoke or fire areas must remain as a single zone on the voice evacuation system. If multiple circuits do exist in a zone, they must all activate and deactivate simultaneously. The exception to this rule is where different signal zones perform different functions, such as presignal and general alarm functions, or predischarge or discharge signals from a suppression system.

Two Way Telephone Communications Service

Two way telephone communications service, commonly called fireman's phone, provides communication within the building to the fire alarm response authorities. Fireman's phone systems have a control unit, usually located with, or integrated to, the voice evacuation system. The control unit has multiple circuits running through the building with jacks that the firemen can plug their portable fireman's phone into. The fireman's phones are usually kept in a case near the control unit. The system may be used for other non-fire functions also if permitted by the AHJ.

Photo courtesy Evax Systesms, p6.20



If the system is to be used by fire service personnel, at a minimum the system must be common talk (party line), and must have at least one telephone station (or jack) per floor, and at least one per exit stairway. If the building has a fire pump, it must also have a jack in that room. Each telephone station or jack must be clearly identified at the jack. The telephone station or jack is required to be mounted at a height of 3' to 5.5'. If the telephone appliance is accessible to the general public, one telephone per location shall be no more than 48" above floor level. Two or more portable handsets must be provided, as determined by the AHJ, and stored at the fire command center.

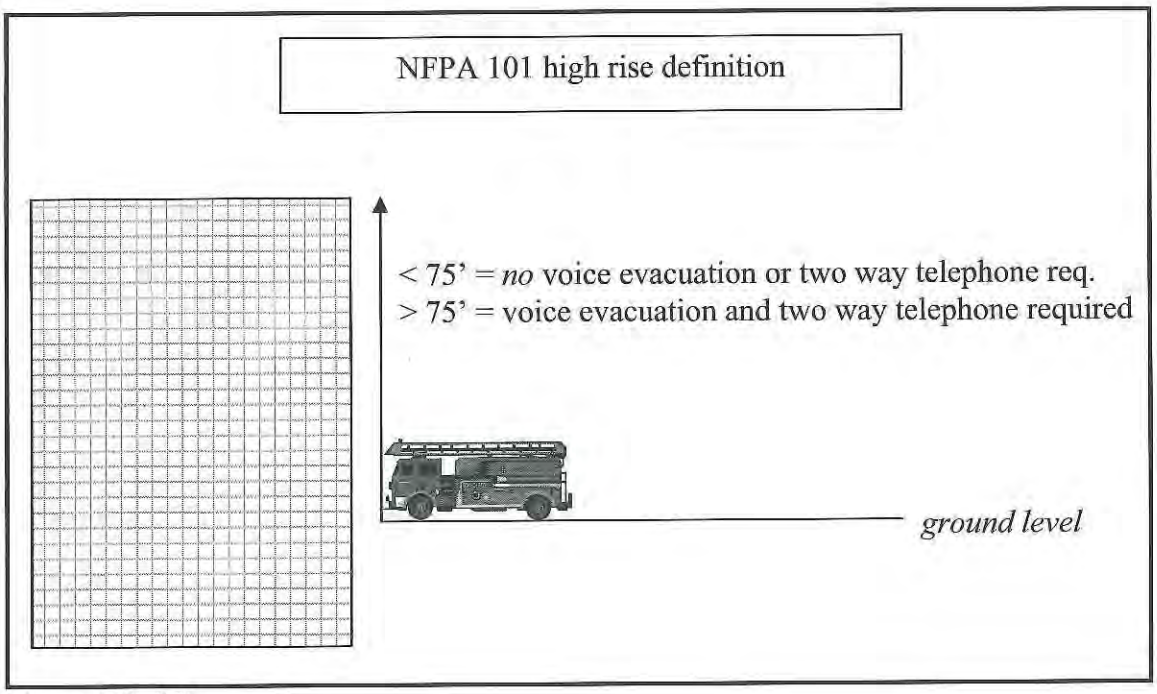
Photo Courtesy Evax Systems, p6.21

Photo courtesy Evax Systems, p6.22

Photo courtesy Evax Systems, p6.23

If the system is to be used by fire wardens (staff person trained to perform duties in event of a fire emergency), at minimum the system must be selective call (phones are selected from the control unit). Jacks or phone stations must be provided as required by the fire service, and at least one jack or phone in each paging zone.

NFPA 101® requires the use of voice evacuation and two way telephone service in high-rise buildings. NFPA 101® defines high-rise buildings as greater than 75 feet measured from the lowest level of fire department vehicle access to the highest occupiable story. The system is required to operate between the communications center and every elevator car, every elevator lobby, and each floor level of exit stairs. The two way telephone system may be omitted if an approved fire department radio system is used.



Diagram, NTC, d6.27

Summary

Fire alarm notification appliances range from the basic single stroke bells of the first automatic fire alarm systems to the electronic signals of today. Whichever signal type is used the audibility and visual intensity requirements for the application remain the same.

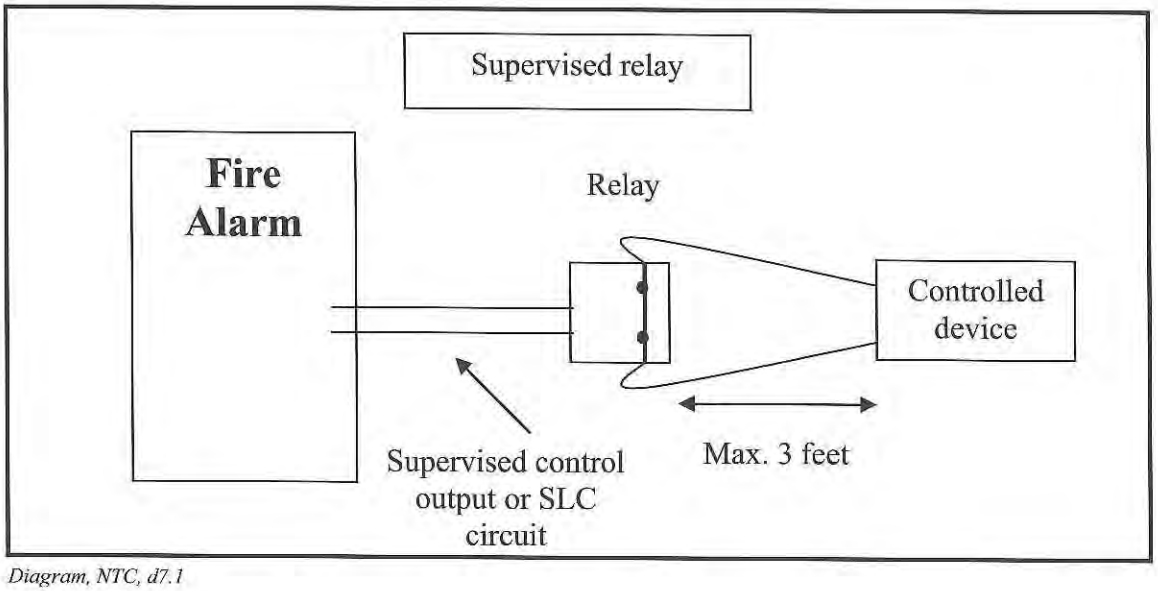
The Americans with Disabilities Act requires additional design and installation concerns for fire alarm installers. Meeting the visual requirements are only half the battle. The increased current draw of these visual signals also make wire gauge, circuit distance, and voltage drop concerns a major factor in fire alarm system design and installation.

Chapter 7

Fire Safety Functions

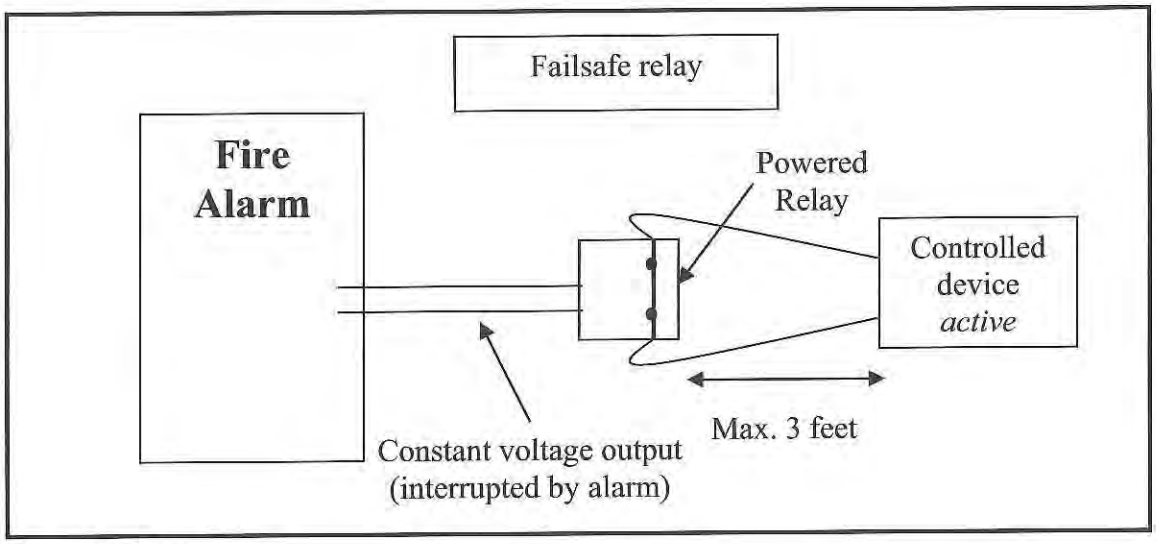
Fire alarm systems are frequently designed to interact with other building systems. Some of these include elevator, smoke doors, exit doors, emergency lighting, dampers, HVAC systems and many more. The intent is to make the building a safer place.

The control of other devices by the fire control panel may be accomplished using a relay, a signaling line circuit, or other listed method approved by the AHJ. The device used to control the other system must be located within 3 feet of the device it is controlling. The device used must be listed for its intended purpose, and it must operate within the voltage and current limits of the fire alarm control panel. The wiring between the control device and fire alarm control must be monitored for integrity.

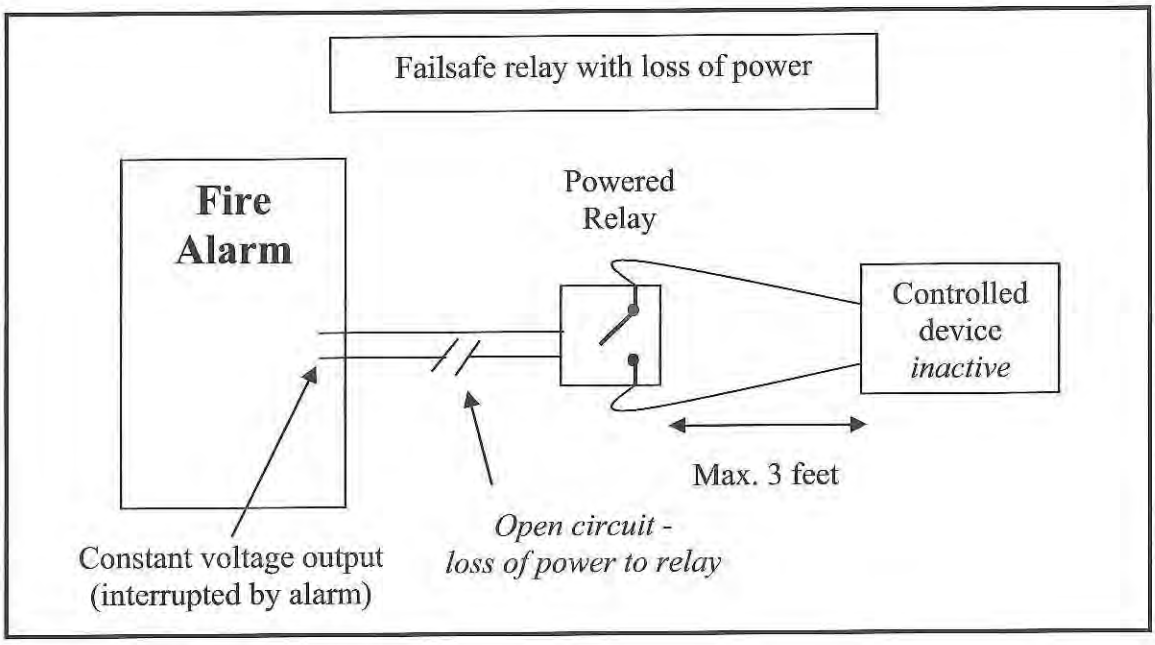


Diagram, NTC, d7.1

If relays or appliances operate on loss of power (fail safe) they are considered to be supervised. These are considered to be self monitoring since a loss of power to the device defaults it to its alarm condition.



Diagram, NTC, d7.2

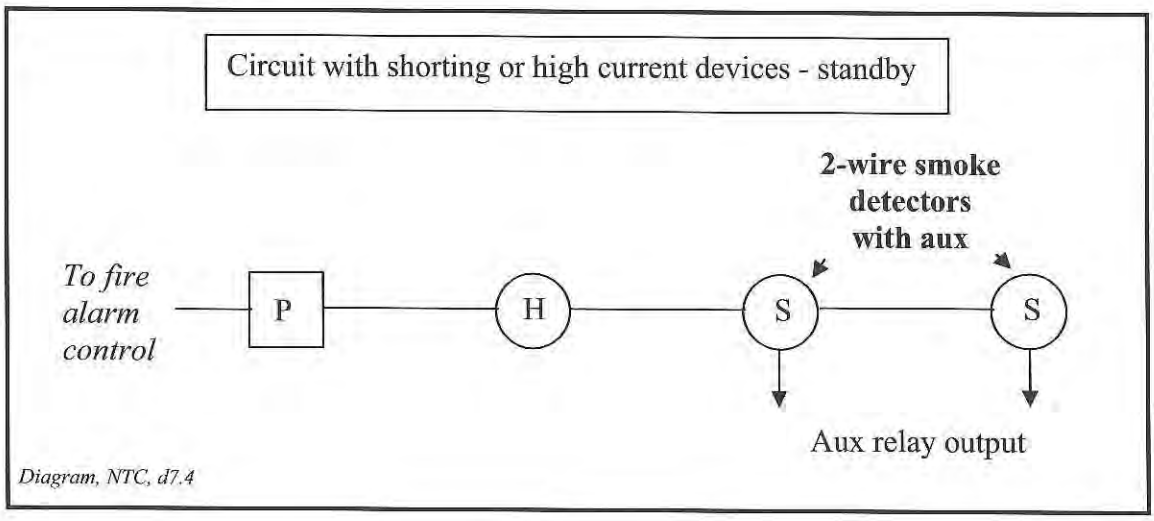


Diagram, NTC, d7.3

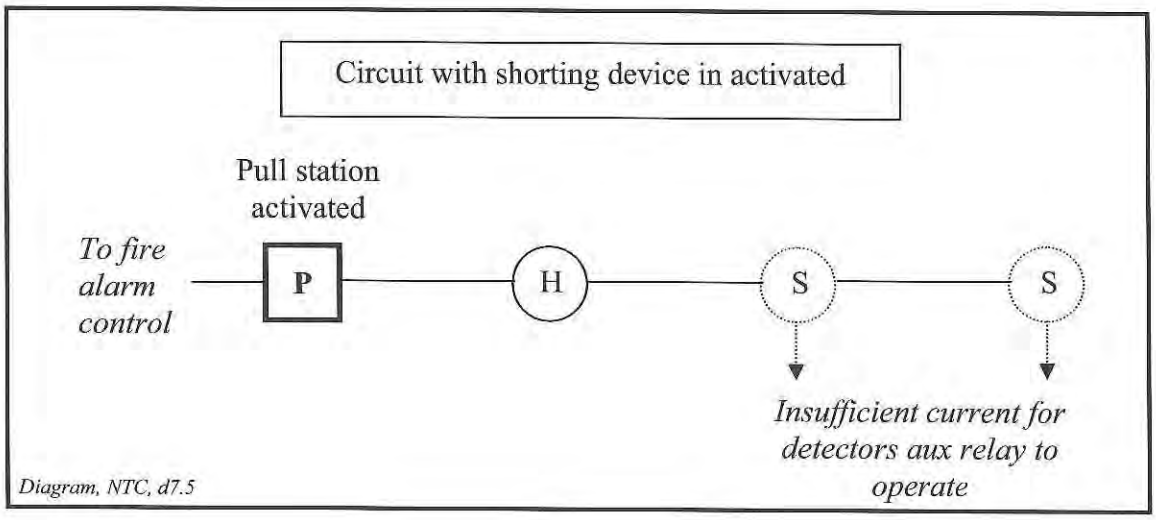
Elevator Recall

System type smoke detectors (or other type automatic detectors if environmental conditions preclude the use of smoke detectors) located in the elevator lobbies, elevator hoistways, and elevator machine rooms must provide fire fighters' service recall and must be connected to the building fire alarm system. If the building does not have a fire alarm system the detectors must be connected to a dedicated fire alarm control unit designated as "elevator control and supervisory panel." The control unit must be permanently marked with this label and must be identified in the system record drawings as such.

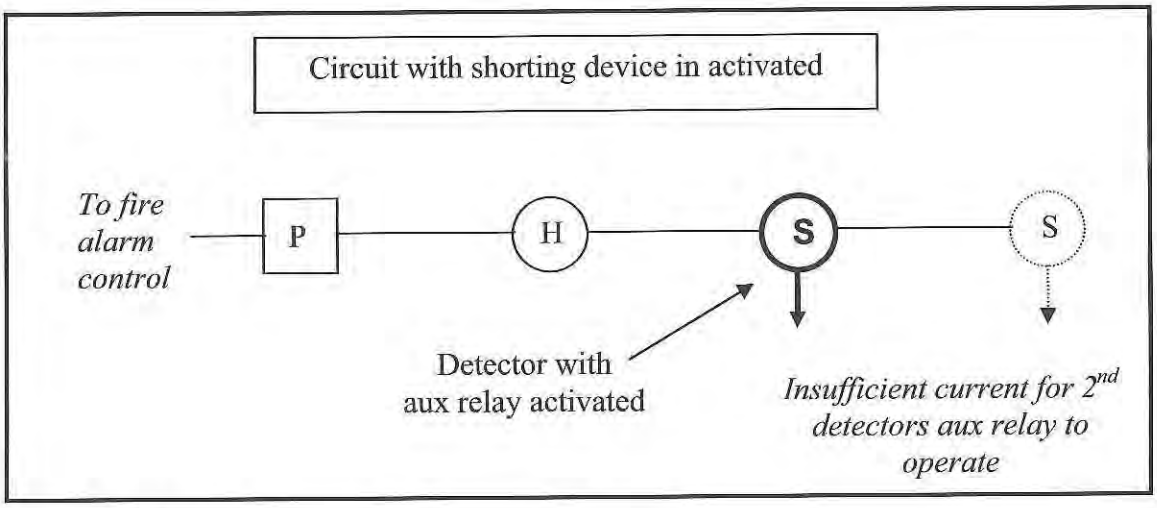
Each elevator recall detector must be capable of recalling the elevator, even if other devices on the same circuit are in alarm condition. This may preclude the use of multiple 2-wire detectors with auxiliary relays, or using manual stations or heat detectors on the same circuit as the detectors. Single 2-wire detector with a relay may consume enough current to prevent subsequent detectors from activating. Pull stations and heat detectors with a short across the circuit wires may prevent the detectors from having sufficient current to activate.



Diagram, NTC, d7.4

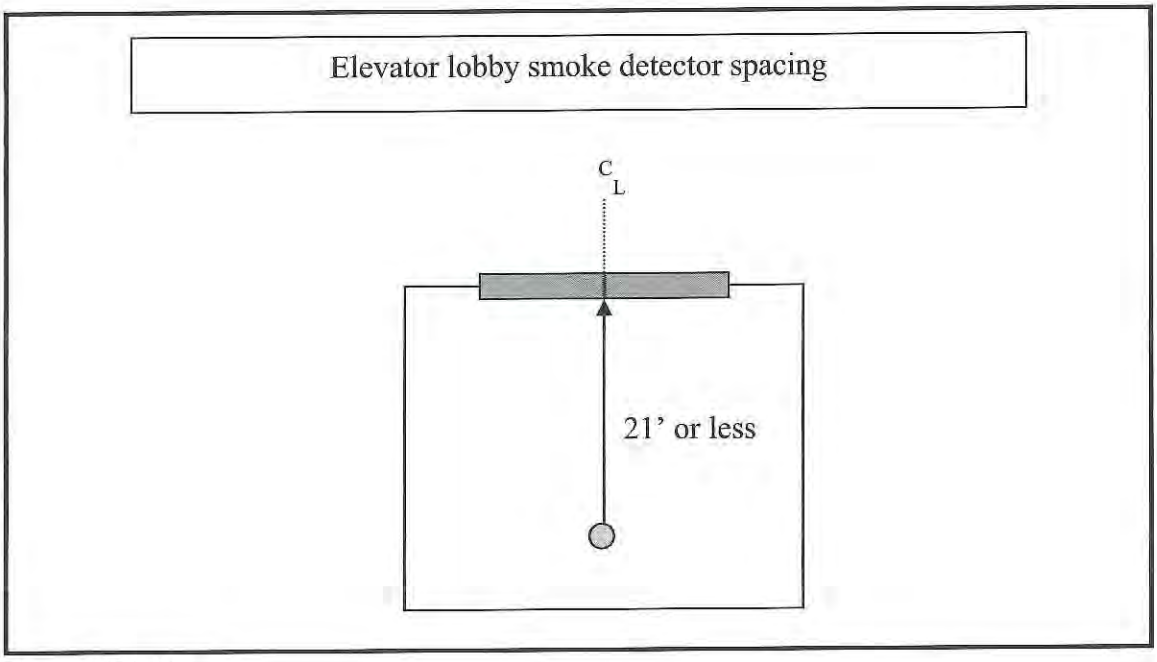


Diagram, NTC, d7.5



Diagram, NTC, d7.6

The lobby smoke detector must be located within 21 feet of the centerline of the elevator door for each elevator bank being controlled by the detector. If the ceiling is 15 feet or greater, or is not flat and smooth (ie, sloped, beams, joists, etc.), the detector spacing must be reduced according to the spacing requirements of NFPA 72®.



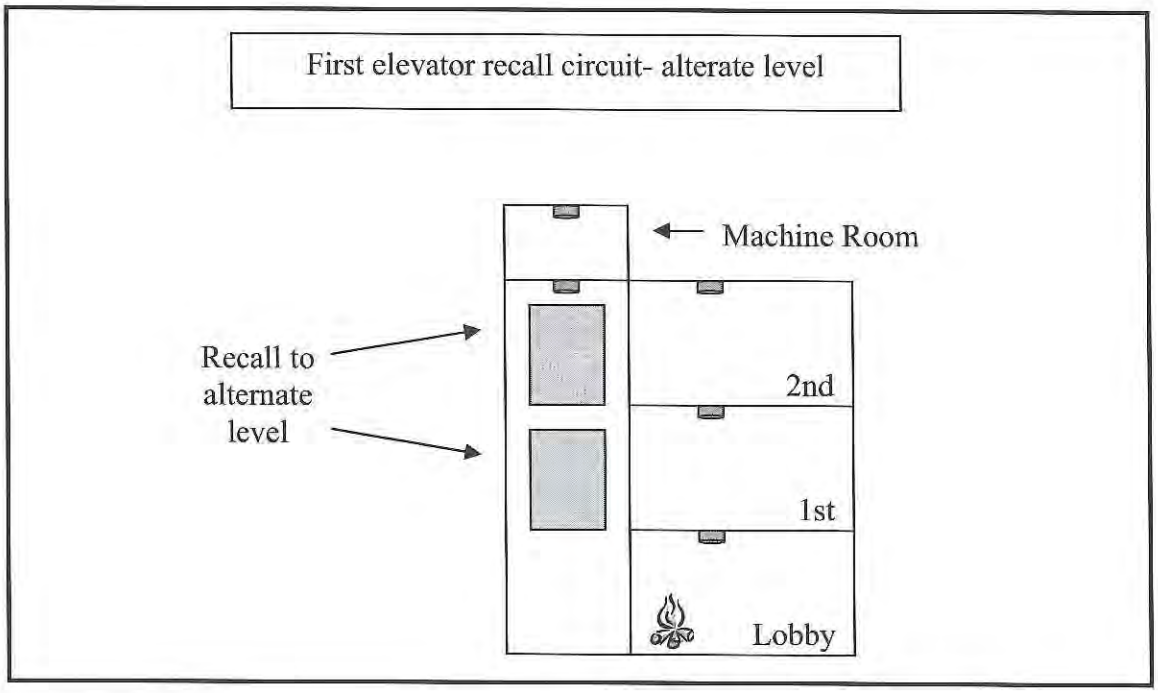
Diagram, NTC, d7.7

Smoke detectors must not be installed in unsprinklered elevator hoistways unless they are for activating smoke relief equipment for that area. Hoistways are not appropriate environments for smoke detectors. Smoke detectors should never be installed in the elevator pit. Elevator hoistway and elevator machine room detectors must indicate a separate and distinct visible indicator at the control unit and the annunciator to alert the fire fighters that the elevators are not safe to use. The detectors do not have to activate the system notification appliances if the alarm signal is indicated in a constantly attended area. They may even initiate a supervisory signal instead of any alarm signal if permitted by the AHJ.

Detector Control Operation

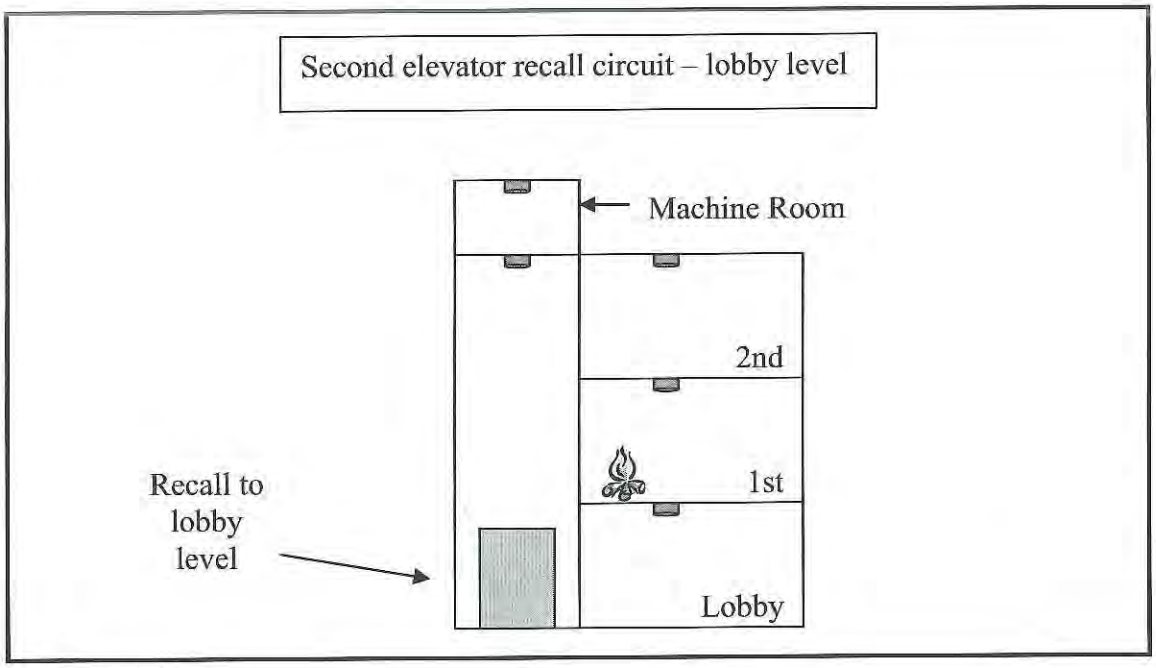
Each group of elevators in the building requires a minimum of three separate control circuits be wired back to the elevator controller. The operation of the elevator after actuation of these circuits is governed by Section 2.27 of ANSI/ASME A17.1 (Safety Code for Elevators and Escalators).

The detector in the designated elevator recall lobby must operate the first recall circuit. When a fire is detected on this circuit the elevator is recalled to an alternate level where there is not a fire. Additionally, if the elevator has front and rear doors, or if the elevator machine room is at the same designated level, the detectors shall operate the same control circuit.



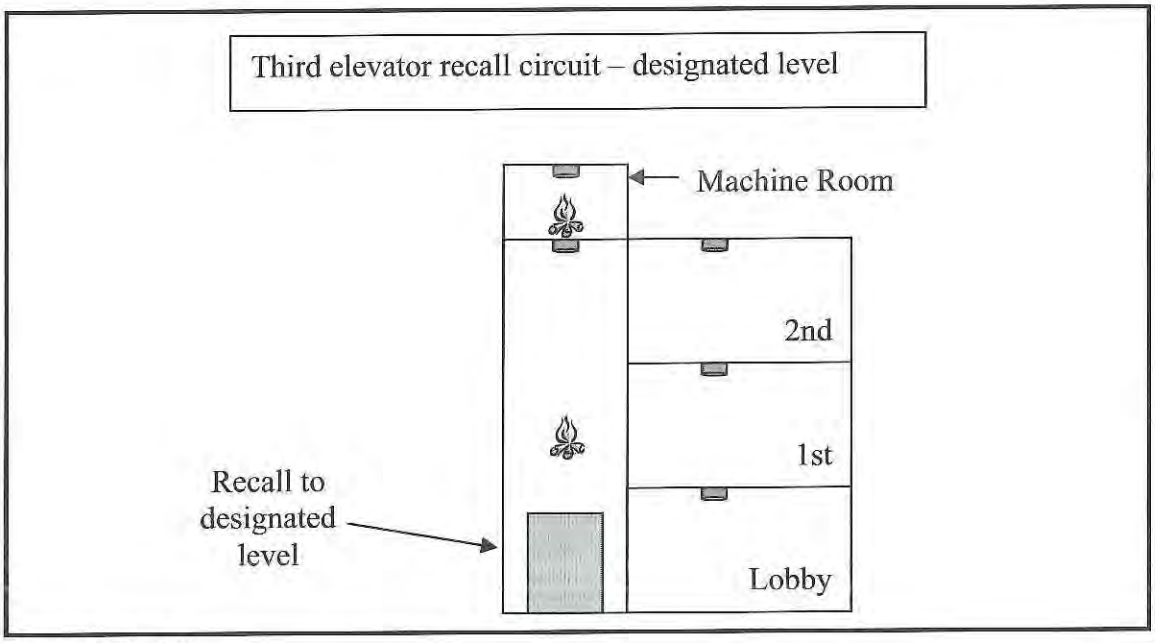
Diagram, NTC, d7.8

The detectors in the other remaining elevator lobbies must activate the second control circuit. When a fire is detected on this circuit the elevator is recalled to the designated elevator lobby level.



Diagram, NTC, d7.9

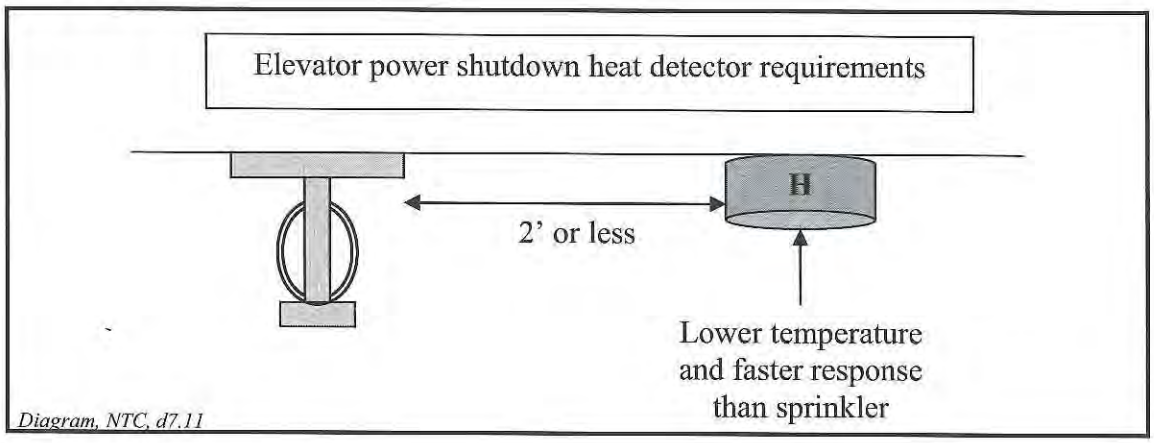
Detectors in the elevator hoistway and elevator machine rooms must activate the third elevator control circuit. When a fire is detected on this circuit the elevator is recalled to the designed level.



Diagram, NTC, d7.10

Elevator Shutdown

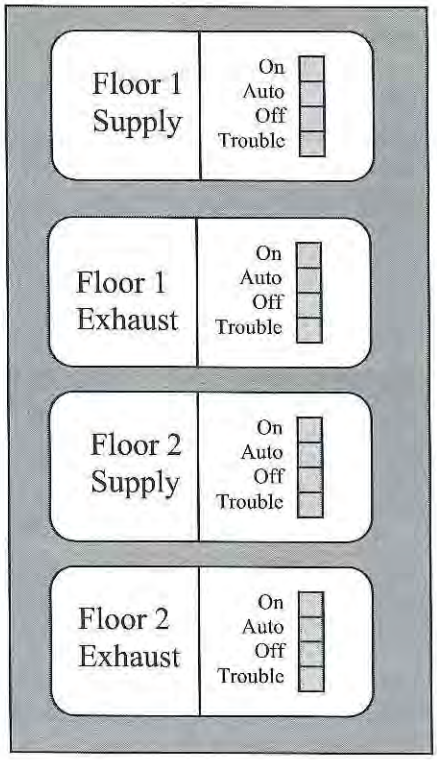
When heat detectors are used to shutdown elevator power prior to sprinkler operation, the detector must have a lower temperature rating and faster response time than the sprinkler. The listed spacing for the heat detector must be 25 feet or greater, and the detector must be located within 2 feet of the sprinkler head. If pressure or waterflow switches are used to monitor the sprinkler system and shutdown the elevator control they must not have any time delay.



Diagram, NTC, d7.11

HVAC System

Duct smoke detectors must initiate an alarm signal or a supervisory signal at a constantly attended location or supervising station. If the fire alarm control activates the HVAC system for smoke control purposes, the automatic detector zones must be coordinated with the smoke control zones they actuate. If interconnected as a combination system, a Firefighter's Smoke Control Station (FSCS) must be provided for manual control override of automatic operations.



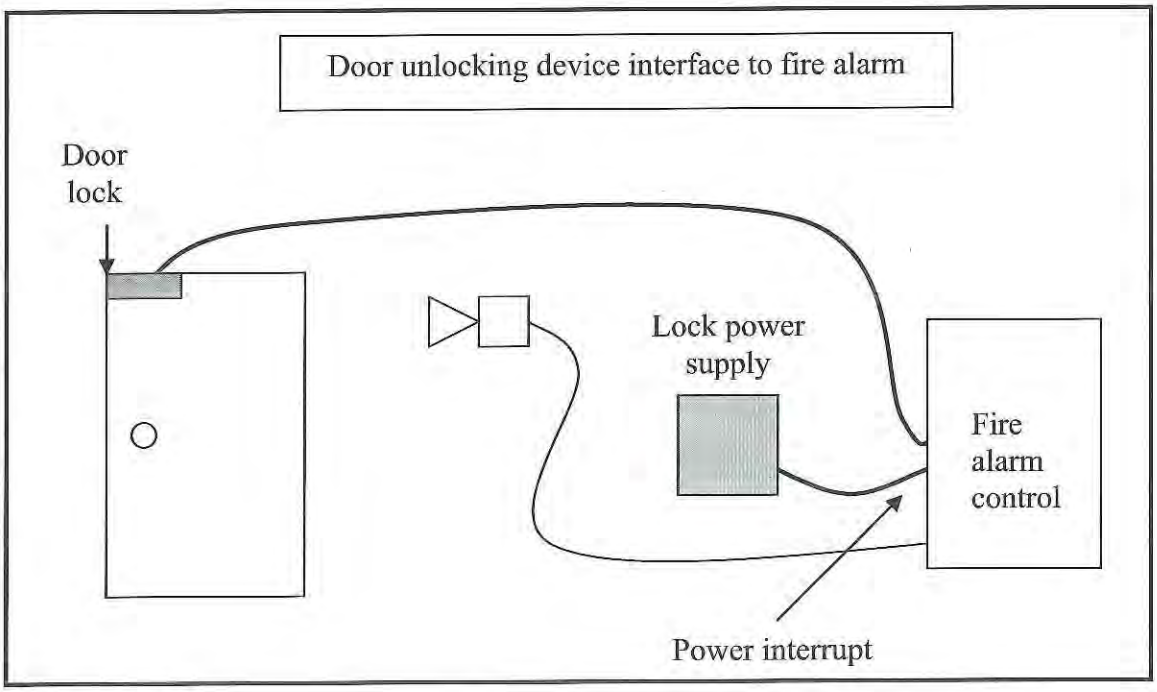
Diagram, NTC, d7.12

Door Release

All devices used for door release must be listed for their intended use. Detectors used for open area detection that also provide door release service must be monitored for integrity. Detectors only used for door release service do not need to be supervised. Magnetic door holders that allow doors to close when they lose power are not required to have a backup power source. Smoke detectors used for door release have to comply with specific requirements for mounting locations. If the header distance from the top of the door to the ceiling is 24 inches or less, the detector is required only on one side of the doorway. If the header distance exceeds 24 inches on both sides of the door, 2 smoke detectors are required (1 on each side of the door). If the header distance is greater than 24 inches on 1 side of the doorway only, then a smoke detector is required on the high side. Chapter 5 of this book has more details for mounting locations and requirements.

Door Unlocking Devices

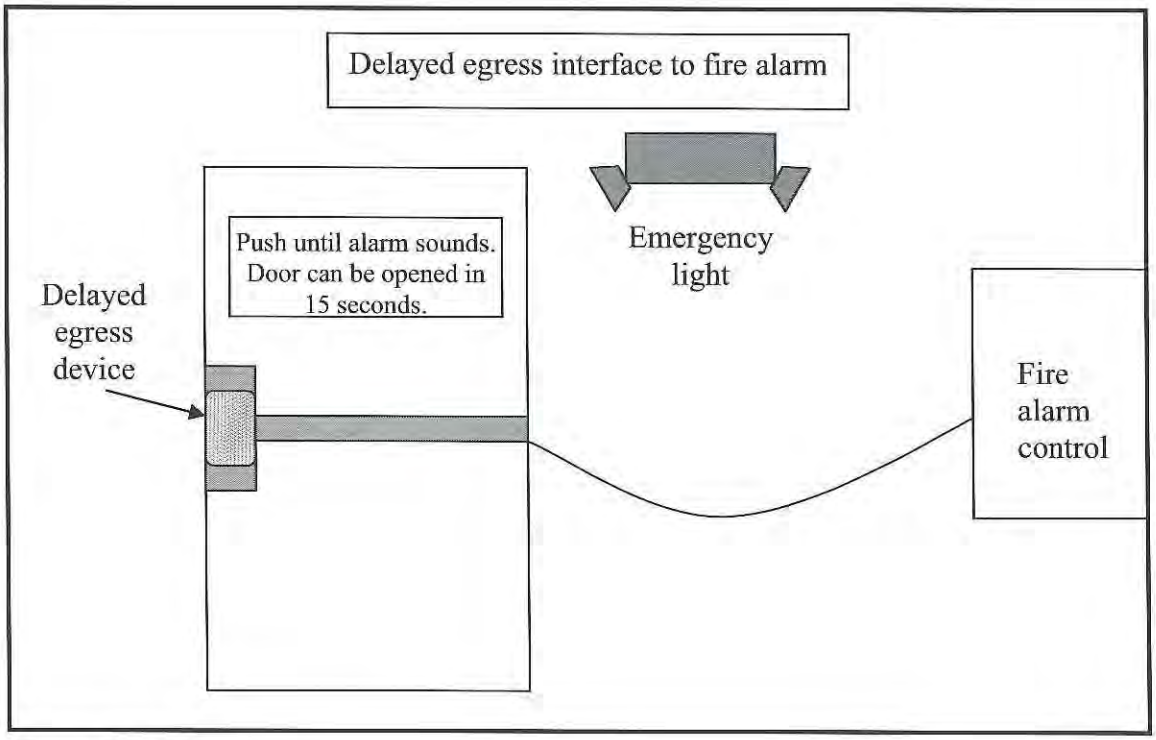
Access control and electrical/electronic door locking systems must be connected to the fire alarm system. All exits connected to the system must immediately unlock in the event of a fire alarm signal (unless otherwise permitted by the AHJ). The release may be accomplished by fire alarm connections to the power supply, or by directly interrupting the power to the lock. The doors must unlock prior to or concurrent with the activation of local notification appliances in the area. All exits must unlock in the event of loss of primary power to the fire alarm system. A secondary power supply is not permitted to maintain these doors in a locked state.



Diagram, NTC, d7.13

Special Locking Arrangements

The life safety and building codes permit special locking arrangements (delayed egress) in certain circumstances. Delayed egress can help thwart or discourage unauthorized use of exit doors during non-emergency situations. Release of the lock can be delayed up to 15 seconds when at least 15 pounds of force is applied to the release device for at least 3 seconds. The door can then release and sound a local alarm. It cannot automatically relock when it closes; it must remain unlocked until reset. The door must have signage that states "Push until alarm sounds. Door can be opened in 15 seconds." The building must have an automatic fire alarm system or a supervised sprinkler system. Upon activation, the door must unlock without delay, and the door must unlock automatically when the lock losses power. Emergency lighting must also be provided at the door.



Diagram, NTC, d7.14

Smoke Control

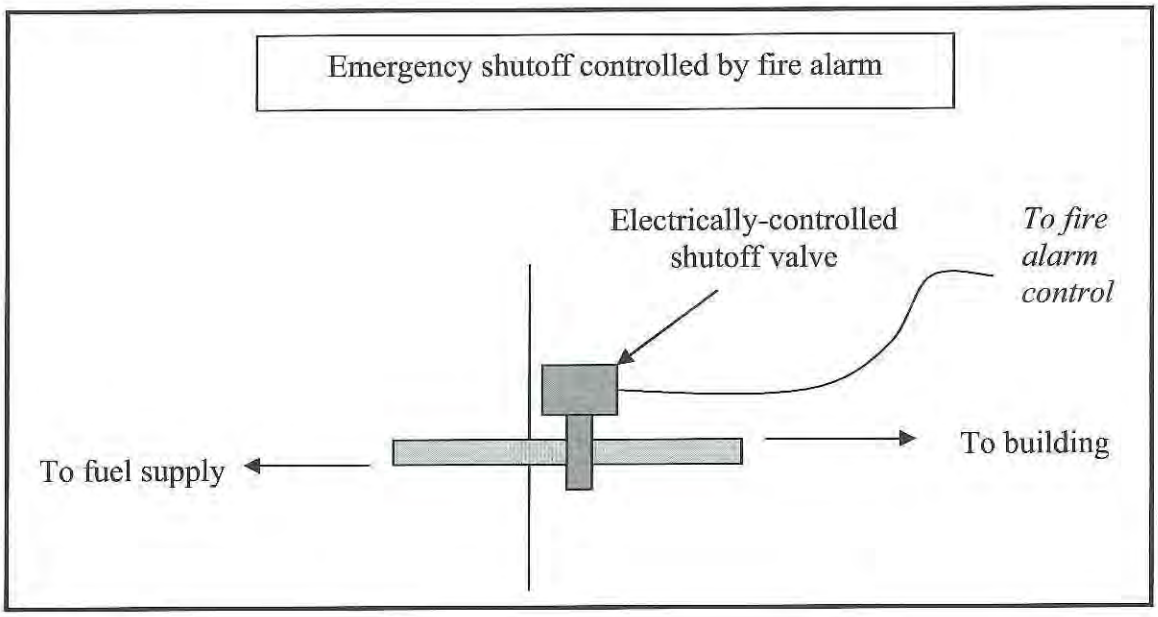
Mechanical ventilation and pressurized stairwell systems can be activated by smoke detectors. The detector operating these systems must be installed within 10 feet of the entrance in a location approved by the AHJ. The systems can also be controlled by waterflow activation (sprinkler system), general alarm condition of the fire control panel, and manually by the fire department. Any device that causes a door to close to any entrance to a smoke proof enclosure must cause all doors at all levels to close at the same time.

Smoke dampers prevent the passage of smoke between compartments. Smoke dampers should be activated when the building fire alarm system detects smoke. When air ducts penetrate between compartments separated by smoke barrier doors, they should also be activated when the local smoke detectors that operate smoke barrier doors are activated. They should also be activated when smoke detectors in the ducts are activated.

Supply side duct smoke detectors are required on air systems greater than 2,000 CFM. The detectors should be installed downstream of any air filters and ahead of any branch connections. Systems with a capacity of greater than 15,000 CFM and serving more than one story must have a detector at each story, prior to connection to a common return or fresh air inlet. Return system detectors are not required if the entire space served by the system is protected by area smoke detectors.

Emergency Lighting
Emergency lighting systems are required in the stairwell and vestibule, and at delayed egress locked doors. Batteries or standby generator power are acceptable as the system's standby power. Proprietary Signaling Supervising Stations are required to have emergency lighting with a standby time of at least 26 hours.

Emergency Shutoff
Solenoid or mechanically operated valves shutoff fuel supplies (gas, liquid) to the building when the fire alarm is activated. These valves must be listed for their intended use.



Diagram, NTC, d7.15

Summary

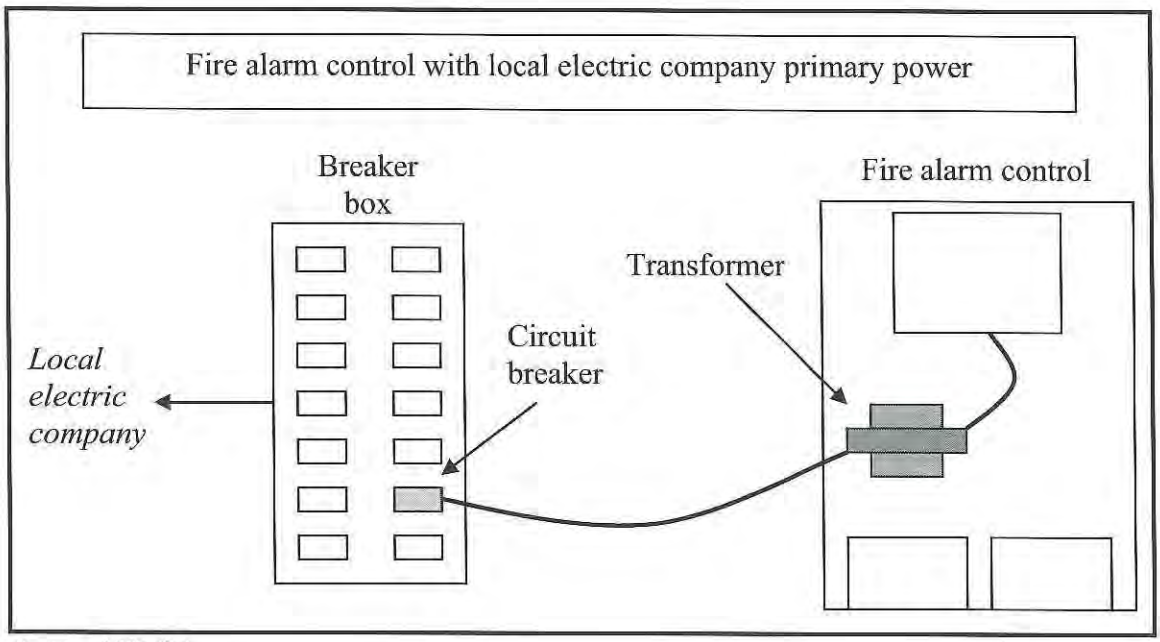
Fire safety functions may not be a part of every fire alarm system a designer or installer works on, but when they are, they must be properly designed and installed. Fire safety functions are a secondary function to occupant notification, but they are still critical to the overall building life safety picture.

Chapter 8

Power Supplies

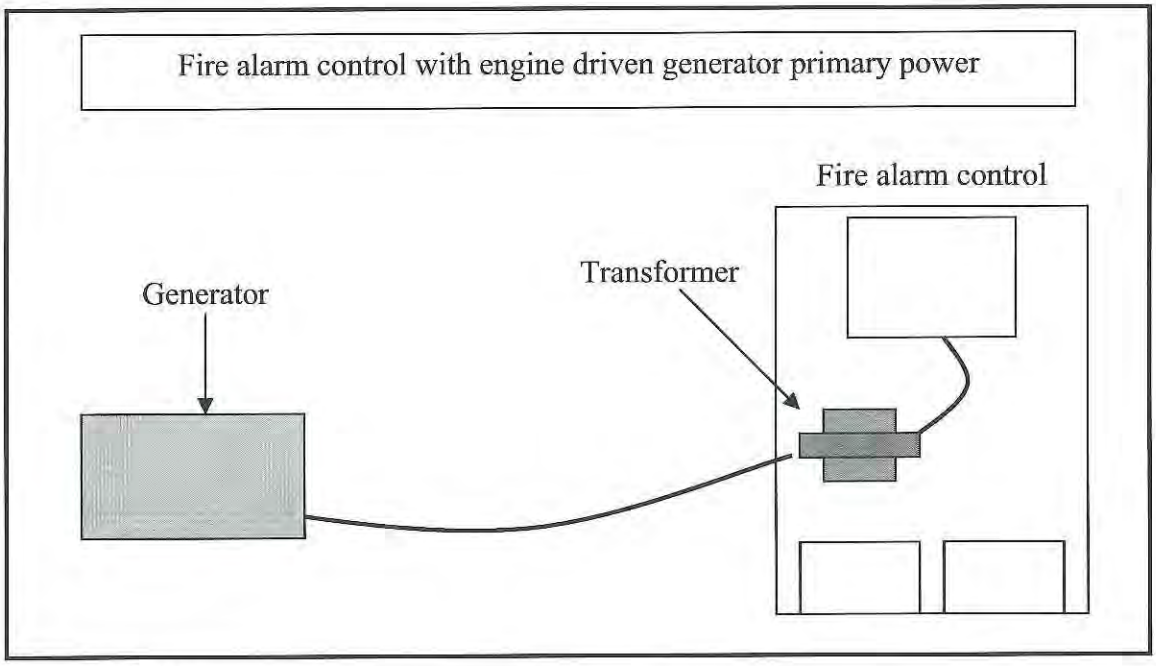
Fire alarm systems are required to have two independent and reliable sources of power. The primary and secondary power supplies must be sized adequately for the fire alarm application. Both must be constantly monitored for integrity.

Primary Power
A fire alarm control panel must have its own dedicated branch circuit connected to the primary power source. The most common source for fire alarm primary power is the local commercial light and power service (electric company). The connection is typically a single high voltage (120 VAC) connection wired directly into a low voltage transformer in the fire alarm control cabinet.



Diagram, NTC, d8.1

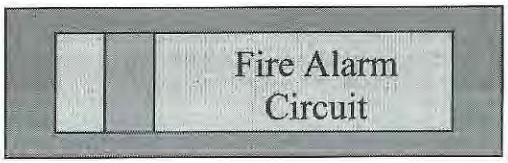
Engine driven generators (alone or in conjunction with local commercial light and power) are also permitted, but less common. Systems that utilize engine driven generators for primary power are required to have a person trained in the unit's operation on duty at all times. Additional engine driven generator requirements are discussed later in this chapter.



Diagram, NTC, d8.2

Circuit Protection

The dedicated branch circuit of the control panel's primary power supply and all of its connections must be mechanically protected from damage. The circuit breaker must have a red marking designating it as "FIRE ALARM CIRCUIT" and must be in a protected breaker box. The box can have a lock, or be in a locked room, so long as it is protected from unauthorized access. Additionally, the location of the breaker box must be identified in the fire alarm control panel as well.

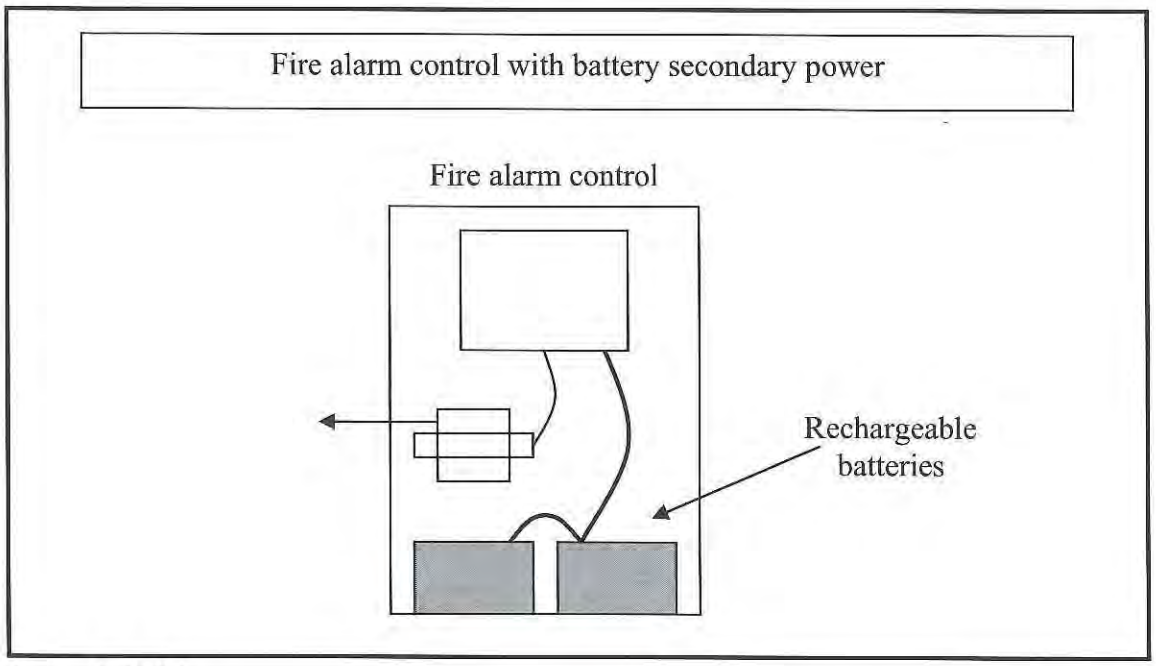


Diagram, NTC, d8.3

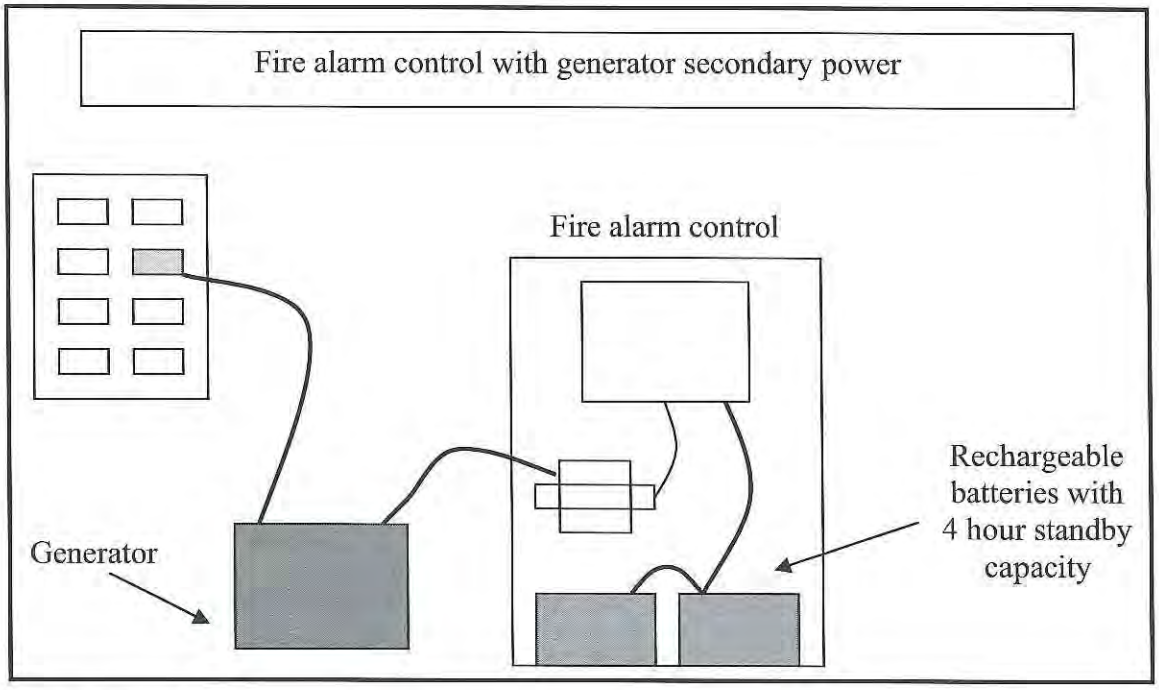
The circuit must have overcurrent protection, capable of handling the maximum short circuit current on the circuit, for each ungrounded conductor. The overcurrent protection shall not exceed 20 amps. Circuit breakers and engine stops for the fire alarm circuit must not interrupt the power for lighting or for elevator operation.

Secondary Power

Secondary power for a fire alarm system most commonly consists of rechargeable storage batteries of the sealed lead acid type (recharged and monitored by the system). Engine driven generators are also permitted as secondary power supplies, but must be automatic starting. Additionally, the control panel must have sufficient batteries to provide 4 hours of standby time (in case the generator does not start automatically).



Diagram, NTC, d8.4



Diagram, NTC, d8.5

Secondary power supplies must have enough capacity to run the system in standby mode for 24 hours, and then run the system in alarm mode for 5 minutes (household systems only require 4 minutes of alarm). Secondary power for voice evacuation systems must be able to power the system for 15 minutes at maximum load (signaling to all zones) in alarm mode after 24 hours of standby.

A calculation form for computing the required battery size is included with the fire alarm control panel's installation manual. The AHJ will want to see this completed calculation before approving the system.

The example below is for a basic, conventional fire alarm system. The standby (non-alarm) requirements for all devices must be added together to give a total standby load requirement.

Standby

Device Type	Number of Devices		Current (Amps)		Total Current (Amps)
Main Circuit Board	1	X	0.123	=	0.123
Remote Annunciator		X	0.006	=	
Relay Module		X		=	
2-wire Detector Heads		X		=	
4-wire Detector Heads		X		=	
SUM COLUMN FOR STANDBY LOAD				=	

Diagram, NTC, d8.6

The current requirement of the main circuit board is a known and required factor, so it has already been inserted into the calculation by the vendor. The remote annunciator is an optional item, but it's current draw is listed also in case it is used. The relay module (if used) current draw is determined by the module used. Two and four-wire detector head current draws are determined by the product used.

The example, will have one remote annunciator, 10 2-wire smoke detectors, and 2 4-wire smoke detectors.

Standby

Device Type	Number of Devices		Current (Amps)		Total Current (Amps)
Main Circuit Board	1	X	0.123	=	0.123
Remote Annunciator	1	X	0.006	=	0.006
Relay Module	0	X	0	=	0
2-wire Detector Heads	10	X	0.005	=	0.05
4-wire Detector Heads	2	X	0.005	=	0.01
SUM COLUMN FOR STANDBY LOAD				=	0.189

Diagram, NTC, d8.7

Next, the alarm current for all the devices is calculated. 2-wire smokes are not normally included in this calculation since they receive power from the main circuit board and are included in its current draw.

Alarm

Device Type	Number of Devices		Current (Amps)		Total Current (Amps)
Main Circuit Board	1	X	0.255	=	0.255
Remote Annunciator		X	0.05	=	
Relay Module		X		=	
4-wire Detector Heads		X		=	
Notification Appliances		X		=	
SUM COLUMN FOR LOAD IN ALARM				=	

Diagram, NTC, d8.8

For the example, we will have 10 horn/strobes.

Alarm

Device Type	Number of Devices		Current (Amps)		Total Current (Amps)
Main Circuit Board	1	X	0.255	=	0.255
Remote Annunciator	1	X	0.05	=	0.05
Relay Module	0	X		=	0
4-wire Detector Heads	2	X	0.23	=	0.46
Notification Appliances	10	X	0.101	=	1.01
SUM COLUMN FOR LOAD IN ALARM				=	1.775

Diagram, NTC, d8.9

Next, the standby and alarm loads are multiplied by the required standby and alarm times. Standby time is required to be 24 hours for all commercial fire alarm systems (NFPA , 72®, 2002 edition). Remote station and auxiliary fire alarm systems required 60 hours of standby in previous editions of the code. Alarm time for commercial fire alarm systems is 5 minutes (5 minutes = .0833 hours). The loads are now expressed in amp-hours.

The amp-hour loads are added together, then multiplied by a battery derating factor of 1.2. The derating factor allows a 20% buffer for reduction of the battery's performance as it ages.

Total

Standby Load Current (Amps)	X	Required Standby Time in Hours (24 or 60 Hrs.) =
Alarm Load Current (Amps)	X	Required Alarm Time in Hours (5 minutes = 0.0833) =
Add Standby and Alarm Load for Required Ampere Hour Battery		
Multiply by the Derating Factor of 1.2 Total Ampere Hours Required		=

Diagram, NTC, d8.10

Our example loads are calculated for a 24 hour standby. All calculations are rounded to the nearest hundredth.

Total

Standby Load Current (Amps)	0.189	X	Required Standby Time in Hours (24 or 60 Hrs.) 24 =	4.54
Alarm Load Current (Amps)	1.775	X	Required Alarm Time in Hours (5 minutes = 0.084) 0.0833 =	0.15
Add Standby and Alarm Load for Required Ampere Hour Battery				4.69
Multiply by the Derating Factor of 1.2 Total Ampere Hours Required			=	5.63

Diagram, NTC, d8.11

The calculation requires a 5.63 amp-hour battery. This is a minimum battery size requirement, and it not a common battery size. For this system, we would use an 8 amp-hour battery.

If the system is a 12V system, a single battery can be used. If the system is a 24V system, two batteries, connected in series, must be used. If the standby battery requirements are large, batteries are available in higher amp hour ratings. Sometimes 4 batteries may be needed. In the case of four batteries, each set of two must first be wired in parallel to increase the amperage. Then the two sets must be wired in series to increase the voltage.

Batteries

Batteries must be located so that any gases emitted by them will not adversely affect any of the fire alarm equipment. They must be insulated against grounds and crosses, and securely mounted to avoid mechanical injury. If they are rack mounted, the racks must be protected against deterioration.

The system must provide a large enough charger to fully recharge the batteries within 48 hours. Once the batteries are recharged, they must be maintained at full charge, and protected from overcharging by overcurrent devices or current limiting design of the charger. The charging equipment must have a charging meter, or the batteries must have accessible terminals for connection by a portable meter. The charger must be supervised and able to initiate a trouble signal in the event of charger or battery failure.

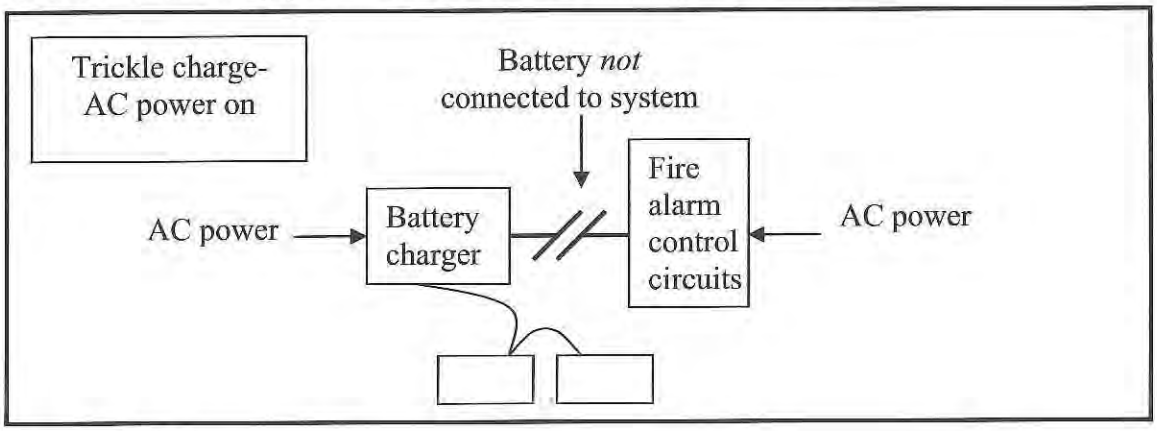
Battery Types

Vented lead acid, gelled, or starved electrolyte type batteries are used in applications that require high current drain or extended standby time at lower current. The voltage of a single cell is 2 volts, so battery voltages are available in multiples of 2 (i.e., 2, 4, 6, 12). Since this type of battery may vent caustic and corrosive gases, care must be taken when storing and using them. The storage shelves should be constructed of material resistant to corrosion. Most modern fire alarm systems do not use these types of batteries.

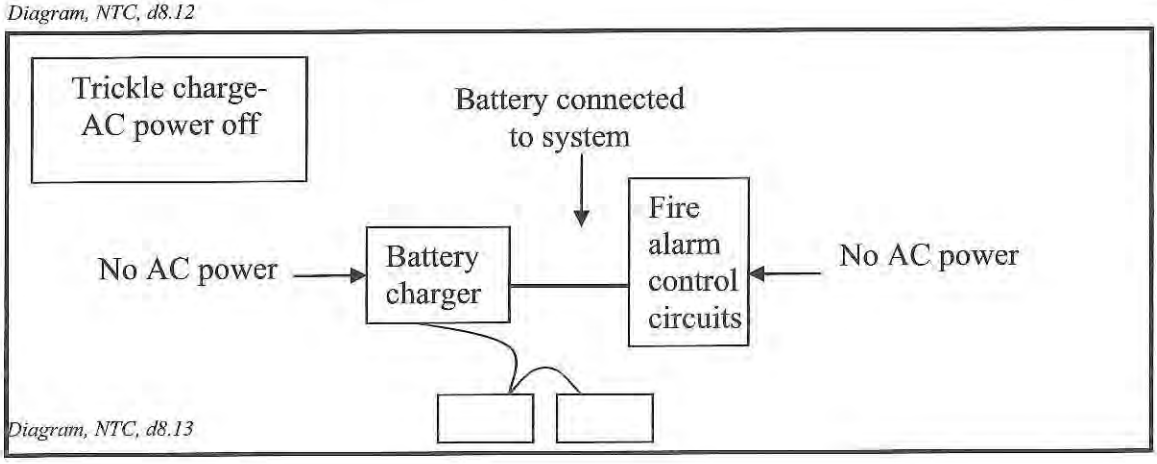
Sealed lead acid batteries do not vent their gases, but rather re-absorb them. Gas developed during the charging cycle is internally recombined, resulting in longer battery life. Sealed lead acid batteries do have an emergency vent to prevent explosion in case of abnormal battery or charger function. Sealed lead acid batteries are normally used as the secondary power supply for most fire alarm systems installed today.

Nickel-Cadmium (NiCad) batteries are typically used in applications where current draw is low (less than 300ma), and fairly constant. The voltage of a single cell is 1.42 volts, so battery voltages are available in multiples of 1.42 (i.e., 12.78, 25.56).

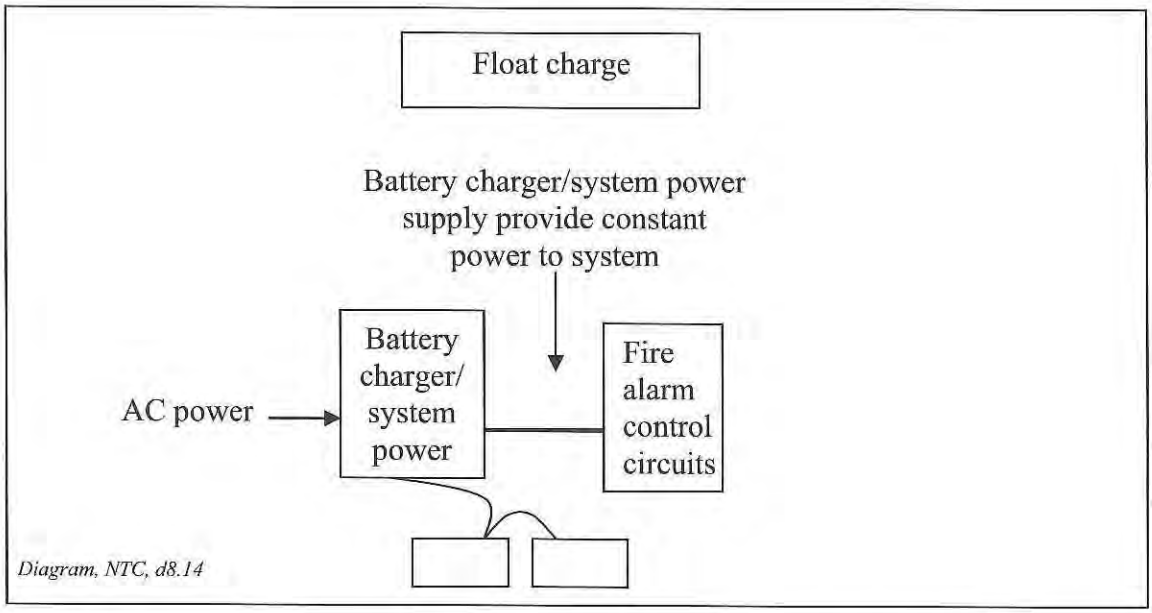
Batteries can be trickle or float charges. Trickle charged batteries are off-line and are waiting to be put under load. Float charged batteries are connected to the output of the power supply rectifiers to help smooth the voltage and to provide instantaneous switchover to battery power in the event of primary power failure.



Diagram, NTC, d8.12



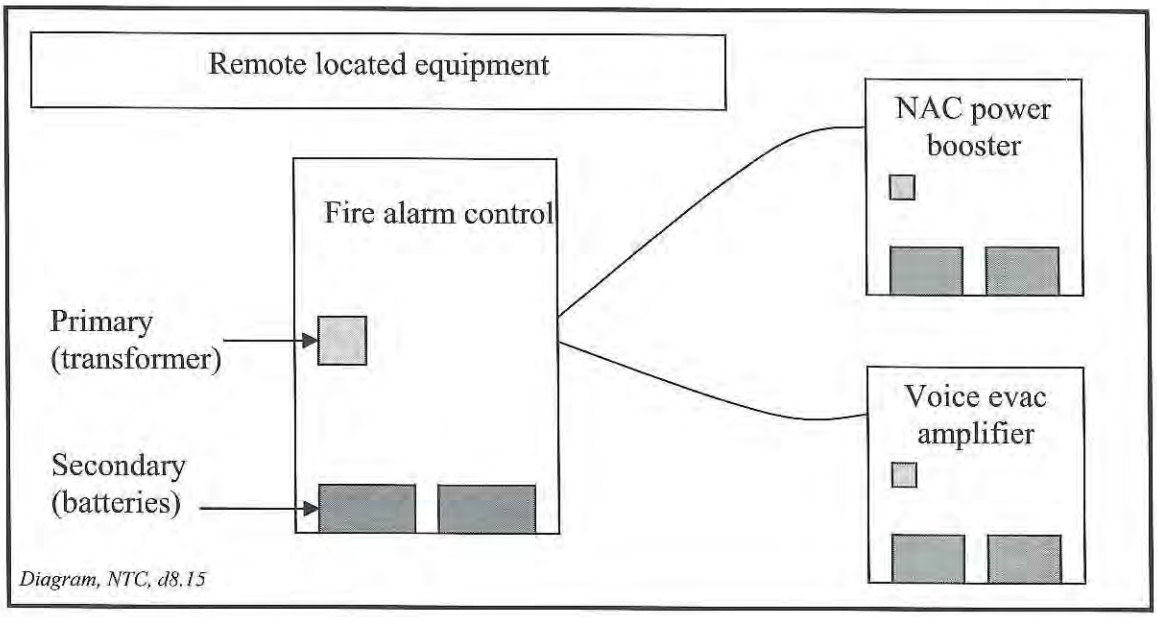
Diagram, NTC, d8.13



Diagram, NTC, d8.14

Continuity
Secondary power supplies must automatically provide backup power to the fire alarm control within 10 seconds of the loss of primary power. Additionally, no signals may be lost, interrupted, or delayed more than 10 seconds. If secondary power is provided by a generator, storage batteries or an uninterruptible power supply (UPS), they are permitted to operate the system during the transfer time.

Remote Located Equipment
Equipment essential to system operation and remotely located from the main control unit (i.e., NAC power boosters, distributed voice evacuation amplifier) must have its own primary and secondary power sources. The power source must be supervised as well.



Diagram, NTC, d8.15

Trouble Power Supplies

Early fire alarm systems had a separate power supply for indicating trouble signals. High current draw bells and lamps provided audible and visible trouble indication. Due to the high current requirement of these devices the fire alarm would malfunction during a trouble situation. The requirement for a separate trouble power supply was written into the code to solve this problem. Modern fire alarm panels use low current draw LEDs and piezo sounders. They are manufactured so that the trouble indication is powered from the secondary power source, not the primary power source.

Engine Driven Generators

Some fire alarm systems may be required to have a connection to an engine driven generator, in addition to its primary power requirements. This requirement is based on the occupancy classification of the building and the requirements of the Life Safety Code NFPA 101®.

The National Electrical Code® (NEC®) recognizes three types of emergency generators used with fire alarm systems and equipment:

1. Emergency Systems (Article 700)	Highest priority
2. Legally Required Standby Systems (Article 701)	2nd highest priority
3. Optional Standby Systems (Article 702)	Lowest priority

In terms of fire alarm systems and equipment, the three types of generators are used in a very specific manner. There are two important and distinct parts of the fire alarm system which may require the use of an engine driven generator. The first is the actual fire alarm control panel and all associated initiating, notification and fire safety equipment located at the protected premise. The second is the monitoring station equipment which receives the fire alarm signals. The types of engine driven generators required for each are detailed below:

1. Fire alarm equipment at the protected premise	Emergency System
2. Monitoring station equipment	Legally Required Standby

Emergency System Generators (Highest Priority)

Emergency system generators are the highest priority of standby engine driven generators. These generators must auto start and provide power to those building systems which have a direct effect on life safety.

Emergency system generators must be approved for use. NFPA 101® identifies the building occupancies which require the fire alarm system connection to the emergency system generator. The generator must have audible and visual signals that indicate derangement, carrying load, not functioning, and ground fault. The AHJ must conduct the initial test of the unit (under maximum load), and additional testing must be done periodically with written records kept. Transfer equipment must be automatic and approved by the AHJ.

Wiring from the emergency source to emergency loads must be kept separate from other wiring and loads, with a few exceptions. The exceptions are transfer equipment enclosures, exit or emergency lights, junction boxes attached to exit or emergency lights, and wiring in a common junction box containing only the branch circuits supplying the equipment and the emergency circuit supplied by the unit equipment. Also, wiring of two or more emergency circuits are permitted in the same raceway

Certain occupancies have additional requirements for the protection of the feeder circuit wiring and equipment. These occupancies include the following: Assembly occupancies with a capacity of 1000 or more persons, Assembly, educational, residential, detention and correction, business, and mercantile occupancies where the building is more than 75 feet high. These all require one of the following forms of protection for the feeder circuit wiring and equipment:

1. Building has approved automatic suppression system
2. Area has minimum1 hour fire rating
3. Wiring protected by listed thermal barrier
4. Wiring embedded in not less than 2 inches of concrete
5. Cable listed to maintain integrity for not less than 1 hour

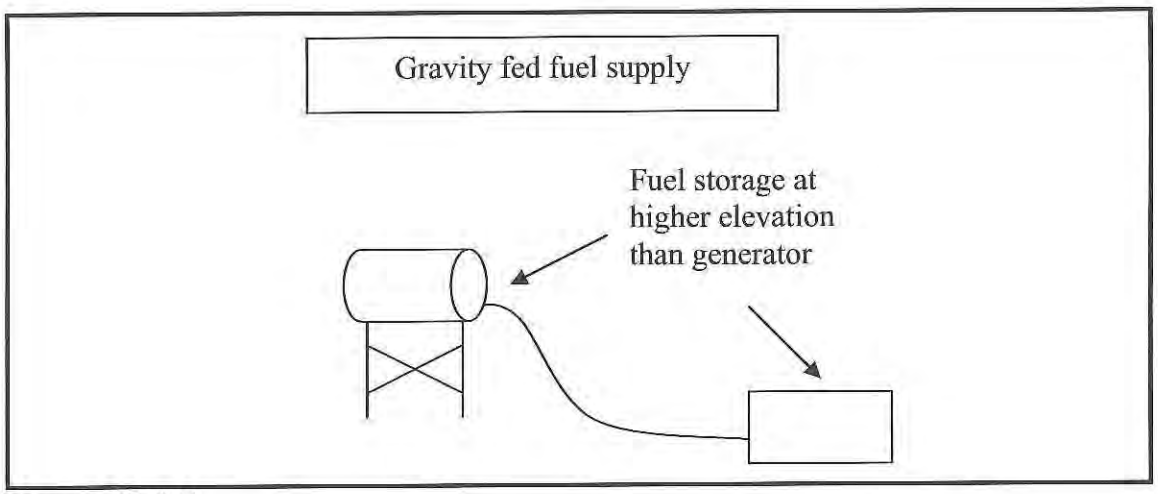
In the event of power failure, the emergency system shall provide power to the emergency lighting, emergency systems or both within 10 seconds.

Legally Required Standby Systems (2nd Highest Priority)
Legally required standby systems are those required by federal, state, or local codes or by any governmental AHJ. These generators are also required to have auto start, and they provide power to facility electrical systems which have an indirect effect on life safety. The approval and testing requirements for these systems are the same as emergency systems, but unlike emergency systems, they must provide power within 60 seconds of primary power failure (rather than 10 seconds). In fire alarm system applications, monitoring station receiving equipment is required to be connected to legally required standby systems. Receiving equipment is considered to have an indirect effect on life safety.

Optional Standby Systems
Optional standby systems have no direct affect on building life safety. They are strictly for providing an alternate source of power in situations where a power loss could cause discomfort, equipment damage, or monetary losses. These generators can be automatic or manual starting.

Fuel
Fuel must be stored in outdoor, underground tanks whenever possible. Gasoline fueled generators require that fuel be supplied from a frequently replenished source to ensure that the fuel is always fresh. Sufficient fuel must be available for 6 months of testing plus the capacity required run the system in standby and alarm modes for the code required amount of time.

NFPA 72® prohibits the use of gravity feed fuel tanks with generators. NFPA 110® permits the use of gravity feed tanks. It is understood in the industry that the storage requirements from NFPA 72® are in direct contradiction with NFPA 110®. Most generators in use today are gravity feed diesel.



Diagram, NTC, d8.16

If a reliable source of fuel is available anytime on 2 hours notice, the fuel storage is permitted to have sufficient fuel for 12 hours of operation. Fuel systems that use natural gas through utility mains are not required to use fuel storage tanks, unless the facility is located in a seismic risk zone of 3 or greater.

Secondary Power for Supervising Stations

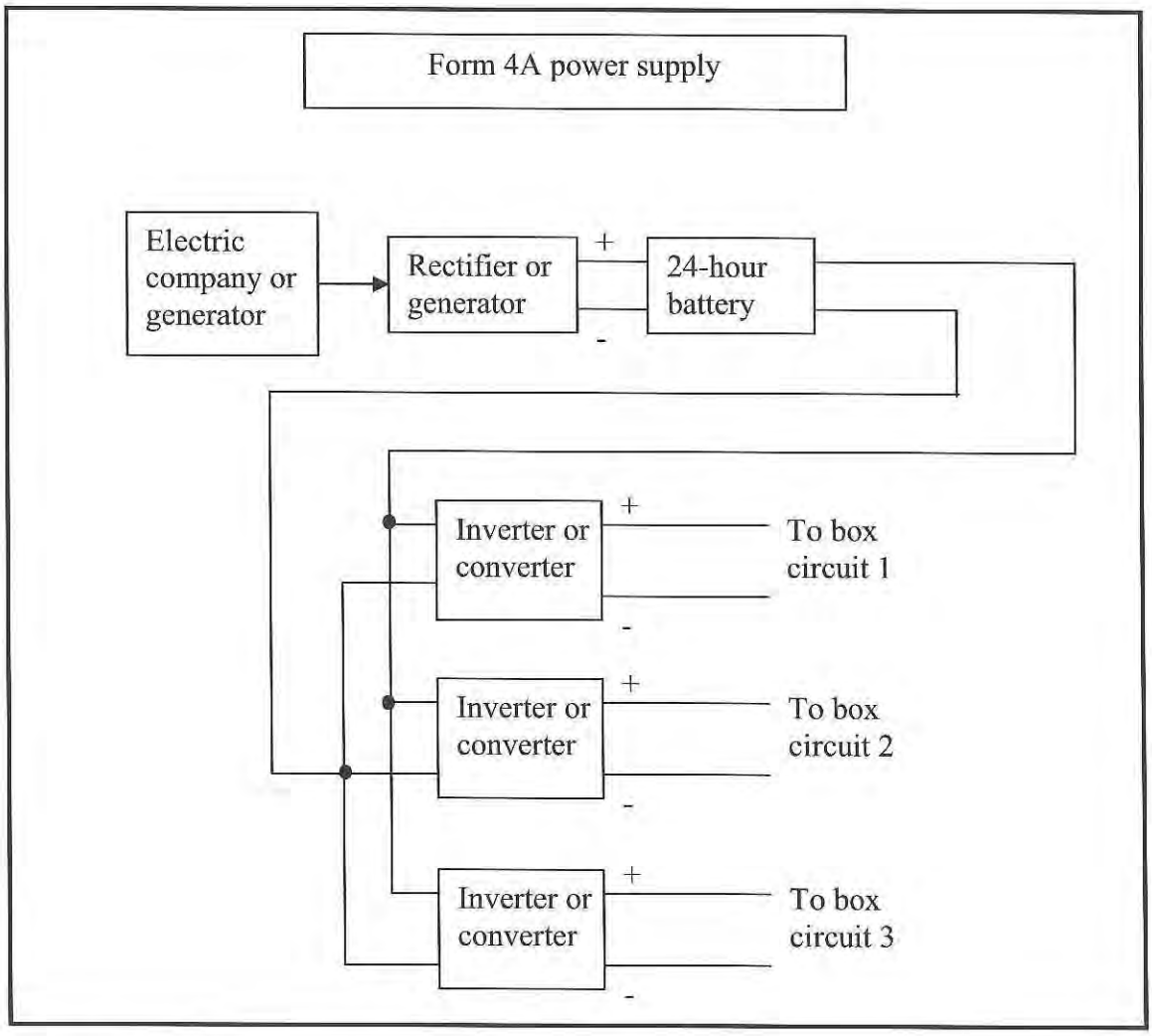
Supervising stations (commonly called central stations) are also required to have secondary power to continue operations in the event of a power failure. Supervising station secondary power requirements are similar to protected premises (fire alarm control) requirements.

Storage batteries may be used, or the dedicated branch circuit of a single automatic starting engine driven generator, or dedicated branch circuit of multiple engine driven generators If the system uses a single generator, it must also have 4 hours of battery standby capacity, and be a Type 10, Class 24, Level 1 system.

If the system is connected to multiple generators, there additional requirements. At least one of the generators must be automatic starting. Each generator must be capable of supplying the power required. Manual start generators must be a Type M, Class 24, Level 2 system. Manual started generators require a person trained in the generator starting procedures to be on duty at all times.

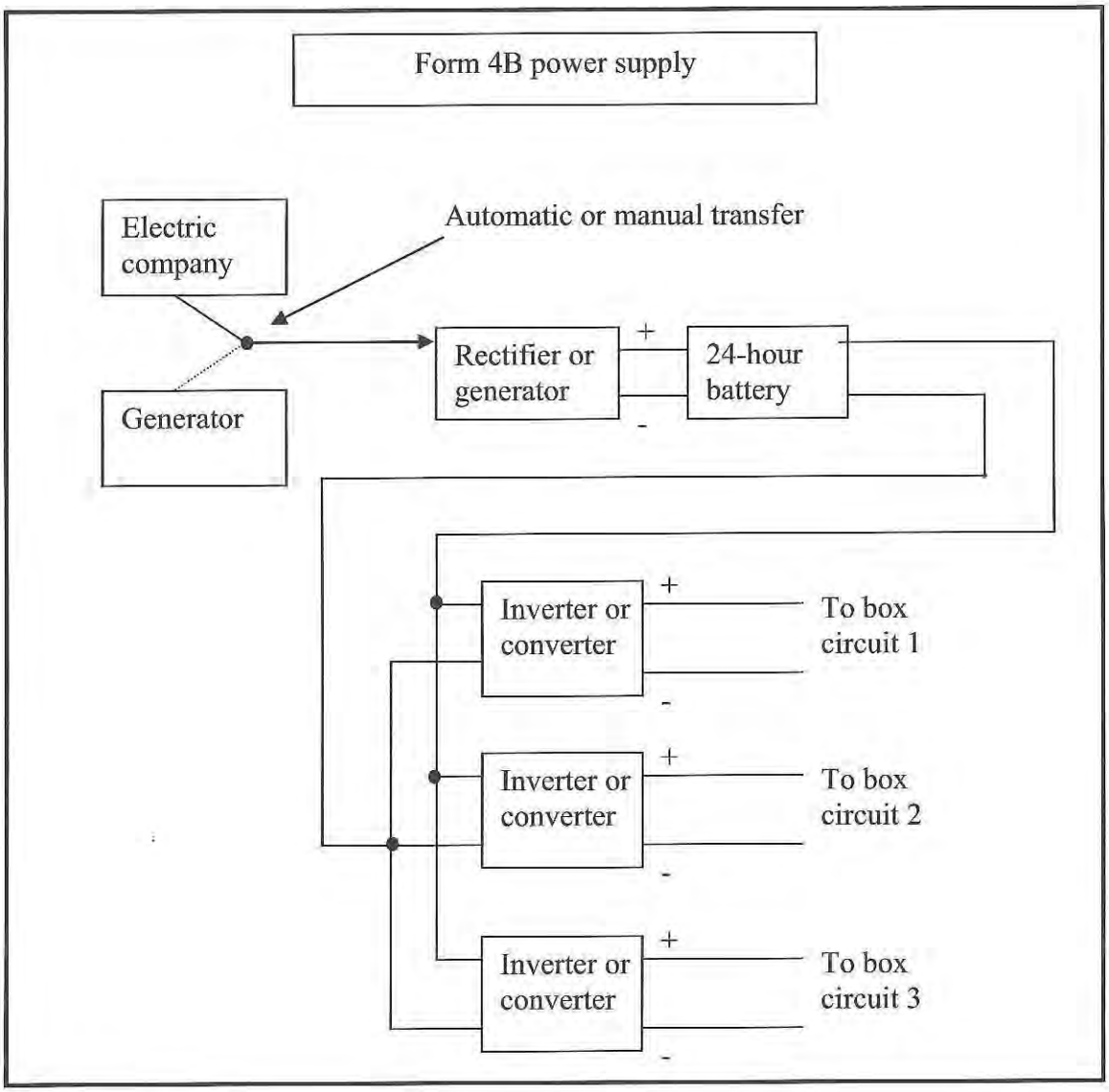
Power Supplies for Public Fire Reporting Systems
Public fire reporting systems have their own set of power requirements in NFPA 72®. Each system must be served by one of the following power sources:

1. Form 4A
   Inverter, powered by a common rectifier, receiving power by a single AC source with a float charged storage battery with a 24 hour standby capacity



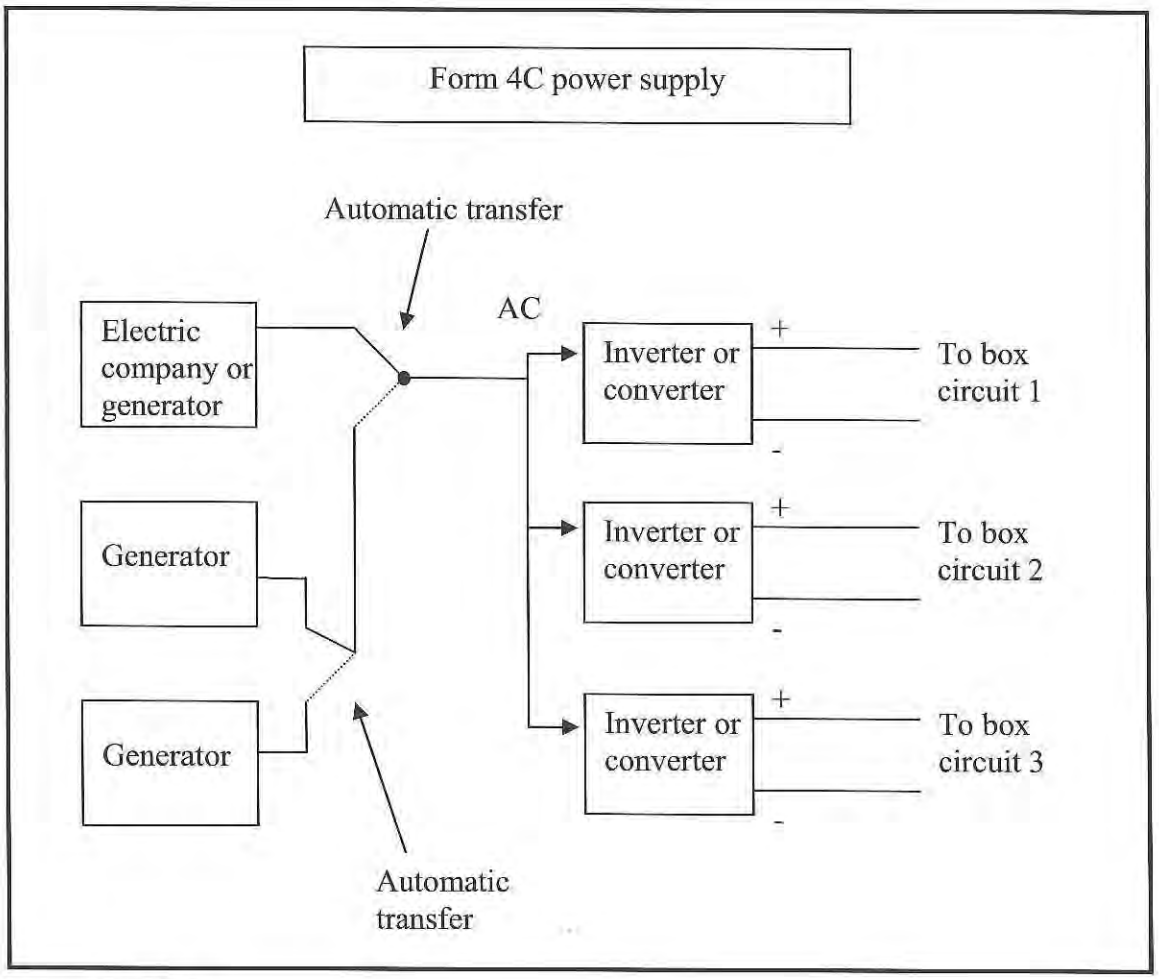
Diagram, NTC, d8.17

2. Form 4B
   Inverter, powered by a common rectifier, receiving power from two AC sources with a float charged storage battery with a 4 hour standby capacity



Diagram, NTC, d8.18

3. Form 4C
   Rectifier, converter, or motor generator receiving power from two AC sources with transfer facilities to apply power from the secondary source within 30 seconds.



Diagram, NTC, d8.19

The rectifiers must be supplied through an isolating transformer from a circuit that does not exceed 250 volts. One spare rectifier must be provided for every 10 operating on the system, with a minimum of 1 spare unit available.

Float charged batteries must be storage type. Dry cells are not permitted. The batteries must be on the same floor of the building as the operating equipment. The battery room must be above ground and must be ventilated to prevent explosive gas build up.

The power system must have provisions for powering any circuit from any battery, generator, or rectifier. Visible and audible indicators must annunciate a 15% or greater reduction of the normal power supply voltage.

Summary

Fire alarm power supplies are the most critical part of a fire alarm system. Without proper primary and secondary power, the fire alarm system would be unable to operate in normal or standby condition.

Standby battery calculations are a critical part of fire alarm system design. They are also a source of confusion for new and experienced fire alarm installers. The calculations are relatively simple if studied and understood for what they are: a basic math equation.

Chapter 9

Signals and Signaling for Fire Alarm Systems

The terms "signals and signaling" cause a great deal of confusion our industry. They are commonly use interchangeably and this adds to the confusion. It is important for industry professionals to understand the differences.

Signals: A status indication communicated by electrical or other means. A signal normally means an input signal to the fire alarm system. There are three types of fire alarm signals.

1. Fire Alarm Signal: A signal generated from a fire alarm initiating device which indicates the presence of a fire or fire signature. Fire alarm initiating devices include smoke / heat detectors, pull stations, waterflow switches etc.

2. Supervisory Signal: A signal generated from an initiating device which indicates an off normal condition. A water temperature switch is an example of this. When the water temperature dips below 40° Fahrenheit, the temperature switch sends a supervisory signal.

3. Trouble Signal: A signal resulting from system or component failure. A trouble signal indicates that there is a malfunction with the fire alarm system. Either the system wiring or a system component is malfunctioning. The fire alarm service technician is required to fix the problem.

Signaling: Using audible, visual or other means to provide notification of a fire alarm, supervisory, or trouble signal.

1. Evacuation signal: A distinctive signal, recognizable by the occupants for the need to evacuate the building. In fire alarm systems, the distinctive signal is the ANSI S3.41 signal (Temporal 3).

2. Emergency Voice Alarm / Communications signal: Dedicated facilities for distributing voice instructions and evacuation signals pertaining to a fire emergency to the building occupants. This is called a voice evacuation system.

3. Private mode signaling: Private mode signals are intended only for those personnel directly involved with emergency action. Private mode signaling is used for Positive Alarm Sequence and Pre Signal.

4. Public mode signaling: Public mode signals are intended to provide notification to all occupants of the building.

5. Positive alarm sequence: Positive alarm sequence provides automatic action. When a fire alarm signal is initiated, it is sent in private mode to a constantly attended location. The attendant has a 15 second window to acknowledge the signal. If the attendant fails to acknowledge the signal in 15 seconds, the building notification plan goes into effect. If the attendant succeeds in acknowledging the signal in 15 seconds, then 3 minutes is allowed for investigation of the signal. If the attendant fails to investigate the signal and reset the system in 3 minutes, then the building notification plan goes into effect. If the attendant investigates the signal and finds it to be a nuisance alarm, they can reset the system. Only certain building occupancies permit the use of positive alarm sequence. Check with the International Building Code or NFPA 101®.

6. Presignal System: A presignal system relies on human action. When a fire alarm signal is initiated, it is sent in private mode to a constantly attended location. The attendant may then investigate the source of the signal. The building notification plan only gets implemented when a human decides to activate it. Upon initiation of a fire alarm signal, immediate notification to the fire dept is required.

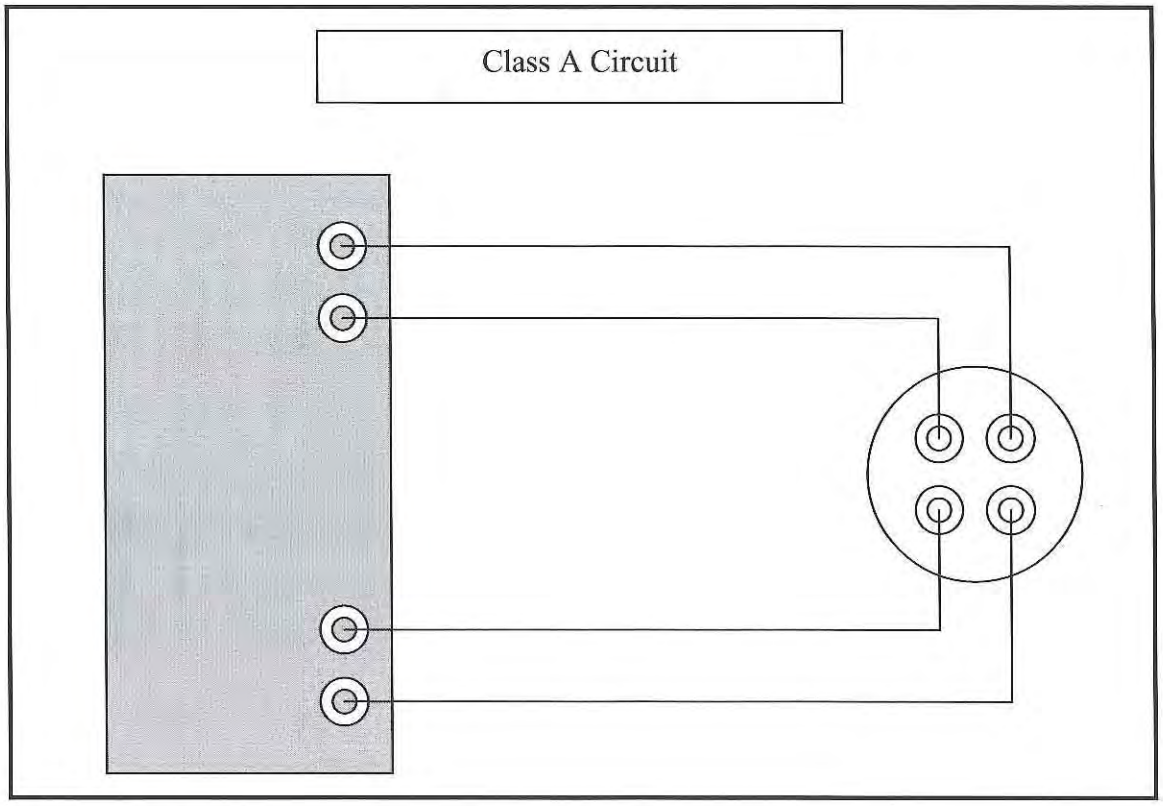
Signal Transmission
System signals are transmitted from detection devices to the control panel in three ways:

1. Wire
2. Wireless
3. Optical fiber

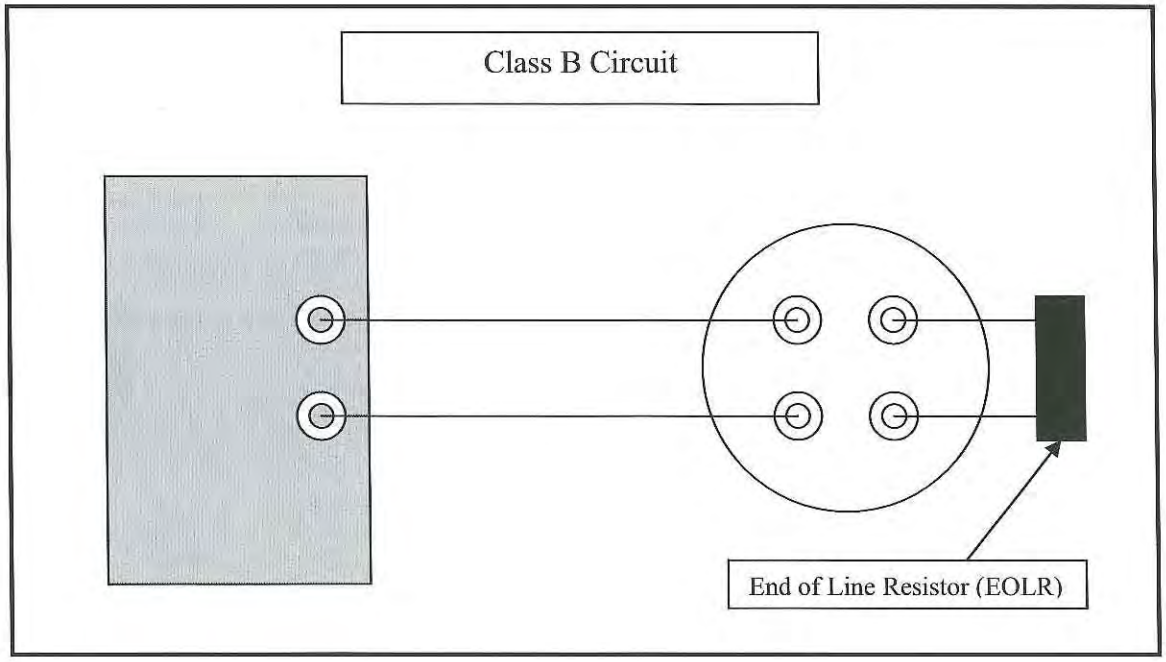
Wire Transmission
NFPA 70® (NEC®) Article 760 governs Fire Alarm System Wiring. Fire alarm systems may be Conventional or Addressable. Additionally NFPA 72® distinguishes circuits by class and style. There are two classes of circuits:

1. Class A Circuits: All devices shall operate during a single open or non simultaneous single ground fault on any circuit conductor.

2. Class B Circuits: Any circuit where devices do not operate beyond the point of a single open or non simultaneous single ground fault on a circuit conductor.

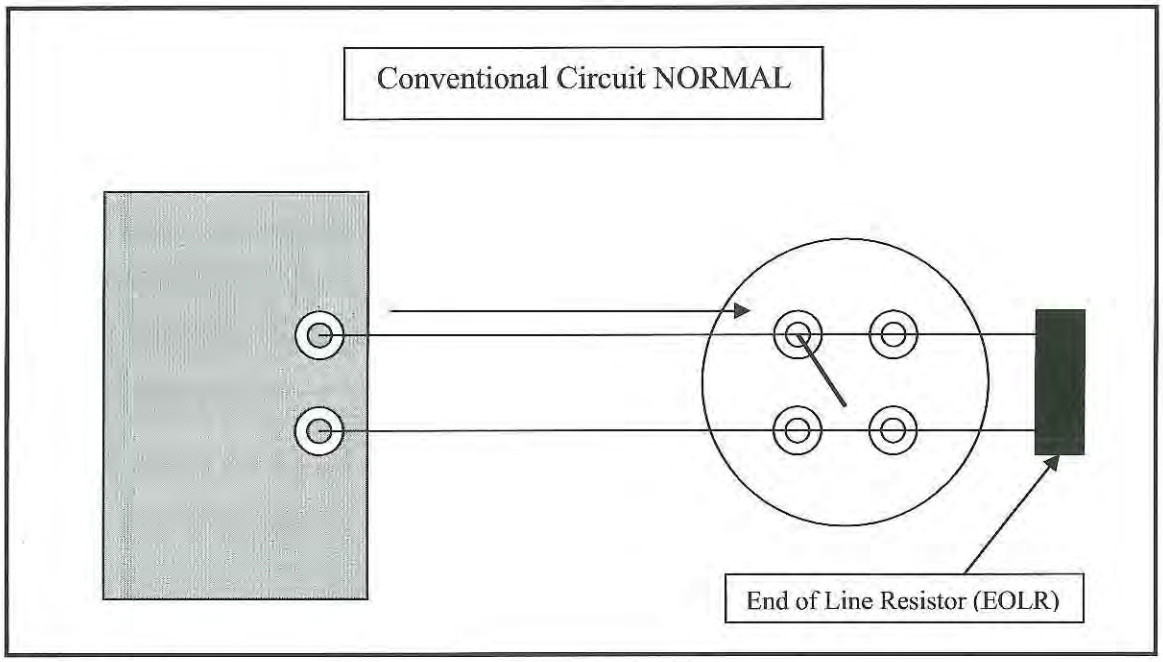


Diagram, NTC, d9.1

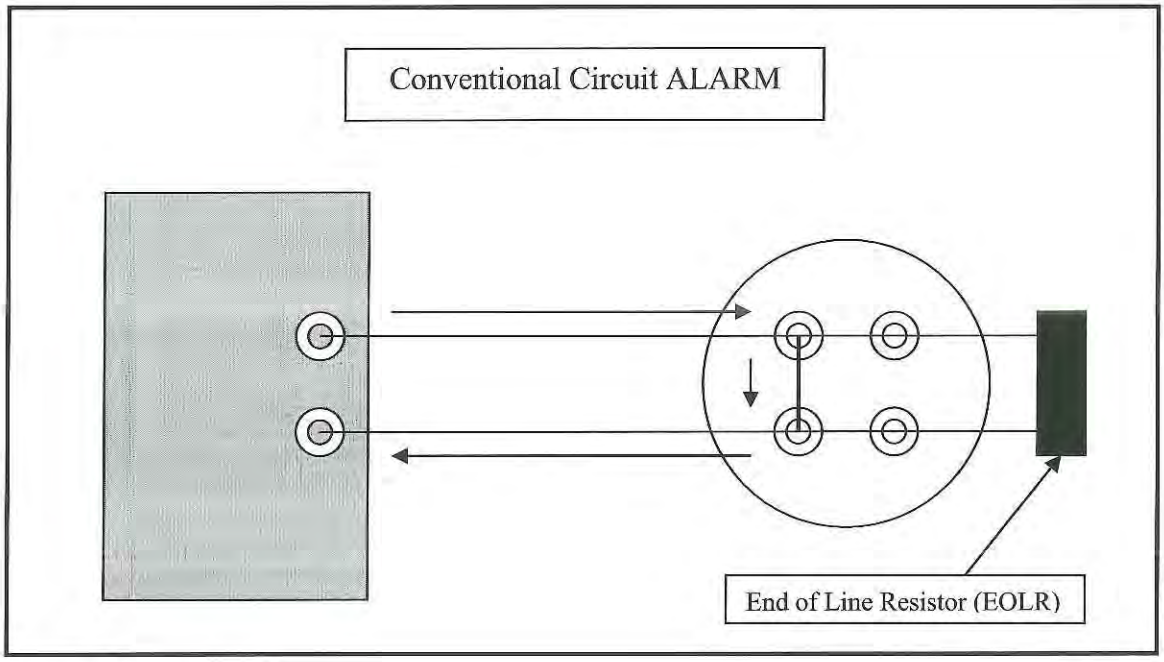


Diagram, NTC, d9.2

Conventional fire alarm devices and circuits use a simple switching action to initiate a signal. Most fire alarm devices are open circuit devices. When the signature of fire is detected, the device closes the circuit. The closing of the circuit allows current to flow in the circuit. The current flow triggers the panel to take action.



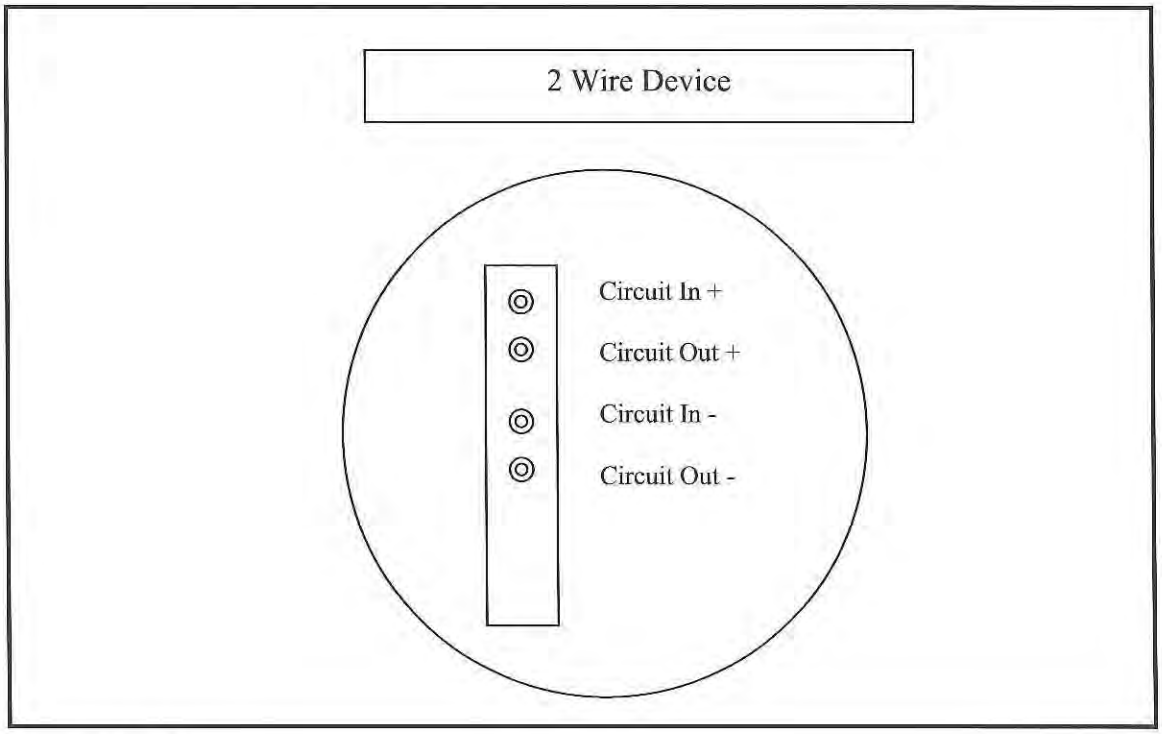
Diagram, NTC, d9.3



Diagram, NTC, d9.4

In the fire alarm systems of today, conventional circuits are supervised by an End of Line Resistor (EOLR) as depicted in the diagrams above. Conventional 2 wire smoke

detectors use circuits which provide power to the device and transmit alarm signals. These initiating device circuits are low current circuits. Therefore the number of 2 wire smoke detectors permitted on a circuit is limited. Additionally, the specific model number of the 2 wire smoke detector must be compatibility listed for use with the control panel. Underwriter's Laboratories conducts tests and provides this compatibility listing for 2 wire smoke detectors.

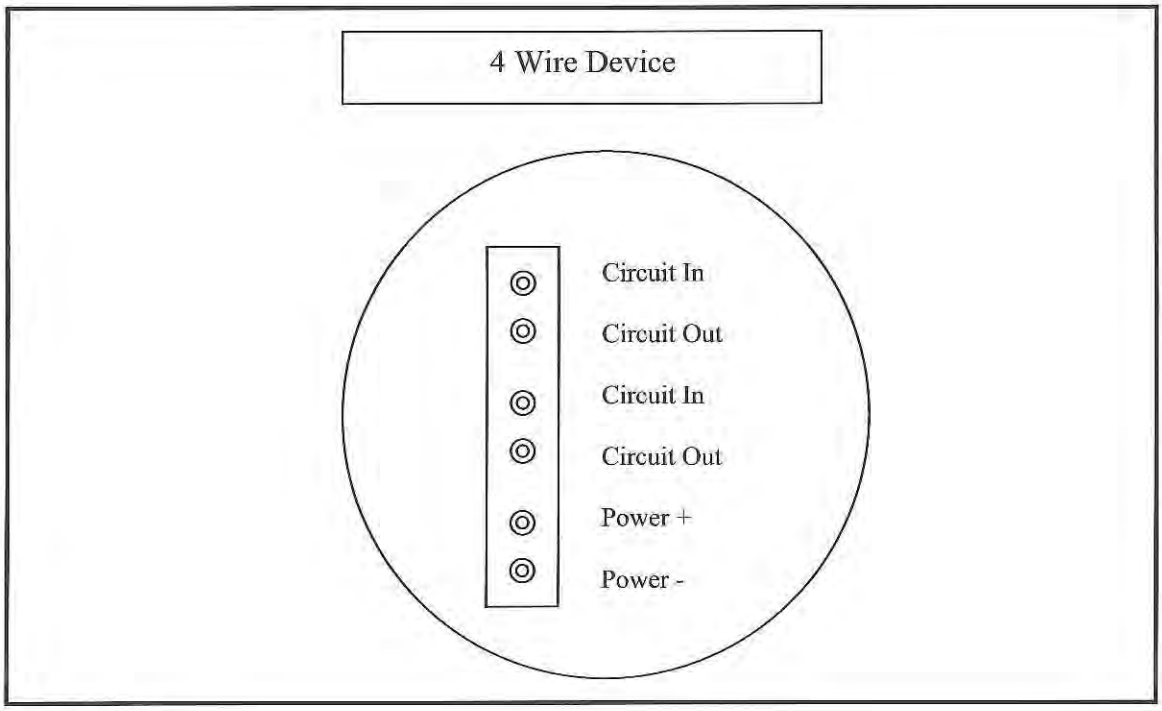


Diagram, NTC, d9.5

In the diagram above, the terminal requires circuit in and circuit out connections for both the positive and negative conductors. Proper polarity must be observed in order for the devices to operate properly. There is no requirement for separate power conductors in this configuration. The device is powered directly from the circuit conductors. Since the circuit conductors have a restricted amount of voltage and current, the total number of 2 wire smoke detectors is restricted. The circuit must be supervised with an end of line device, normally a resistor.

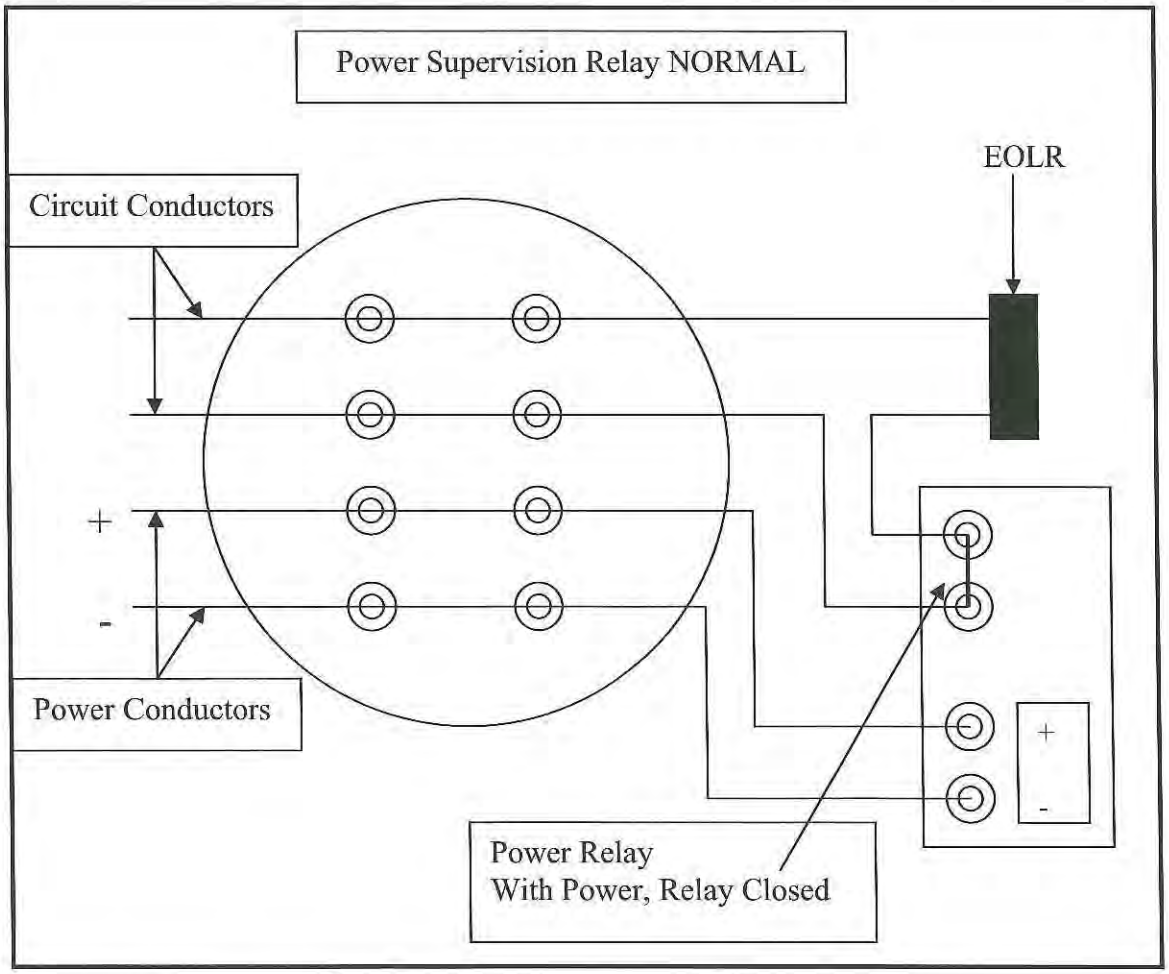
Some 2 wire smoke detectors are available with built in relays. These relays can be used for the activation of fire safety functions. The current draw of the relays must be taken into account in determining the total number of devices on the circuit. All smoke detectors must remain operational even with the relay energized.

Conventional 4 wire smoke detectors require 2 conductors for circuit response (alarm signals) and 2 conductors for power. Because the power is run separately from the circuit conductors, the number of devices is only limited by the power supply used for the application. Many more 4 wire smoke detectors may be employed this way. Also, 4 wire smoke detectors are not required to be compatibility listed. The 4 wire smoke detector is required to operate within the voltage limitations of the panel. Only 2 wire smoke detectors require compatibility listing.

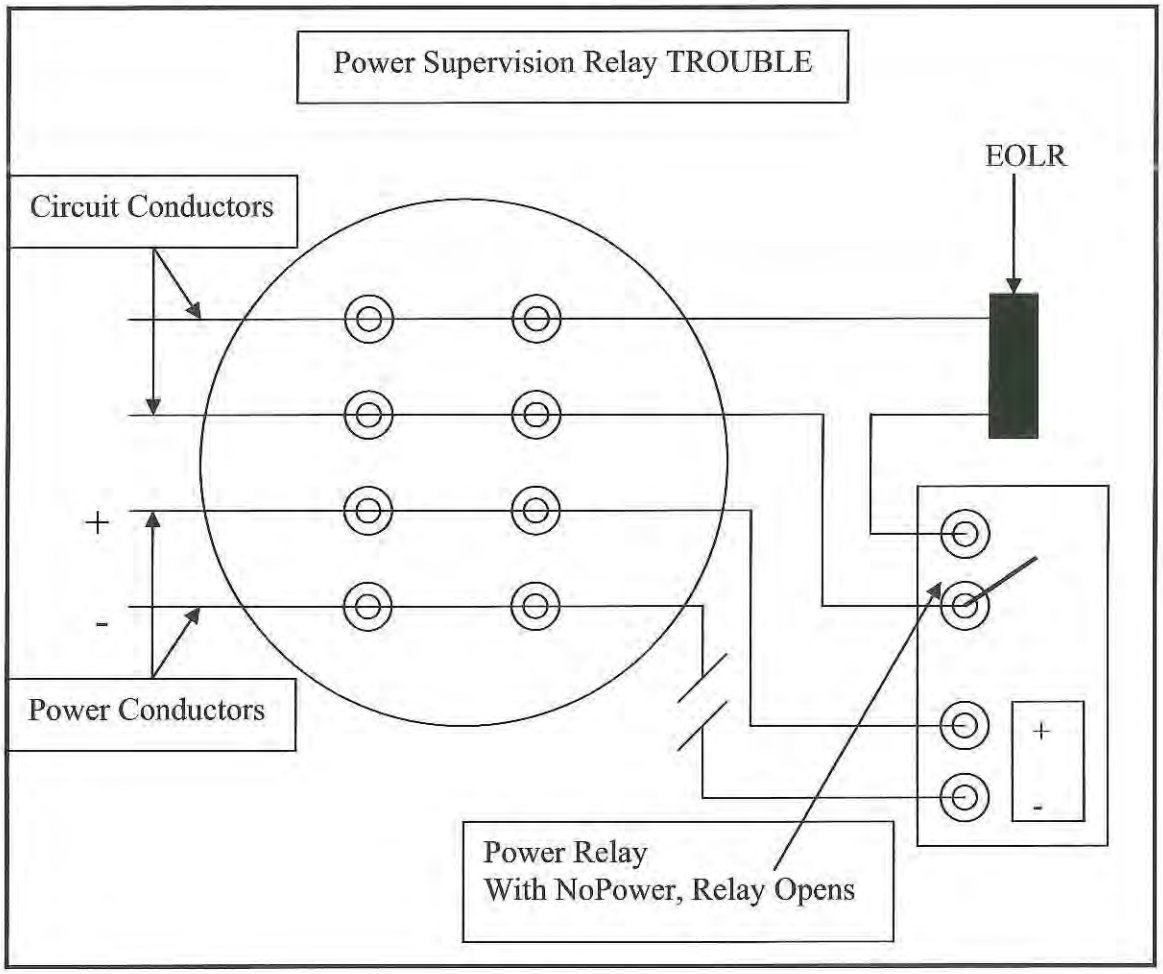


Diagram, NTC, d9.6

The circuit conductors are supervised with an EOL for 4 wire smoke detectors. The power conductors also must be supervised. This is done using a power supervision relay connected past the last device in the circuit. If an abnormal condition on the power conductors occurs (open or short), the power supervision relay will trip, open the circuit conductor, thus indicating a trouble condition.



Diagram, NTC, d9.7



Diagram, NTC, d9.8

Some smoke detectors may have a built in relay. This relay can be used for several functions. Some examples are:

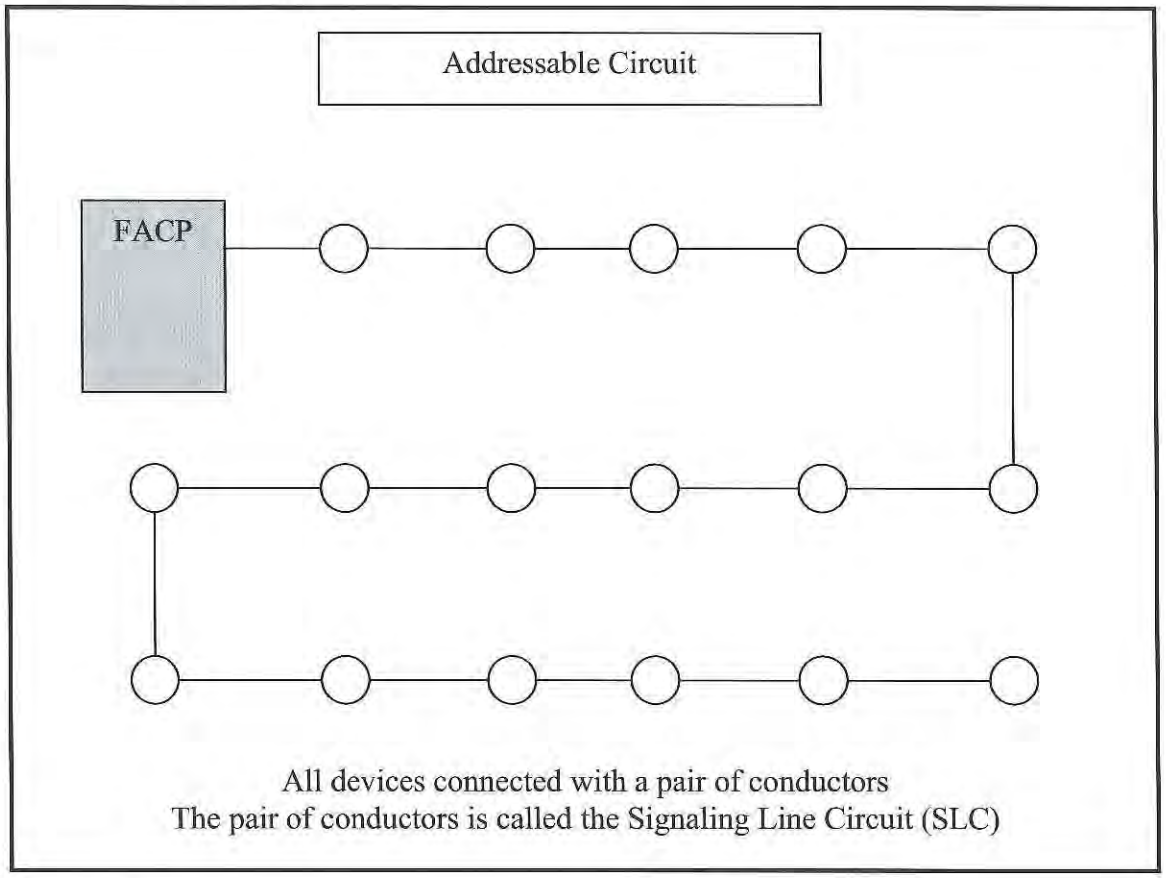
1. Door release
2. Elevator recall
3. Annunciation
4. Damper motor control

There are some restrictions on the use of these relays. Make sure the device is properly listed for its use. Also, for 2 wire detectors, the use of the relay may be limited. The power available to the relay will be limited by the circuit. It is important to ensure the circuit can handle the use of a relay.

Addressable Fire Alarm Circuits

Addressable fire alarm systems provide many options and advantages over conventional fire alarm systems. Addressable systems use a signaling line circuit to communicate information from the detector to the control panel and visa versa. Signals are multiplexed

and sent over the communications path. Addressable systems typically have the ability to use analog technology.



Diagram, NTC, d9.9

1. Addressable device. A fire alarm system component (like a smoke detector) with the capability of individual identification. These components are capable of transmitting several pieces of information over the same communications channel.
2. Signaling Line Circuit (SLC). This is a circuit used for addressable systems. Many different system input and output signals are transmitted and received. Multiplexing technology is used to send several pieces of information over the same pair of wires at the same time.
3. Multiplexing. This is a communications method which uses simultaneous or sequential transmission and reception of multiple signals over the same pair of wires. Multiplexing communications in modern fire alarm systems are microprocessor, or computer based communications methods. There are 2 types of multiplexing, Active and Passive multiplexing.
4. Analog smoke detectors. Analog detectors have the ability to detect and indicate specific increases in smoke concentration. This information is transmitted and stored at the control. If the concentration increases rapidly, the control makes the decision to initiate an alarm signal (not the device). The smoke detector just

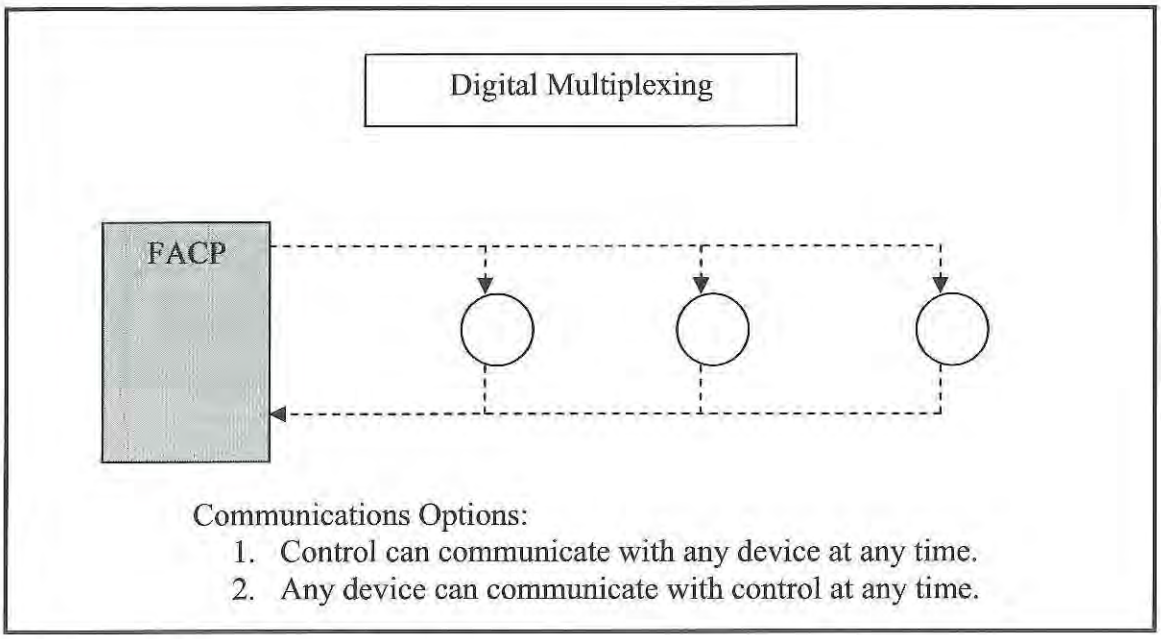
reports information. If the concentration increases slowly over time, then the control will indicate the need for detector cleaning.

Active Multiplexing. Most modern addressable fire alarm panels use active multiplexing. This technology allows for 2 way communication between the control panel and the addressable devices. This means communication can occur in the following ways:

1. Addressable devices can initiate communication to the control panel.
2. The control panel can initiate communication to the addressable devices.

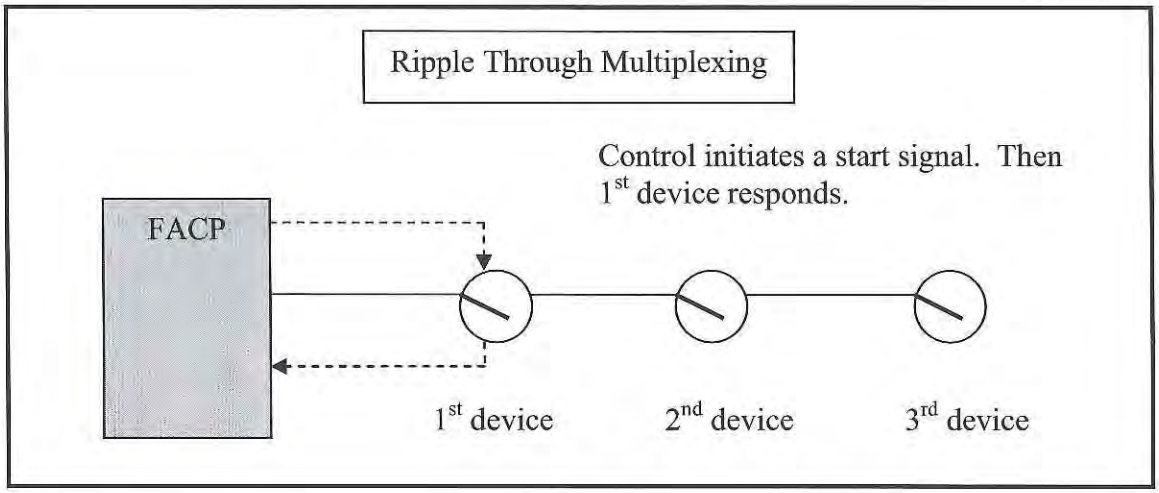
There are 3 categories of active multiplexing. They are:

1. Digitally addressable. This type of active multiplexing is what most modern addressable fire alarm panels use. Each device has an individual digital address. This makes random communications between the control and devices possible. Digital also allows for interrupt capability. Higher speed transmission is required for digitally addressable systems.

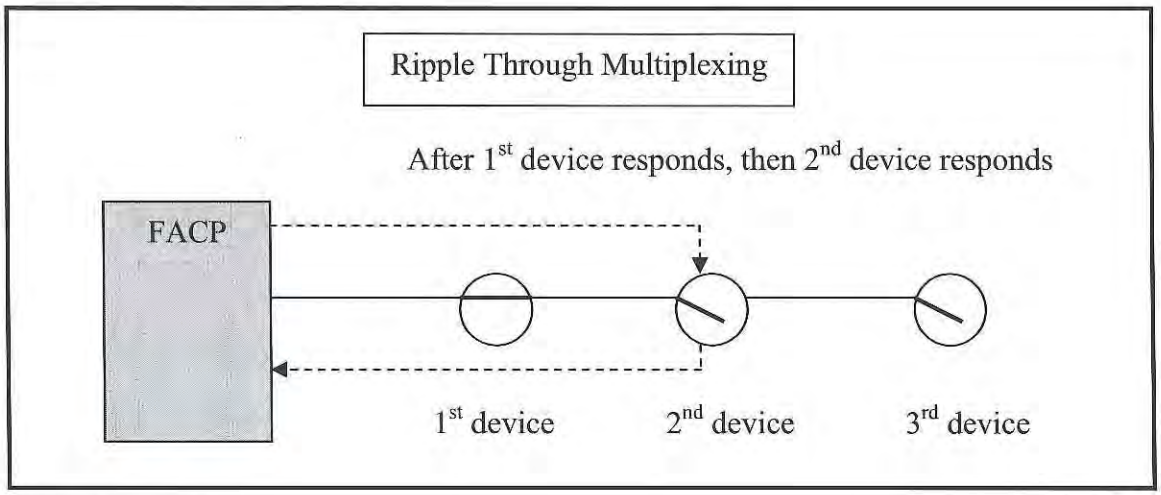


Diagram, NTC, d9.10

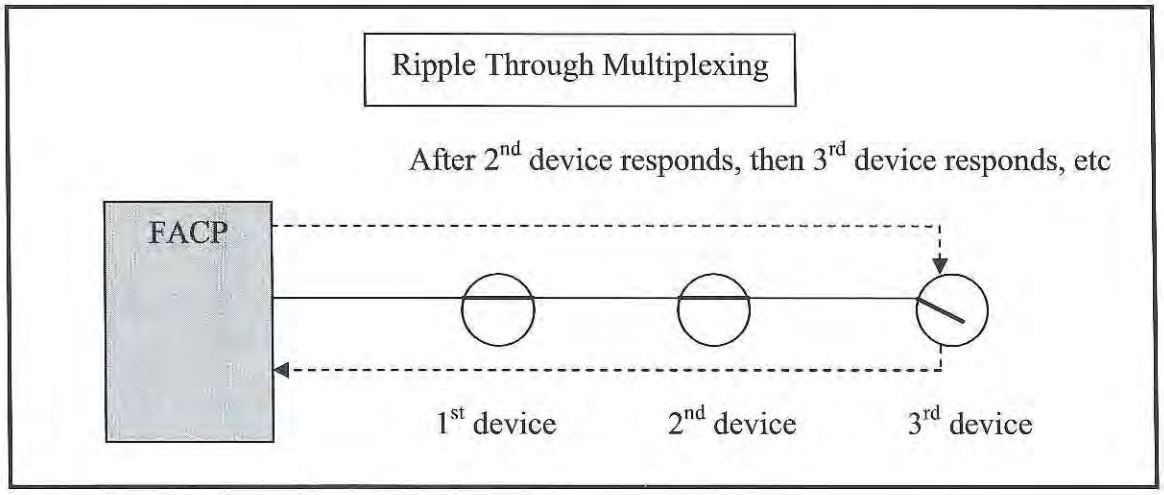
2. Ripple through. This is an older outdated type of multiplexing. Most modern systems do not use this. Ripple through functions like this:
   a. Devices are connected in series on a 2 wire circuit.
   b. Devices are NOT individually addressed. They are identified by their position in the sequential arrangement.
   c. The control sends 1 start signal. Then the first device in the sequence responds. Then the second device responds. Then the third device responds, etc.
   d. Since devices are required to be in series, T – tapping is not permitted.
   e. Interrupt capability is not possible.



Diagram, NTC,d9.11

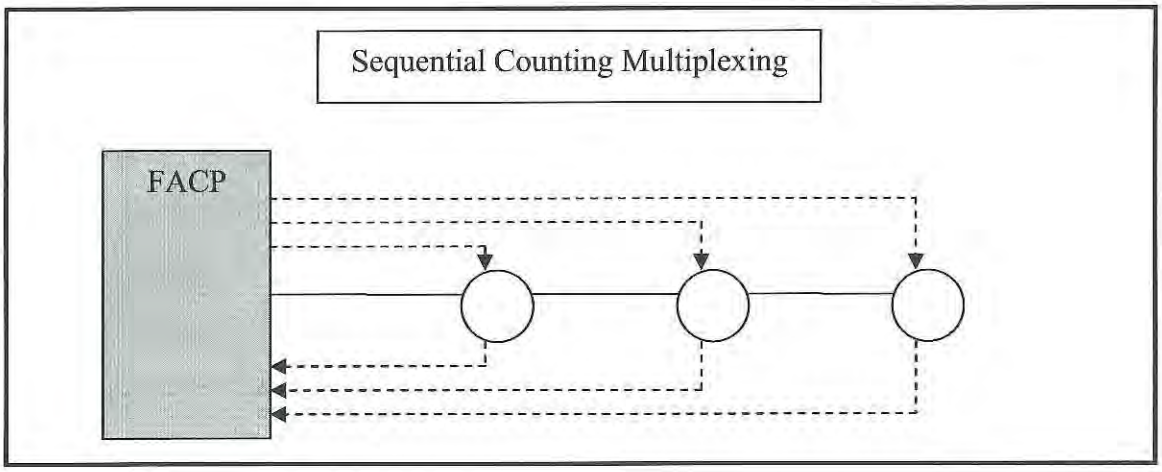


Diagram, NTC, d9.12



Diagram, NTC, d9.13

3. Sequential counting. This type of multiplexing is outdated. Most modern controls do not use sequential counting. Sequential counting functions like this:
    a. Devices are connected in parallel on a 2 wire circuit.
    b. Devices are individually addressed.
    c. The control initiates a start signal to the first device. The first device responds.
    d. Then the control initiates a start signal to the second device. The second device then responds.
    e. Then the control initiates a start signal to the third device. The third device then responds etc.
    f. T – tapping is inherent with sequential counting.
    g. Interrupt capability is not possible.



Diagram, NTC, d9.14

Digitally addressable is the type most common in today's equipment. You may encounter the others out in the field. It is also possible that you will encounter certification questions on the other types. That is why they are included here.

Passive Multiplexing. This permits 1 way communication only. Modern fire alarm systems do not use passive multiplexing. Addressable devices may report at any time. The control does not have the ability to check the status of devices. An example of passive multiplexing is a simple coded fire alarm system. A McColloh circuit provides an example of passive multiplexing. McColloh was used for fire alarm systems from the 1870s to the 1960s. They are now only in limited use across the country. Passive devices have a unique address and can identify their address, and an alarm condition.

Microprocessor based control units. Back in the late 1980s and early 1990s this was a big deal. Microprocessor based controls were the cutting edge of technology. Today practically all of the controls manufactured are microprocessor based. It is very easy to tell whether a control panel is microprocessor based or not. If you have to program it, then it is microprocessor based. Older controls were simply a series of switches. Programming involved setting dip switches. Modern controls are almost all

microprocessor based controls. Microprocessors employ thousands of transistors incorporated into integrated circuits. They perform the basic operations of a computer. All modern addressable systems are microprocessor based and most conventional controls are as well. There are many advantages to using microprocessor based controls. These include:

1. System diagnostics
2. Analog capability
3. Modular design
4. Expanded output options
5. Event history storage

Photo courtesy Firelite, p9.1

Wireless Transmission

There are two types of wireless transmission described in NFPA 72®, the National Fire Alarm Code®:

1. Low Power Radio (i.e. a wireless smoke detector)
2. RF Communications Methods (i.e. wireless transmission from a control panel to the monitoring station)

This chapter will cover Low Power Radio transmission. RF Communications methods are covered in detail in Chapter 10.

Low Power Radio

Low power radio means wireless fire alarm systems. This specifically refers to wireless initiating devices which communicate to the control panel. There are very limited

situations in which these are currently used. Check with the AHJ before using wireless fire alarm equipment for commercial use. There are some instances where they are used:

1. Historical buildings where invasive wiring is not acceptable
2. Existing installations where construction materials do not permit wiring methods
3. Limited instances where wiring is not possible / feasible

The power supplies for fire alarm systems are not permitted to use dry cell batteries with one exception. Dry cell batteries can be used for low power radio applications. When dry cell batteries are used for wireless fire alarm equipment they must be used as the primary power source and they are required to be supervised. Additionally, transmitters may serve only one device and they must be individually zoned. The battery is required to last for at least 1 year and must produce a low battery signal 7 days prior to the battery failure. The low battery signal is required to resound every 4 hours.

When a transmitter is actuated it is required to send an alarm signal. Alarm signals are required to be repeated every 60 seconds until the device is returned to normal. Signals have 90 seconds from the activation of an alarm signal until the notification appliances sound. Wireless devices are required to be supervised so that the removal of a device generates a supervisory signal.

There are many requirements in place to ensure the reliability of commercially listed wireless fire alarm equipment. There are also common sense issues when installing wireless equipment. Some important considerations are as follows:

1. Only mount wireless devices to a permanent structure and / or the appropriate back box they are designed to fit
2. Stay away from sources of possible interference
3. Do not exceed the maximum range of the device
4. Make sure the device is tamperproof

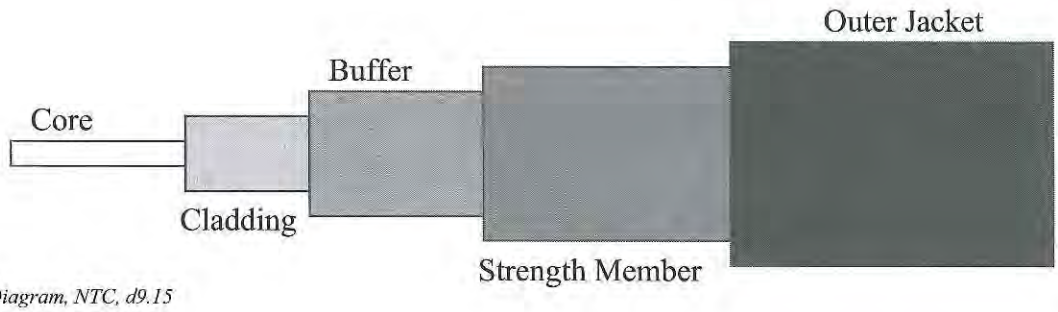
Optical Fiber Transmission

This method of signal transmission is gaining in popularity as the technology of fiber optics is becoming more wide spread. Fiber optics offers the ability to transmit much more information with less cable. For fire alarm systems, this transmission method is most commonly used to interconnect control panels from several different buildings or locations or to connect an annunciator or printer. Fiber optic cable is not commonly used for initiating device circuits.

Fiber optics is the transmission of light through glass fibers for communications and signaling. Fiber optic equipment converts electronic signals into light, which is then pulsed into fine strands of glass. The light received at the other end is converted back into electronic signals.

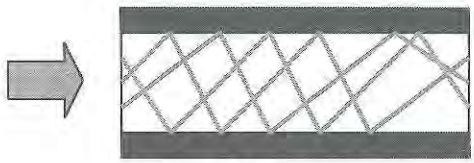
Fiber optic cable consists of five parts. The core is a very fine strand of glass, which carries the actual light signal. The core is the most delicate part of the fiber. Cladding

covers the core with a mirrored inner surface that helps keep the light within the core. The buffer protects the core and cladding from physical damage, it also helps to keep moisture out of the cladding. The strength member helps protect the fiber from pulling and flexing, and is usually made from Kevlar® or aramid yarn. The outer jacket covers the outside of the fiber cable and helps protect the fiber from damage.

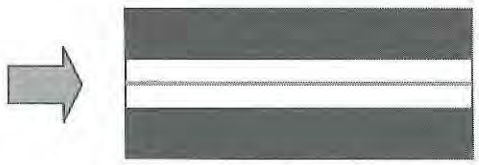


Diagram, NTC, d9.15

Mode is a description of how light travels down a fiber. Multimode fiber allows light to travel down it indirectly along multiple paths, bouncing off the cladding as it goes. Singlemode fiber only allows light to travel directly in straight line.



Diagram, NTC, d9.16



Diagram, NTC, d9.17

Multimode cable has a larger core diameter than singlemode, but unlike copper cable, larger diameter means shorter distance. Multimode cable is suitable for shorter range applications (under 5 miles). Multimode cable is more economical and easier to work with. The electronics for multimode, use LEDs, making them less expensive than singlemode electronics.

Singlemode cable has a smaller core diameter than multimode. Singlemode cable is best for longer range applications (up to 30 miles). Singlemode cable is more expensive and harder to work with than multimode. The electronics for singlemode use lasers or laser LEDs, making them more expensive.

Fiber size is expressed as the core diameter and the cladding diameter. 62.5/125 micron is common for multimode cable, 8/125 is common for singlemode cable. Most cables have a 125 micron cladding diameter. A micron is $1/1000^{th}$ of a millimeter. A human hair is 85 microns.

Tight buffer cable has the buffer close to the core fiber. This style of buffer is best suited for indoor applications where moisture is not a concern. Loose tube buffer cable has a buffer filled with a gel to resist moisture and protect the core from being damaged. Loose tube is best suited for outdoor and high moisture areas. Some vendors now offer an indoor/outdoor tight buffer cable.

Tight Buffer

Diagram, NTC, d9.18

Loose Tube

Diagram, NTC, d9.19

Fiber optic equipment uses light in the infrared range, above 780nm (nanometers). 850nm is the most common, least expensive, and shortest range. 1300nm provides longer range, and 1550nm provides the longest range.

Never look down a fiber connected to a laser transmitter! The output from the laser can damage your eyes. Always power down equipment before disconnecting fibers.

Fiber optic connectors differ from other connectors in appearance and installation. The ST is a twist style bayonet connector similar to the BNC. Many other types of connectors are available, but most are only common to datacom. The FC, SC, and LC connectors are push style connectors, similar to telephone plugs.

Diagram, NTC, d9.20

Fiber optic cable requires a termination kit to properly install connectors and repair cables. Various versions of these kits in varying price ranges are available. Fiber optic termination is relatively simple. With practice, a technician can become proficient enough to install a connector in a few minutes.

Photo courtesy Ideal Tools, p9.2

Most cable manufacturer's offer training in fiber optic termination. Most manufacturer's of tools offer training specific to their tools. This training is readily available and should be taken prior to making fiber optic terminations. It is also possible to hire professional fiber optic contractors to make your terminations.

More sophisticated (and expensive) test instruments can be used to test the quality and connections of a fiber optic cable. A power meter uses a light source of known power at one end of the cable and measures how much of the light power reaches the receiver at the other end. An OTDR (optical time domain reflectometer) can tell the length of a fiber optic cable, as well as tell the location of all splices, connectors, breaks, and terminations.

When a fiber optic cable needs to be spliced or repaired a coupler is typically used. A passive coupler is similar to a BNC inline splice. It requires connectors to be installed on each end of the cable. A mechanical splice does not require connector installation, and has less signal loss than a passive couple. A fusion splice has the least signal loss because it actually fuses the glass fibers together, but it requires special equipment to make the splice.

A fiber optic patch panel provides a junction point for terminations and splices. It provides protection for delicate fiber strands and makes interconnection of devices easier. Using patch cables makes moves, add ons, and changes even easier.

Fiber Optic Patch Panel

Photo courtesy Leviton, p9.3

Fiber Optic Patch Cable

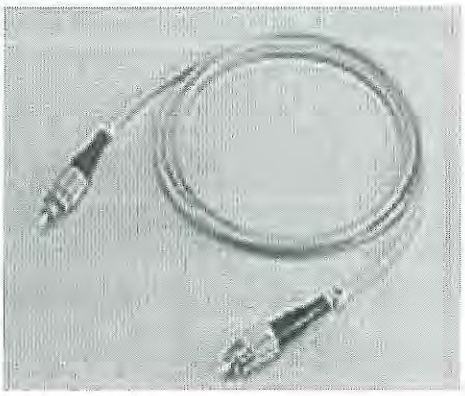


Photo courtesy Leviton, p9.4

Loss budget is the difference between transmitter power and receiver sensitivity. All losses through cable, connectors, and splices cannot exceed this number. Additionally, at least 3dB should be allowed for future repairs. The system margin is the signal power after all losses have been deducted from the loss budget. The system margin can be calculated by deducting the total losses from the loss budget.

Fiber Loss Per 1000'

	850nm	1300nm	1550nm
Multimode	1dB	0.5dB	N/A
Singlemode	N/A	0.13db	0.1dB

Connector/Splice Loss

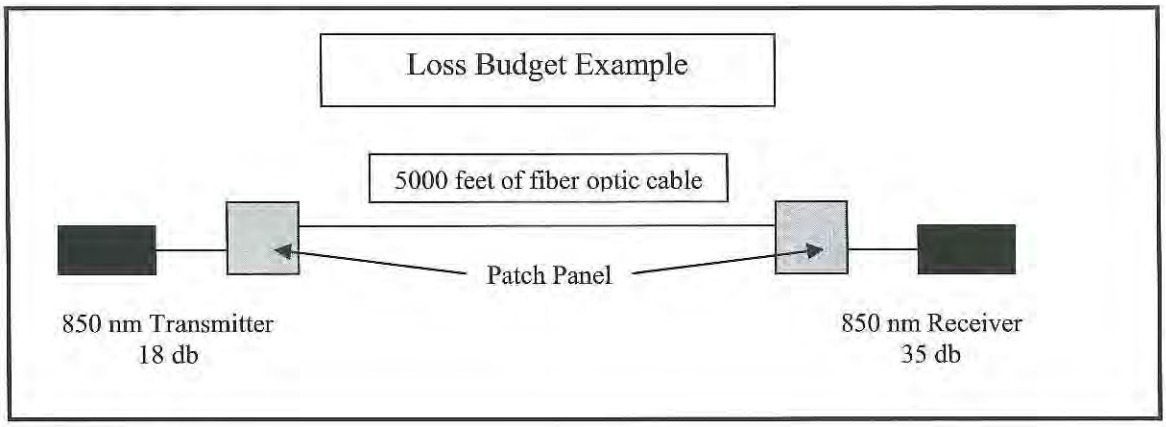
Connector	0.5dB
Patch Panel	1dB
Passive Splice	1dB
Mechanical Splice	0.5dB
Fusion Splice	0.2dB

System Margin Calculation

Loss Budget (electronics) _____
Cable Loss _____
Connector Loss _____
Patch Panel Loss _____
Splice Loss _____

System Margin *(minimum 3dB)* _____

System Margin Example



Diagram, NTC, d9.21

Loss budget: 35dB – 18dB = 17dB

Loss Budget (electronics)	17dB
Cable Loss	5dB *(5 x 1dB)*
Connector Loss	1dB *(2 x 0.5dB)*
Patch Panel Loss	2dB *(2 x 1dB)*
Splice Loss	0dB *(no splices)*
System Margin *(minimum 3dB)*	9dB

When pulling fiber optic cable, the rated pulling tension should never be exceeded. Fiber should always be hand pulled, and never jerked. Observe the minimum bend radius when bending fiber and spooling excess. The width of a coffee cup is a good rule of thumb. Always use a lubricant when pulling fiber cable through conduit. Failure to observe these precautions could result in broken fibers, which will degrade system performance.

Fiber optic cable is smaller and lighter than other cable. Fiber optic cable is completely immune from lightning since glass is not a conductor. Fiber optic cable can be run in the same cable tray as high voltage cabling (consult National Electrical Code®, Article 770 for details). Fiber optic cable is completely immune from RF and EM interference. It is electrically isolated, so it will never incur a ground loop. Fiber is the most secure means of signal transmission, as it cannot be easily tapped.

Article 770 of the NEC® governs fiber optic cable. It classifies fiber optic cable into two main types, conductive and nonconductive. Conductive fibers contain metallic materials, nonconductive do not contain any metal materials. The fibers are additionally sub-classified as general purpose (OFN for nonconductive, OFC for conductive), riser (OFNR and OFCR), and plenum (OFNP and OFCP) just like copper cables. Both types of fiber optic cables are permitted in the same raceway as high voltage cables.

Summary

There is much confusion in our industry regarding fire alarm signals and signaling. There are three types of fire alarm signals:

1. Fire Alarm signals
2. Fire Supervisory signals
3. Fire Trouble signals

Fire alarm Signaling includes the ways in which the fire alarm system conveys information to users and occupants. Signaling includes the following:

1. Evacuation signaling (temporal 3, Public Mode).
2. Voice evacuation signaling (Public Mode).
3. Positive alarm sequence (Private Mode).
4. Pre signal (Private Mode).

Signal transmission is the way in which signals move from a device to the control, or the control to a notification appliance. There are 3 signal transmission methods:

1. Signal transmission over wire.
2. Wireless signal transmission.
3. Optical fiber signal transmission.

Getting familiar with these concepts will put you on your way to understanding how fire alarm systems work. These key concepts are important in your everyday work and if your jurisdiction requires certification, you will surely be tested on them.

Chapter 10

Communications Methods for Fire Alarm Systems

Communications methods is a term which refers to the way a control panel communicates with the monitoring facility. There are several methods of communications. This section will discuss methods which have been used in the past, as well as methods currently used today.

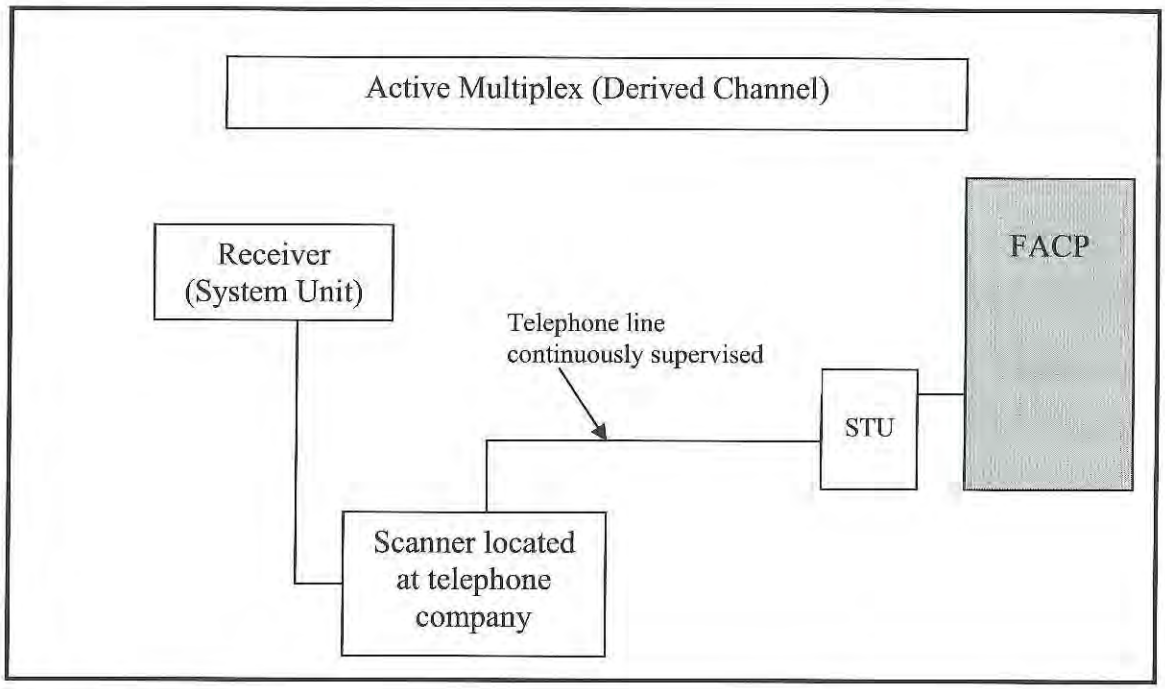
The use of public fire alarm reporting methods will not be covered in this chapter. Please refer to Chapter 11 for details on public fire alarm reporting communication methods.

There are seven different communications methods for fire alarm systems.

1. Active Multiplex (also known as derived channel).
2. Digital Alarm Communications Systems (DACS)
3. Digital Alarm Radio Systems (DARS).
4. McCulloh Systems.
5. Two way Radio Frequency (RF) Multiplex Systems.
6. One way Radio Frequency (RF) Multiplex Systems.
7. Directly connected non coded systems.

Active Multiplex (Derived Channel)
During the 1980's, the telephone companies attempted to break into the monitoring industry. They devised a supervised and highly reliable communications method from the fire alarm control panel, to the monitoring station. The critical parts of this system are:

1. Subscriber Terminal Unit (STU) connected to the fire alarm control panel and connected to a telephone line.
2. Scanner. This piece of equipment is located at the telephone company's central office and receives any signals from the STU. Then the Scanner duplicates the messages and transmits both to the monitoring station.
3. Derived channel receiver (also called a system unit). This is located at the monitoring station and receives signals from the scanner.



Diagram, NTC, d10.1

The telephone lines to each fire alarm control panel are continuously monitored by the scanner. If a telephone line is disabled, a signal is immediately sent to the monitoring station by the scanner. Active multiplexing systems are provided by local telephone companies, and are not available in all areas.

Type 1 Systems.
Type 1 systems are the active multiplex systems with the highest degree of reliability. They must meet the following requirements:

1. Provide dual control. This requires the use of an alternate means of transmitting signals (2 phone lines).
2. Adverse conditions which are limited to a leg facility must not affect any other trunk or leg facility.
3. Any adverse conditions on the communications method must be indicated at the supervising station including its location.

Type 2 & 3 Systems.
Type 2 active multiplex systems are similar to Type 1 Systems, but they do not require dual control. Type 3 systems are active multiplex systems which automatically indicate and record an adverse condition on the phone lines. Dual control is also not required for Type 3 systems.

Loading capacities are the ability of a transmission channel to successfully process signals generated by fire alarm systems. The maximum number of fire alarm systems or devices which are permitted on a single transmission channel is the loading capacity for that technology. The loading capacities for active multiplex systems are detailed in the following table.

Active Multiplex System Loading Capacities

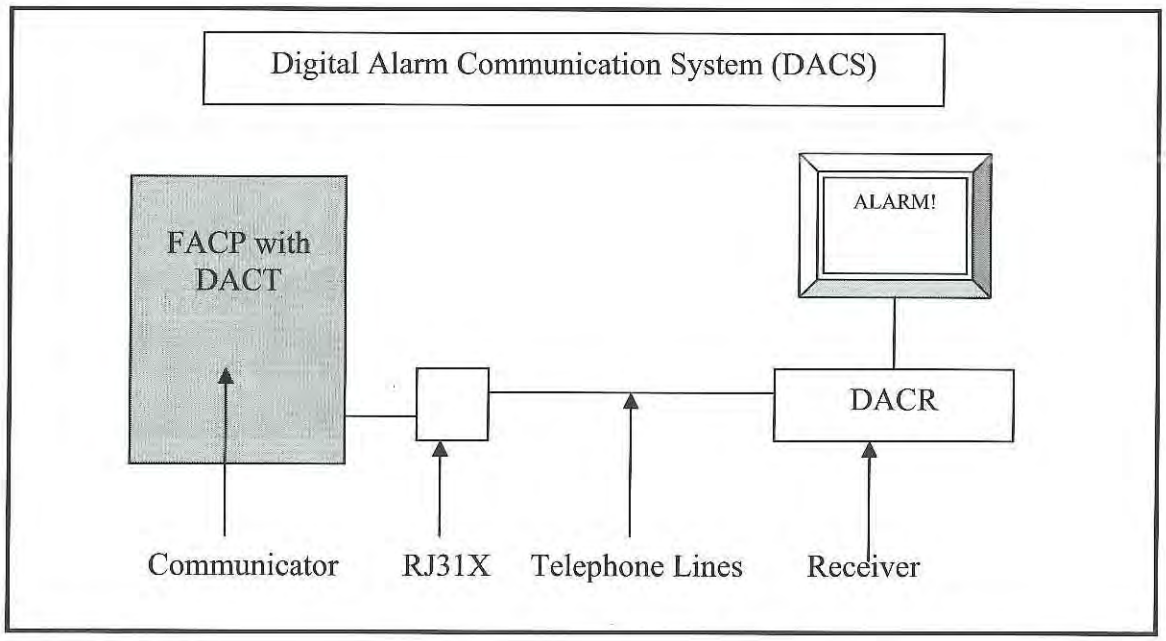
Trunks	Type 1 Systems	Type 2 Systems	Type 3 Systems
Fire Alarm Initiating Device Circuits/Primary Trunk	5120	1280	256
Fire Alarm Leg Facilities / Primary Trunk	512	128	64
Fire Alarm Leg Facilities / Secondary Trunk	128	128	128
All Initiating Device Circuits / Primary Trunk	10240	2560	512
(All Fire Alarm and Burglar Alarm)			
All Leg Facilities / Primary Trunk	1024	256	128
System Units at Supervising Station			
All Initiating Device Circuits / System Unit	10240	10240	10240
Protected Buildings (Premises) / System Unit	512	512	512
Fire Alarm Initiating Device Circuits / System Unit	5120	5120	5120
NOTE: If all receiving equipment at the supervising station is duplicated and switchover can be done within 30 seconds, then the loading capacity is unlimited			

Diagram, NTC, d10.2

Digital Alarm Communicator Systems (DACS)
This is the most popular communications method in use today. This method is characterized by the use of the Public Switched Telephone Network.

NFPA 72® provides several requirements designed to safeguard the integrity of signal transmission using DACS. The primary components of a DACS are as follows:

1. Digital Alarm Communicator Transmitter (DACT), commonly referred to as a digital communicator, a communicator or a dialer.
2. Digital Alarm Communicator Receiver (DACR), commonly referred to as the receiver.



Diagram, NTC, d10.3

Digital Alarm Communicator Transmitter (DACT). The DACT is normally integrated into modern control panels or collocated with the control panel. Important requirements in the use of these devices are specified in NFPA 72®. These are designed to ensure the reliability and accuracy of signal transmission.

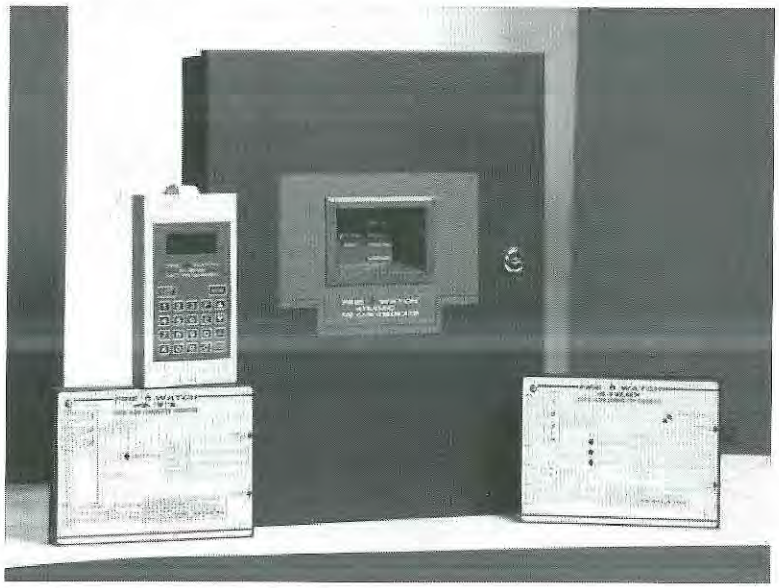
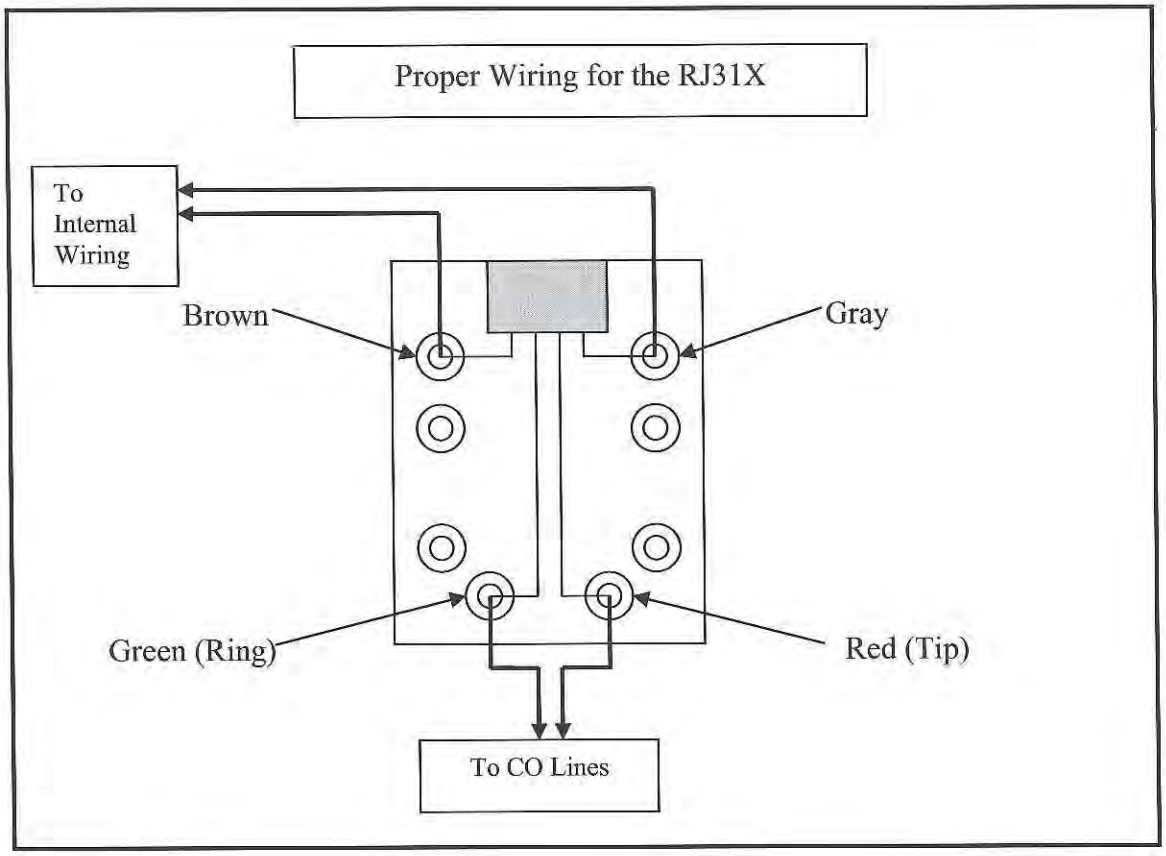


Photo courtesy Firelite Alarms, p10.1

A digital communicator (DACT) is required to have line seizure. This ensures fire alarm signals will have priority. If the phone line is in use, the DACT will seize the line. The DACT will cut off any other users on the line, get dial tone and send its signals. Line seizure is commonly accomplished using an RJ31X telephone block. The configuration for line seizure is presented in the following diagram:



Diagram, NTC, 10.4

It is important to make sure that the DACT is only connected to phone lines which belong to the subscriber. Loop start lines are required to be used (dial tone present when you pick up the handset). Ground start lines are not permitted for fire alarm system communications. The signals transmitted by the DACT have to be digital. Voice messages (like those from a tape dialer) are not permitted.

The on hook to off hook communication is required to be completed within 90 seconds. The DACT is not supposed to seize control of the phone line for longer than this time period. In the event of a communication failure, the DACT must continue to try to communicate for a minimum of 5 attempts and a maximum of 10 attempts. Once the communication has failed 10 times, a trouble signal is required to be indicated at the fire alarm control and remote annunciators.

DACT communications requires a primary and secondary means of communication. Normally acceptable methods include:

1. 2 telephone lines.
2. 1 telephone line and 1 cellular telephone connection.
3. 1 telephone line and a one way radio.
4. 1 telephone line equipped with derived local channel (no longer available).

5. 1 telephone line and a one way private radio system.
6. 1 telephone line and a private microwave system.
7. 1 telephone line and 1 two way RF multiplex system.
8. 1 ISDN line with a listed terminal adapter.

When using a DACT for fire alarm communication, the transmission channels must be appropriately supervised. Additionally both transmission channels have to be tested at intervals not to exceed 24 hours. This means that the test signal is required to rotate from the primary channel to the secondary channel every 24 hours. This pattern would work like this:

Sunday	Test signal primary transmission channel
Monday	Test signal secondary transmission channel
Tuesday	Test signal primary transmission channel
Wednesday	Test signal secondary transmission channel
Thursday	Test signal primary transmission channel
Friday	Test signal secondary transmission channel
Saturday	Test signal primary transmission channel

If either the primary or secondary transmission channel fails, a trouble signal indicating the failure is required to be sent on the operating transmission channel within 4 minutes. It is acceptable to send all signals over both channels. This increases the likelihood that the signals will be properly received.

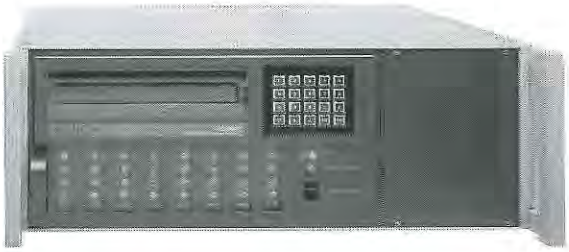
DACT communications require the use of a telephone line as the primary transmission channel. If the DACT calls a number which is long distance, the primary and secondary telephone lines have to use different long distance carriers.

It is permitted to send fire alarm signals on a telephone line which is programmed to call forward to a different line. The integrity of the call forwarding is required to be verified every 4 hours. There are 2 primary reasons why this call forwarding may be used. The first may occur when a supervising station has a back up monitoring station. In the event a problem occurs at the supervising station, signals can be call forwarded to a back up monitoring station. The second situation may involve the fire alarm contractor. The contractor may prefer using a telephone line under his / her control as the number to program into the fire alarm panels. This allows the contractor to maintain control of all accounts. Call forwarding can be used to send the signals to a supervising station.

Digital Alarm Communicator Receivers (DACR). The DACR is a critical link in the chain of communications. NFPA 72®, The National Fire Alarm Code® has several requirements for the use of receivers. All of the requirements are designed to increase the likelihood that all signals will be properly received. The requirements implement redundancies so that if a problem occurs with the receiving equipment, signals can still be received and acted upon. Failure to receive signals from a DACT, may delay the response of the fire fighters and this could cause lives to be at risk. Responsible supervising stations realize how important the DACR link is to the communications chain

and they follow the requirements of the code in order to ensure all signals are properly received and acted upon.

Photo courtesy Bosch, p10.2



The supervising station is required to have spare receivers in place in case a DACR fails. The ratio is 1 spare receiver for every 5 primary receivers in use. Normally the spare receivers are set up for automatic transfer in case of failure of a primary DACR. This transfer must occur in less than 30 seconds. If the supervising station is not set up for automatic transfer, then the maximum number of incoming telephone lines to each receiver is limited to 8. The minimum number of incoming telephone lines to each receiver is 2.

It is also important for all DACR telephone lines to be unlisted. Telemarketers could interfere with the transmission of alarm signals. The loss of any receiver telephone line requires visible and audible annunciation at the supervising station. All receivers are required to receive at least one signal every 24 hours. Also, failure of a receiver to receive a signal within a 24 hour period requires a trouble indication at the supervising station.

Hunt groups are commonly used in conjunction with supervising station operations. They provide a method for incoming calls to be routed to an open phone line. Their specific definition is: a group of associated telephone lines within which an incoming call is automatically routed to an idle telephone line for completion. In order to avoid problems, hunt groups have specific loading capacities.

The loading capacities for hunt groups are designed to prevent conflicting signals from interfering with signal transmission. It is important to ensure that all fire alarm signals are properly received and that is the intent of these loading capacity limitations.

Hunt Group Loading Capacities

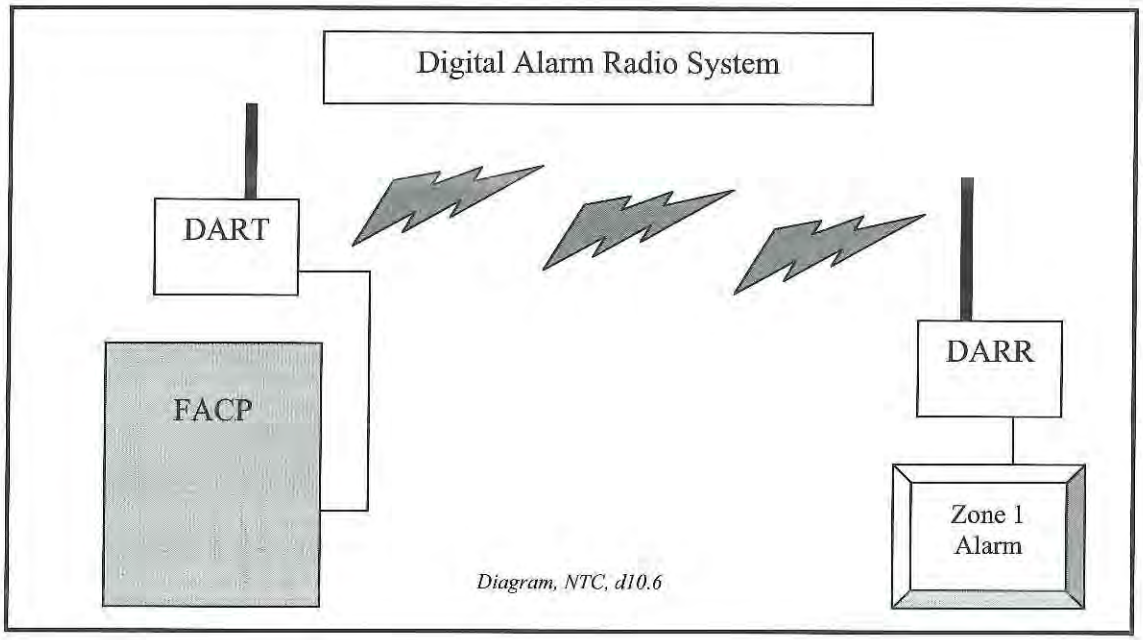
System Loading at Supervising Station	2 Lines	3 Lines	4 Lines	5-8 Lines
With DACR Lines Processed in Parallel				
Initiationg Device Circuits	5000	10000	20000	20000
DACTs	500	1500	3000	3000
With DACR Lines Processed in Series				
(put on hold then answered 1 at at time)				
Initiating Device Circuits	3000	5000	6000	6000
DACTs	300	800	1000	1000

Diagram, NTC, d10.5

Digital Alarm Radio Systems (DARS)

DARS systems are common today, although they are not as widespread as the DACS systems. They are available in limited locations across the country. A digital alarm radio system is designed to transmit the exact same digital information produced by the panel. A DARS will send zone information and any other information developed by the control panel. NFPA 72®, The National Fire Alarm Code® has specific requirements for the installation and use of this communications method.

The DARS is very different from other types of radio technology. It is capable of sending more information. A normal 1 way or 2 way radio only sends 3 types of signals, Alarm, Trouble and Supervisory. A digital radio is capable of sending the same type of information that would be sent using a DACT.



Diagram, NTC, d10.6

The system includes a Digital Alarm Radio Transmitter (DART) This device is normally located near the control panel. A Digital Alarm Radio Receiver (DARR) is also required and normally this piece of equipment is located at the supervising station. Some systems may use a repeater site as well to extend the coverage.

AES 7750F
Fire Transceiver

AES Central Receiver

AES 7050
Remote Control
Transceiver

Photos courtesy AES, p10.3

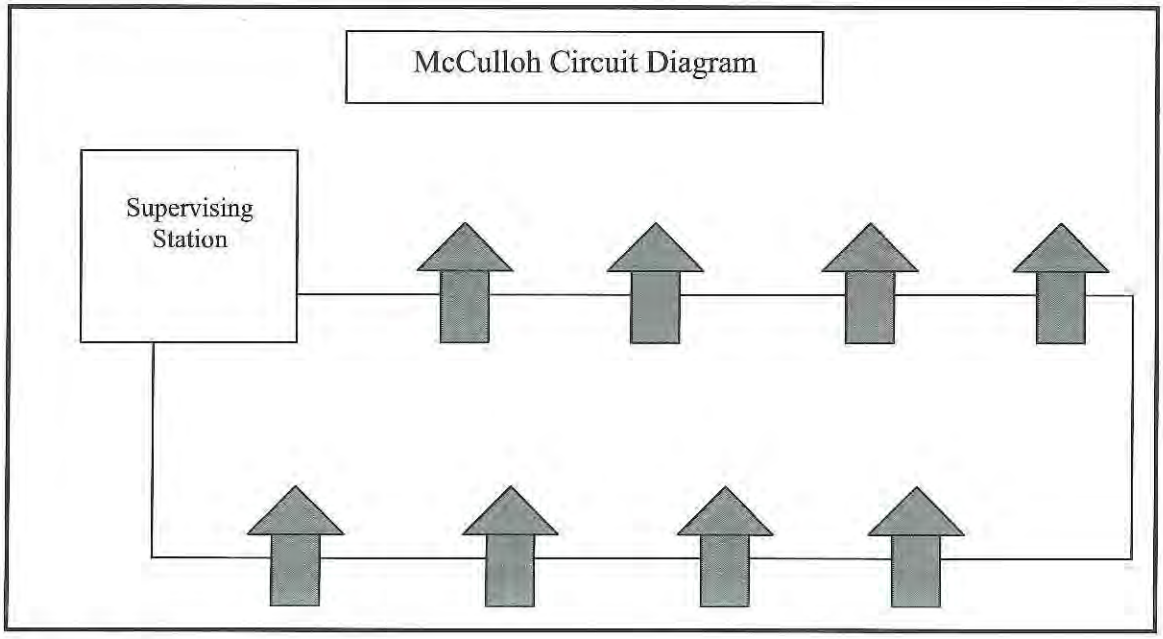
It is very important for a DARS to demonstrate an acceptable level of reliability. The standard detailed by NFPA 72® The National Fire Alarm Code® is 90% probability of successful signal transmission. The DART is required to repeat the signal a minimum of 5 times or until the signal has been transmitted successfully. Just like with other transmission methods, a test signal is required to be sent every 24 hours. At the supervising station, a spare DARR is required and in the event of DARR failure, the spare is required to be operational within 30 seconds.

Some Digital Alarm Radio Systems may use a subsidiary (or repeater) station. For these systems, the subsidiary station must be supervised in the event of a malfunction. Supervision includes power fail, equipment malfunction, switchover to the spare DARR, and improper data transmission.

McCulloh Systems

This type of communications method is not commonly used today. According to NFPA 72®, new McCulloh systems are not permitted (as of June 30, 2003). McCulloh systems are a type of old technology which may still be in use with existing systems. McCulloh systems are a form of automated Morse code. In the early 1900's, privately owned supervising stations used McCulloh technology to receive signals. Municipalities also employed this technology. Cities would install public fire alarm reporting systems by placing fire alarm boxes at street locations throughout the city. Public fire alarm systems are covered in more detail in Chapter 11 of this book.

The wiring for a McCulloh transmission channel starts at the supervising station and runs to each fire alarm box on the circuit. Each fire alarm box would be electrically connected to the other boxes on the circuit. At the last fire alarm box on the transmission channel, the wire would then be run back to the supervising station and terminated there.



Diagram, NTC, d10.7

McCulloh transmitter

A McCulloh transmitter (Fire Alarm Box) was located with the subscriber's fire alarm control panel. The transmitter contained a wind up code wheel with teeth. Specific teeth of the code wheel were broken off providing a unique method for identifying the transmitter.

Photo courtesy NTC, p10.4

Below is a picture of the internal code wheel of a McCulloh fire alarm box.

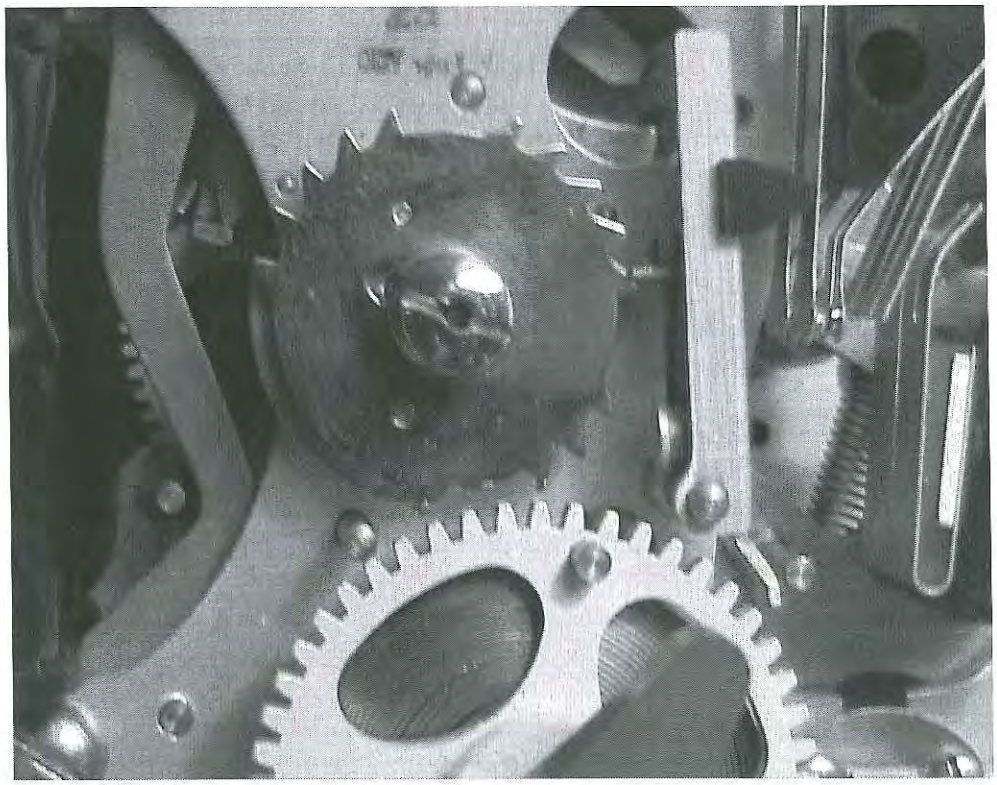


Photo courtesy NTC, p10.5

McCulloh Receiver

This receiver was located at the supervising station. The receiver would punch a tape as it received signals. The operator would look at the tape to determine the McCulloh transmitter sending the signal.

Photo courtesy BIS, p10.6

Old types of fire alarm systems were connected to a fire alarm box for communications. This was generally done prior to the widespread use of digital communicators. When a fire alarm signal was generated by the fire alarm system, the control panel would trip the McCulloh transmitter. The McCulloh transmitter would unwind thus spinning the code wheel. As the wheel would spin, the teeth would tap a specific code on the transmission wiring. The signal was then transported along the wiring to the receiver. The receiver would repeat the signal on the tape. Although new installations do not use this technology, NFPA 72®, The National Fire Alarm Code® still lists requirements for these systems.

In order to make sure the signal had the best chance of being correctly sent, the code wheel was required to spin at least 3 complete times, thus sending 3 complete rounds of the signal. Reliability of the circuit under adverse conditions was also an important consideration. The circuit had to be configured so that an open or ground would not generate a false alarm signal. Additionally, the circuit was required to have alarm capability when any one of these conditions was present, open circuit, ground, short, open and a ground.

McCulloh circuits have maximum loading capacities just like other communications methods. The maximum number of McCulloh transmitters on a circuit (transmission channel) is limited to 250 or less. The maximum number of waterflow devices connected to a single McCulloh transmitter is limited to 5 or less. The maximum number of

supervisory devices permitted to be connected to a single McCulloh transmitter is limited to 20 or less.

In order to prevent signals from being transmitted at the same time, a signal priority was developed. The highest priority signals are fire alarm box signals, then waterflow signals, then supervisory and finally trouble signals.

In the early days of fire alarm systems and McCulloh technology, some fire alarm boxes were used for both fire alarm signals and guard tour supervisory signals. No such boxes are in manufactured today (at least none which we could find).

In order to prevent guard tour signals from interfering with alarm signals, a limit was placed on the number of guard supervisory signals. No more than 60 guard tour supervisory signals were permitted on a transmission channel during any hour.

It is unlikely that today's technician will regularly install service or repair McCulloh circuits or equipment. It is possible to encounter these old systems in the field. Additionally, information on these systems may appear on certification exams. That is why it has been included here.

Two-Way RF Multiplex Systems

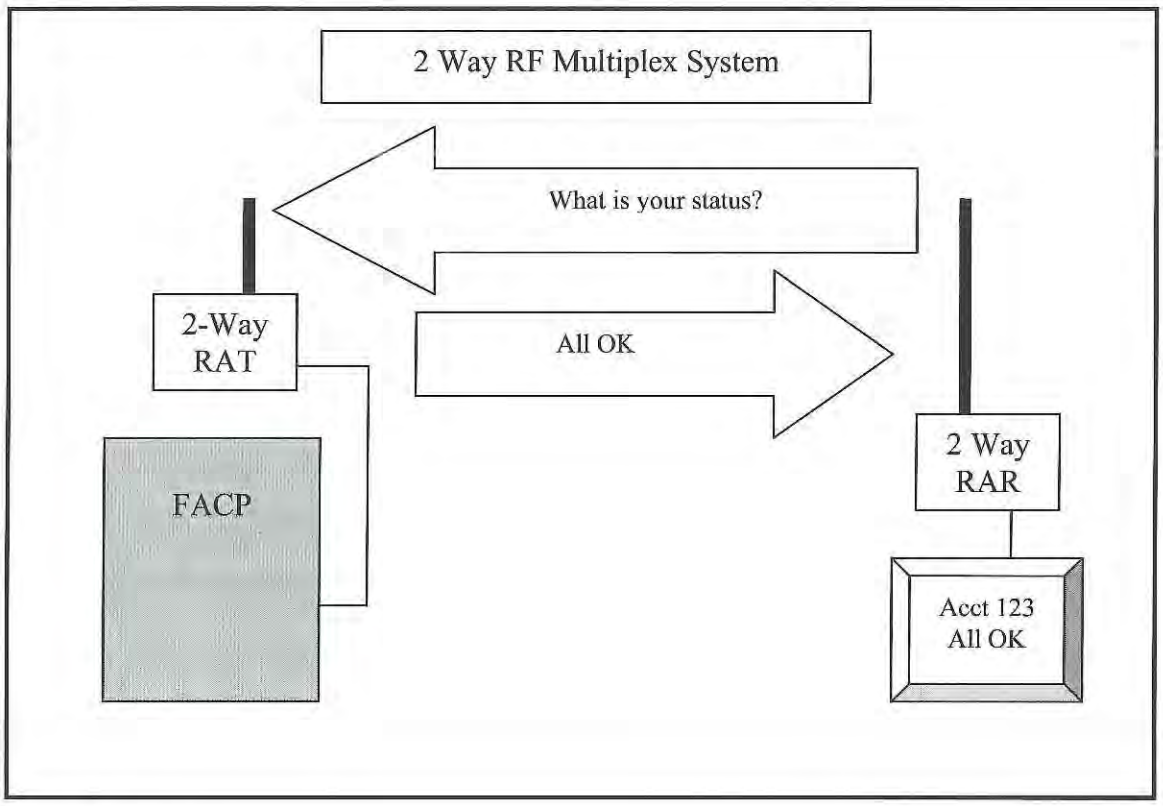
This communications method does not duplicate the digital information produced by the fire alarm control panel. A two-way RF multiplex system, provides three signal options, Alarm, Supervisory or Trouble.

When a fire alarm signal is generated from a particular device, the fire alarm control panel will trip the radio. The radio will send an alarm signal to the supervising station. The supervising station will not have any other information than the account and the type of signal.

Digital Alarm Radio Systems transmit the entire digital signal, including zone information.

With two-way radio systems, it is possible for the radio transmitter located at the fire alarm control panel to send signals to the radio receiver located at the supervising station. It is also possible for the radio receiver at the supervising station to send signals to the radio transmitter at the fire alarm control panel location.

The supervising station can poll the radios in order to make sure that they are in contact with the radio receiver. If there is a radio which cannot respond, the receiver has the capability to indicate which radios are missing. This polling is a useful way to determine communications reliability. Non responding radios may require service in order to ensure future communications with the receiver.



Diagram, NTC, d10.8

A Radio Alarm Transmitter (RAT) is located at the fire alarm control panel. A Radio Alarm Receiver (RAR) is located at the supervising station. Signals can be sent two ways, from the RAT to the RAR and from the RAR to the RAT. When an alarm signal is transmitted, it is required to be recorded at the supervising station within 90 seconds.

Type 4 and 5 Systems

There are two types of two-way RF multiplex systems. These types are differentiated based on their reliability. Type 4 systems provide a higher degree of reliability. Type 4 systems provide two or more control sites. Each site requires interconnection of the receiver to the supervising station by a separate channel or method. The RF transceiver located at the protected premise must be within range of at least two repeater sites. All RF transmitters are required to be capable of use at all times and the supervising station must have the ability to operate any off line transmitter every 8 hours. The failure of any RF receiver cannot affect the operation of other receivers. Additionally the failure of any RF receiver needs to annunciate a trouble at the supervising station. Type 5 systems require only single control site configuration.

Two way RF multiplex systems have specific loading capacities just like other communications methods. The following table shows the loading capacities for two-way RF multiplex systems.

2 way RF Loading Capacities

Trunks	Type 4 System	Type 5 System
Fire Alarm Initiating Device Circuits / Primary Trunk	5120	1280
Fire Alarm Leg Facilities / Primary Trunk	512	128
Fire Alarm Leg Facilities / Secondary Trunk	128	128
All Initiating Device Circuits / Primary Trunk	10240	2560
(All Fire Alarm and Burglar Alarm)		
All Leg Facilities / Primary Trunk	1024	256
System Units at Supervising Station		
All Initiating Device Circuits / System Unit	10240	10240
Protected Buildings (Premises) / System Unit	512	512
Fire Alarm Initiating Device Circuits / System Unit	5120	5120
NOTE: If all receiving equipment at the supervising station is duplicated and switchover can be accomplished within 30 seconds, then the loading capacity is unlimited.		

Diagram, NTC, d10.9

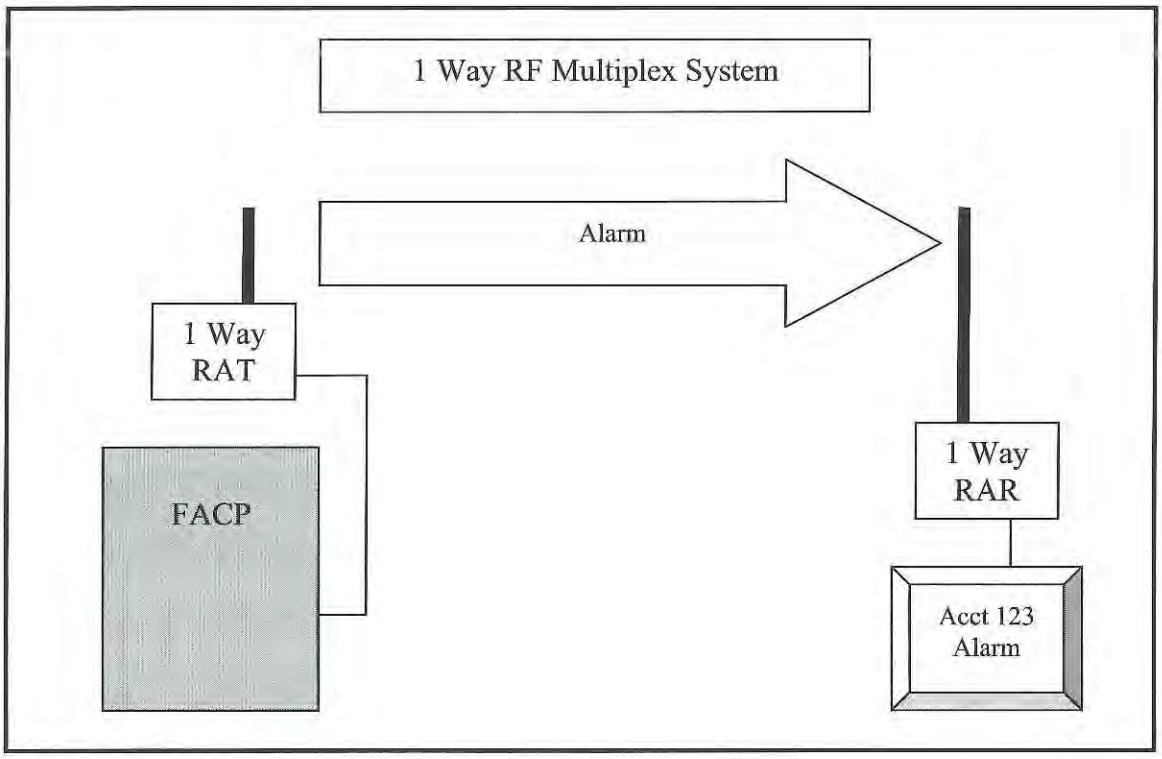
One-Way RF Multiplex System

This communications method does not duplicate the digital information produced by the fire alarm control panel. A one way multiplex system provides three signal options, Alarm, Supervisory or Trouble.

When a fire alarm signal is generated from a particular device, the fire alarm control panel will trip the radio. The radio will send an alarm signal to the supervising station. The supervising station will not have any other information than the account and the type of signal. Digital Alarm Radio Systems on the other hand, transmit the entire digital signal, including zone.

A Radio Alarm Transmitter (RAT) is located at the fire alarm control panel. A Radio Alarm Receiver (RAR) is located at the supervising station. Signals can be sent only from the RAT to the RAR. When an alarm signal is transmitted, it is required to be recorded at the supervising station within 90 seconds.

The supervising station does not have the ability to communicate with the radio at the fire alarm control panel. Because of this, additional requirements exist for 1 way radio systems. NFPA 72® specifies several requirements to ensure a reliable communication path for fire alarm systems using this technology.



Diagram, NTC, d10.10

One way RF multiplex systems are required to successfully send signals to the supervising station with the following minimum success rates:

90% probability of successful transmission within 90 seconds
99% probability of successful transmission within 180 seconds
99.999% probability of successful transmission within 450 seconds

The radio equipment is required to be supervised so that failure will be properly annunciated at the supervising station. Additionally the wiring between the radio equipment and the antennae is required to be in conduit.

Type 6 and 7 Systems
There are two types of one-way RF multiplex systems. These types are differentiated based on their reliability. Type 6 systems require only one radio receiver at the supervising station. Type 6 systems require at least two repeater stations. Type 7 systems require a higher degree of reliability. They require more than one radio receiver at the supervising station. Type 7 systems require at least two repeater stations.

Most radios and RF systems available today provide two-way communications. The two-way systems provide better supervision and ensure a higher degree of reliability.

Additionally the cost difference between two-way and one-way is not as significant as it used to be.

One way RF multiplex systems have specific loading capacities just like other communications methods. These loading capacities prevent the system from being overloaded and the resulting potential loss of signals. Ensuring that the alarm signal is received at the supervising station is the critical link in the communications path. The table below shows the loading capacities for one- way RF multiplex systems.

1 Way RF Loading Capacities

Radio Alarm Repeater Station Receiver	Type 6 System	Type 7 System
Fire Alarm Initiating Device Circuits / RARSR	5120	5120
Fire Alarm Radio Alarm Transmitters / RARSR	512	512
All Initiating Device Circuits / RARSR	10240	10240
All Radio Alarm Transmitters / RARSR	1024	1024
System Units at the Supervising Station		
All Initiating Device Circuits / System Unit	10240	10240
Buildings Protected by Fire Alarms / System Unit	512	512
Fire Alarm Initiating Device Circuits / System Unit	5120	5120
NOTE: If all receiving equipment at the supervising station is duplicated and switchover can be accomplished within 30 seconds, then the loading capacity is unlimited.		

Diagram, NTC, 10.11

Directly Connected Non Coded Systems

Direct connect systems operate using reverse polarity. The fire alarm panel is directly wired to the receiving equipment at the supervising station. A reverse polarity system is used so that when an alarm signal is generated, the polarity is reversed and a red light illuminates on the receiving equipment. NFPA 72® specifies requirements for these systems. Direct connect systems are no longer in widespread use.

Summary

There are many different communications methods for getting the signal from the fire alarm control panel to the supervising station. Many of the methods described reflect the history of the fire alarm business. Some are commonly in use today. The single overriding theme for communications methods is REDUNDANCY. It is critical to make sure the signal gets through whether you are using any of these methods.

1. Active Multiplex (also known as derived channel
2. Digital Alarm Communications Systems (DACS). Most popular communications method.
3. Digital Alarm Radio Systems (DARS).
4. McCulloh Systems.
5. Two way Radio Frequency (RF) Multiplex Systems.
6. One way Radio Frequency (RF) Multiplex Systems.
7. Directly connected non coded systems.

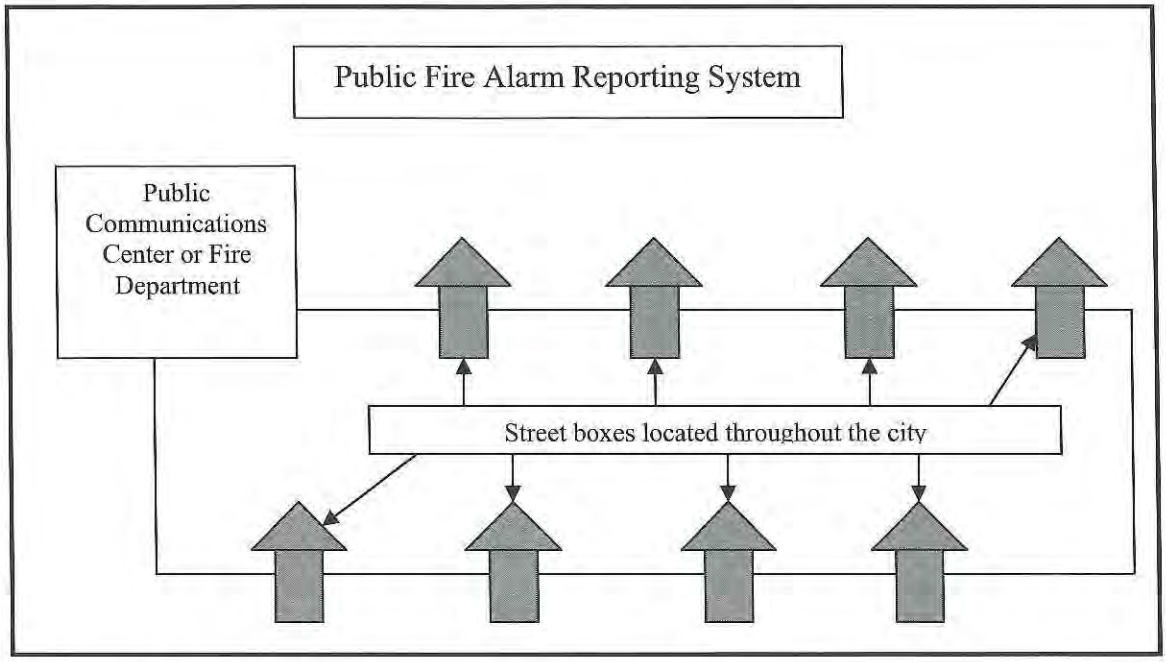
Chapter 11

Public Fire Alarm Systems and Communications

The terminology, "Public Fire Alarm" usually refers to a system or a means of retransmission to the fire department. This chapter is divided into two major parts:

1. Public Fire Alarm Reporting Systems
2. Public Fire Communications Service

Public Fire Alarm Reporting Systems
Public fire alarm systems are based on technology which is more than 100 years old. Public fire alarm reporting systems still linger in some communities in the country. These systems are owned by the municipality and consist of a series of street boxes located throughout the city. The street boxes are connected by a circuit owned by the municipality to a communications center or fire department.

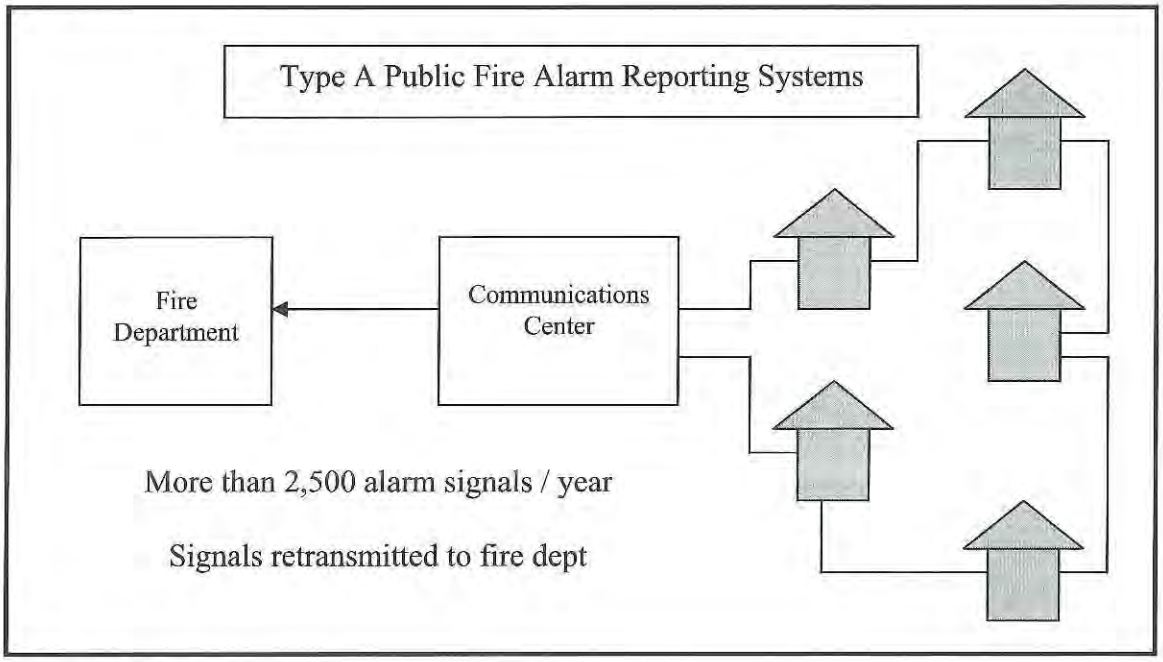


Diagram, NTC, d11.1

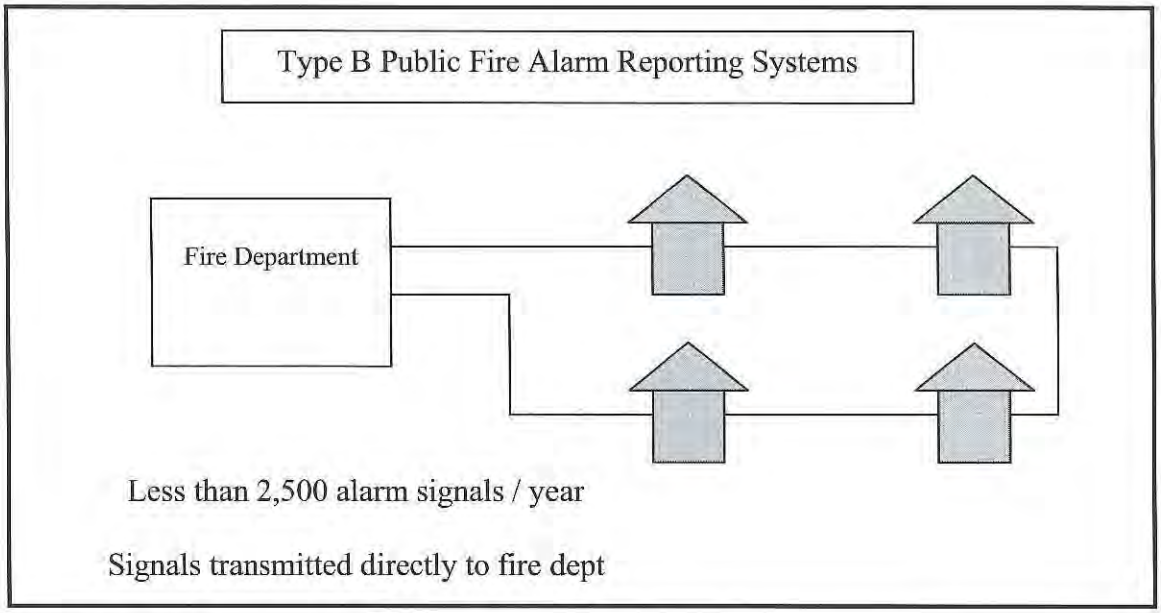
NFPA 72®, The National Fire Alarm Code® provides several requirements for public fire alarm reporting systems. Most technicians in the industry today will not have the opportunity to install or service these systems and their components. However, since they do still exist and many certification tests have some focus on these types of systems, we have included them in this book.

Type A public fire alarm reporting systems transmit more than 2,500 alarm signals in one year. Since the volume of alarm signals is high, Type A systems are required to send their signals to a communications center, then the signals are retransmitted to the appropriate fire department.

Type B public fire alarm reporting systems transmit 2,500 alarm signals or less in one year. Since the volume of alarm signals is lower, Type B systems transmit signals directly to the fire department for dispatch.



Diagram, NTC, d11.2



Diagram, NTC, d11.3

The municipality may employ maintenance personnel to service and maintain the public fire alarm reporting systems. The municipality may contract with a private company to perform service and maintenance on the system. If the municipality contracts a private company, the contract must be in writing.

Fire Alarm boxes (Street Boxes). Street boxes located throughout the city provide the means for actuating a fire alarm signal. Normally these boxes are Coded (they send several discrete bits of information). They typically send a box location number and a signal. NFPA 72® requires they be capable of sending three types of signals, in addition to the box number:

1. Test (1 repetition)
2. Tamper (1 repetition)
3. Fire alarm (3 repetitions)

Fire alarm box signal transmission is similar to a telegraph. The box number provides the exact location (street corner) where the box is located. The coded mechanism inside the box consists of a series of code wheels with little teeth. In the event of an alarm, the code wheels will rotate.

This causes the teeth to contact the transmission circuit as they spin. This action causes the generation of an automatic code. For fire alarm signals, this code is required to be repeated 3 times to ensure accurate transmission. In the event of an actual fire, responding personnel would use the municipal circuit and morse code to report and ask for additional support. As technology developed, Coded Radio street boxes were used as well as the Coded Wired street boxes.

Photo courtesy NTC, p11.1

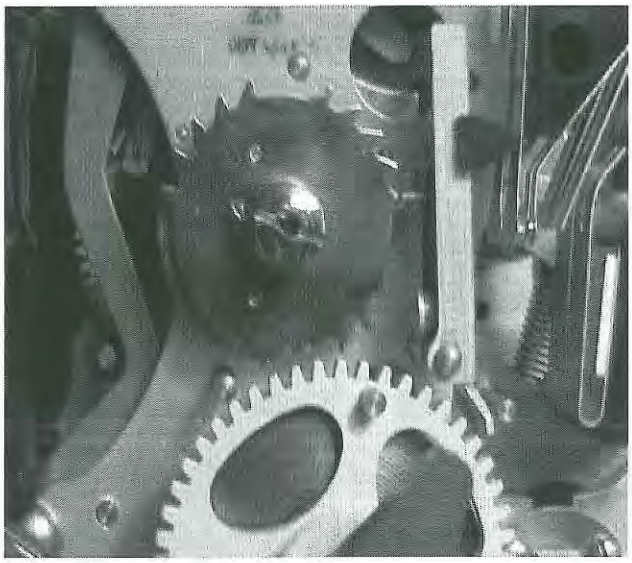


Photo courtesy NTC, p11.2

There are a wide variety of street boxes which have been used over the years. They are generally classified as follows:

1. Manual Fire Alarm box. This box has provision for manual actuation. These boxes are not intended for any means of electronic actuation. Fire alarm control panels are not intended to be connected to these boxes.
2. Master Fire Alarm box. This box has provisions for manual and electronic actuation. This type of fire alarm box is intended to allow connection to a fire alarm control panel.
3. Master Transmitter. This box has provision for electronic actuation. This box cannot be manually actuated. It is intended to be collocated with a fire alarm control panel for the purpose of transmitting signals from the control.

Street boxes have a requirement for power. There are several methods for providing power to the street boxes.

1. Utility powered boxes. Power for these boxes is provided directly from a reliable utility company. This is normally 120 VAC with a battery back up.

2. Battery powered boxes (Self Powered). Power for these boxes is provided from a battery collocated with the box. The battery is required to be of sufficient size to power the box for at least 6 months.

3. Solar powered boxes (Photovoltaic Powered). Power for these boxes is generated by a solar panel / storage battery combination.

Receiving equipment for street box signals.
The receiving station for public fire alarm reporting systems may be a communications center (type A systems) or an actual fire department location (type B systems). The receiving equipment includes a printer / tape device. As a signal is received from a street box, the code is automatically punched onto the tape. This identifies the street box number and the type of signal.

Photo courtesy BIS, p11.3

The next picture is a closer look at the tape reel used to print out the public fire alarm reporting system signals. As the signal would be received, they would tap out a code on the tape. An operator would read the code, and identify the street box which sent the signal.

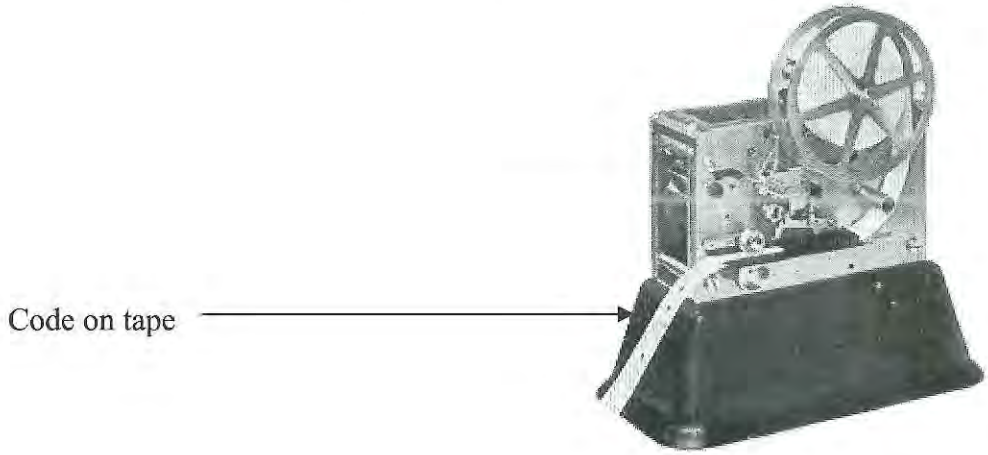


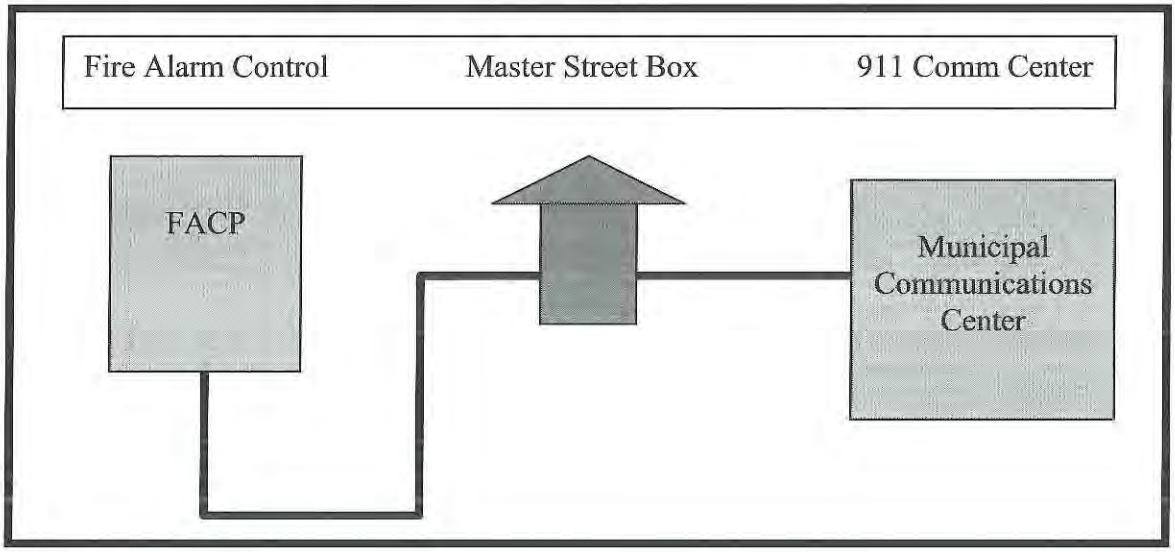
Photo courtesy BIS, p11.4

The receiving station is required to provide a permanent visual record for receipt of all alarm signals. When an alarm signal is received, an audible indication is also required. The time and date of all alarm signals is required to be recorded. The receiving station is required to maintain spare equipment to receive signals. As a minimum 5% of the total number of recording device are required on site as spare equipment.

The receiving station is required to monitor all box circuits for integrity. Audible and visual annunciation is required whenever the line current drops or increases 20% or more from normal. Standby power is required for the receiving station.

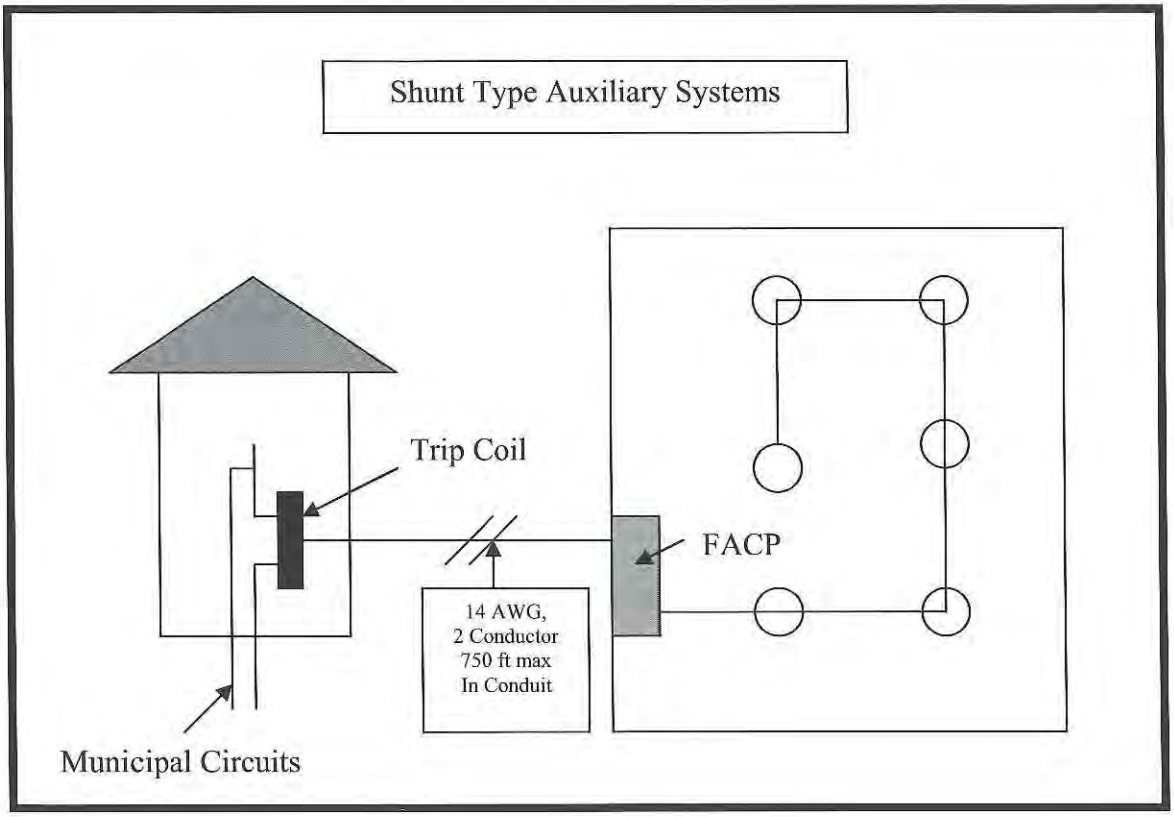
Auxiliary Fire Alarm Systems

Auxiliary fire alarm systems use the municipal fire alarm system to send signals. The control panel uses a connection between the control panel and a street box. When a fire alarm signal is actuated, the control panel trips the street box and a signal is sent to the communications center or fire department. Auxiliary fire alarm systems do not use a DACT to transmit fire alarm signals.

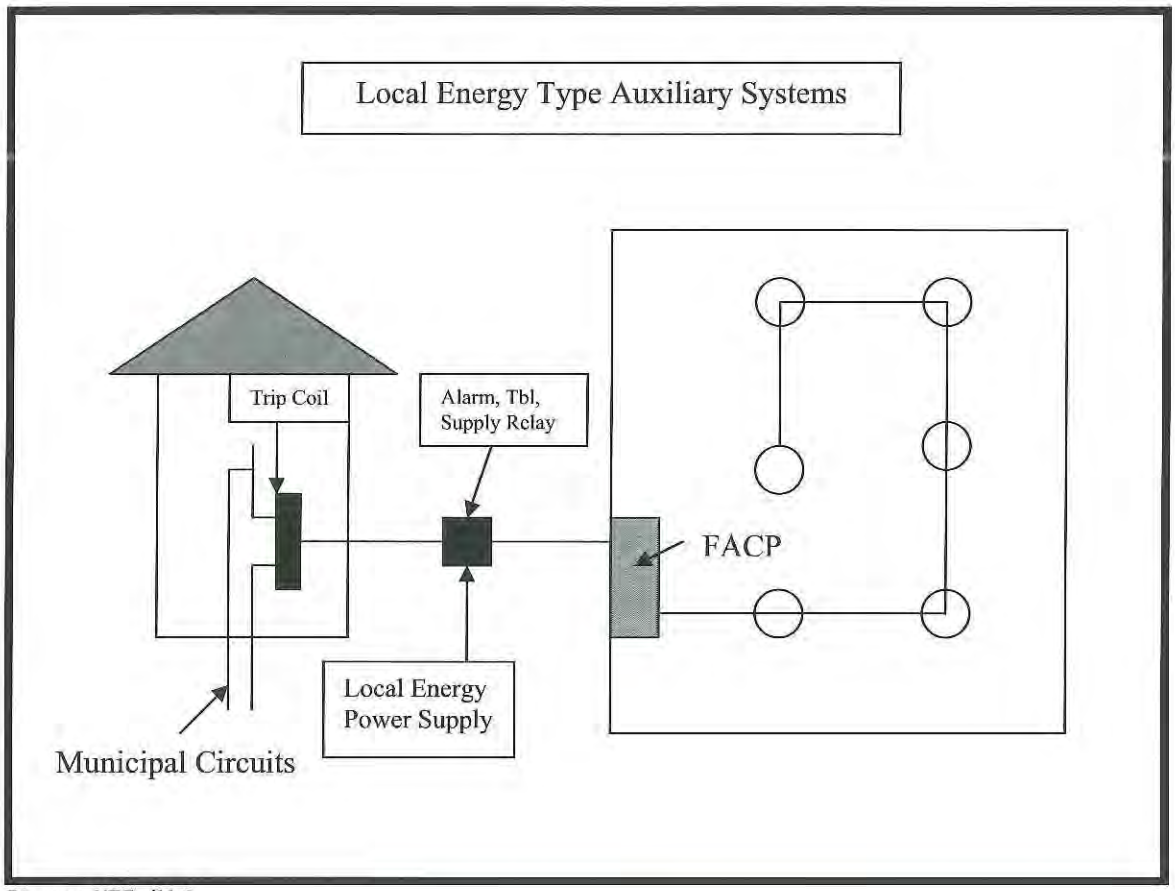


Diagram, NTC, d11.4

The fire alarm control panel is connected to a Master Fire Alarm Box or a Master Transmitter. Both of these boxes are capable of electronic actuation. The street box may be a Coded Wired Box (telephone series) or a Coded Radio Box. Additionally, auxiliary systems may be Shunt Type or Local Energy Type.



Diagram, NTC, d11.5



Diagram, NTC, d11.6

Auxiliary fire alarm systems are the only type of fire alarm system which uses the public fire alarm reporting system for communication. During the early 1900's this was the primary way in which fire alarm systems communicated alarm signals to the fire department. Auxiliary systems do not require visual or audible signals. Shunt type or local energy type auxiliary systems are the only type of connection permitted. Local energy systems may be coded or non-coded type systems.

Shunt type systems are required to be non-coded. The circuits for shunt type auxiliary systems must be in conduit and the maximum loop length is 750 feet. Conductors are required to be a minimum of 14 AWG. A relay is not permitted as a method for auxiliarizing a local system. The maximum area that 1 auxiliary transmitter can serve is 100,000 square feet. Automatic detectors are not permitted for shunt type auxiliary systems.

The interface of auxiliary systems with the municipal street box system must follow specific requirements. These requirements are in place in order to make sure the auxiliary system does not conflict with the public fire alarm reporting system. They also are intended to increase the reliability of the auxiliary fire alarm system. The following table details the requirements for auxiliary systems.

Box Type vs System Type

Box Type	Aux Local Energy	Aux Shunt Type
Coded Wired Box	Permitted	Permitted
Coded Radio Box	Permitted	Not Permitted
Telephone Series Box	Permitted	Not Permitted

Diagram, NTC, d11.7

Each building is required to have a separate and individual auxiliary transmitter. The design of the system requires that a single fault on the auxiliary circuit cannot affect the operation of the public fire alarm reporting system. Additionally the system requires a design so a single fault cannot cause a false alarm.

Public Fire Communications

Most communities have a communications center for receiving emergency calls (911 center). Fire alarm signals may be retransmitted to the communications center from a Central Station, Remote Station or Proprietary Station. Additionally, some municipalities have a public fire alarm reporting system which can transmit signals to the communications center. The communications center is also capable of receiving telephone calls to report a fire. The communications center must be properly equipped, staffed and maintained in order to ensure reliability that the fire alarm signal will receive a proper response from the fire department.

There are several important factors to consider in the design and use of a communications center. All of these have a direct impact on fire alarm signal routing and response:

1. Communications center location and construction
2. Communications center operations
3. Retransmission equipment and methods
4. Communications center dispatch.

Communications center location and construction. Normally the fire communications center is collocated with a fire department building although this is not a requirement. The communications center should be located 150 feet or more from other buildings. If located within 150 feet of other buildings special precautions should be taken. These precautions should be designed to protect against damage which might occur due to degradation of the nearby buildings. The communications center should not be located in an area which might be flooded. Normally locating the communications center below grade is not appropriate. The construction materials used in the construction of the

building should be appropriately fire resistive. Always follow the applicable building and construction codes.

Sometimes the communication center may be housed in a building which is unprotected noncombustible or ordinary construction. Extra measures should be taken in this case which include:

1. A Class A fire resistive roof
2. A complete supervised sprinkler system installed in all parts of the building except the communications center and power room

When the communication center is located in a non fire department building additional precautions should be taken. The communications center should have controlled access. Only those directly involved in communication center operations should be permitted access. A double door (man trap) should be used. The entire communication center should be provided with fire resistive walls with a 2 hour rating. Areas adjoining the communication center should be provided with an automatic fire alarm system or an automatic sprinkler system depending on the hazard rating.

Automated building systems for the communication center should be independent. Water piping should not pass through the communication center. Water mains, sewer and sprinkler lines should be routed around the communication center. Additionally a fire alarm system should be provided for the communication center. Other items the communications center should be provided with are:

1. At least two fire extinguishers
2. Emergency lighting
3. Two sources of power

Communication Center Operations
The communication center receives information about fire and fire alarms from these sources:

1. The general public (by telephone)
2. Monitoring stations reporting fire alarm signals
3. Public fire alarm reporting systems

Monitoring stations (central station, remote station, proprietary station) all use telephones to report fire alarm signals to the communication center. Also public fire alarm reporting systems send fire alarm signals directly to the communication center in most instances.

Retransmission
Retransmission is basically the communication link between the communication center and the fire station being dispatched. There are specific ways in which fire alarm signals may be Retransmitted from the communication center to the responding personnel. NFPA 72® lists several ways this retransmission can be accomplished:

1. A dedicated circuit (preferred method)
2. One way telephone (not capable of outgoing calls)
3. Private radio system using the fire department frequency
4. Other means approved by the AHJ.

It is recommended that two means of providing retransmission be available at the communication center. Every retransmission should be recorded with the time, date, location and signal.

Communication Center Dispatch

Computer aided dispatch is in common use now. Most communication centers are provided with this automation in one form or another. Computer aided dispatch can provide a great service by:

1. Logging the status for responding personnel
2. Identifying important information about assets available at the scene
3. Providing directions
4. Detailing important information about the facility (hazards, etc)

Computer aided dispatch systems use modern computers, servers and related equipment and software. It is important to make sure the equipment meets the specifications of the software. Smaller communities may run their systems with normal PCs. Larger communities and systems may require specialized terminals. Computer aided dispatch systems have three classifications:

1. Class 1: Computer equipment makes the decision. The system determines which assets to dispatch to a particular emergency and the dispatch is automatic.
2. Class 2: Provides support to assist in the dispatch with graphics and other means.
3. Class 3: Provides very basic support, status information and storing of information.

Summary

The term "Public Fire" has generally two references in our industry. It may refer to Public Fire Alarm Reporting Systems. These are municipality owned fire alarm systems which use street boxes to allow for reporting of fire emergencies. They use morse code technology to transmit signals to the receiving station. Public Fire Communications is the way in which a communication center dispatches the proper responding personnel. Both are important parts of the fire alarm picture.

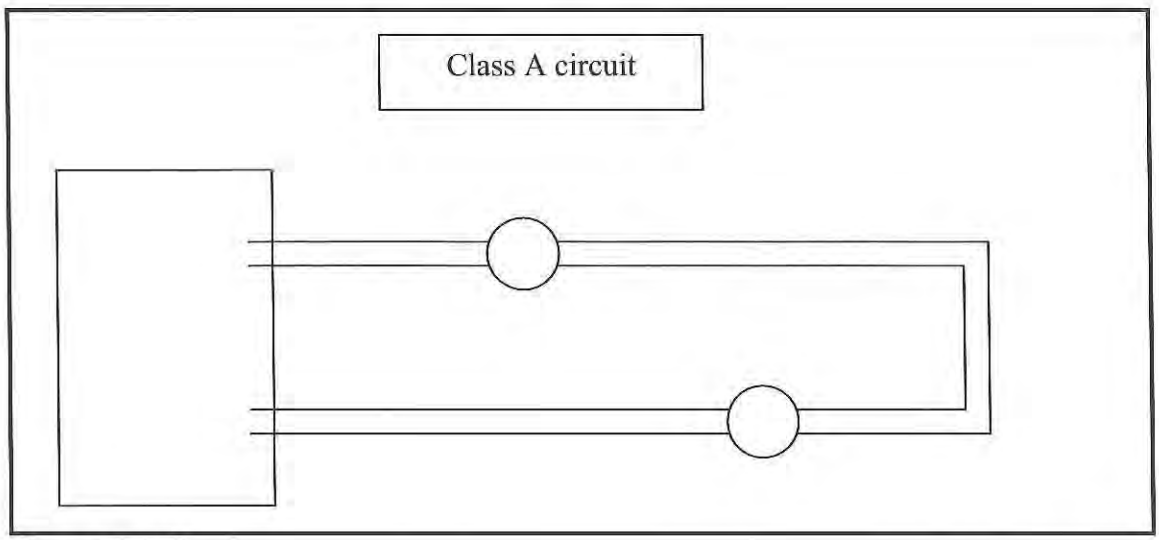
Chapter 12

Fire Alarm System Wiring

The requirements for fire alarm system wiring are defined in NFPA 70® and NFPA 72®. NFPA 70® describes wiring types and methods, NFPA 72® describes the circuits and functions. Understanding of both of these codes is critical to understanding fire alarm system wiring.

Circuit Classes and Styles
Fire alarm circuits are classified by class, and then sub-classified by style. Class determines the general function and wiring of the circuit, style further defines the circuit by describing its function under adverse conditions.

Class A
Class A circuits allow alarm and supervisory signals to be transmitted or notification signals to continue to operate with single open or ground fault on any circuit conductor. Class A circuits are installed and function to a higher standard than Class B circuits. Class A circuits do not have an end of line resistor, instead they have an outgoing and return circuit. The circuits are required to be routed separately; they cannot be run in the same conduit, enclosure or raceway (with a few exceptions).



Diagram, NTC, 12.1

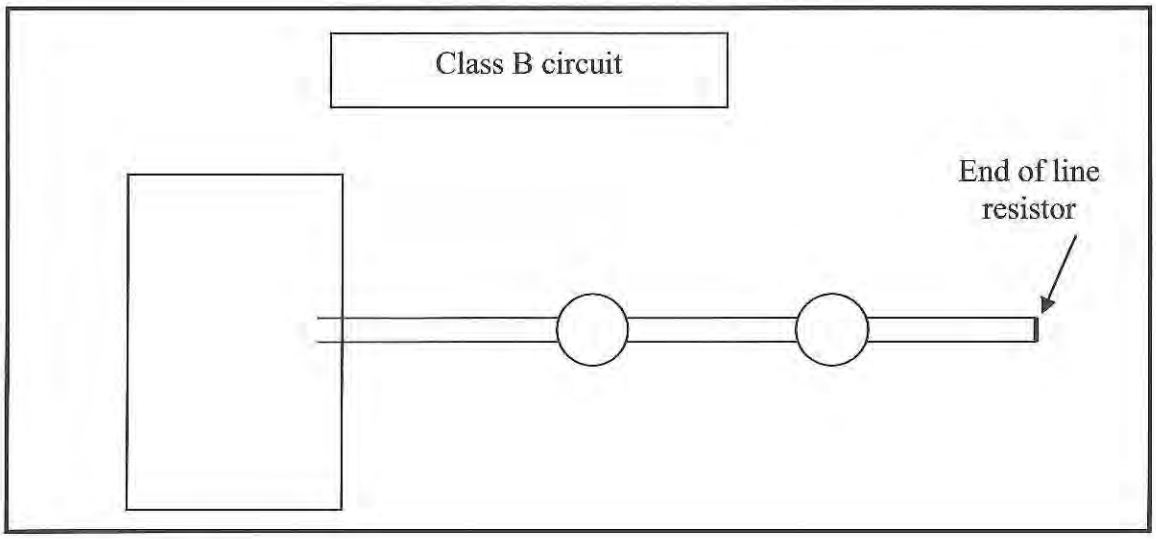
Class A Circuit Wiring Requirements

Outgoing and return conductors can be in the same conduit, enclosure, or raceway:

1. for a distance of 10 feet when they enter or exit a initiating device, notification appliance, or control unit enclosure
2. single conduit or raceway drops to individual initiating devices or notification appliances
3. single conduit or raceway drops to multiple initiating devices or notification appliances installed in a single room not more than 1000 square feet

Class B

Class B circuits allow alarm and supervisory to be transmitted or notification signals to continue to operate between the control panel and the location of a single open or ground fault. Class B circuits are end of line resistor supervised, and do not have a return path to the control panel.



Diagram, NTC, d12.2

Class A circuits are not required to be the code. They are required for certain job specifications or by insurance authorities to provide a higher degree of system reliability. Most fire alarm system installations use class B circuits. When a higher degree of reliability is required, class A circuits are used.

Styles

Class A and B circuits are sub-classified by "style." Style designations further detail the circuit's performance under adverse conditions such as opens, shorts, grounds, and loss of carrier. Initiating circuits are sub-classified as Style A through E, notification circuits are sub-classified as Style W though Z, signaling line circuits are sub-classified as Style 0.5 to 7. The performances of circuit styles are detailed in the following charts.

Performance of Initiating Device Circuits (IDC)

Class	B			B			B			A			A		
Style	A			B			C			D			E*		
Function	A	T	R	A	T	R	A	T	R	A	T	R	A	T	R
Abnormal Condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Single open	-	X	-	-	X	-	-	X	-	-	X	R	-	X	R
Single grnd	-	X	-	-	X	R	-	X	R	-	X	R	-	X	R
Short	X	-	-	X	-	-	-	X	-	X	-	-	-	X	-
Loss/carrier	-	-	-	-	-	-	-	X	-	-	-	-	-	X	-

Diagram, NTC, d12.3

Function:
A – Alarm
T – Trouble
R – Alarm receipt during abnormal condition

Abnormal Condition:
R – Required capacity
X – Indication required at protected premises and as required by Chapter 8 of NFPA 72®

* - Style exceeds minimum requirement of Class A

Performance of Signaling Line Circuits (SLC)

Class	B			B			A			B			B		
Style	0.5			1			2*			3			3.5		
Function	A	T	R	A	T	R	A	T	R	A	T	R	A	T	R
Abnormal Condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Single open	-	X	-	-	X	-	-	X	R	-	X	-	-	X	-
Single ground	-	X	-	-	X	R	-	X	R	-	X	R	-	X	-
Short	-	-	-	-	-	-	-	-	M	-	X	-	-	X	-
Short&open	-	-	-	-	-	-	-	-	M	-	X	-	-	X	-
Short&ground	-	-	-	-	-	-	-	X	M	-	X	-	-	X	-
Open&ground	-	-	-	-	-	-	-	X	R	-	X	-	-	X	-
Loss/carrier	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-

Diagram, NTC, d12.4

Performance of Signaling Line Circuits (SLC)

Class	B			B			A			A			A		
Style	4			4.5			5*			6*			7*		
Function	A	T	R	A	T	R	A	T	R	A	T	R	A	T	R
Abnormal Condition	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Single open	-	X	-	-	X	R	-	X	R	-	X	R	-	X	R
Single ground	-	X	R	-	X	-	-	X	R	-	X	R	-	X	R
Short	-	X	-	-	X	-	-	X	-	-	X	-	-	X	R
Short&open	-	X	-	-	X	-	-	X	-	-	X	-	-	X	-
Short&ground	-	X	-	-	X	-	-	X	-	-	X	-	-	X	-
Open&ground	-	X	-	-	X	-	-	X	-	-	X	R	-	X	R
Loss/carrier	-	X	-	-	X	-	-	X	-	-	X	-	-	X	-

Diagram, NTC, d12.5

Function:
A – Alarm
T – Trouble
M – May be capable of alarm with wire to wire short
R – Alarm receipt during abnormal condition
Abnormal Condition:
R – Required capacity
X – Indication required at protected premises and as required by Chapter 8 of NFPA 72®
* - Style exceeds minimum requirement of Class A

Performance of Notification Appliance Circuits (NAC)

Class	B		B		B		A	
Style	W		X		Y		Z	
	Tbl ind at prot prem.	Alarm during abn. cond.	Tbl ind at prot prem.	Alarm during abn. cond.	Tbl ind at prot prem.	Alarm during abn. cond.	Tbl ind at prot prem.	Alarm during abn. cond.
Abnormal Condition	1	2	3	4	5	6	7	8
Single open	X	-	X	R	X	-	X	R
Single ground	X	-	X	-	X	R	X	R
Wire-to-wire short	X	-	X	-	X	-	X	-

Diagram, NTC, d12.6

Abnormal Condition:
R – Required capability
X – Indication required at protected premises

Fire Alarm System Cabling

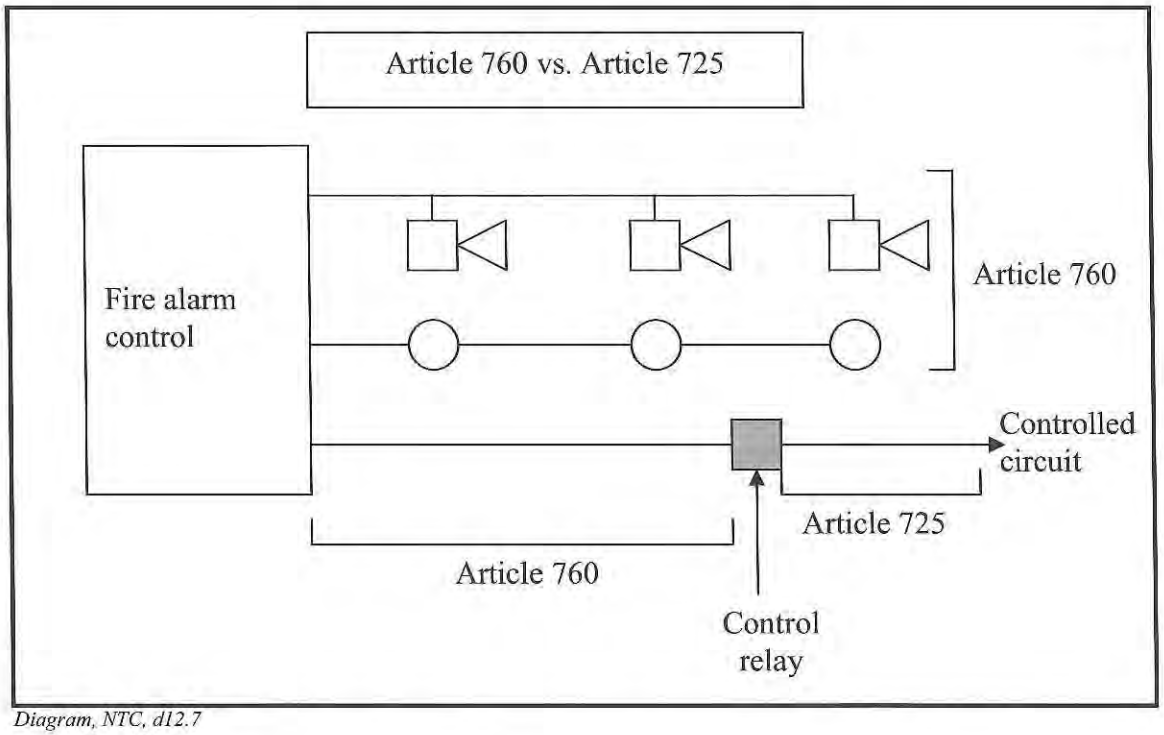
The requirements for fire alarm system cable and cabling are primarily covered in NFPA 70®, The National Electrical Code®. Article 760 directly covers fire alarm systems. Article 725 covers remote control and signaling circuits (that may be controlled by the fire alarm). Article 250 covers grounding requirements. Other articles pertain in part or apply to fire alarm systems as well.

General Requirements

Fire alarm circuits must be identified at all terminal and junction locations. All splices must be protected by a box or enclosure. The cabling must be secured to the building structure, and it cannot inhibit access to suspended ceiling panels. Cable run in environmental air spaces (plenums) must be run in conduit, or be plenum-rated cable (discussed later). Cables that penetrate fire resistant walls and barriers must be fire stopped to maintain the fire resistance rating. Cables run in hazardous (explosive), corrosive, damp, or wet locations must be installed per the requirements of specific articles of NFPA 70® covering those applications.

Article 760

Article 760 covers the installation and wiring of fire alarm systems, including all circuits controlled and powered by the fire alarm system. Article 760 only covers circuits directly associated with the fire alarm system. This article applies to circuits that are powered and/or controlled by it, such as detection and notification circuits. Circuits that are associated with the fire alarm, but not directly controlled by it, such as elevator recall or HVAC shutdown, are covered under the requirements of Article 725.



Diagram, NTC, d12.7

Nonpower Limited Fire Alarm (NPLFA)

NPLFA circuits are typically 120-volt circuits, and must comply with the requirements of Chapter 1 – 4 of NFPA 70. The power source for these circuits must not exceed 600 volts. The circuit may require overcurrent protection, and the required protection is determined by the conductor size used. NPLFA circuits are not very common in modern fire alarm systems.

Conductor Size	Ampacity	Overcurrent Protection
18 AWG	6A	7A
16 AWG	8A	10A
14 AWG	15A	15A
12 AWG	20A	20A
10 AWG	30A	30A

Diagram, NTC, d12.8

Power Limited Fire Alarm (PLFA)
PLFA circuits are typically 30 volts or less, and the power is limited at the source. The circuit is supervised, and the circuit is identified as power limited at all terminations. Any circuits that are not marked should be treated as nonpower limited. Power sources for these circuits must be supplied by a listed PLFA or Class 3 transformer or power supply, or listed equipment marked to identify the PLFA power source (i.e., fire alarm control with an integral power supply). This is the most common type of circuit in modern fire alarm systems.

Mixed Circuit
Once a circuit has been designated power limited or nonpower limited it must be wired and treated as such throughout the circuit. It is not permissible to run a circuit as power limited for part of it, and nonpower limited through another part.

Article 725
Article 725 of NFPA 70® defines the requirements for Class 1, 2 and 3 remote control, signaling, and power limited circuits. Remote control circuits control one or more circuits by operating the coil of a relay or similar device. These circuits are typically used for control of auxiliary devices by the fire alarm system.

Signaling circuits supply energy to an appliance or device that gives an audible and/or visual signal. These circuits are used for horns, strobes, and other notification appliances.

Power limited circuits are used for functions other than remote control or signaling. These circuits are all located on the load side of the over current protection or the power limited power supply and all the connected equipment.

Circuit Classes
Class 1 Power Limited circuits are limited to 30 volts and 1,000 volt-amperes (VA). They are not considered safe from a fire initiation standpoint and do not provide

acceptable protection from electric shock. Class 1 Power Limited circuits are used when the current requirements of the circuit exceed the capabilities of Class 2 or Class 3 circuits. An example of a Class 1 Power Limited circuit would be a 24V circuit used to operate low voltage HVAC damper motor.

Class 1 Remote Control and Signaling circuits are limited to 600 volts, but do not have a limit on the power output from the source. They are not considered to be safe from fire initiation standpoint and do not provide acceptable protection from electric shock. An example of a Class 1 Remote Control circuit would be an HVAC shutdown relay remotely powered and triggered by the fire control panel.

Class 2 circuits are generally 150 volts or less, and the power is limited based on the circuit voltage. For circuits up to 30 volts, the power is limited to 100 VA. For circuits 31 to 150 volts, the circuits are limited to 0.5 VA. They are considered safe from a fire initiation standpoint and provide acceptable protection from electric shock. They are typically used for low energy, low voltage circuits. Examples of a Class 2 circuit would be a burglar alarm, sound, and thermostat circuits.

Class 3 circuits are limited to 150 volts and 100 volt-amperes. They are considered safe from a fire initiation standpoint and provide acceptable protection from shock. Class 3 circuits are used when current requirement exceeds 0.5VA for circuits over 30 volts. Examples of Class 3 circuits would be signaling circuits for burglar alarm, sound, and some nurse call systems.

Circuit Class Comparison

Circuit Type	Max. Voltage	Max. VA	Fire Safe	Shock Safe
Class 1 Power Limited	30V	1,000 VA	No	No
Class 1 Remote Signaling	600V	n/a	No	No
Class 2	0-30V	100 VA	Yes	Yes
Class 2	31-150V	0.50 VA	Yes	Yes
Class 3	31-100V	100 VA	Yes	Yes

Diagram, NTC, d12.9

Grounding

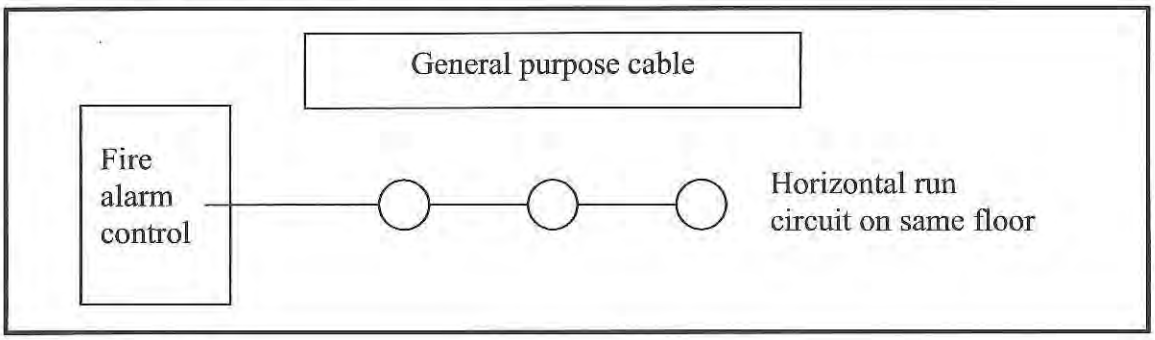
Article 250 of NFPA 70® covers grounding requirements, and system grounding is essential to proper operation. One of the main concerns for a system ground is the quality of the ground itself. Article 250 spells out several specific requirements:

1. Grounding electrode (ground rods) must be at least 8 feet long and at least 3/8 inch in diameter
2. Ground wire must be at least 14 gauge and have a green jacket
3. Grounding conductor must be attached to grounding electrode by a listed bolt clamp made of cast bronze, brass, or iron
4. Ground plate electrodes must expose at least 2 square feet to soil and be at least ¼ inch thick

5. Metal underground water pipes used for grounding must have at least 10 feet in direct contact with the soil, and the grounding attachment point must be within 5 feet of the entrance to the building
6. Building with more than one ground must have all their grounds bonded (connected together)

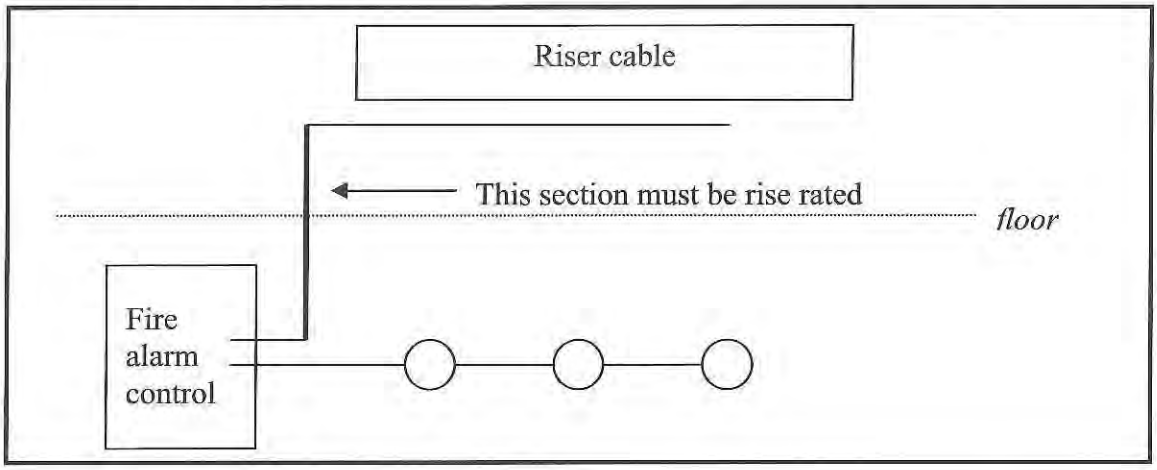
Circuits that operate at less than 50 volts are not required to be grounded by NFPA 70®. This would include most modern fire alarm systems. However, most fire alarm control panel manufacturers require that the system be grounded.

Insulation on cables is subject to burn during a fire. The burning cable could possibly spread the fire to other parts of the building, and the fumes from the burning cable could be toxic to the building inhabitants. Cables are classified as three types based on their application and toxicity. General Purpose cable is used for general horizontal wiring from the control unit to devices on the same floor. FPL type cable is used on Power Limited Fire Alarm circuits, and NPLF is used on Nonpower Limited Fire Alarm circuits.



Diagram, NTC, d12.10

Riser cable is used for vertical runs between floors. The jacket of riser cable is less toxic than General Purpose, and is more resistant to fire spread. Riser cable may be used in general-purpose applications, but general purpose may not be used in riser applications. FPLR is used on Power Limited Fire Alarm circuits, and NPLFR is used on Nonpower Limited Fire Alarm circuits.

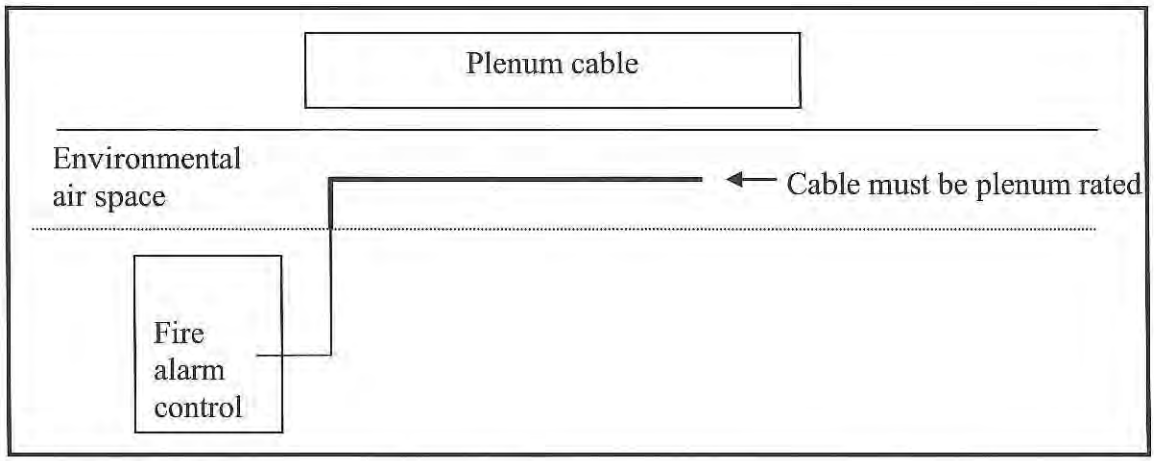


Diagram, NTC, d12.11

Plenum cable is used for cable runs in environmental air spaces (plenums). A plenum is a chamber or compartment to which one or more air ducts are connected to form part of an air distribution system.

The jacket of plenum cable is less toxic than riser, or more resistant to fire spread. Plenum cable may be used in general purpose and riser applications, but general purpose and riser cables may not be used in plenum applications.

FPLP is used in Power Limited Fire Alarm circuits, and NPLFP is used in Non power Limited Fire Alarm circuits.



Diagram, NTC, d12.12

During the 1980's a fire occurred at the MGM Grand Hotel in Las Vegas. The fire was limited to a section of the building. Toxic fumes from the burning cable (nonplenum rated) were carried to other parts of the building which were not affected by the fire.

More than 80 people died as a result of breathing the toxic fumes from the nonplenum rated cable. This incident started the widespread emphasis of plenum rated cable.

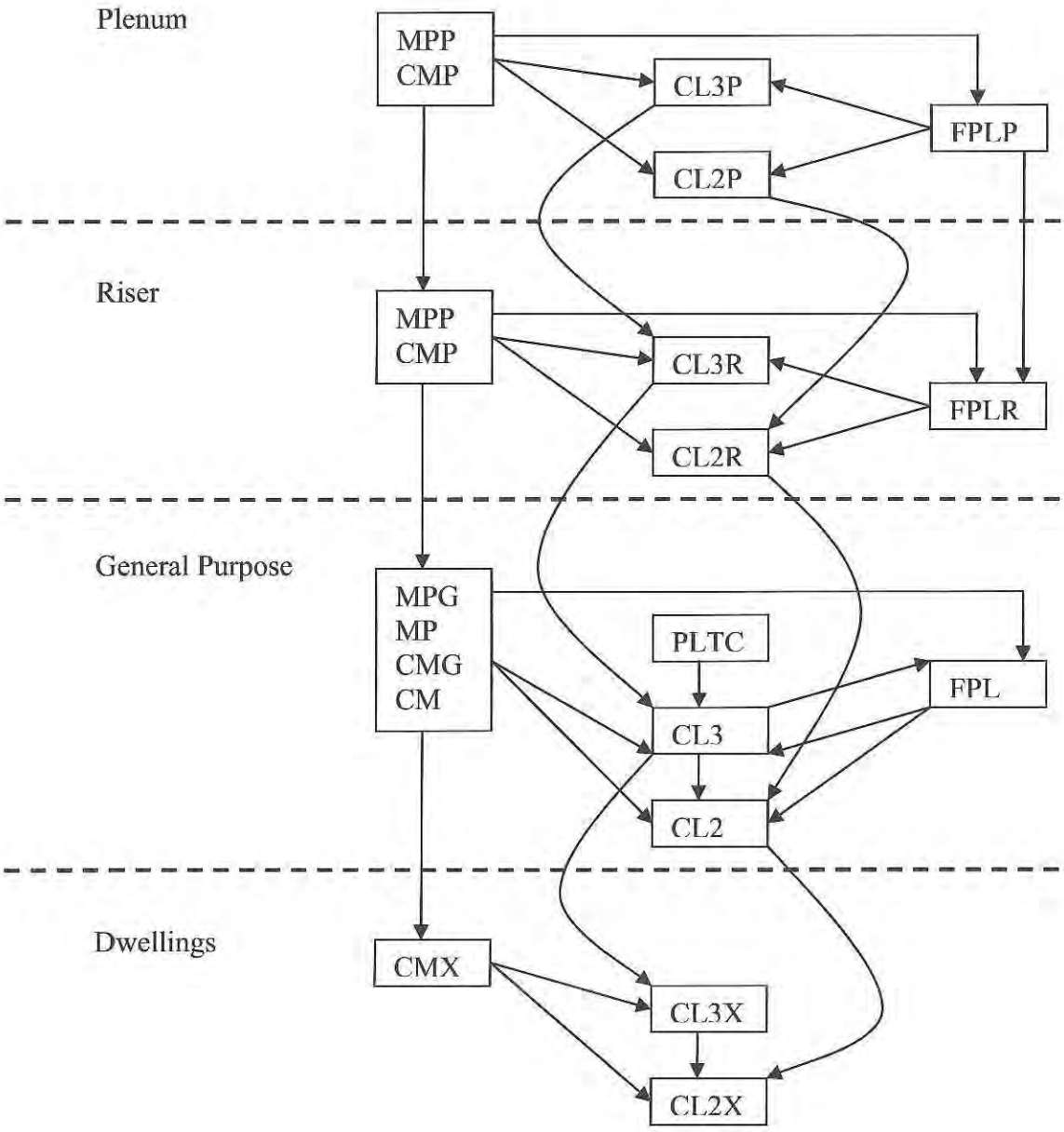
Cable Substitution

Certain multiconductor (CM) type and coaxial (MP) type cables may be substituted for FPL type cables. The cable grade can be replaced by the same grade (general purpose, riser, or plenum) of the substitute cable. The same substitution rules for different grades apply as apply for FPL type substitutions.

It is acceptable to replace general purpose cable with riser cable. It is acceptable to replace riser cable with plenum cable. It is acceptable to replace general purpose cable with plenum cable.

It is not acceptable to replace plenum cable with general purpose cable. It is not acceptable to replace riser cable with general purpose cable. A distinct hierarchy exits with plenum cable being at the top and general purpose cable at the bottom.

A higher grade cable can replace a lower grade cable, but a lower grade cable cannot replace a higher grade cable.



Diagram, NTC, d12.13

Box and Conduit Fill

The requirements for the maximum number of conductors in an electrical box are detailed in NFPA 70®. The size, depth, and shape of the box and the gauge of the conductors are all used determine the number of conductors that a box can support. If conductors of the same size are used, the following table details the requirements

Box Fill Requirements

Box Dimension, Shape, or Type	Min. Volume (in^3)	Maximum Number of Conductors						
		18	16	14	12	10	8	6
4 x 1-1/4 round or octagonal	12.5	8	7	6	5	5	5	2
4 x 1-1/2 round or octagonal	15.5	10	8	7	6	6	5	3
4 x 4-1/8 round or octagonal	21.5	14	12	10	9	8	7	4
4 x 1-1/4 square	18.0	12	10	9	8	7	6	3
4 x 4-1/2 square	21.0	14	12	10	9	8	7	4
4 x 2-1/8 square	30.3	20	17	15	13	12	10	6
4-11/16 x 1-1/4 square	25.5	17	14	12	11	10	8	5
4-11/16 x 1-1/2 square	29.5	19	16	14	13	11	9	5
4-11/16 x 2 1/8 square	42.0	28	24	21	18	16	14	8
3 x 2 x 1-1/2 device	7.5	5	4	3	3	3	2	1
3 x 2 x 2 device	10.0	6	5	5	4	4	3	2
3 x 2 x 2-1/4 device	10.5	7	6	5	4	4	3	2
3 x 2 x 2-1/2 device	12.5	8	7	6	5	5	4	2
3 x 2 x 2-3/4 device	14.0	9	8	7	6	5	4	2
3 x 2 x 3-1/2 device	18.0	12	10	9	8	7	6	3
4 x 2-1/8 x 1-1/2 device	10.3	6	5	5	4	4	3	2
4 x 2-1/8 x 1-7/8 device	13.0	8	7	6	5	5	4	2
4 x 2-1/8 x 2-1/8 device	14.5	9	8	7	6	5	4	2
3-3/4 x 2 x 2-1/2 masonry	14.0	9	8	7	6	5	4	2
3-3/4 x 2 x 3-1/2 masonry	21.0	14	12	10	9	8	7	2
FS-min. 1-3/4 deep	13.5	9	7	6	6	5	4	2
FD-min. 2-3/8 deep	18.0	12	10	9	8	7	6	3
FS-min. 1-3/4 deep	18.0	12	10	9	8	7	6	3
FD-min. 2-3/8 deep	24.0	16	13	12	10	9	8	4

Diagram, NTC, d12.14

If different sized conductors are used the volume required for each type of conductor must be used. The total volume required for all conductors cannot exceed the volume available in the box.

Boxes less than 100 cubic inches, having more than 2 conduit entries, and nonmetallic boxes must have their capacity marked on the box. The manufacturer is responsible for providing this capacity on the box itself. It is part of the box's listing from the agency which provides it.

Volume Allowance per Conductor

Size of Conductor (AWG)	Free Space Within Box for Each Conductor cm^3	in^3
18	24.6	1.50
16	28.7	1.75
14	32.8	2.0
12	36.9	2.25
10	41.0	2.50
8	49.2	3.00
6	81.9	5.00

Diagram, NTC, d12.15

NFPA 70® also specifies how many conductors can be used in specific conduit sizes. These limitations are in place to ensure that conductors are protected from ground faults. Overfilling of conduits can cause severe service problems for your system.

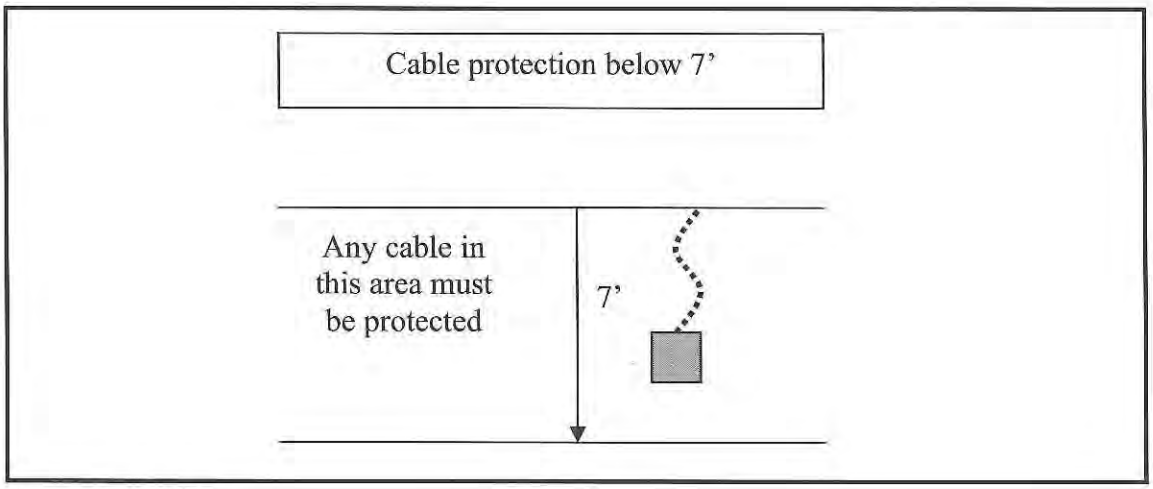
Conduit fills can be calculated two ways: percentage of fill (NFPA 70®, Chapter 9) or conductors of the same size, maximum fill tables (NFPA 70®, Annex C). Percentage of fill must be used when conductors of different sizes are occupying the same conduit.

When using these tables you must be careful to make sure you are using the proper table for your conduit type, the right conduit size from the top of the table, and the proper wire type from the left side of the table.

Power Limited Fire Alarm Circuit Wiring Methods
Power limited fire alarm cable must have an insulation rating of 300 volts. Single conductor power limited fire alarm cable must be a minimum of 18 AWG. Multiconductor power limited cable can be as small as 26 AWG.

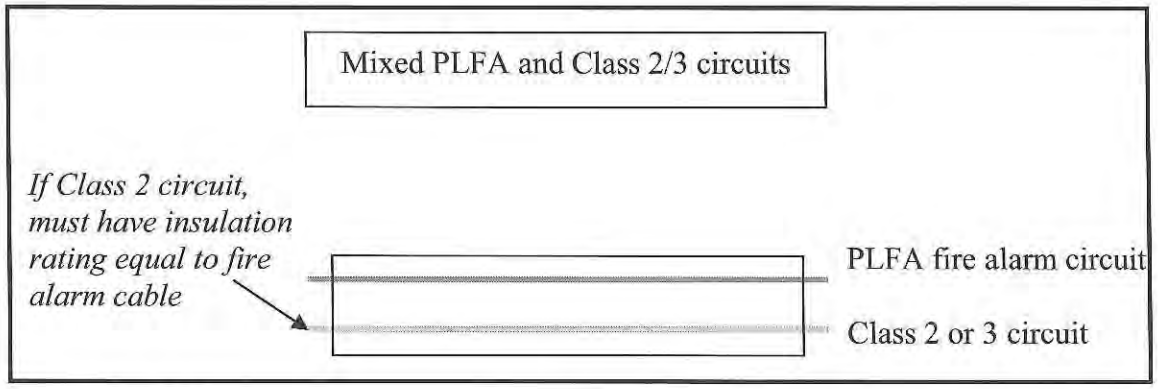
Cable for power-limited fire alarm circuits can be run in raceways or exposed (if more than 7 feet above the floor). Exposed cable must be supported and protected against physical damage. Power limited cable which is run within 7 feet of the finished floor must be protected from physical damage. This can be accomplished with conduit, wire mold, running the cable inside of the wall or in whatever manner is acceptable to the AHJ.

It is recommended that fire alarm cabling be supported every 18 inches. This ensures secure mounting and installation. Additionally care must be taken when running fire alarm cable. It is not permitted to attach fire alarm cable to someone else's conduit. Further, access to ceiling panels is required. All fire alarm cabling must be secured to the building structure. It is not permitted to lie fire alarm cabling across ceiling tiles or attach cabling to the support grid. Fire alarm cable cannot be attached to sprinkler pipe. Make sure these general requirements are followed for power limited cable installations.



Diagram, NTC, d12.16

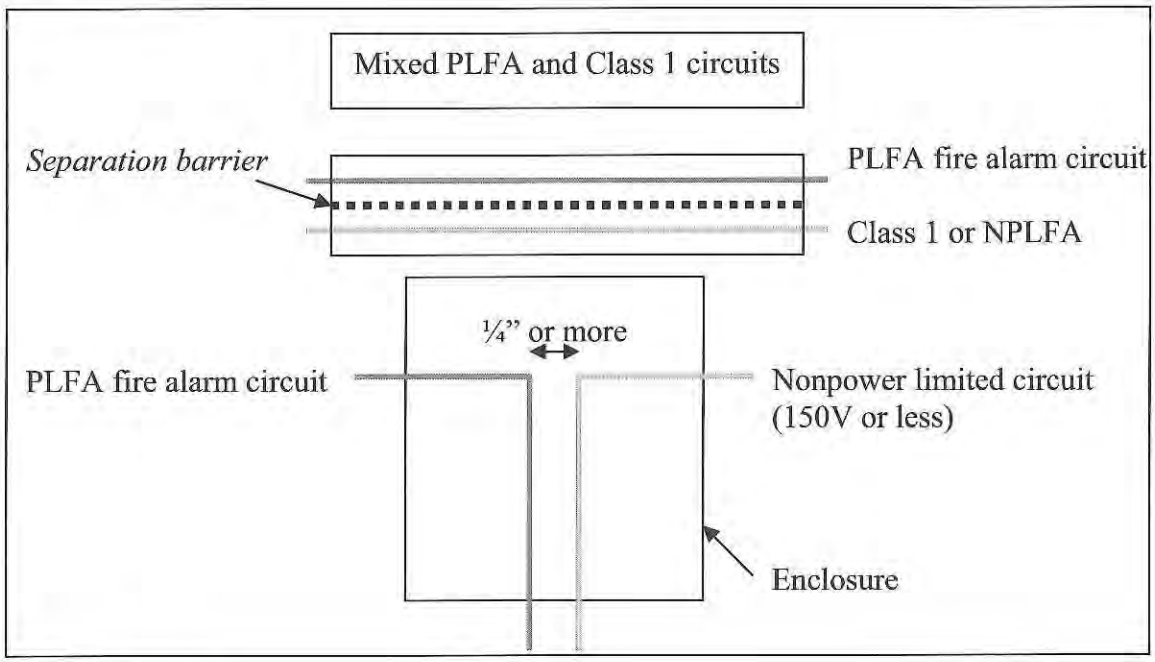
Cables of two or more power-limited fire alarm (PLFA) circuits or Class 3 circuits are permitted in the same cable, enclosure, or raceway. Cables of one or more Class 2 circuits are permitted in the same cable, enclosure, or raceway with power-limited fire alarm circuits, as long as the insulation of the Class 2 cable is at least equal to the requirements of power limited fire alarm circuits.



Diagram, NTC, d12.17

PLFA cables cannot be installed in the same raceway, enclosure, or cables with cables from electric light, power, Class 1, or nonpower limited fire alarm wiring. Such wiring methods are permitted if they are separated by barriers or installed in a raceway within the enclosure.

PLFA cables can be mixed with non-power limited cables within an enclosure if they are separated by ¼ inch or more, and they are 150 volts or less.



Diagram, NTC, d12.18

In other applications, PLFA circuits must be separated by at least 2 inches from other conductors such as electric light, power, Class 1, or nonpower limited fire alarm, or nonpower limited energy conductors.

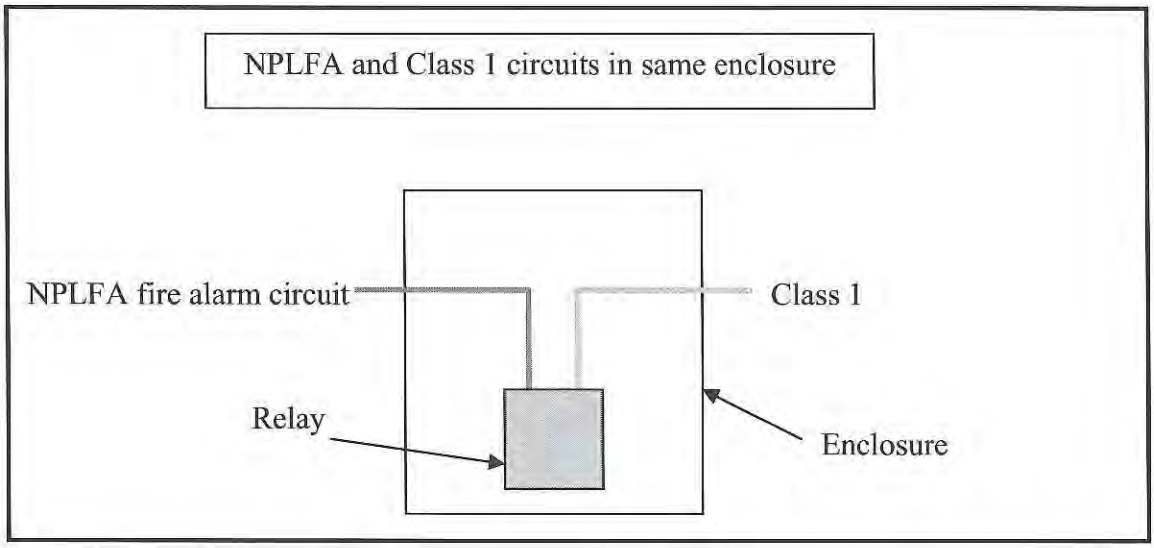
Separation is not required if the other conductors are installed in raceway, or use nonmetallic sheathed cable (NM) or underground feeder (UF) cable.

PLFA cables can be installed in hoistways if they are installed in rigid or intermediate metal conduit, or electrical metal tubing. In elevator hoistways, the only cable permitted must directly relate to the operation of the elevator itself.

Non Power Limited Fire Alarm Circuit Wiring

Non power limited fire alarm conductors must have an insulation rating of 600 volts. The minimum conductor size is 18 AWG. Nonpower limited fire alarm circuits must be installed according to the requirements of NFPA70®, Chapter 3. Multiconductor fire alarm cable is only permitted in circuits operating at 150 volts or less.

Class 1 and NPLFA circuits can be run in the same cable, enclosure, or raceway as long as all cables are insulated for the maximum voltage of any conductor. NPLFA circuits can be in the same cable enclosure or raceway as power supply circuits as long as the equipment is functionally associated with the NPLFA circuit.

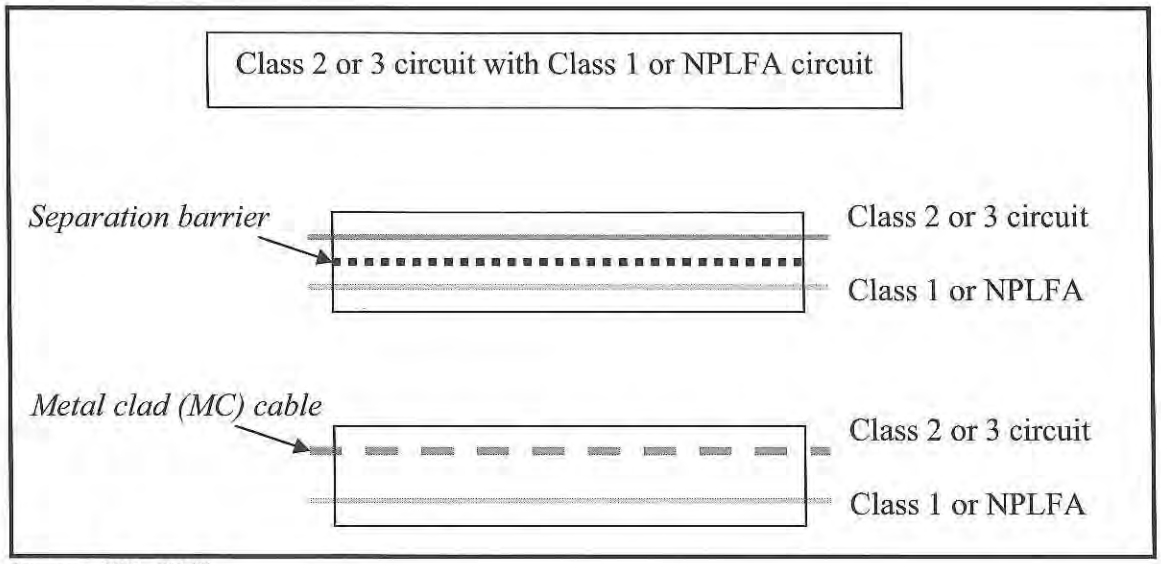


Diagram, NTC, d12.19

Class 1, 2, and 3 Circuit Wiring

Class 1 circuits are wired per the requirements of Chapter 3 in NFPA 70®. Two or more Class 1 circuits are permitted in the same cable, raceway, or enclosure. They can be installed with power supply circuits only when the power supply cabling is functionally associated with the Class 1 circuit.

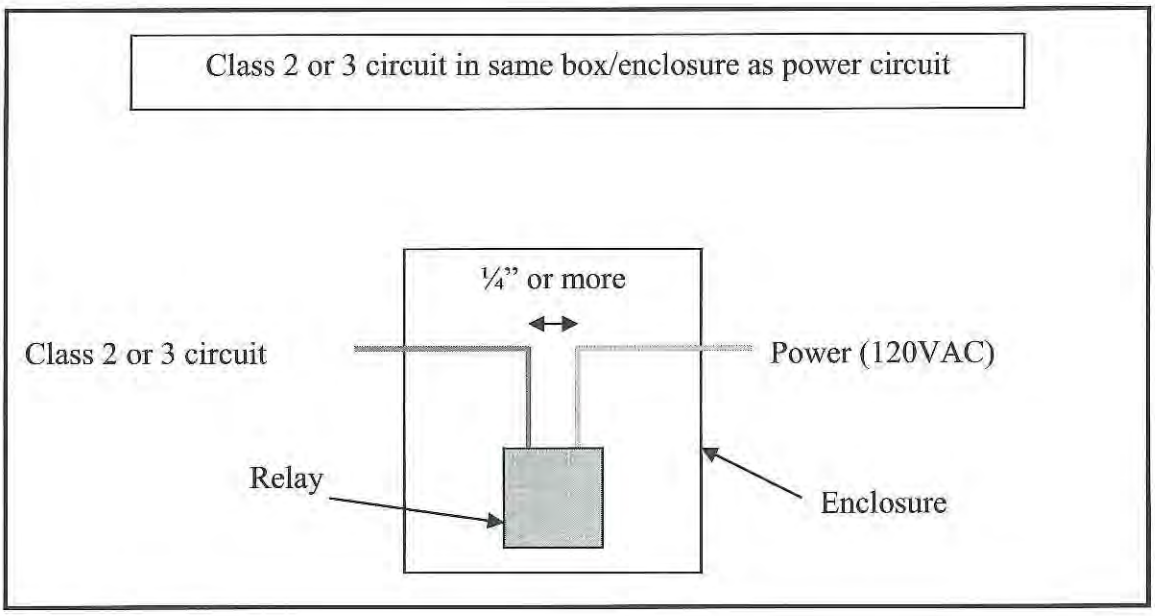
Class 2 and 3 circuits cannot be run directly in the same cable, enclosure, or raceway as power supply or Class 1 circuits. Class 2 and 3 circuits can be installed with Class 1 and nonpower limited fire alarm where they are separated by a barrier, or a in a raceway with a separate enclosure for the Class 2 and 3 circuits. The circuits can also be installed in a cable tray with a solid fixed barrier, or when the Class 2 and 3 circuits use metal clad (MC) cable.



Diagram, NTC, d12.20

Class 2 and 3 circuits can be installed in other applications with power or Class 1 circuits if they are separated by 2 inches. They can be closer if the power or Class 1 circuits are installed in a raceway, use nonmetallic sheathed cable, or UF type cable.

Class 2 and 3 circuits can be installed in the same box or enclosure as power circuits if the power circuit is used to for equipment connected to the Class 2 and 3 circuits. The power and Class 2 and 3 conductors must be separated by at least ¼ inch.



Diagram, NTC, d12.21

Class 2 and 3 circuits can be intermixed as long as the Class 2 circuit cabling has an insulation rated as high as the Class 3 circuit cable. Class 2 and 3 circuits are also permitted to be installed with communications and power limited fire alarm circuits.

Fiber Optic Cables

Fiber optic cables are used in fire alarm systems for remote annunciators, panel interconnection, and networking to other systems. Since fiber optic cables are non-conductors they are resistant to lighting, RF, and EMI interference. Article 770 covers the requirements for fiber optic cables.

Fiber cables are classified as conductive, nonconductive, and composite. Conductive cables have some sort of metallic element (armoring, strength member, etc.) that is capable of carrying voltage.

Nonconductive cables have no metallic elements in their construction. Composite cables have both electrical (metallic) cables and fiber optic cables in the same jacket.

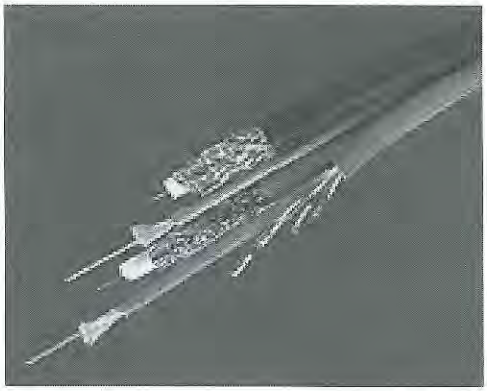


Photo Courtesy NTC, p12.1

Fiber optic cables are also categorized by application, just like fire alarm cables. The cable types all begin "OF" (optical fiber), then have "N" for nonconductive or "C" for conductive, and then the cable type (general purpose, riser, plenum).

OFN – General purpose nonconductive
OFNR – Riser nonconductive
OFNP – Plenum nonconductive

OFC – General purpose conductive
OFCR – Riser conductive
OFCP – Plenum conductive

Fiber optic cables can be installed in the same raceway as Class 1 and high voltage circuits of 600 volts or less where the electrical and fiber optic cable functions are associated.

Nonconductive fiber optic cables can be installed in the same raceway or cable tray as Class 1 or high voltage circuits. Conductive cables should not be installed this way.

Fiber optic cables, both conductive and nonconductive, can be run in the same raceway, cable tray, or enclosure as conductors for Class 2 and Class 3 circuits and power limited fire alarm.

Device Installation

Proper initiating device and notification appliance mounting is critical to proper operation of the fire alarm system. Improperly mounted equipment can impair system operation and reduce the life safety capabilities of the system.

Fire alarm system devices are designed to be mounted to standard electrical boxes. The installation instructions for the device specifically state which boxes are appropriate for the device. All fire alarm system wiring which enters a box or enclosure must use a listed bushing for protection.

Protection

If the equipment is subject to physical damage it must be protected with a mechanical guard. The guard must be listed for use with the equipment it is protecting. If the equipment is used in a hostile environment (outdoor, explosive, corrosive, etc) it must be designed and listed for use in that environment.

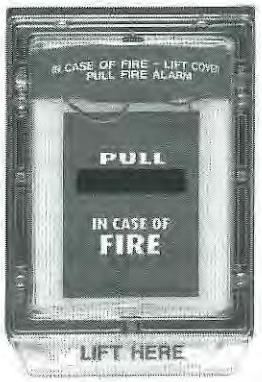


Photo courtesy STI, p12.2

Photo courtesy STI, p12.3

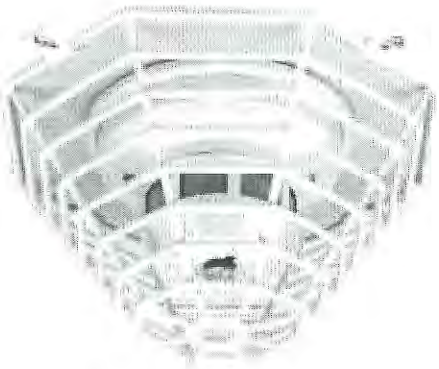
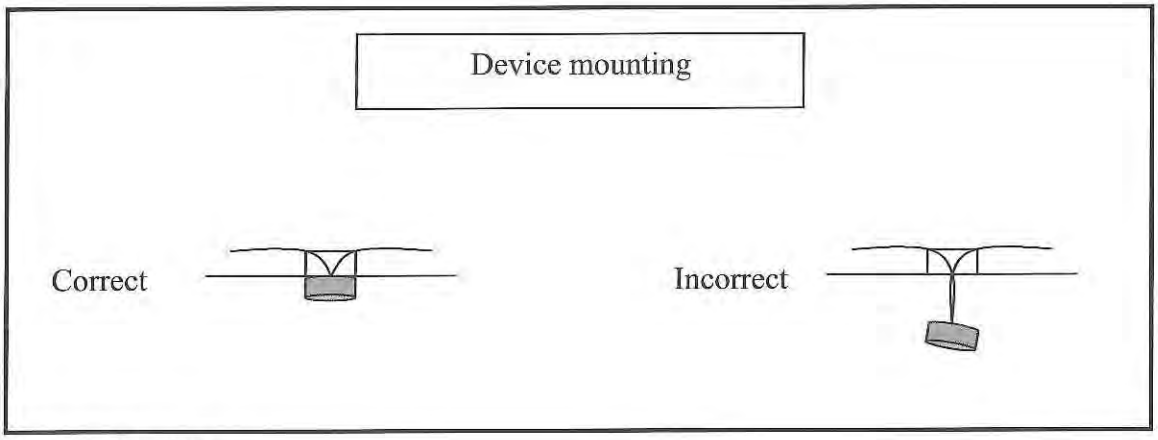


Photo courtesy STI, p12.4

Location

Fire alarm system devices must be supported by the appropriate box they are designed to be installed with. It is not appropriate for a device to be supported by its installation conductors.

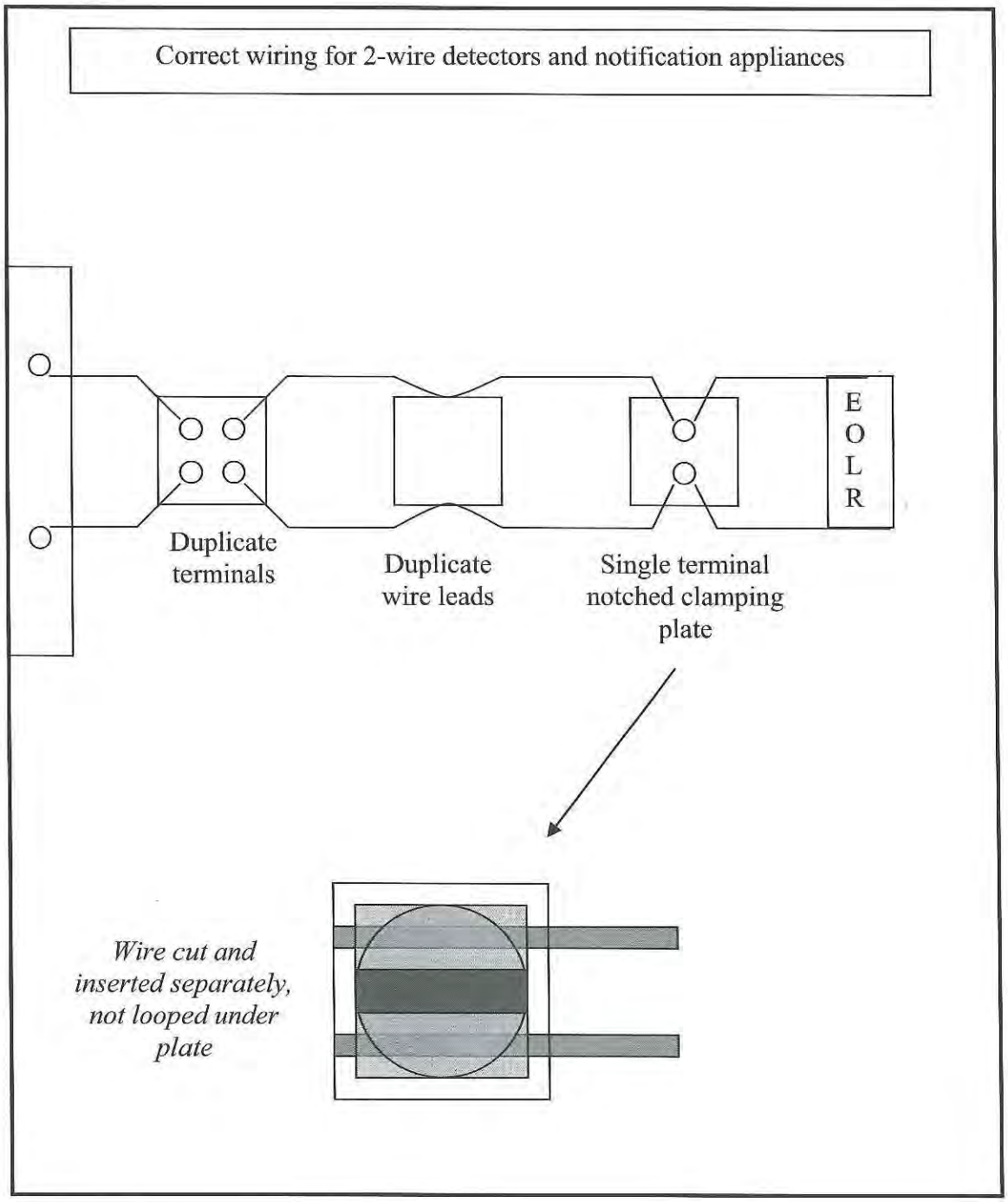
The equipment must be accessible for maintenance purposes. The equipment must be installed per the manufacturer's instructions.



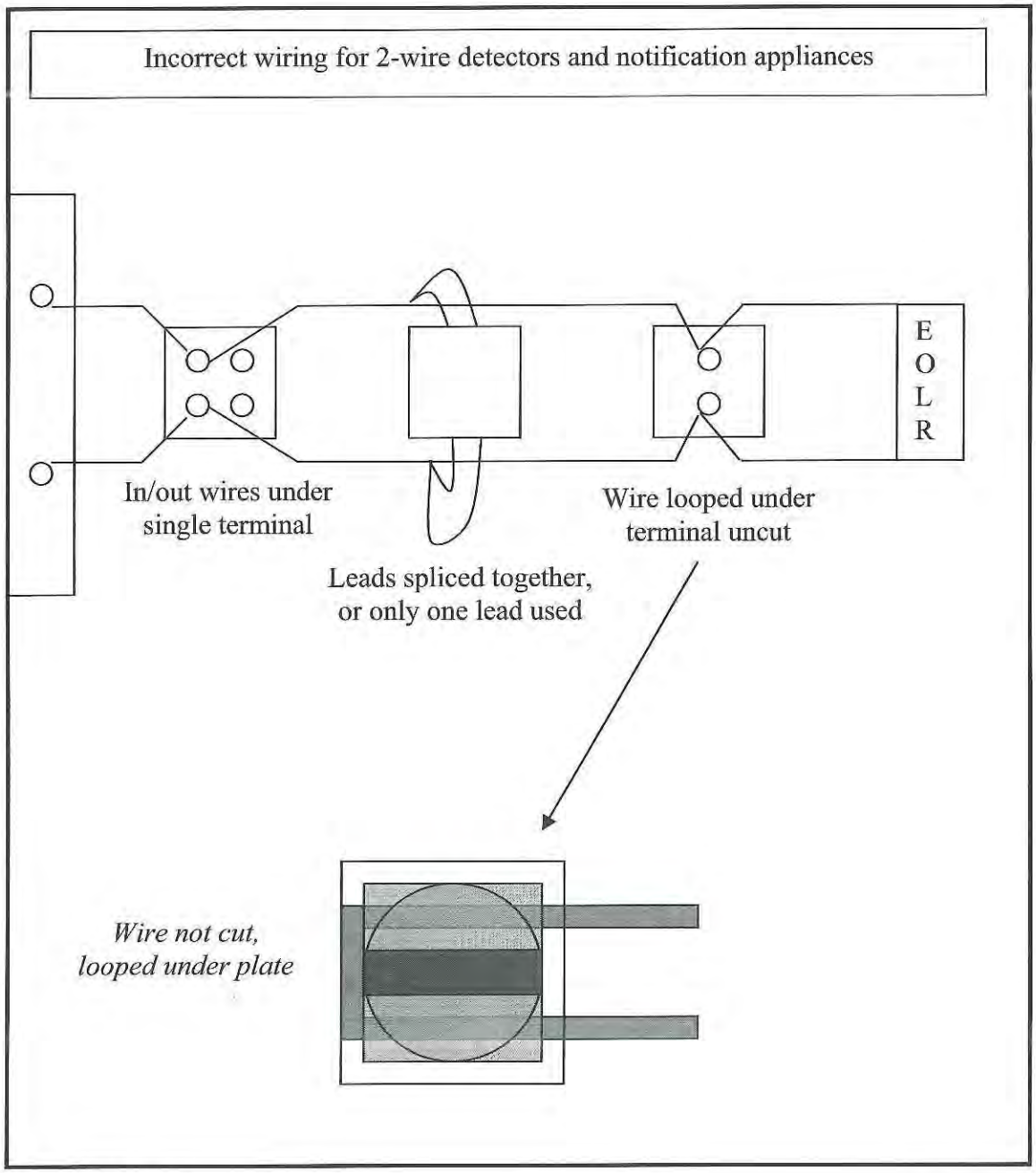
Diagram, NTC, d12.22

Wiring

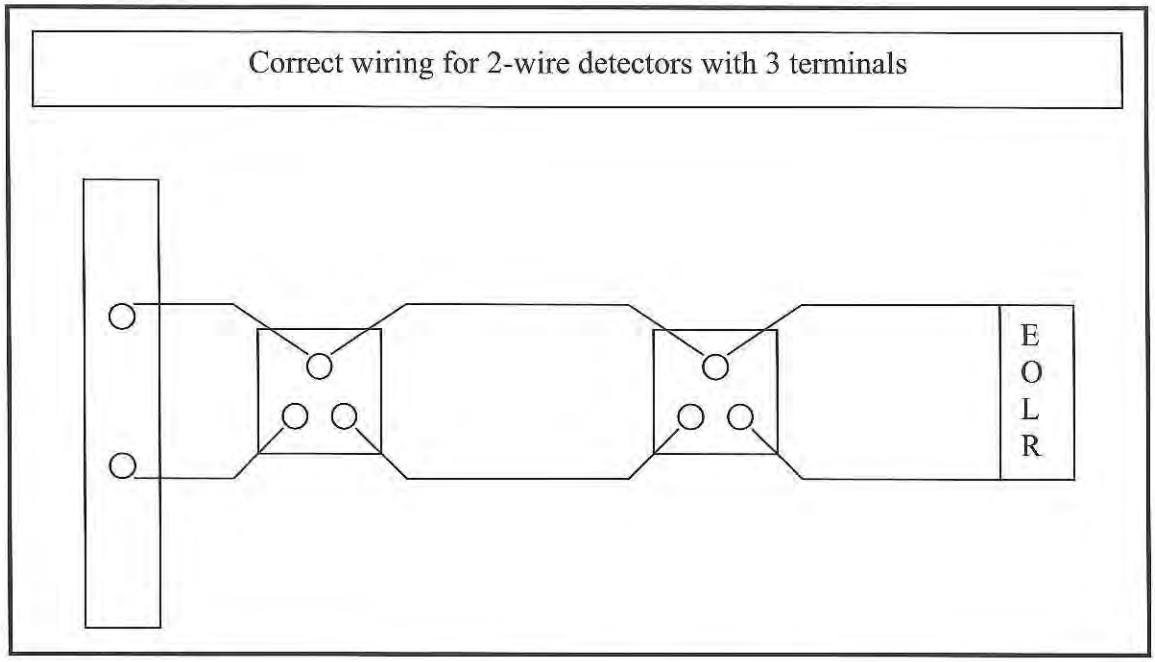
The equipment must provide duplicate terminals or leads so that the circuit may be monitored for integrity up to the device. Equipment wiring must never be looped under a single terminal or spliced to a single wire lead.



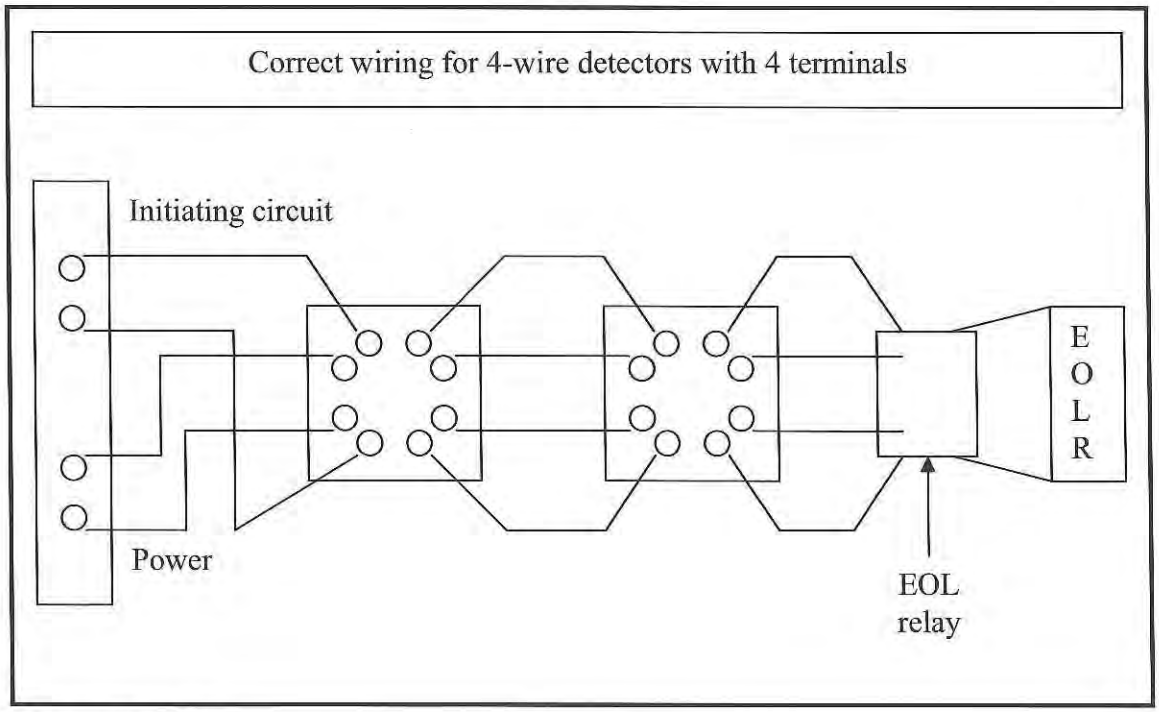
Diagram, NTC, d12.23



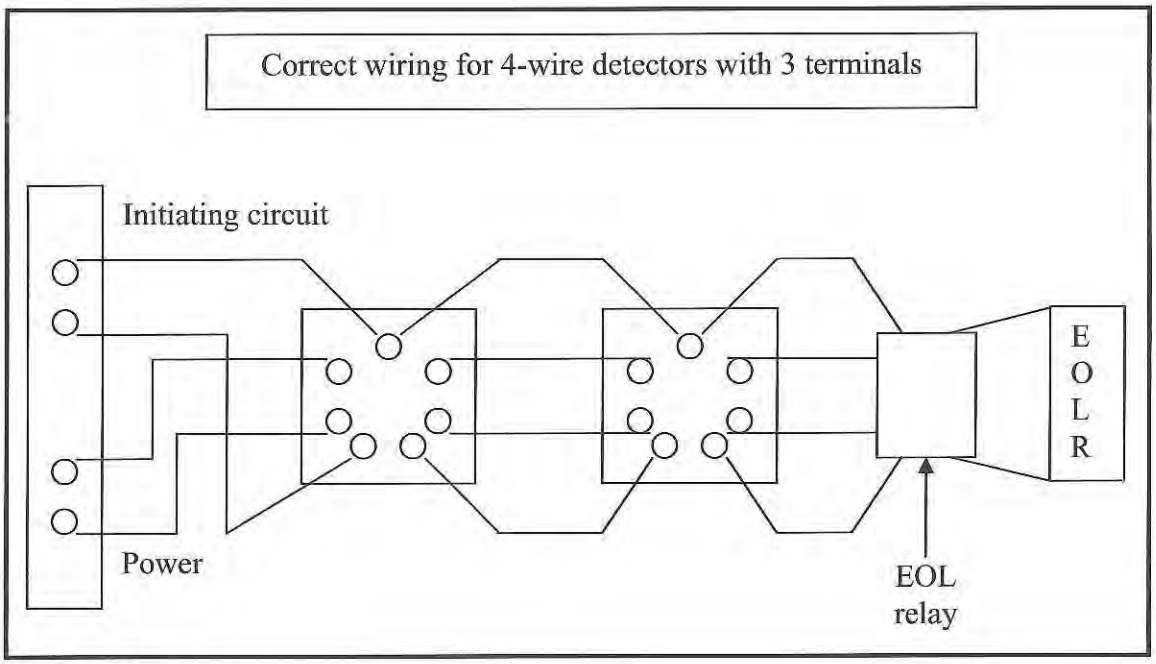
Diagram, NTC, d12.24



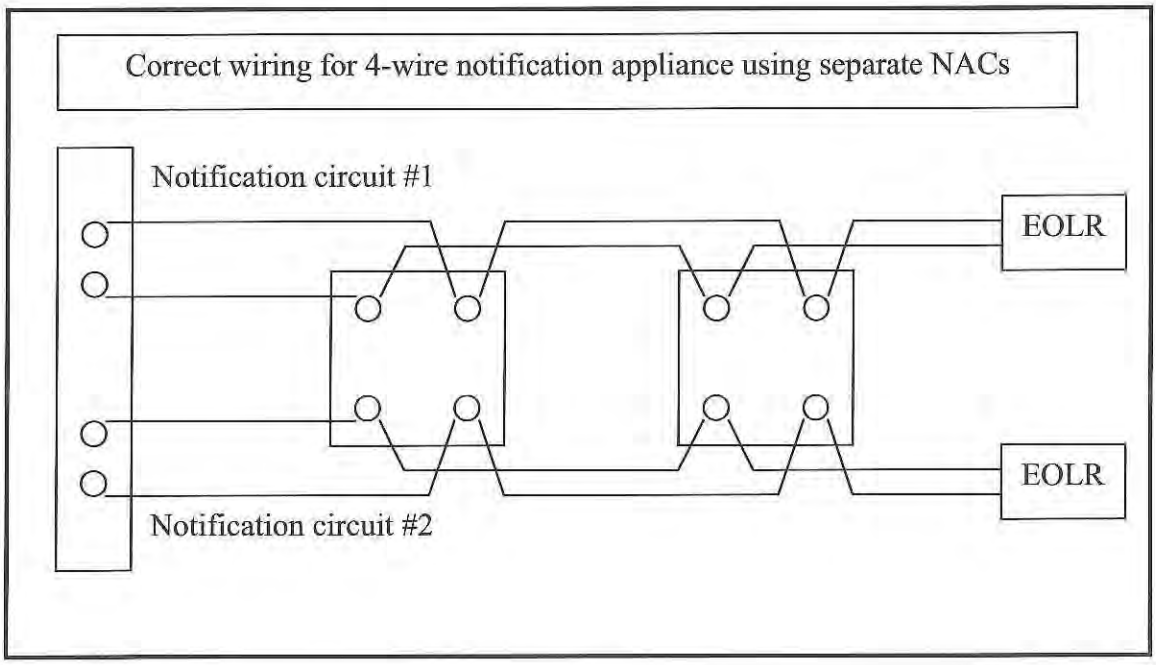
Diagram, NTC, d12.25



Diagram, NTC, d12.26



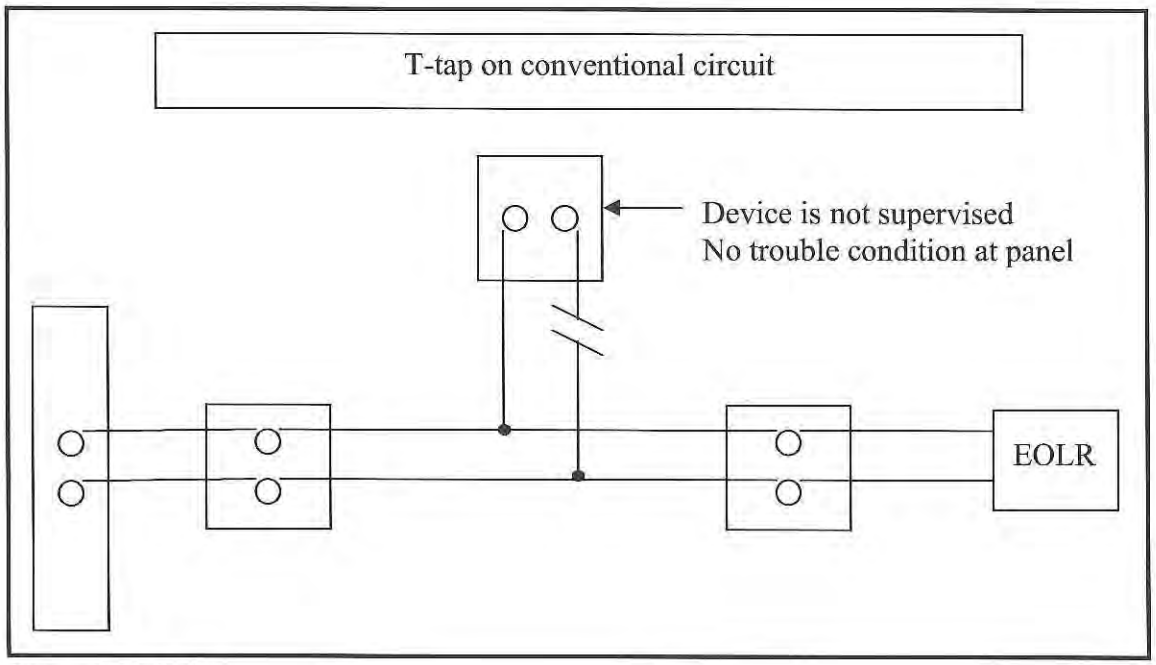
Diagram, NTC, d12.27



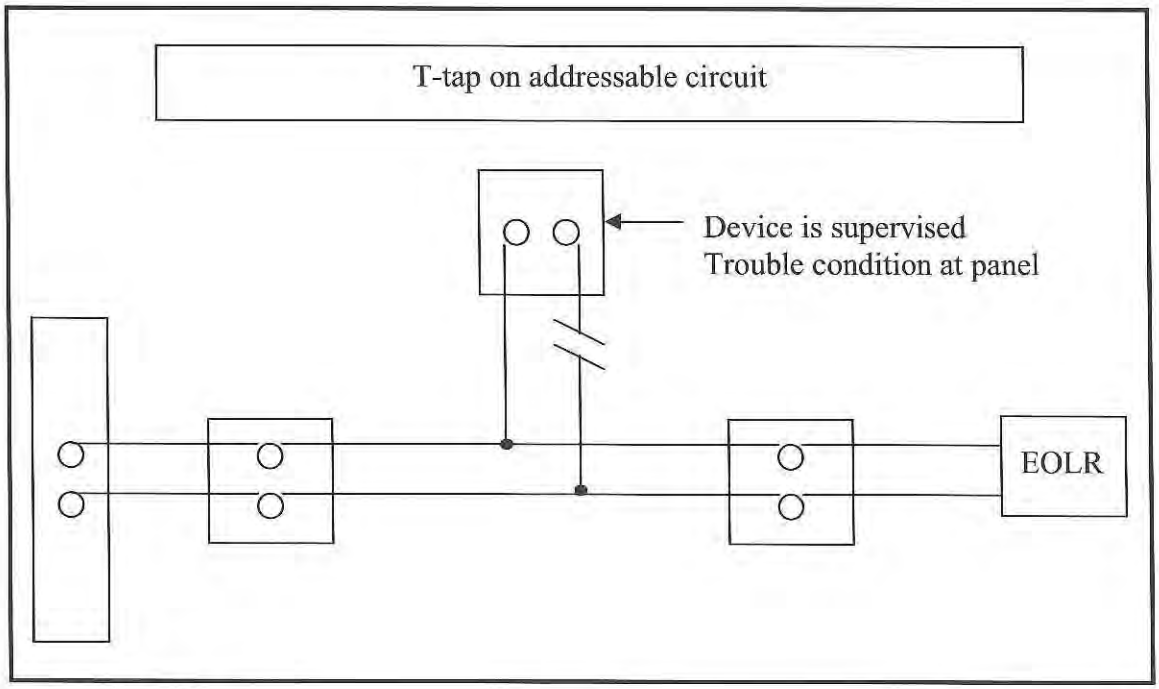
Diagram, NTC, d12.28

T-Taps

Fire alarm circuit must never be T-tapped. Devices that are T-tapped are not supervised. The exception is Class B addressable (SLC) circuits. Since SLC circuits are supervised by device rather than end of line resistor, the supervision remains even if the circuit is T-tapped.

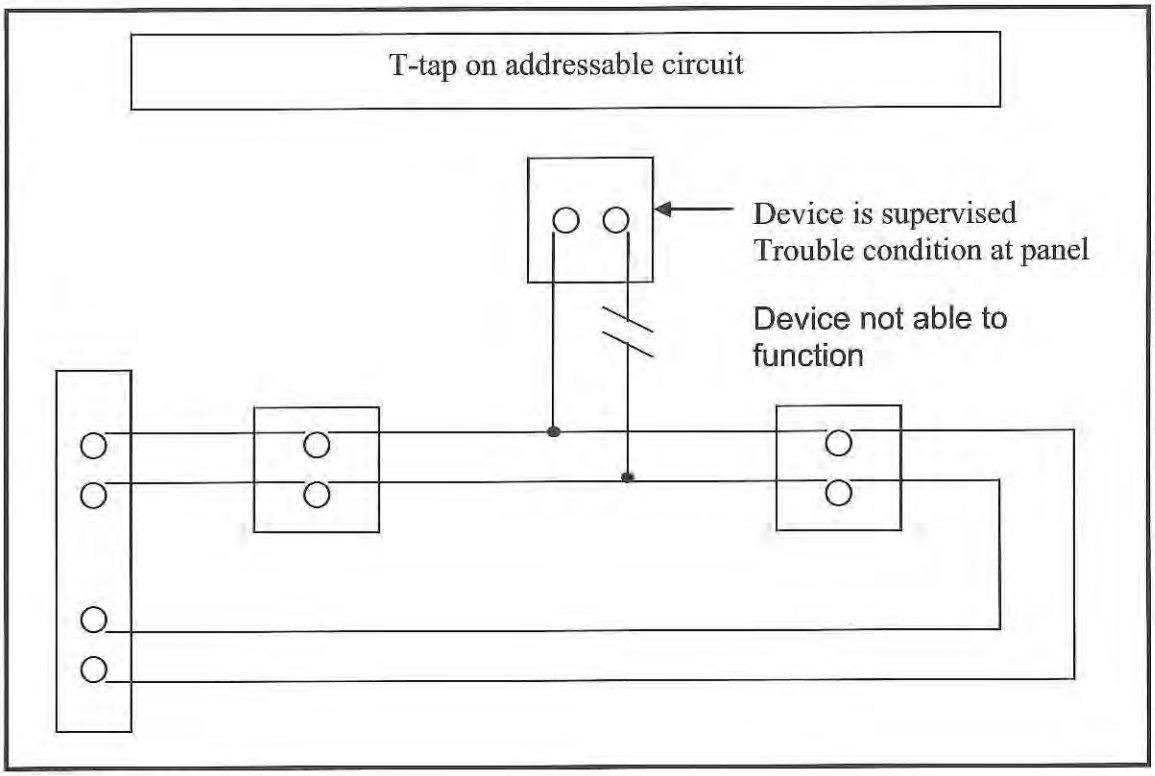


Diagram, NTC, d12.29



Diagram, NTC, d12.30

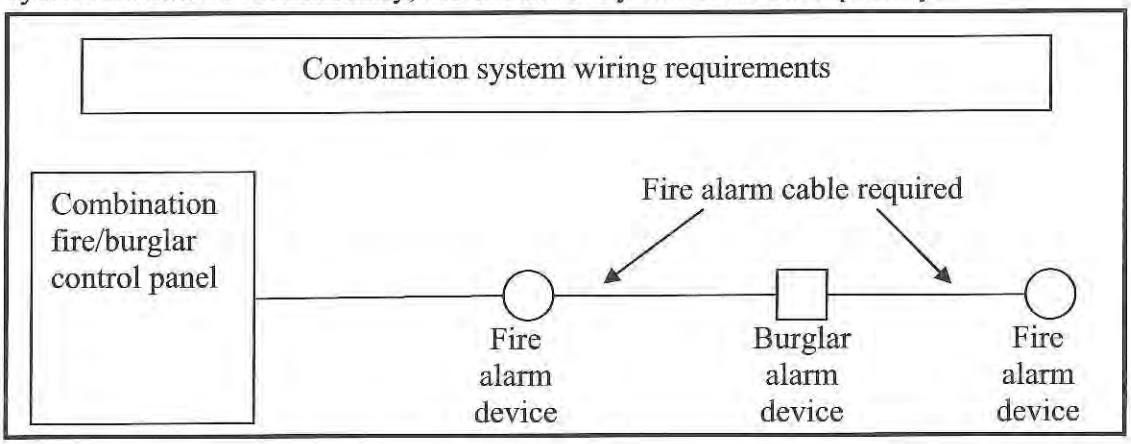
Class A signaling line circuits cannot be T-tapped either because a single fault on the T-tapped portion disables the devices on the T-tapped section. Class A circuits require that all devices continue to function in the event of single fault. Since the fault is on the part of the circuit that is T-tapped, the device cannot communicate and operate. A trouble condition is still reported by the control panel.



Diagram, NTC, d12.31

Combination Systems

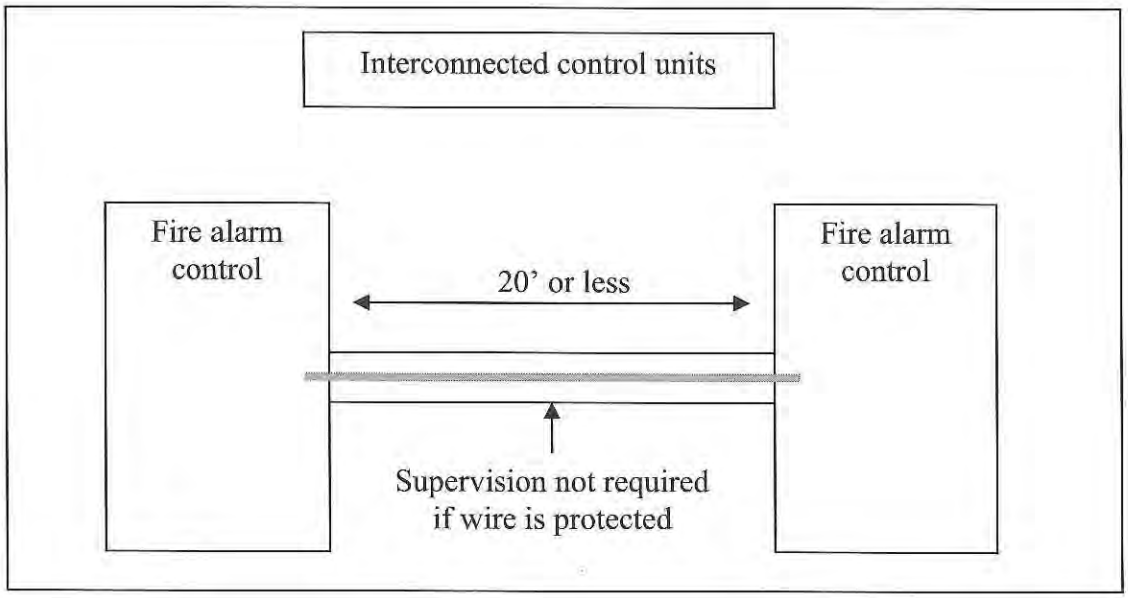
Non-fire alarm equipment is permitted to be connected to fire alarm system wiring, but all wiring directly related to the fire alarm system must be listed for fire alarm use. Problems with the non-fire alarm system are not permitted to interfere with the fire alarm system functions. Additionally, the fire alarm system must have priority.



Diagram, NTC, d12.32

Interconnected Control Units

Fire alarm control units are permitted to be interconnected. Control units within 20 feet of each other do not require supervision of the interconnection if the wiring is installed in conduit or protected from damage by other means.



Diagram, NTC, d12.33

Summary

Fire alarm system wiring is the route of communication between the fire alarm initiating devices and the fire alarm control panel, and the route of communication from the fire alarm system to the notification and control devices.

Circuits are classified as Class A or Class B, and further classified by Style. The Style determines the function of the circuit under adverse conditions.

The National Electrical Code® (NFPA 70®) states the wiring requirements for fire alarm and fire alarm related circuits.

Chapter 13

Fire Alarm System Service & Maintenance

Fire Alarm System Testing and Inspections
Maintaining the fire alarm system, once it is installed, is the most important factor in system operation. NFPA 72® specifically requires the building owner to take responsibility for the Testing and Inspection of the fire alarm system. The building owner can conduct the testing and inspections with qualified personnel (NICET Level II Certified) or contract the maintenance of the fire alarm system with a company qualified to perform the service. The testing and inspection service should be formally provided with a contract between the building owner and the qualified company.

Understanding all of the requirements of the code in terms of testing and inspections can be confusing. There are ways to make this easier. Companies like BuildingReports.com provide a method for easily keeping track of the testing and inspection of fire alarm equipment. Their service can be effectively used by institutions who may elect to perform their own testing and inspections program or by fire alarm system contractors who provide this service to their customer base.

The requirements for testing and inspection of fire alarm systems apply to both new and existing systems. This requirement exists to increase the effectiveness of the fire alarm system. Identifying and correcting any system deficiencies will help to save lives. If appropriate repairs to the fire alarm system cannot be made within 24 hours, the building owner should be notified in writing.

There are some specific requirements for testing fire alarm systems which are addressed by the code. A test is an actual functional test to make sure the equipment performs properly. The requirements of the code are in place to ensure that the testing process is done in an effective and efficient manner.

Before testing, it is important to make appropriate notification. Notification to the supervising station in order to place the account on test and notification to the building occupants are paramount. Once testing is concluded, notification should be made that testing is complete.

The building owner is responsible for maintaining all of the records for the installation and service of the fire alarm system. The building owner should provide service personnel with the record of completion, information concerning any alterations to the fire alarm system, system specifications and wiring diagrams. It is important for the fire alarm contractor to maintain spare copies of this information so the service technician will have access to it.

Fire alarm technicians are not required to perform discharge testing of suppression systems. Suppression systems should be secured from accidental actuation prior to any testing.

All new fire alarm systems are required to have a 100% acceptance test performed. A record of completion is required for all new fire alarm system installations. Additionally, reacceptance testing is required when system components are added or deleted, modifications occur with system hardware or wiring, and when changes are made to site specific software. All components known to be affected by any changes require 100% testing and 10% of initiating devices not affected should be tested.

Smoke detector sensitivity is required to be checked within the first year of installation. After the first year, sensitivity testing is required every alternate year. If the sensitivity remains within the listed range, the testing can be extended to 5 years. There are several methods for conducting the sensitivity tests such as the calibrated test method, manufacturer's calibrated sensitivity test, and listed control equipment. If a smoke detector falls outside of the sensitivity range, that detector should be recalibrated or replaced.

In addition to a regular schedule of testing, NFPA 72® requires that visual inspections be conducted as well. A visual inspection is just a check to see that all appears as normal. Recording of all testing and inspections is a requirement. NFPA 72® provides a testing and inspection form.

Testing and inspection records are required to be retained until the next test and for 1 year thereafter. A permanent record of all inspections, testing and maintenance is required and must contain all pertinent information.

There are specific records which must be filled out and completed for fire alarm system testing and inspections. Examples of these forms can be found in Appendix C Documentation and include the following:

1. Record of Completion
2. Testing and Inspections form

The testing and inspection frequency for fire alarm equipment must comply with the tables listed in NFPA 72®. The required frequencies for testing and inspections can be confusing. Following the frequencies listed in the following table will keep things on track.

Category	Device	Inspection	Testing
Control Equipment for	Functions		A
Monitored Systems	Fuses	A	A
	Interfaced equipment	A	A
	Lamps and LEDs	A	A
	Primary (main) power supply	A	A
	Transponders		A
Control Equipment for	Functions		Q
Unmonitored Systems	Fuses	S	Q
	Interfaced equipment	S	Q
	Lamps and LEDs	S	Q
	Primary (main) power supply	S	Q
	Transponders		Q
Engine Driven Generators	Central station facilities		M
	Fire alarm systems		M
	Public fire alarm reporting systems		W
Batteries Central Station	Lead acid	M	
Facilities	Charger test (replace batt as needed)		A
	Discharge test (30 minutes)		M
	Load voltage test		M
	Specific gravity test		S
	Nickel Cadmium	S	
	Charger test (replace batt as needed)		Q
	Discharge test (30 minutes)		A
	Load voltage test		A
	Sealed Lead acid	S	
	Charger test (replace batt as needed)		M
	Discharge test (30 minutes)		M
	Specific gravity test		M
Batteries Fire Alarm Systems	Lead acid	M	
	Charger test (replace batt as needed)		A
	Discharge test (30 minutes)		S
	Load voltage test		S
	Specific gravity test		S
	Nickel Cadmium	S	
	Charger test (replace batt as needed)		A
	Discharge test (30 minutes)		A
	Load voltage test		S
	Primary type (dry cell) load voltage test	M	M

Category	Device	Inspection	Testing
Batteries Fire Alarm Systems	Sealed Lead acid	S	
	Charger test (replace batt as needed)		A
	Discharge test (30 minutes)		A
	Specific gravity test		S
Batteries Public Fire Alarm Reporting Systems	Lead acid	M	
	Charger test (replace batt as needed)		A
	Discharge test (30 minutes)		Q
	Load voltage test		Q
	Specific gravity test		S
	Nickel Cadmium	S	
	Charger test (replace batt as needed)		A
	Discharge test (30 minutes)		A
	Load voltage test		Q
	Sealed Lead acid (replace every 5 yrs min)	S	
	Charger test (replace batt as needed)		A
	Discharge test (30 minutes)		A
	Specific gravity test		Q
Transient Suppressors	All Types	S	
Control Unit Trouble Signal		S	A
Fiber Optic	Cable connection	A	
	Cable power		A
Conductors	Metallic		INITIAL
	Non metallic		INITIAL
Emergency Voice and Communications equipment		S	A
Retransmission Equipment			INITIAL
Remote Annunciators		S	A
Initiating Devices	Air sampling	S	
	Duct detectors	S	A
	Electromechanical releasing devices	S	A
	Fire extinguishing systems switches	S	A
	Suppression system switches	S	A
	Fire gas and other detectors		A
	Fire alarm boxes	S	A
	Heat detectors	S	A
	Radiant energy sensing fire detectors	Q	S

Category	Device	Inspection	Testing
Initiating Devices	Smoke detectors, system type	S	A
	Smoke detector sensitivity test		See Note
	Single & multiple station smoke alarms		A
	Single & multiple station heat alarms		A
	Supervisory devices (except valve tamper)	Q	Q
	Valve tamper switches	Q	S
	Waterflow devices	Q	S
Guards Tour Equipment		S	A
Interface Equipment		S	A
Special Hazard Equipment			A
Alarm Notification Devices		S	A
Off Premises Transmission Equip			Q
Supervising Station Fire Alarm Systems--Transmitters	DACT	S	A
	DART	S	A
	McColloh	S	A
	RAT	S	A
Special Procedures		S	A
Supervising Station Fire Alarm Systems--Receivers	DACR	M	M
	DARR	S	M
	McColloh Systems	S	M
	Two way RF mulitplex	S	M
	RASSR	S	M
	RARS	S	M
	Private microwave	S	M
M = Monthly	NOTE: Smoke Sensitivity testing		
Q = Quarterly	1st year and every alternate year		
S = Semi Annually	After 2nd test, extend test to 5yrs		
A = Annually	Maintain records of nuisance alarms		

Diagram, NTC, 13.1

The above chart is based on NFPA 72®, 2002 Edition. It is for general reference only. For current test and inspection requirements consult the current version of NFPA 72® being used by your local AHJ.

Fire Alarm System Service

Fire alarm system service is very important to effective detection. It can also be very confusing. There are certain techniques and methods which technicians can use to make this process less difficult.

The most important factor in performing service on the fire alarm system is ensuring the installation of the system meets all of the requirements of the code and the manufacturer's instructions. If the original installation is out of compliance with the manufacturer's instructions, it is likely that the equipment will not perform as intended.

In the event that a service technician encounters an improperly installed fire alarm system, the proper course of action is to identify the discrepancies, and have the original installation problems fixed. It is crucial that all fire alarm equipment be installed in accordance with the manufacturer's instructions. Performing service on a fire alarm system which is not properly installed is a waste of time.

Fire Alarm System Statistics

All fire alarm systems have devices and components which will eventurally fail. All equipment fails eventually, including fire alarm equipment. A regular schedule of testing and inspection can ensure the appropriate level of maintenance is performed for the fire alarm system to work properly. A study conducted by the Los Angeles county fire chiefs on the effectiveness of fire alarm systems connected to monitoring facilities revealed some interesting information. 13% of the fire alarm systems included in the survey had malfunctioned. The top reasons for the failure of the fire alarm systems were:

1. Faulty water flow switch
2. Lack of maintenance
3. Water in conduit
4. Power failure
5. Telephone line failure
6. Detector failure
7. Damage to devices and components
8. Battery failure
9. Smoke detectors too sensitive
10. Poor installation

Another study conducted for fire alarm systems in hotel occupancies revealed the following facts:

Tested Component	New Fire Alarm System	Fire Alarm Less than 3 yrs old
Control Panels	60% with problems	99% with problems
Smoke Detectors	3.5% with problems	30% with problems
Notification App.	5.5% with problems	25% with problems

The failure rate of smoke detectors is also important. It really demonstrates the importance of regular testing and inspections for fire alarm systems. NFPA 72®, The National Fire Alarm Code® specifically details how frequently fire alarm testing and inspections are required to be performed. Following the requirements in the code will ensure the fire alarm system functions when required. Review these failure rates for smoke detectors.

Failure in 1 year	3% of smoke detectors fail
Failure in 10 years	29.6% of smoke detectors fail
Failure in 20 years	50.4% of smoke detectors fail
Failure in 30 years	60.1% of smoke detectors fail

Based on these statistics, it is easy to identify the need for annual testing of smoke detectors. They will fail. They need to be regularly tested and serviced.

Developing and implementing a program of testing and maintenance for every fire alarm system installed is critical to ensuring the ongoing effectiveness of the system. It is also a method of generating recurring revenue for your company. It is good for your customer. It is good for your company. It is a requirement in the code.

Fire Alarm System Troubleshooting Methodology

Providing excellent service starts with making sure the fire alarm system was correctly installed in accordance with the code and the manufacturer's instructions. Once it has been established that the system meets the requirements of the manufacturer and the code, the process of identifying the problem can commence. The methodology for troubleshooting fire alarm systems is as follows:

1. Talk with building owner / representative to identify the problem
2. Check the control panel / annunciator
3. Check power to the control
4. Check power to devices
5. Check continuity of the circuits
6. Check the devices in question
7. Identify the source of the problem
8. Take corrective action

Unfortunately, troubleshooting is not an exact science. Following these steps will not guarantee immediate success. It will provide a step by step process which usually will allow identification of the problem and corrective action.

Talking with the building owner or representative will provide valuable information about when the problem occurred and what other activities may have contributed to the problem. For example, the building owner might reveal that the system was working fine until the telephone repair man worked on the phone lines. Then the annunciator indicated a failure to communicate message.

Check the Control Panel / Annunciator
Most fire alarm systems today are capable of providing detailed information about any system trouble condition. If the annunciator indicates a failure to communicate, it is clear where to look for the problem. Additionally, analog systems are capable of providing a great deal of information about the status of devices such as smoke detectors.

Check Power to The Control Panel
This sounds basic, but it is surprising how many technicians fail to do this. Checking power includes the feed to the control and the secondary batteries. Failure of either can cause problems for the fire alarm system.

Check Power to The Devices
Addressable fire alarm devices and some conventional devices require power from the control panel. Ensuring the proper voltage and current to the device in accordance with the manufacturer's requirements is necessary in order to verify proper operation.

Check Continuity of the Circuit
There are an incredible number of tools available to the technician for checking continuity. This step will ensure the circuit tests free of opens, shorts or ground faults.

Check the Devices In Question
If one of the other steps identified a specific malfunctioning device, then the device should be individually tested to verify proper operation.

Identify the Source of the Problem
The other steps should provide enough information to more narrowly identify the source of the problem. Normally, the source of the problem will fall into one of the following categories.

1. Device problem: A specific device is malfunctioning.
2. Wiring problem: This could be an open, short, ground fault, or intermittent problem.
3. Programming problem: Errors in programming can cause system wide problems.

Take Corrective Action
This requires taking the corrective action necessary to fix the problem. Usually, the solution is more simple than complex. Remember, the system was working fine, then suddenly had a problem. More complex problems are usually characterized by longer term difficulty with the system. Generally go with the solution which is simpler first. Move on to more difficult solutions (like pulling new wire) only when other solutions do not work.

Common Problems
There are several service situations which occur with fire alarm systems on a regular basis. Some of these areas are:

1. Power problems

2. False alarms
3. Device malfunction
4. Wiring problems
5. Failure to communicate

Power Problems

Power problems are one of the most common problems associated with fire alarm systems. Lack of adequate power can cause devices to function incorrectly or not at all. Power problems can affect almost any part of the system. Power problems are generally easy to diagnose and fix.

Symptoms

False alarms, malfunctioning devices, lack of proper voltage and current to the extremities of the system, excessive draw on the system batteries. Power problems are easy to identify with notification circuits. If the audible devices fail to sound at the proper level, they are not receiving the correct power. Visible notification appliances are required to flash at least once per second. If the device flashes once every five seconds, it is not receiving the required power. Voltage drop calculations are used to determine proper wire size for circuits.

Identifying the Problem

A voltmeter can identify whether the panel is receiving the proper voltage, whether devices are receiving the voltage they require and whether adequate current is available to the circuit.

Corrective Action

Re establish connection to the power source if it has been interrupted. Sometimes it may be necessary to add an additional power supply. For fire systems, additional power supplies are required to be appropriately listed and supervised. Some power problems are the result of undersized wiring. These problems are corrected by installing wire of the proper size for the application.

False Alarms

False alarms are one of the biggest problems for building owners, fire fighters and fire alarm system contractors. They are the source of frustration, wasted time and lost revenue for all parties concerned. The best way to prevent false alarms is to follow the code and the manufacturer's instructions during installation. Proper system installation will eliminate a vast majority of false alarms. False alarms usually fall into one of the following categories:

1. Improper location of equipment
2. Inadequate power / wire size to devices
3. Human action

All of the above categories directly relate to the original installation of the system. All of them can be significantly reduced by following the codes and the manufacturer's instructions for the fire alarm equipment.

Symptoms
An alarm activation occurs when no fire exists.

Identifying the Problem
First, check that the device is appropriate for its location. For example, installing a smoke detector in a dusty warehouse which is not environmentally controlled will cause the detector to false alarm. Also, installing a 135° heat detector on a ceiling where the temperature will hit 160° in the middle of summer will cause the detector to false alarm.

It is important to ensure the panel is capable of providing the correct voltage and current to all of the devices connected to it. Further, the wiring has to be capable of transmitting the proper voltage and current to the devices while under load. Doing proper voltage drop calculations will ensure that the system has wiring which is appropriate to the task.

The nuisance activation of a pull station can be another source of false alarms. The same can be said for someone smoking in an inappropriate place. These are both human induced false alarms. In these cases, the devices responded appropriately, but humans caused the alarm. Steps can be taken to reduce this such as protective guards for pull stations and proper ventilation for smoking areas.

Corrective Action
The most effective corrective action for false alarms comes from installing the system properly to start with. If false alarms occur, place appropriate devices in the correct environment. Make sure adequate power is available to the system and all devices. Use protective guards if necessary to reduce nuisance alarms.

Device Malfunctions
Device malfunctions are another service problem encountered with fire alarm systems. All devices will fail eventually. Too often though, technicians use this as a crutch when they run into service situations. Manufacturer's consistently report that 98% of the equipment returned to them as malfunctioning works fine.

Just because a false alarm originated at a smoke detector, that does not mean the smoke detector malfunctioned. Finding the cause of the false alarm is required to solve the problem. If the environment is not appropriate for a smoke detector, install a device which is appropriate for the environment.

Symptoms
Devices which are inoperable, or intermittent in the way they function.

Corrective Action
Replace the device.

Wiring Problems
Wiring problems normally result from poor installation techniques. This holds true when too small of a gauge of wire is used or the wiring is damaged during installation. Both of these situations can cause problems for the fire alarm system throughout its life. Other problems with wiring can occur as well such as damage by other trades, or damage caused by accident in the normal use of the building.

Symptoms
Wiring problems can show a variety of different symptoms including shorts, opens, ground faults, intermittent operation of devices, inadequate power to devices, false alarms and the list goes on.

Corrective Action
Using a voltmeter and / or a continuity tester can identify many of the problems with wiring whether they are a short, open, ground fault, or improper wire size. Usually wiring problems require pulling new wire in part or in full for the circuit affected.

Failure to Communicate
Failure to communicate is a common problem with fire alarm systems. Normally, for most fire alarm systems, the use of telephone lines provides the means for communication to the monitoring facility. Fire alarm systems require the use of 2 separate phone lines for communication which are required to be tested at 24 hour intervals. A failure to communicate can mean either one or both lines failed.

Symptoms
The monitoring station does not receive the required 24 hour test signal. The annunciator displays a failure to communicate message.

Corrective Action
Normally when a failure to communicate occurs it is due to a temporary telephone service outage for the area or due to the disconnection / improper connection of the communicator to the telephone line. The communicator is required to have line seizure capability. Make sure the connection to the telephone line is correct and operational.

Summary
The most effective ways to avoid service problems with fire alarm systems are to properly install the system in the first place and implement a regular schedule of testing and inspections. Ensuring the proper operation of the system once it is installed is the most important part of maintaining a higher degree of fire protection and detection.

All electronic equipment including fire alarm system devices and components will fail eventually. Testing in accordance with the code makes sure those failures are discovered and fixed so the fire alarm system will work when it really counts.

Chapter 14

Insurance Authorities and Government Agencies

The insurance industry and the fire alarm industry share a long history spanning more than 100 years. Government agencies also have had an affect on the fire alarm industry. Both of these groups have played a major role in the development of fire alarm systems standards and requirements. Both groups have had an influence on the technology added to fire alarm systems as well.

Insurance authorities

It started in 1899. The insurance industry produced the first *National Fire Alarm Code®* in 1899. It was compiled by the National Board of Fire Underwriter's (NBFU) and enforcement was directly under their control. This publication was updated in 1936 by the NBFU and remained under their control until 1950. In 1950, responsibility for the *National Fire Alarm Code* was transferred to the NFPA. The NFPA titled the new document *NFPA 72®, Standards for the Installation, Maintenance, and Use of Proprietary, Auxiliary, and Local Protective Signaling Systems*. Responsibility for enforcement of the code also shifted from the NBFU to governmental agencies.

This is a picture of the oldest edition of the Fire Alarm code in NFPA's possession. It dates to September 15, 1931

Photo courtesy NTC, p14.1

Even though responsibility for the code shifted, insurance organizations played a major role in the development of fire alarm products, installation and service requirements for fire alarm systems. They had a vested interest. The better a building or facility was protected from potential fires, the less likely they would have to pay major claims. During the 1970s thru the 1990s several insurance agencies were instrumental in setting some of the fire alarm system requirements. They include the following:

1. FMRC (Factory Mutual Research Corporation)
2. FMI (Factory Mutual Insurance)
3. IRI (Industrial Risk Insurers)
4. Kemper Insurance
5. ISO (Insurance Services Office)

Underwriter's Laboratories (UL)
UL is not an insurance agency. Many insurance agencies use the requirements for UL as a standard. UL specializes in testing and listing equipment for performance. UL also provides listing for monitoring companies, installing companies and for actual fire alarm systems that are installed at a specific facility.

Factory Mutual (Now FM Global)
Factory Mutual used to have two separate divisions which had direct involvement with fire alarm systems. Factory Mutual Research Corporation (FMRC) provided testing of fire alarm equipment to ensure the equipment performs adequately. Then they would approve (list) the equipment in a fashion similar to Underwriter's Laboratories. FMRC provided approval (listing) for Central Stations and Installation Companies. The second division used to be called Factory Mutual Insurance (FMI). FMI is owned by Allendale, Arkwright and Protection Mutual. They underwrite insurance policies for property coverage and loss prevention. Their primary business is large industrial and institutional properties. FM Global provides an approval standard for *Central Station Service for Fire Alarms and Protective Equipment*. This is identified by Class Number 3011. The requirements follow NFPA 72®, The National Fire Alarm Code® requirements for Central Station Service with a few notable exceptions.

Central station fire alarm systems. Central station fire alarm systems include all of the fire alarm equipment which is installed at the protected premise, the central station facility, exterior communications channels and any subsidiary stations.

Central station fire alarm service. Central station fire alarm service includes the installation of fire alarm equipment, signal monitoring, signal retransmission, record keeping, testing, maintenance, and runner service. Each of these services is required to be provided under contract. There are specific contractual relationships which must be maintained for compliance. The contract is required between the subscriber and one of the following:

1. An FM approved central station which provides all of the service elements for central station fire alarm service.

2. An FM approved central station which subcontracts the installation, testing and runner service.
3. An FM approved Installation Company which subcontracts signal monitoring, record keeping and signal retransmission to an FM approved central station.

Prime contractor. This is the FM approved agency that holds the contract with the subscriber. The prime contractor is required to have an FM approvals inspector, verify the installation to ensure compliance with NFPA 72® and other FM requirements. The installation must be certificated by FM Approvals procedures. A letter of certification is required to be located within 36 inches of the fire alarm control panel. Additionally FM Approvals will maintain a repository of certifications so the AHJ may review them at any time. A placard is also required for the installation. The placard must be at least 20 square inches and located within 36 inches of the fire alarm control panel.

Central Station Facilities

The central station itself is required to conform to the latest edition of NFPA 72® The National Fire Alarm Code®. All primary systems must be monitored by the central station to include intrusion, fire, power and environmental controls. Any subsidiary stations are required to be inspected every month by personnel from the central station. Subsidiary stations also need to have the capability of switching to backup systems in the event of equipment failure. This switch must be accomplished within 90 seconds.

The subsidiary station is required to conduct an annual exercise to implement restoral of service procedures in the event of failure. If a failure causes the loss of signals between the subsidiary station and the central station, the failure is required to be repaired within 4 hours.

Central Station Equipment / Personnel Requirements

Hardware and software to aid computer receipt of alarm and supervisory signals requires appropriate listing. Signal retransmission to the public fire service must have the capability of being accomplished by two independent means. The retransmission of signals to the public fire service must be recorded at the central station. The central station is required to have no less than two persons on duty at all times. The only duty of the operators is the disposition of signals.

Central Station Operations

Operations include those special functions that the central station is required to accomplish. One of the most important functions of the central station is disposition of signals. There are specific procedures required for each type of fire signal received.

Upon receipt of an alarm signal the central station is required to accomplish the following functions:

1. Immediately retransmit to public fire service communications center. This means within 90 seconds.

2. If equipment needs to be reset by the prime contractor, dispatch a runner to arrive within 1 hour (NFPA72®, 2002 edition requires 2 hours).
3. Immediately notify the subscriber.
4. Provide notice to the subscriber or AHJ or both if required.

Upon receipt of a guard's tour supervisory fail signal (discrepancy reporting) the central station is required to accomplish the following functions:

1. Notify personnel at the protected premise.
2. Dispatch a runner if communications cannot be established. The runner is required to arrive within 30 minutes of the delinquency.
3. Report all delinquencies to the subscriber or AHJ or both.
4. Failure to follow a prescribed guard route shall be treated as a delinquency.

Upon receipt of a suppression system supervisory signal the central station is required to accomplish the follow functions:

1. Notify the subscriber or designated representative within 4 minutes.
2. Dispatch a runner to arrive within 1 hour (NFPA 72®, 2002 edition requires 2 hours).
3. Notify the fire department, law enforcement or both if required.
4. If any part of the suppression system remains out of service for more than 8 hours, the central station must notify the AHJ.
5. Once the suppression system is restored to normal operation (after 8 hours of being out of service), notify the subscriber, AHJ or both

Upon receipt of a trouble signal, the central station is required to accomplish the following functions:

1. Notify the subscriber or designated representative within 4 minutes.
2. Dispatch maintenance persons to arrive within 4 hours.
3. When the trouble persists for more than 8 hours, notify the subscriber or AHJ or both.

The central station is required to record the date time and type of all signals, including test signals. If regularly scheduled test signals are not received, they must be investigated by central station personnel immediately. The central station is also responsible for dispatching runners to arrive at a protected premise for the purpose of resetting the system. The runner must arrive within 1 hour. Records of all signals must be kept for a period of 1 year. If the AHJ requests reports of received signals, the central station is required to provide them in the format required by FM Approvals

The prime contractor is required to provide individual codes for all of its representatives and for all users. Service personnel are required to provide the central station with a personal identification number in order to place the system in test mode. The central

station personnel are required to check the personal identification code with their records to make sure proper authorization exists to place the system in test mode.

A secondary power supply is required at the central station. The secondary power supply is required to power central station equipment (including subsidiary and repeater stations) for a period of 60 hours. This 60 hour requirement exists to cover the time from the close of business on Friday, until opening on Monday morning.

Industrial Risk Insurer's (IRI) (Now GE Global Asset Protection)
IRI no longer exists. They have been incorporated into General Electric Corporation. They are now called GE Global Asset Protection Services. IRI provided underwriting for insurance policies. They also developed data sheets for many fire alarm devices and interpretive guides for NFPA Standards. IRI required all equipment to be Underwriters Laboratories Listed. Additionally, all insured property required Central Station Service as defined by NFPA 72® and Listed by Underwriters Laboratories.

IRI requirements for fire alarm systems follow NFPA 72®, The National Fire Alarm Code® and Underwriters Laboratories requirements. They also had some of their own written requirements. Some of these are as follows:

Fire Protection Surveillance Levels
The table below identifies the fire protection surveillance levels for IRI. The specific surveillance level required for a facility would depend on several factors like construction, hazards present, loss potential, and occupancy damageability. The definitions which are pertinent for the table are listed below as well. These definitions apply to IRI systems and are not intended to apply to other insurance agencies. To determine the appropriate surveillance level for a facility, contact an IRI account consultant for guidance. They will provide you with the fire protection surveillance level needed for design purposes.

Surveillance Level	Min Surveillance Acceptable	Comments
1	Waterflow alarm service only OR Watchman service with a local waterflow alarm at each riser	A drop in pressure type waterflow that will allow alarm initiation even when sprinkler control valve is shut
2	Complete alarm & supervisory service…OR… Watchman service and waterflow alarms connected to local panel	Include 1 unrecorded patrol tour following last shift Waterflow alarm to be transmitted to listed control installed per NFPA 72®

Surveillance Level	Min Surveillance Acceptable	Comments
3	Complete alarm & supervisiory service…OR… Watchman service and waterflow Alarms connected to local panel	Waterflow alarm to be transmitted to listed control installed per NFPA 72®
4	Watchman service with bi-hourly patrol tours covering all unoccupied areas and alarm service consisting of sprinkler waterflow and alarm from actuation of special extinguishing systems. OR Watchman service with frequency of patrol tours bi-hourly or less and alarm service consisting of sprinkler waterflow, alarm from actuation of special extinguishing systems and valve supervision.	To reduce the frequency of guard patrol tours a facility must have excellent management programs and overall protection. See the section titled Excellent Quality Facilities. IRI Area Management must approve the reduced frequency.

Diagram, NTC, d14.1

Definitions for IRI Purposes.

Standard Watchman Service: Consists of recorded guard patrol tours made hourly at night and bi-hourly during daylight. The guard patrol area covers all unoccupied areas of the facility.

Alarm Service: IRI uses Underwriters Laboratories (UL) requirements. Alarm service is Central Station Service as defined by NFPA 72®, using UL Listing. All alarm service systems are required to be certificated in accordance with UL requirements.

Complete Alarm and Supervisory Service: When an electronic surveillance system is employed instead of standard watchman service, an unrecorded patrol tour is required at the close of the last work shift. Specifically the patrol tour should note the possibility of any combustibles placed in areas with the possibility of transience which are not sprinkled. Such areas need to be provided with automatic sprinkler protection.

Complete alarm and supervisory service includes monitoring by a central station. The fire alarm system should cover the following:

1. Fire alarm signals from the discharge of all extinguishing systems and automatic sprinkler systems. Fire alarm signals from all automatic detectors.

2. Supervisory signals from the closing of all sprinkler system control valves, divisional control valves and control valves for all fire protection systems which are 2.5 inches or larger.
3. Supervisory signals which monitor the water pressure tanks and high / low air pressure of all dry pipe sprinkler valves.
4. Supervisory signals which monitor the integrity of all private water supplies. This should include storage tank level, low temperature, fire pump running and driver / controller availability.
5. Supervisory signal to monitor the following fire pump conditions:
    a. Electric pumps: pump running, loss of power, phase reversal.
    b. Diesel engine driven pumps: pump running, engine trouble (fail to start), controller trouble, controller switch in position other than automatic.
    c. Automatic steam driven pumps: pump running, steam availability.
6. Supervisory signals which monitor the low pressure of all questionable public water supplies.
7. Supervisory signals for low temperature (for areas subject to freeze) of all buildings equipped with wet pipe sprinkler systems, all dry pipe sprinkler valve rooms and all fire pump rooms.
8. Supervisory signals which monitor the safe operating parameters of critical processes such as a backup to the operating controls, excess pressure, temperature, or external conditions such as flooding. The facility's hazard identification and evaluation program should be used to determine the processes to be monitored.

Intrusion detection provides a burglar alarm system which is connected to a listed central station or directly connected to the police department (not permitted in most areas today). The system shall have a local bell. The local bell is required to provide an added deterrent where police response may be slow. The intent of the burglar alarm is to detect the penetration of the facility's perimeter by unauthorized individuals.

Excellent Quality Facilities

Facilities which have excellent management programs may be permitted to reduce the frequency of guard patrol tours. The frequency of the guard patrol tours must be tailored to meet the needs of the facility. More frequent guard patrol tours are required for facilities with a greater susceptibility to loss or facilities with more critical or hazardous operations.

All factors should be reviewed with IRI consultants to determine specific guard patrol requirements for a given facility. These corporate guidelines should specifically state the occupancy (see table below) for each building, and permit customizing the frequency of guard patrol tours. In most situations such customizing should result in more frequent guard patrol tours, not less. In all cases, a recorded guard tour should be made within 1 hour after an area becomes unoccupied. After this point the frequency listed below should be used:

Facility vs Guard Tour

Occupancy	Freq of Guard Tours
Light Hazard	8 hours
Ordinary Hazard Mftring	4 hours
Warehouses	4 hours
Moderate Hazard Mftring	3 hours
Extra Hazard Mftring	2 hours

Diagram, NTC, d14.2

Detached portions of a facility should be evaluated as if they were a smaller facility. As an example, consider a manufacturing facility with a detached finished product warehouse. The detached warehouse should have surveillance level 2 provided there are no adverse conditions and it is provided with complete alarm and supervisory service.

Continuous operations can satisfy the need for fire protection surveillance. The appropriate surveillance level can be affected by security needs as well and those should be taken into account before making a final determination. Continuous operations are typically found at manufacturing facilities. Surveillance requirements may be satisfied by human occupancy for the intended use of the individual buildings or structures. Human occupancy for intended use includes production staff in a manufacturing building, warehousing personnel in a warehouse and office staff in an office building. Transient personnel in a building do not constitute occupancy when the facility is not staffed for its normal use.

There are many areas which need to be considered to ensure alarm and supervisory signals are received and unauthorized intrusion does not take place. Some of these considerations are:

1. During the course of a normal production week, are there any important areas which are unoccupied for any significant amount of time? What surveillance is in place during idle periods? What loss prevention concerns exits for the facility?
2. What additional surveillance may be required as the level of production decreases? What additional areas may become unoccupied?
3. How do holidays affect occupancy for various areas?
4. When production stops (for annual maintenance or whatever) how are the surveillance needs met? Standard watchman service is normally required during such times.

Adverse conditions can influence the frequency of guard tour patrols. Such conditions can also affect whether additional electronic surveillance is needed.

Some of those adverse conditions are:

1. Unattended operations such as the burning in of electronic components, continuous testing of electronic gear or extended baking or curing of a product.
2. Facilities which are covered by a "Difference in Conditions / All Other Perils" (DIC / AOP) property insurance policy for valuable storage or products which might invite theft. In these cases, more frequent guard patrol tours may be appropriate. Additionally, hazard specific burglar alarm systems and general intrusion systems may be required.
3. Finished products facilities, such as computer storage, may require increased frequency of guard patrol tours or additional electronic security.
4. Extensive or high value yard storage.
5. Significant exposure from adjacent properties.
6. Facilities located in high crime areas.
7. Facilities which are involved in public controversy.
8. Facilities which may experience labor unrest.
9. Facilities which are located in remote areas and response times are extensive.

Insurance Services Office (ISO)
The Insurance Services Office is an information collection and consulting organization. They provide information to insurance companies for the purpose of analyzing risk. Insurance companies use this information to set pricing, and underwrite policies. ISO serves the insurance marketplace with statistical, actuarial, underwriting and claims information. ISO also provides services for policy language, fraud identification and loss control. They are able to provide information to insurance companies on specific locations.

ISO collects such information as:

1. Evaluation of public fire protection (effectiveness of local fire departments based on training programs, equipment and funding).
2. Flood risk.
3. Enforcement of building codes in individual communities.

The ISO has two important programs which directly relate to the fire alarm industry. These two programs are:

1. Public Protection Classification Program
2. Building Code Effectiveness Grading Schedule

Through the public protection classification program, ISO evaluates municipal fire protection efforts in communities throughout the country. A community's investment in fire mitigation is a proven and reliable predictor of future fire losses. Insurance

companies use this information to help establish lower premiums in communities with better fire protection. Communities can also use this program to benchmark their fire protection programs and plan future budgetary requirements.

The ISO developed the building code effectiveness grading schedule to assess individual communities in terms of the code in effect and emphasis on enforcement. The assessments place special emphasis on mitigation of losses from natural hazards. The concept is simple: municipalities with well-enforced, up-to-date codes demonstrate a better loss experience. In other words, they have significantly reduced risk. Based on this, insurance companies can adjust rates accordingly. The prospect of lessening catastrophe related damage and ultimately lowering insurance costs provides an incentive for communities to enforce their building codes rigorously.

ISO also evaluates sprinkled and non sprinkled commercial buildings and residential properties and supplies important underwriting and rating information to insurance companies.

Kemper Insurance Group
Kemper is a provider of insurance and they use NFPA standards as their guidelines for fire alarm installations.

When designing and bidding a fire alarm system, it is important to consider insurance agencies and their requirements. This becomes especially true for an industrial or institutional type of building occupancy. The insurance agency may have a significant affect on the final cost of the system.

Governmental Agencies
There are several government agencies that have influence over the installation requirements for fire alarm systems. These agencies require that labor be paid at prevailing wage. Normally there is a fixed pricing structure which is firmly established for equipment as well. It is called the GSA schedule. Generally the installation of fire alarm equipment for these agencies conforms to the requirements detailed by NFPA 72®, The National Fire Alarm Code®. There are other requirements that need to be met. Some of the governmental agencies are:

1. Veterans Administration (VA)
2. Governmental Services Administration (GSA)
3. Department of Defense (DOD)
4. Department of Energy (DOE)
5. Corps of Engineers

Most fire alarm system installations for government agencies fall into the GSA or VA requirements.

Governmental Services Administration (GSA) Requirements
The GSA has adopted NFPA 72®, The National Fire Alarm Code® as its primary reference for the installation of fire alarm systems. The GSA considers the information in the Annex as part of the code. NFPA considers the Annex material as supplemental and explanatory in nature.

Fire alarm technicians performing fire alarm work shall be NICET Level II certified as a minimum, and must have recent fire alarm experience (within the last 5 years). The experience of the technician must be commensurate with the scope of the project on which they will be working. For addressable systems, the technicians must be properly trained and certified for the operating system being used including the correct version of the software.

Contractors and subcontractors must possess certificates of training, licenses, and permits as required by the state, county, parish, city and jurisdiction where the fire alarm system will be installed. The contractor is required to provide documentation of training and licensing at least 7 days prior to the start of work. All employees of the contractor are required to sign in when they arrive at the job site and sign out when they leave.

The contractor is required to provide information relating to the background of employees working on the project. This information is used for security clearance purposes. The contractor is required to provide:

1. Two fingerprint charts (GSA Form FD-258)
2. One Statement of Personal History (GSA Form 176)
3. One background criminal history check from the state of residence for each employee working on the project.

No employee or subcontractor will be allowed to perform any work without receiving the proper clearance from the GSA. Cleared employees will be given a pass. All employees are required to carry the pass with them during duty hours and show it upon request.

The GSA requires that fire alarm systems be regularly and appropriately tested in accordance with the schedules detailed in NFPA 72®, The National Fire Alarm Code®. Additionally, the testing methods detailed in the code are required to be used. If a malfunction is discovered during routine testing, the contractor is required to provide documentation to the building representative concerning the malfunction. The documentation shall include the cause of the malfunction, actions taken to prevent reoccurrence, a list of components required to make repairs and the hours required to fix the malfunction.

Veterans Administration (VA) Requirements
The Veterans Administration has adopted the NFPA codes for use in the installation of fire alarm systems. These codes include:

1. NFPA 1®, The National Fire Code®

2. NFPA 72®, The National Fire Alarm Code®
3. NFPA 101®, The Life Safety Code®

The fire protection design shall be based on the most current edition of the codes on the date the contract is awarded. Fire protection features not addressed by the NFPA codes shall comply with the latest edition of the International Building / Fire Codes. Americans with Disabilities Act requirements are not recognized by the Veterans Administration. The Veterans Administration follows the requirements of the Uniform Federal Accessibility Standards (UFAS).

Specific Occupancy Classifications for the Veterans Administration are listed in the table below.

Health Care	Business	Residential	Industrial	Day Care
Hospitals	Psychiatric outpatient	Blind Rehab	Research Bdg	Child Day Care
Nursing Homes	Alcohol Drug outpatient	Alcohol Drug treatment	Free Standing laundries	Adult day care
Ambulatory Care facilities	Methadone clinic	Domiciliaries	Power plants	Day Treatment
Alcohol Drug	Ambulatory Care facility	Quarters Bldg Hostels	Free standing shop	
Domiciliary	Admin office	Homeless shelter		

Diagram, NTC, d14.3

Fire alarm systems for Veterans Administration facilities shall be installed and maintained in accordance with NFPA 72®, The National Fire Alarm Code®. Facilities fall into one of the following categories:

1. Health care (excluding free standing Ambulatory Health Care)
2. High Rise non health care
3. Other, including free standing Ambulatory Health Care

These categories will be used to identify the type of notification required as well as the correct placement of appliances.

Fire alarm systems are not permitted to be used in combination with other systems such as burglar, access control, and paging. The reason for this is so any down time on another system will in no way affect the fire alarm system. Wiring for fire alarm systems shall comply with the following:

1. Initiating Device Circuits: Class B, Style B
2. Signaling Line Circuits: Class B, Style 4.0
3. Notification Appliance Circuits: Class B, Style Y
4. Communications between buildings: Class A, Style 7

The Veterans Administration prefers the use of analog addressable systems when the number of smoke detectors used is significant. This is due to the savings on sensitivity testing of the detectors. Fire alarm system outputs are as follows:

1. Building category, Health care: Positive alarm sequence
2. Building category, Health care High rise: Positive alarm sequence
3. Building category, High rise (non health care): General alarm
4. Building category, Other: General alarm
5. The following outputs are common to all building categories:
    a. Notify the fire department
    b. Initiate supervisory signal to a 24 hour manned point for immediate response
    c. Close smoke barrier doors, dampers and HVAC on the floor
    d. Recall elevator, initiate elevator shutdown and disconnect elevator power
    e. Open locked egress doors
    f. Disconnect fuel source from cooking equipment

Additional requirements include notification to the staff shall be by digital voice systems unless it is not warranted by existing conditions. New systems should not use coded or taped voice recordings. Fire alarm zones shall be coordinated with smoke compartments and sprinkler zones.

Initiating devices must be installed according to the requirements of NFPA 101® and NFPA 72®. A manual fire alarm box (pull station) must be installed at each nurse's station for health care facilities. Any pull stations in psychiatric areas must be key operated. Additionally, all pull stations in child care areas must be provided with protective covers.

Notification appliances must comply with NFPA 72®, and selected based upon the purpose of notification in that area. The selection requirements are based on the building or areas to be evacuated. Many areas should be provided with general evacuation. The facility will not have adequate staffing to ensure all occupants are escorted out. These areas include cafeterias, administrative sections, basements, etc. Audible appliances

should be located so as to be heard throughout the premises. Visible appliances should be located in all publicly accessible areas. Visible appliances are not required in individual offices, spaces which are less than 100 square feet, stairways and elevators.

Audible appliances should be provided throughout the premises for staff response. In health care facilities, use the nursing wards for responders because they are always staffed. Audible notification devices should not be located in operating rooms. Private mode audibles must be used in critical care areas.

Two way telephones must be provided when required by NFPA 101®. A telephone jack is required at the fire pump.

The fire alarm control panel should be located at the front entrance, or a 24 hour location coordinated with the facility. This is primarily for fire department use. Smoke alarms should be provided in all sleeping rooms in non patient areas. Single station 120 VAC alarms are preferred. UFAS requires at least 1 sleeping room out of 25 be provided with a visible appliance activated by the smoke alarm.

All smoke detectors must be photoelectric. Generator rooms require a heat detector rated at 325 – 375° Fahrenheit when the building is not sprinkled. Concealed duct detectors require a remote test switch mounted at 7 feet above the finished floor (AFF). When an annunciator is required, it must be located at the front entrance for fire fighter use.

Elevator recall and shutdown must comply with all appropriate codes and standards. Specifically, this includes NFPA 13®, NFPA 70®, NFPA 72®, and ANSI / ASME A17.1 or ASME A17.3. The Veterans Administration uses the heat detector option for shutdown when the hoistway is sprinkled. The requirements are as follows:

1. For new elevators, install smoke detection for Phase 1 recall. For existing elevators with a travel distance of 25 feet or more above or below the fire department response, install smoke detection for Phase 1 recall.
2. Phase 1 recall requirements do not apply if the hoistway is required to be fire resistive, if the travel distance does not exceed 6 feet 8 inches, or the hoistway does not penetrate the floor.
3. Install smoke detectors in the elevator lobbies and machine rooms to activate Phase 1 recall.
4. Provide 2 supervised circuits to a point within three feet of the elevator controller for Phase 1 elevator interface. These two signals will be for the designated and alternate levels.

5. A third circuit will flash the fire fighter's hat in the elevator car when a smoke detector located in elevator hoistway or machine room activates during phase 2 operation. The fire fighter's hat is a light in the elevator car that indicates the elevator is out of normal service and under the control of fire fighter's with an appropriate elevator key.

6. If sprinklers are installed, provide a heat detector to remove power from the elevator before water is deployed. In noncombustible hoistways and when cars meet the flammability requirements of ASME A17.1, the sprinkler at the top of the hoistway should be omitted.

7. NOTE: Elevator cars built to the requirements of the ANSI code since 1985 have a flame spread no greater than 75 and a smoke development rating no greater than 450 (class B per ASTM E 84 / NFPA 255). If an elevator car meets these requirements, NFPA 13 allows sprinklers to be omitted from the top of the hoistway. NFPA 72® does not permit a smoke detector to be installed at the top of the hoistway except where it actuates smoke relief equipment for the hoistway.

8. Power shall be removed immediately upon activation of a heat detector in the machine room or hoistway (if sprinkler installed). The heat detector shall trip a shunt breaker removing power from the elevators within the hoistway.

9. A 135° Fahrenheit rate compensation heat detector shall be located within 2 feet of each sprinkler head in the machine room and hoistway. Do not install heat detectors in the pit.

10. The elevator shutdown circuit shall be supervised.

11. A 110 VAC power source shall be provided to the shunt breaker. This is independent of the elevator controller and shall be supervised by the fire alarm control panel as a supervisory signal.

Summary

Insurance authorities and governmental agencies play an important role in the development of codes and installation of fire alarm systems. Insurance authorities provided the basis for the modern codes as we use them today. They continue to have a major influence in the way fire alarm systems are designed and installed, especially for industrial and institutional facilities.

Governmental agencies have installation requirements which are unique to them. Most fire alarm contractors have the opportunity to provide installation and service to these agencies. It is important to be fully familiar with their requirements prior to bidding on projects and executing work.

Chapter 15

Household Fire Protection

All of the applicable codes recognize the need for household (residential) fire protection. Reading the reports of property damage, injury and death from household fires every year emphasizes the point. In terms of detection, there are three options:

1. Single station smoke alarms
2. Multiple station smoke alarm
3. Residential fire alarm system

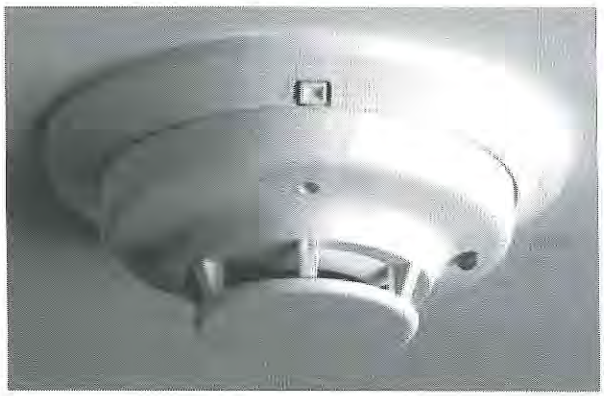


Photo courtesy System Sensor, p15.1

Single Station Smoke Alarms
These smoke alarms have a built in detection capability, control, and notification appliance. Single station smoke alarms are not interconnected with other smoke alarms. They are stand alone devices. A good example is a battery operated smoke alarm available for purchase at any hardware store.

Multiple Station Smoke Alarms
Multiple station smoke alarms operate like single station except they have the capability of being interconnected. This interconnection is important. If any interconnected multiple station smoke alarm goes into alarm, all of the interconnected devices sound. This provides for the fire alarm signal to sound throughout the residence, not just at one location. This more complete alarm signal increases the opportunity for occupants to escape.

System Type Smoke detectors.
System type smoke detectors are connected to a household listed fire alarm control panel.

Household fire alarm system.
Underwriter's laboratories provide a special listing for household fire alarm systems and equipment. All fire alarm equipment used in a household occupancy must be properly listed for use. Common equipment installed with a household fire alarm system is:

1. Household fire alarm control panel
2. System type smoke detectors
3. System type heat detectors
4. Carbon monoxide detectors
5. Notification appliances

Requirements for Household Occupancies.
The codes provide many requirements for the installation of fire alarm equipment in household situations. Additionally there are several cases where household requirements may apply. Some common applications are as follows:

1. One and two family dwellings
2. Apartments
3. Dormitories
4. Hotel rooms
5. Lodging or rooming houses

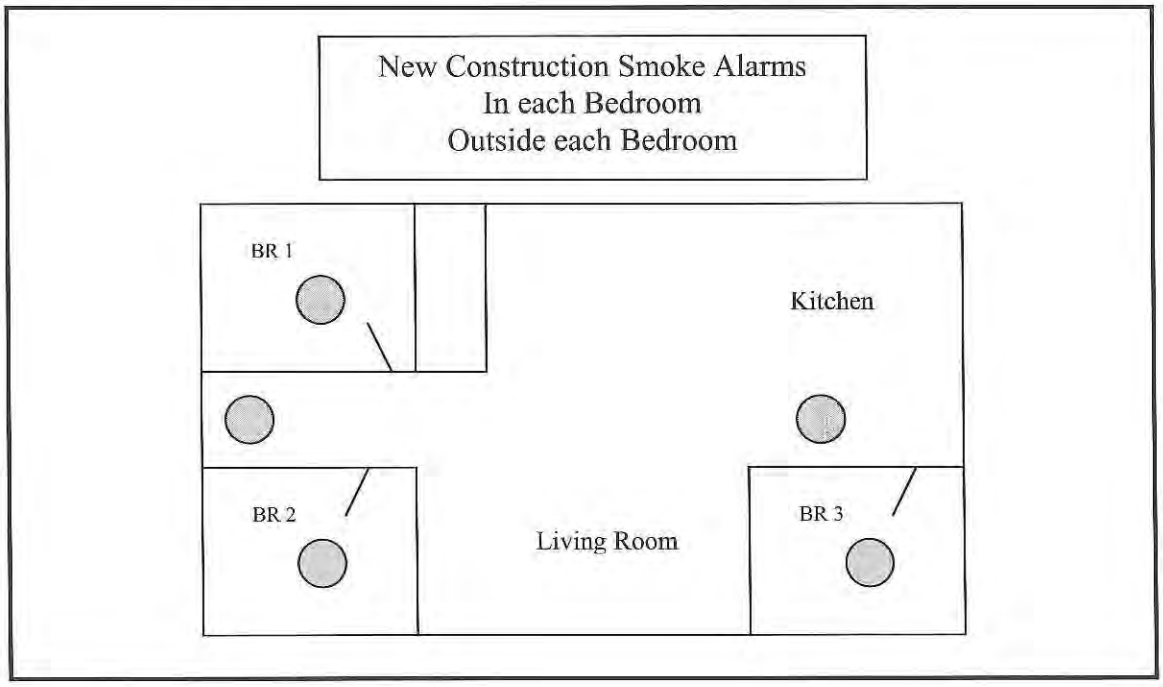
NFPA 72®, The National Fire Alarm Code® specifies requirements for all of the above situations. For one & two family dwelling units, the requirements are as follows:

New construction: New construction requires the installation of interconnected multiple station smoke alarms. The smoke alarms are required in the following areas:

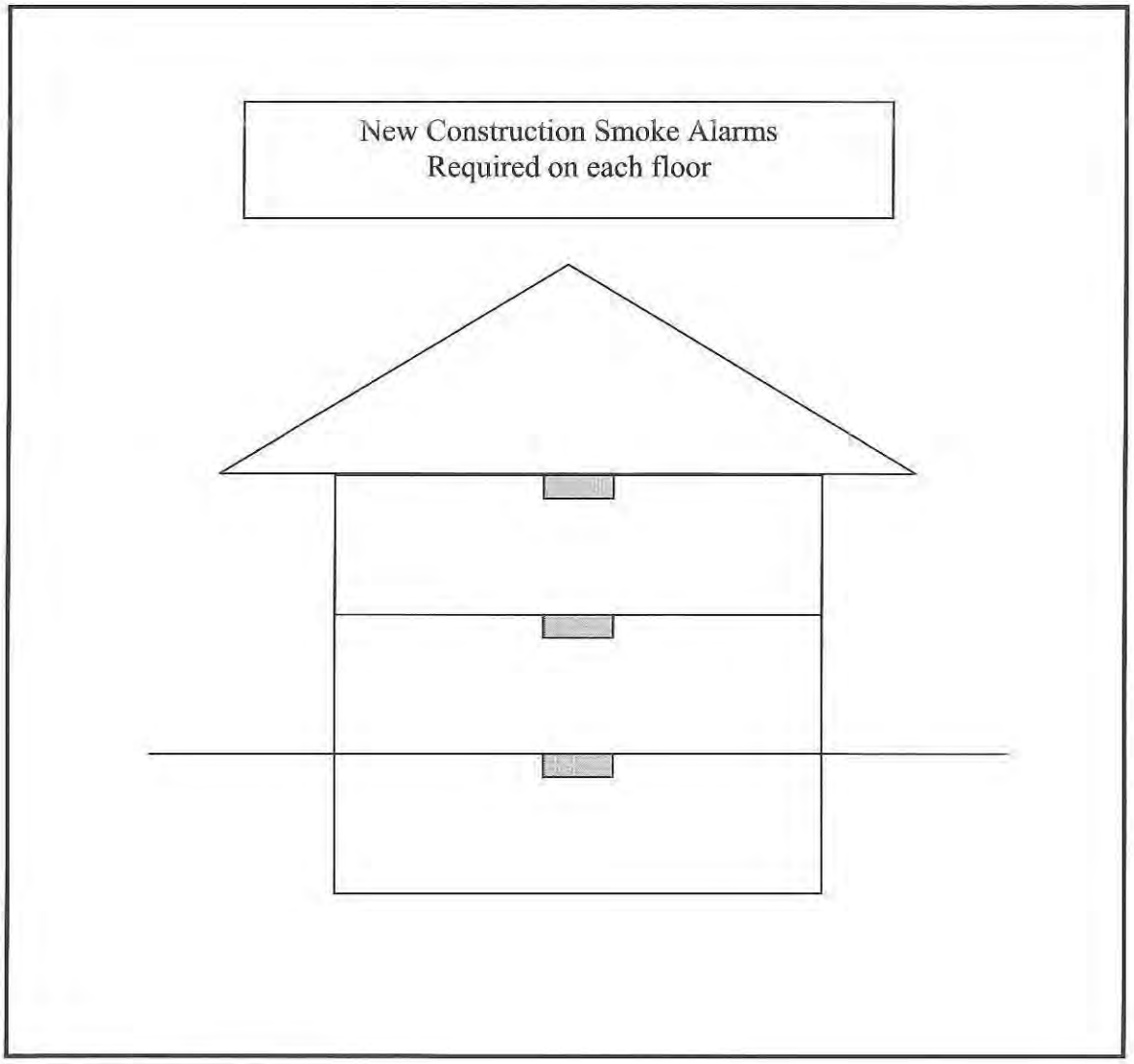
1. Inside each bedroom
2. Outside each bedroom
3. On each floor of the residence

If the residence has all the bedrooms within one hallway, it is possible for a single smoke alarm to provide adequate coverage in the hallway outside of the bedrooms. If bedrooms are located on opposite sides of the house, then separate smoke alarms are required

outside of all bedroom locations. Every bedroom door should have a smoke alarm located within 21 feet. Additionally smoke alarms should be located away from bathroom doors and at least 3 feet from HVAC diffusers. In certain types of household construction, finding an appropriate place for the smoke alarm can be challenging. Check with the AHJ when these types of issues arise.



Diagram, NTC, d15.1

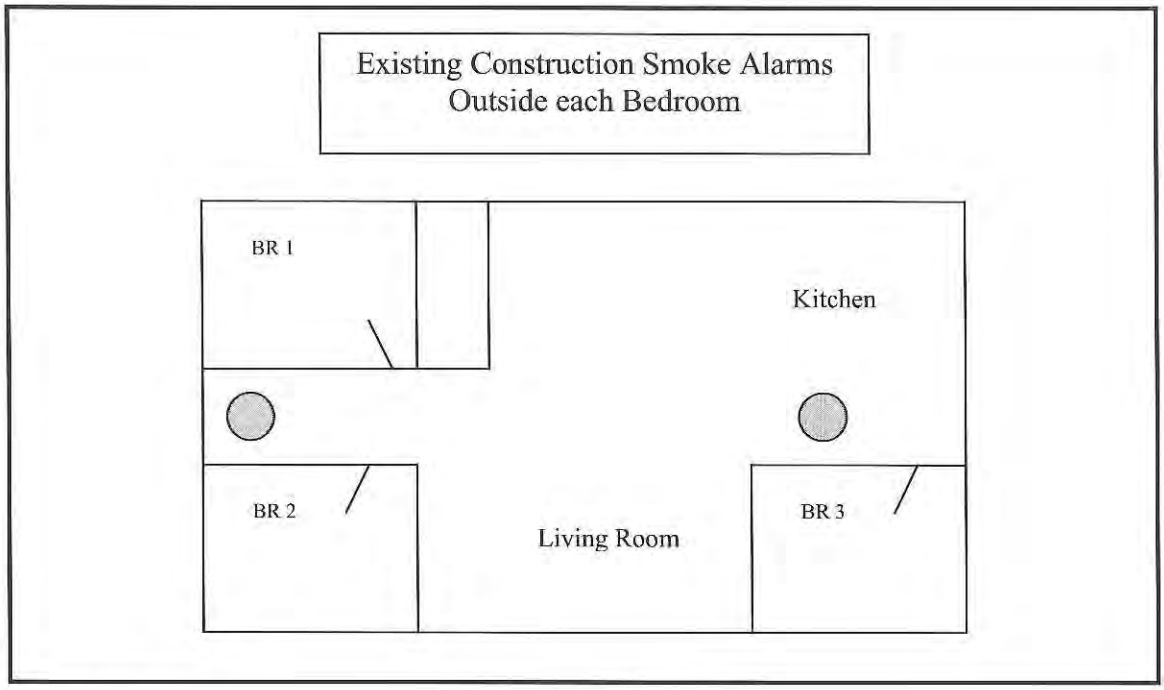


Diagram, NTC, d15.2

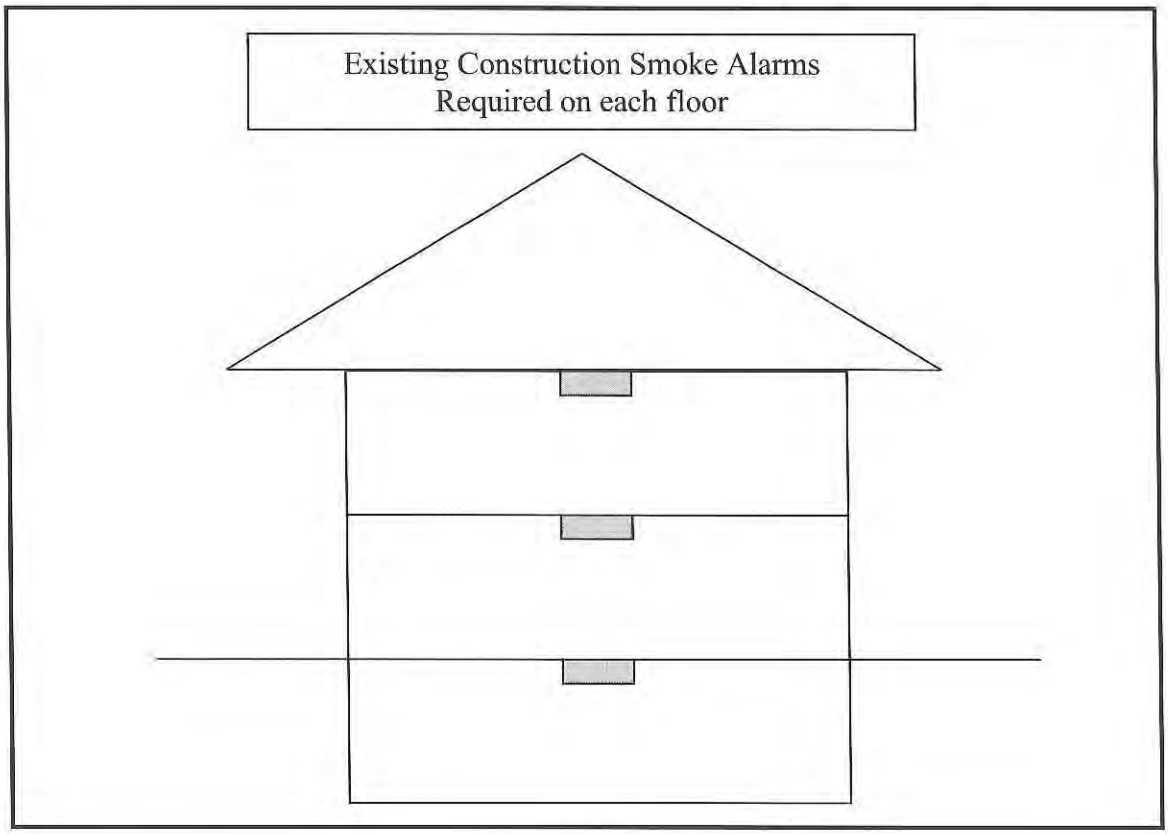
Existing Construction

Existing construction requires the installation of interconnected multiple station smoke alarms. The smoke alarms are required in the following areas:

1. Outside each bedroom
2. On each floor of the residence



Diagram, NTC, d15.3

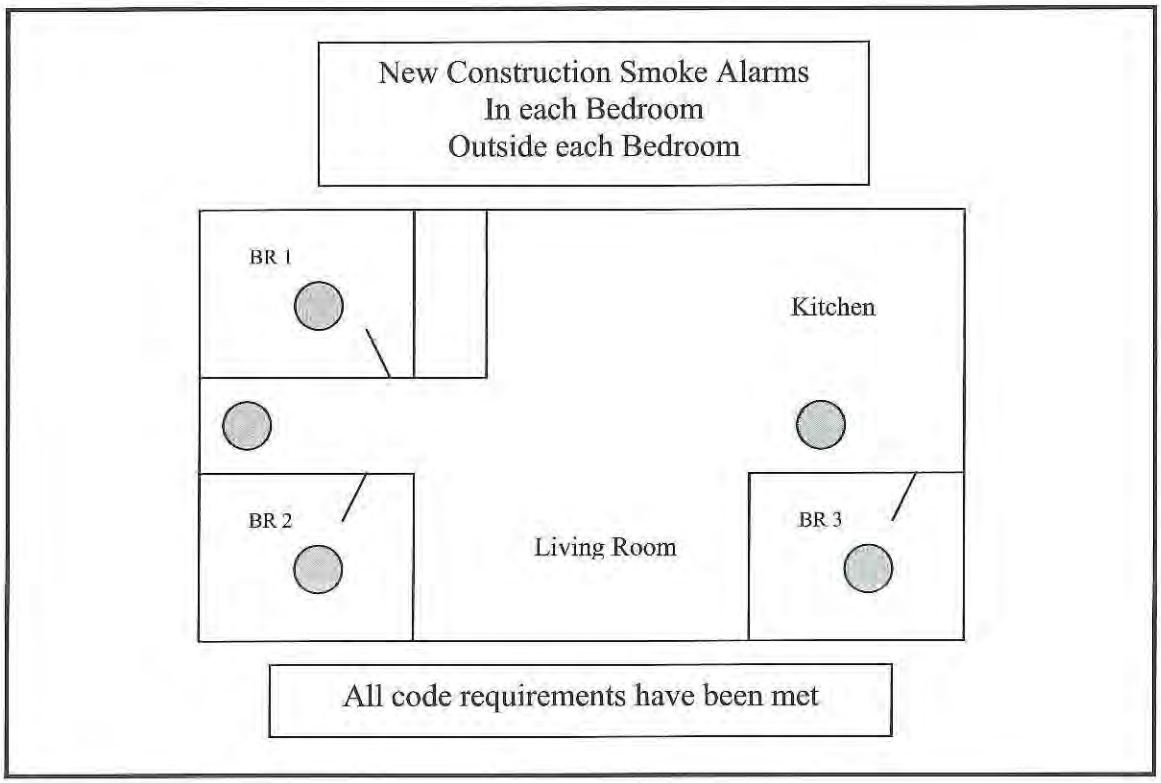


Diagram, NTC, d15.4

In addition to the above requirements for smoke alarms, NFPA 72® requires that audible devices provide a sound level of 70 db in all sleeping areas (measured at the pillow with the door closed).

The smoke alarm locations just covered represent the minimum requirements. Fire alarm systems actually provide a superior degree of protection. It is acceptable to install a fire alarm system in addition to the smoke alarms in residential occupancies. Since the minimum requirements have already been met, any fire alarm system devices installed are acceptable.

For example, consider a new residential occupancy which has interconnected multiple station smoke alarms installed in all required locations. It is acceptable to install a fire alarm system with just 1 smoke detector. The minimum requirements of the code have already been met with the smoke alarms. The addition of the smoke detector exceeds the minimum requirements.

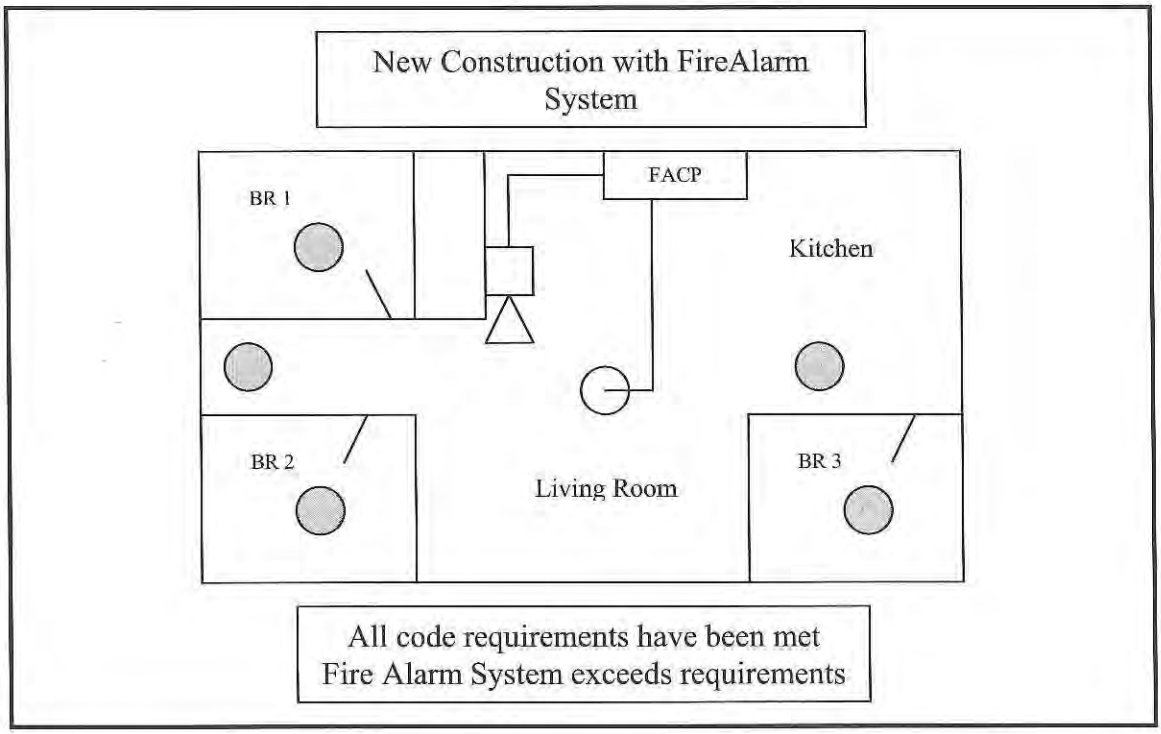


Diagram, NTC, d15.5

The above example shows a new construction residential application where all of the code requirements have been met. Anything which may be added will exceed the minimum requirements of the code. Further, a fire alarm system is considered superior to smoke alarms anyway.

It is acceptable to have all of the smoke alarms removed and replace all of them with smoke detectors. NFPA 72® recognizes that this will provide a superior degree of

protection. It is always a good idea to check with your AHJ prior to having the smoke alarms removed.



Diagram, NTC, d15.6

New Apartments require basically the same thing as new residential construction. Smoke alarms are required inside and outside each bedroom. Smoke alarms are required on each floor of new apartments. All smoke alarms are required to be interconnected.

The smoke alarms are not permitted to actuate the building fire alarm system. It is acceptable to annunciate the activation of a smoke alarm. The smoke alarm requirements apply to the actual apartment. These requirements are not intended for common areas, hallways or any other area.

Existing Apartments require basically the same thing as existing residential construction. Smoke alarms are required outside each bedroom. Smoke alarms are required on each floor of existing apartments. All smoke alarms are required to be interconnected.

The smoke alarms are not permitted to actuate the building fire alarm system. It is acceptable to annunciate the activation of a smoke alarm. The smoke alarm requirements apply to the actual apartment. These requirements are not intended for common areas, hallways or any other area.

New Hotels and Dormitories require basically the same thing as new residential construction. Smoke alarms are required inside and outside each bedroom. Smoke

alarms are required on each floor of new hotels and dormitories. All smoke alarms are required to be interconnected.

The smoke alarms are not permitted to actuate the building fire alarm system. It is acceptable to annunciate the activation of a smoke alarm. The smoke alarm requirements apply to the actual new hotel or dormitory rooms. These requirements are not intended for common areas, hallways or any other area.

Existing Hotels and Dormitories require single station smoke alarms in every guest room. Single station alarms are required in every living area and guest room within a guest suite. It is permitted to use smoke alarms without a secondary power source. The smoke alarms are not required to be interconnected and are not permitted to actuate the building fire alarm system. Remote annunciation of smoke alarm activation is permitted.

Lodging or Rooming Houses require single station smoke alarms in every sleeping room. The smoke alarms do not require interconnection. Battery powered smoke alarms are permitted with the permission of the AHJ.

There are many other options for residential fire protection. Some of these options and their requirements are covered in NFPA 72®.

Optional Functions. The following optional functions are permitted:

1. Notification to the fire department
2. Monitoring of other safety systems
3. Notification to occupants of potentially dangerous conditions
4. Notification of occupants of the activation of intrusion sensors
5. Any other function that may share components or wiring

Smoke alarms installed in New Apartments, Existing Apartments and One & Two Family Dwellings are required to be replaced when they fail to respond to tests. Smoke alarms installed in New Apartments, Existing Apartments and One & Two Family Dwellings are required to be replaced every 10 years.

Residential fire alarm systems have specific requirements. The power source for a residential fire alarm system must be the commercial light and power source. Secondary power for the fire alarm system is required to power the system in normal operation for 24 hours, and then operate in alarm condition for 4 minutes.

The digital communicator for a residential fire alarm system requires only 1 telephone line (not 2 as with commercial systems). Residential fire alarm systems require test signals monthly and alarm verification from the supervising station is permitted as long as the delay does not exceed 90 seconds.

Summary

Residential fire equipment may be as simple as a single smoke alarm, multiple interconnected smoke alarms or a residential fire alarm system. All of these are designed to save lives and property.

Chapter 16

Fire Signatures and Detection

A fire signature is a detectable product of combustion. These signatures can come in many forms. Some of the more common forms are:

1. Smoke (Aerosol)
2. Heat (Thermal)
3. Flame (Energy Release)
4. Gas

Each signature experiences its own peak during the combustion process. This can be used to determine the best type of detector to use in certain situations. A fire can be divided into four prevalent stages. They are as follows:

1. Incipient
2. Smoldering
3. Flame
4. Heat.

The following chart shows which detectors are appropriate based on the stage of fire:

Stages of Fire

Fire Stage	Characteristics	Detection Device	Environmental Issues
Incipient	Colorless Smoke	Air Sampling Ionization Smoke	None Altitudes above 3000 ft
Smoldering	Colored Smoke	Photoelectric Smoke	Color of Smoke
Flame	Energy Release	Flame Detector	Line of Sight
Heat	Thermal Energy	Heat Detector	20° above ceiling temp

Diagram, NTC, d16.1

Smoke

Smoke is simply the airborne particles (some solid, some liquid, some gaseous) which are released into the air during combustion. Smoke particles may range in size from 5×10^4 to 10 micrometers. As smoke gets older, particles tend to grow in size.

Brownian motion causes this agglomeration. The larger particles tend to be deposited on the floor. Smoke particles are either visible, or invisible. Visible particles are larger than 0.3 micrometers.

Invisible particles are less than 0.3 micrometers in size. The visible particles effectively scatter light. Visible particles also add color to smoke. Photoelectric smoke detectors are better at detecting visible, light scattering particles.

Thermal Particulate Point

As materials are heated, they release particles. The thermal particulate point is the temperature at which a material releases sub micrometer sized particles. For example, consider a single sheet of normal copier paper. As the paper is heated, sub micrometer particles will be generated.

This occurs prior to the paper actually igniting. When a large enough quantity of these particles is generated, they will start to agglomerate and form larger particles. The table below lists the thermal particulate point of several materials:

Material	**Temp F°**	**Temp C°**
PVC Insulation	290	142
Motor Oil (SAE30)	310	153
Pine Board	320	158
Acrylan Carpet	340	169
Wool	360	180
Bakelite	380	191
Polyethylene	410	208
Paper	500	257
Polystyrene	710	373

Diagram, NTC, d16.2

Visible particles can be produced during pre-ignition heating. This usually occurs at several hundred degrees Fahrenheit greater than the thermal particulate point. Generally, smoldering fires produce more large particles than other stages of fire, including the flaming stage. The majority of particles generated from both a smoldering fire and a flaming fire are invisible particles (smaller than 0.3 micrometers).

Infrared and ultraviolet energy are usually one of the earliest signatures which are able to be detected. Infrared signatures from carbon dioxide (CO_2) are best in the 4.4 micrometer range. Infrared signatures from water vapor (H_2O) are best in the 2.7 micrometer range. With infrared signatures, it is possible that noise (other sources of infrared energy) from the sun or manmade sources could produce a false alarm. Due to this, most modern infrared flame detectors also include flame flicker detection. Flame has a characteristic flicker of 5 Hz to 30 Hz. Infrared flame detectors actuate when both conditions exist, thus reducing problems with nuisance alarms.

Ultraviolet fire signatures result from particles in the 0.27 – 0.29 micrometer range. These particles are Carbon Dioxide (CO_2), Hydroxal (OH), and Carbon Monoxide (CO). There is less noise involved with ultraviolet detection.

Burning magnesium produces particles in the 0.28 micrometer range and ultraviolet detectors are very effective in detecting magnesium fires.

Heat

Heat energy is released during all fires. The time required to produce a detectable heat signature may be as quick as 1 minute or less for rapid fires. It could take many hours for slow burning or smoldering fires to produce a detectable heat signature.

Detectable heat signatures frequently are not present until the fire has developed to the point where deadly conditions exist. Because of this, heat detectors are not considered a life safety device.

Gas

The combustion involved in a fire produces a variety of gases which are not normally present in normal air. The ratio of gases present in the area of a fire is drastically different than the normal environment. These gases and / or changes in concentration can be used to detect a fire.

Carbon Monoxide (CO)

Carbon monoxide poisoning is responsible for more fire fatalities than any other gas. In fact, studies have shown that carbon monoxide fatalities account for as much as 50% of fire related deaths.

Carbon monoxide also played a major contributing role in another 30% of fire related fatalities. Carbon monoxide is so deadly for two reasons: it depletes the amount of available oxygen in the air and carbon monoxide when inhaled combines with the blood and prevents oxygen from combining with the blood.

The amount of CO which is considered the threshold limit is 50 ppm with an exposure over 8 hours. Amounts of CO recorded in some fires exceed 138,000 ppm.

The deadly effects of this gas have become so well known, that many homes today are constructed with CO detection built in. CO detectors are also readily available through most hardware and department stores.

The effects of CO exposure are detailed in the following table.

CO PPM	Exposure Time	Concentration %	Effects
12,800	1-3 minutes	1.28%	Unconsciousness, death
6,900	10-15 minutes	0.69%	Dizziness, death
3,200	30 minutes	0.32%	Dizziness, death
800	2 hours	0.08%	Mild headache possible death
200	2-3 hours	0.02%	Mild headache

Diagram, NTC, d16.3

Carbon Dioxide (CO_2). Carbon dioxide is another gas which is produced by flaming and smoldering fires. This gas is not as deadly as carbon monoxide. Carbon dioxide can have an intoxicating effect on people.

This can cause them to make bad choices in a fire emergency which can result in death. Fatal concentrations of CO_2 are 90,000 ppm with an exposure time of 4 hours. The effects of CO_2 exposure are detailed in the table below.

CO_2 PPM	Concentration %	Effects
100,000	10.0%	Possible death, even with sufficient oxygen
50,000	5.0%	300% increase in breathing
30,000	3.0%	Breathing rate doubles
5,000	0.5%	Noticeable increase in breathing

Diagram, NTC, d16.4

Hydrogen Chloride (HCl). Most burning plastics produce hydrogen chloride (except cellulosic fires). HCl has a threshold limit of 5 ppm. The threshold limit is the point at which it will have an adverse affect on people. 35 ppm causes noticeable damage to mucus membranes. Severe reactions which may be fatal occur at concentrations of 1,000 to 2,000 ppm.

Other Gases

There are many other gases which can be present during a fire. Most of these other gases are less lethal and less frequent than those already covered. Certain gases may be present in one fire and not in another.

Many factors influence this including the fuel for the fire, atmospheric conditions, ventilation etc. The one major effect of these other gases is oxygen depletion. With the creation of gases from a fire, oxygen is consumed, forced out and reduced in its normal concentration.

This oxygen depletion makes it hard to breath and can have several effects as listed in the following table .

O_2 Concentration %	Exposure Time	Effect
6.0%	1-2 minutes	Death
9.0%	5 minutes	Unconsciousness
11%-14%	30 minutes	Nausea, vomiting, paralysis
14%-17%	2 hours	Rapid pulse, dizziness
17%-21%	Indefinite	Loss of coordination, difficulty concentrating

Diagram, NTC, d16.5

Fire Alarm System Detection

The building fire alarm system will detect those signatures based on the detectors employed. For example, smoke detectors will detect smoke, heat detectors will detect heat, flame detectors, for flame so it becomes very important to use the correct type of detector for each application.

It is also important to consider the nuisance alarm affects. Smoke detectors provide detection earlier than heat detectors but are not appropriate for some environmental conditions and will cause nuisance alarms. Therefore a heat detector may be more appropriate. Additionally the proper detector and amount of detection is dependant on the fire protection goals for the building..

The International Building Code® (IBC®) details the fire protection requirements for most building occupancies and use groups. NFPA 101® Life Safety Code® also details the fire alarm requirements for building occupancies.

These prescriptive code requirements represent the minimum protection levels. Meeting the minimum level of protection as required by code, will provide some protection in the following categories:

1. Life Safety Protection
2. Property Protection
3. Mission Protection

If the goal of the fire alarm system is to provide a higher level of protection in any of these areas, then a Fire Protection Engineer should be consulted. In order to meet the complete goals in any of the above categories, protection in excess of the code will be required.

Summary

All fires produce certain detectable signatures. Normally in fire protection, the goal is to detect Heat, Smoke, or Flame. Additionally, fires produce many gases which can be toxic. Specific detectors are used to detect these gases and can be employed with modern fire alarm systems. It is always important to review the requirements of the codes when installing fire alarm systems. Meeting those code requirements is the absolute minimum protection which is permitted. In order to meet specific fire protection goals, exceeding the code requirements will usually be necessary.

Chapter 17

Plans Review

Fire alarm plans review provides the checks and balances for our industry. The plans review is normally completed by the AHJ. The purpose of the plans review is to make sure the fire alarm system design meets all national, state or local codes and requirements. It is a very important step in the process.

It is important to remember, the plans review process does not alleviate responsibility from the fire alarm system designer. If the AHJ in plans review misses something, the responsibility still lies with the designer.

There are two critical factors in submitting fire alarm system design for plans review:

1. Submit the design on time (this means on time for the entire review process to be complete prior to the start of installation).
2. Submit a complete package to the AHJ. Do not leave any required documents out of the submission.

Installation of the fire alarm system should not commence until after the plans have been approved by the AHJ. In most cases, the installation cannot begin until the plans review process is complete and the plans are approved. Additionally, the AHJ who ultimately inspects the job may have alterations from the approved plans. Make sure these alterations are in writing. The paperwork trail is very important.

The plans review process should be performed at least twice. The fire alarm system designer should conduct a plans review of the system design before submitting it to the AHJ. This will ensure a more accurate and correct set of drawings for the AHJ. Fire alarm system design should be conducted by an industry professional holding a NICET Certification Level III, or by a Fire Protection Engineer. Engineering disciplines other than fire protection engineers lack the understanding and technical knowledge to perform fire alarm systems design. The AHJ who conducts the plans review should meet these same requirements.

The basic paperwork for a thorough plans review should be submitted by the fire alarm system designer and should include the following:

1. Architectural Drawings (signed by architect)
2. Occupancy Classification
3. Reflected Ceiling Plans
4. Specifications
5. Riser Diagram
6. Fire Alarm Contract Drawings (signed by NICET Level III or Fire Protection Engineer)*
7. Point to Point Diagrams
8. Voltage Drop Calculations
9. Battery Calculations
10. Equipment Specifications (Cut Sheets)

*Note: Check with your local AHJ to determine their exact requirements. Normally most will accept NICET Level III Certified or Fire Protection Engineer designers. Other engineering professionals are NOT qualified to perform fire alarm system design.

The AHJ may require additional paperwork depending on the jurisdiction and the building. All documents submitted to the AHJ for plans review should be professionally prepared. Hand drawn diagrams, narratives or calculations should not be submitted. Getting professional documents prepared is easy in the industry today. Most engineering firms provide this service for a fee. Some AHJs accept plans review submissions on CD as well. Make sure to identify the AHJ's requirements prior to submission.

In order to conduct a proper plans review of submitted documents, there are some basic tools which should be in the possession of the reviewer. These items include the following:

1. NFPA 72® The National Fire Alarm Code®
2. Appropriate Building Code for the jurisdiction
3. NFPA 70® The National Electrical Code®
4. Scale Master or similar device
5. A calculator
6. An architect or engineers scale ruler

NFPA 72®, The National Fire Alarm Code®
NFPA 72® is used to detail the installation requirements for fire alarm systems. NFPA 72® details how to install fire alarm systems and their components. It is important for the plans review process to address the requirements of the code. The most important code requirements for modern fire alarm systems are derived from the following chapters of the fire alarm code:

1. Fundamentals

2. Initiating Devices
3. Protected Premise
4. Notification Appliances
5. Supervising Station

Fundamental Fire Alarm Requirements
The plans reviewer should specifically check requirements from the fundamentals chapter of the code. All equipment used in fire alarm systems is required to be listed. The design of fire alarm systems should be completed by NICET Level III Certified persons. The installation of fire alarm systems should be supervised by NICET Level II Certified persons.

The fire alarm system is required to have standby power. The standby power source must be capable of powering the system for 24 hours of normal operation and 5 minutes in alarm for all commercial systems. Voice evacuation systems require 24 hours and 15 minutes at maximum load. Residential requirements are 24 hours in normal operation and 4 minutes in alarm.

All annunciators and remote annunciators are required to be located so responding personnel have easy access to them. The AHJ makes the final determination on the best location for the annunciators. In plans review, each floor of a building should be annunciated as a separate zone. Each building should be annunciated as a separate zone.

Fire Alarm Initiating Device Requirements
The initiating devices chapter of the code contains some of the most important requirements for the plans reviewer. Nonrequired fire alarm systems are one of the most misunderstood parts of the code. Some jurisdictions do not conduct plans review for non required systems. Check with the AHJ for their requirements.

Non required systems must meet all code requirements just as required systems have to meet the code, with one exception. The spacing of initiating devices does not have to comply with the code. This means smoke detectors can be placed wherever desired with no regard to spacing. It is acceptable for non required systems to design and install only one smoke detector for example, in a 10,000 square foot building. For a required system, that same 10,000 square foot building might require 15 smoke detectors. It is always important to check with the AHJ.

Spacing of automatic detectors is one of the most important checks for the plans reviewer. Chapter 5 of this book provides all the detailed requirements for automatic detector spacing.

Heat detectors are required to be spaced according to the device's listed spacing. Each heat detector has a specific listed spacing based on its ability to detect heat. Typically rate of rise detectors will have a listed spacing of 50 feet. Fixed temperature heat detectors rated at 135°, will typically have a listed spacing of 50 feet. Fixed temperature

heat detectors rated at 190° will typically have a listed spacing of 15 feet. The listed spacing can make a big difference. Additionally, for heat detector spacing, any ceiling height above 10 feet requires a reduction in detector spacing. The specific reduction schedule based on ceiling height can be found in Chapter 5 of this book.

Smoke detector spacing is permitted to be 30 feet by NFPA 72®. Smoke detector do not have a listed spacing, 30 feet is used as a guide. Unlike heat detectors, ceiling height does not affect smoke detector spacing. Any ceiling greater than 28 feet, should have an engineering survey conducted to determine appropriate detection methods. This engineering survey should be conducted by a licensed fire protection engineer. No other engineering discipline is qualified to conduct a fire protection engineering survey.

The plans reviewer should have a scale master when conducting plans review. This tool allows for easy calculation of device spacing and numerical requirements.

The scale master can be adjusted to the appropriate scale of the blueprints and can be rolled from point to point on the diagram. The display automatically tabulates the correct number of devices required.

Photo courtesy Scalemaster Inc, p17.1

Heat and Smoke Detector Spacing Quick Reference

Ceiling Type

Smooth – no projections (beams, joists, ducts) more than 4" below surface
Solid joist – more than 4" high, less than 3' apart
Beam – more than 4" high, more than 3' apart
Sloping – ceiling with slope of more than 1 in 8
Sloping shed – ceiling with slope in one direction only
Sloping peaked – ceiling with slope in two directions from highest point

Heat Detector

Smooth, 10' or less high	Listed spacing
Smooth, more than 10' high	Spacing reduced based on 72-5.6.5.5.1
Solid joist	Mount to bottom of joist, spacing reduced by ½ perpendicular to joist
Beam, 4" or less	Listed spacing
Beam, more than 4"	Spacing reduced by 1/3
Beam, more than 18" *and* more than 8' apart	Each bay considered separate area
Peaked, more than 30°	Row of detectors within 3' of peak, spacing based on average ceiling height
Peaked, less than 30°	Row of detectors within 3' of peak, spacing based on highest ceiling height
Shed, more than 30°	Row of detectors within 3' of peak, spacing based on average ceiling height
Shed, less than 30°	Row of detectors within 3' of peak, spacing based on highest ceiling height

Diagram, NTC, d17.1

Smoke Detector

Smooth	30' spacing
Solid joist/beam 1' or less, ceiling 12' or less	30' spacing parallel to joist/beam, ½ spacing perpendicular to joist/beam mounted on ceiling or bottom of beam
Solid joist/beam, more than 1', ceiling less than 12'	On the ceiling in every beam pocket
Solid joist/beam, more than 1' ceiling more than 12'	On ceiling in every beam pocket
Sloped ceiling, beams parallel to slope	Use joist/beam spacing above, spacing determined by average height Mount on bottom of beams, for slopes more than 10° no detectors required at ½ spacing from low end
Sloped ceiling, beams perpendicular to slope	Use joist/beam spacing above, spacing determined by average height, mount detectors on bottom of beam.joist
Peaked	Use sloped ceiling spacing above, plus row of detectors with 3' of peak
Shed	Use sloped ceiling spacing above, plus row of detectors with 3' of high side

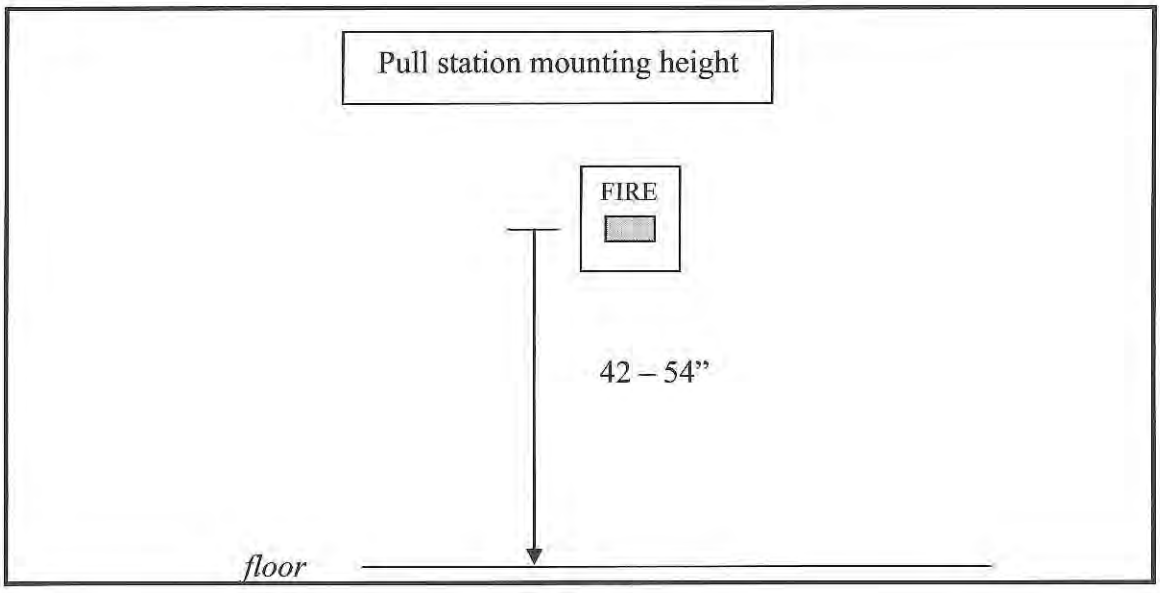
Diagram, NTC, d17.2

Manual Fire Alarm Boxes

Pull Stations are referred to in the code as manual fire alarm boxes. Chapter 5 of this book details the requirements for installing pull stations. The plans review process should check the spacing and location of pull stations to ensure compliance with the code requirements.

Location and Spacing

Manual stations are required to be mounted so that the operable part of the station (actuator) is between 3-1/2 and 4-1/2 feet off the floor. Mounting at this height allows easy access by a standing person or a handicapped person in a wheelchair.



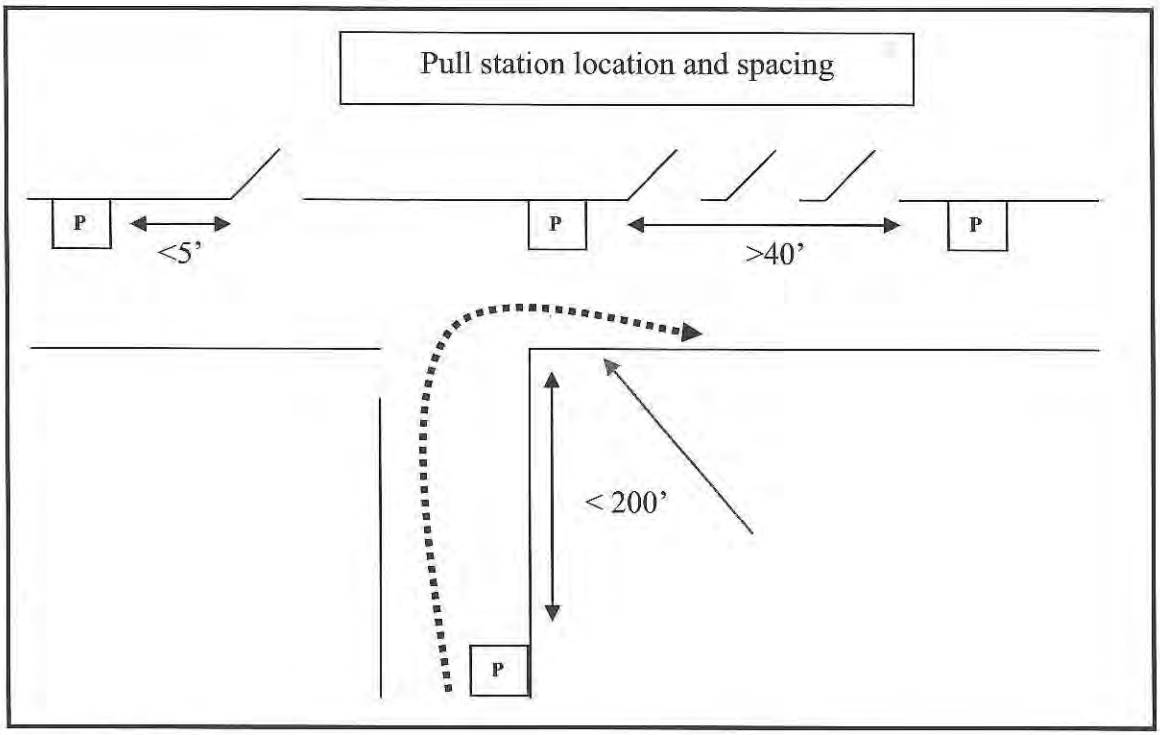
Diagram, NTC, d17.3

Manual stations need to be located throughout the protected area in locations where they are easily accessible and along the normal path of exit from an area. At least one manual station must be provided on each floor.

At least one pull station must be located within 5 feet of each exit door on a floor. Additional units must also be provided within 200 feet horizontal travel distance on the floor. Grouped openings over 40 feet wide should have a pull station within 5 feet of either side.

All fire alarm systems which use automatic detectors or waterflow devices require at least one pull station. This pull station needs to be located in an area that is accessible to the general public. The purpose of the pull station is to provide early detection of the fire.

A person is capable of detecting a fire prior to a smoke detector. Having the pull station in an accessible area ensures the person can activate the fire alarm system.



Diagram, NTC, d17.4

If they are subject to abuse, a mechanical guard must protect them.

Photo courtesy STI, p17.2

Duct Smoke Detectors

The primary purpose of duct smoke detectors is to prevent the spread of smoke via the HVAC system. The detector is designed to detect fires within the system, or to detect smoke drawn in by the system from rooms connected to it. It is not designed to be a replacement for primary fire detection in the building.

Requirements for Duct Detectors

Smoke detectors are required for the HVAC system on the supply side when the capacity rating of the HVAC unit exceeds 2,000 CFM. Duct detectors are required on the return

side when the capacity of the HVAC unit exceeds 15,000 CFM and serves 2 or more floors.

Duct Detector With Sampling Tube

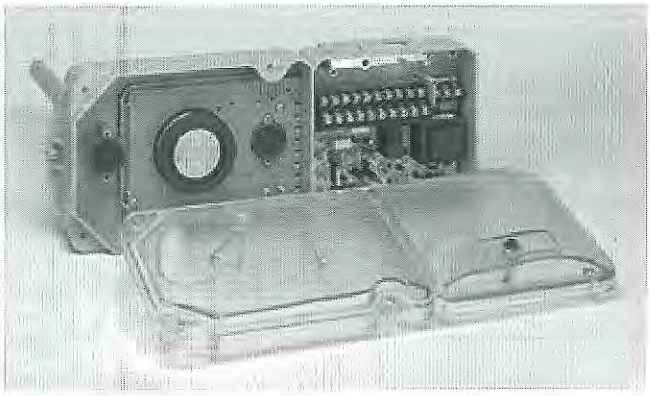
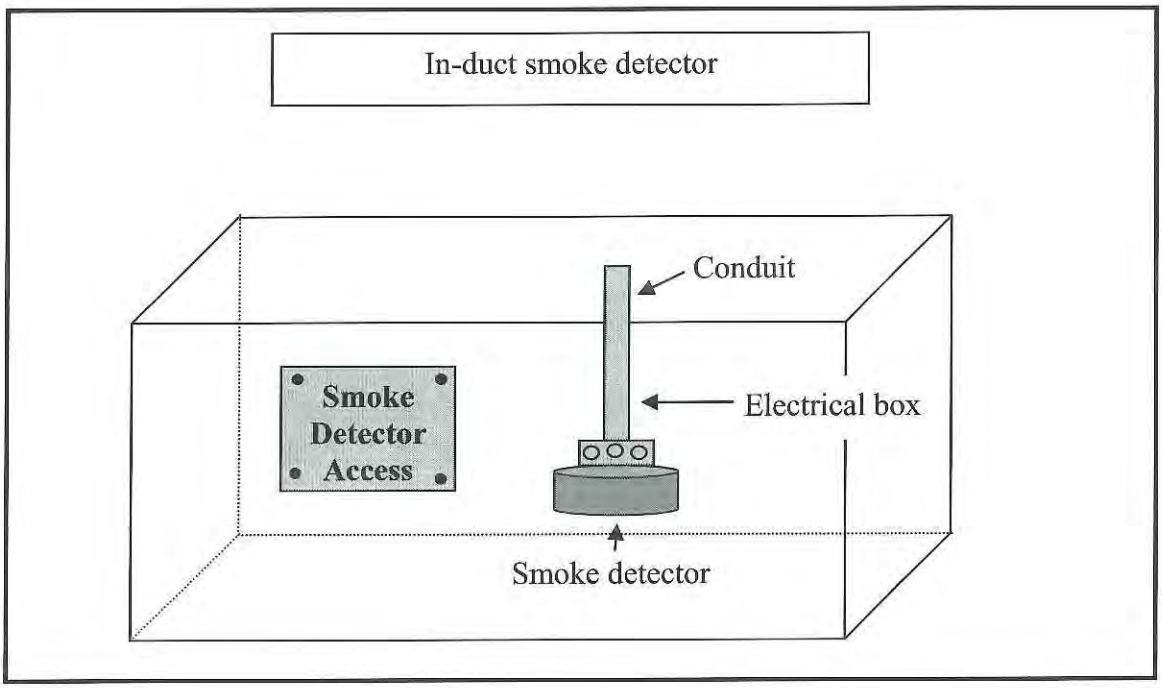


Photo courtesy System Sensor, p17.3

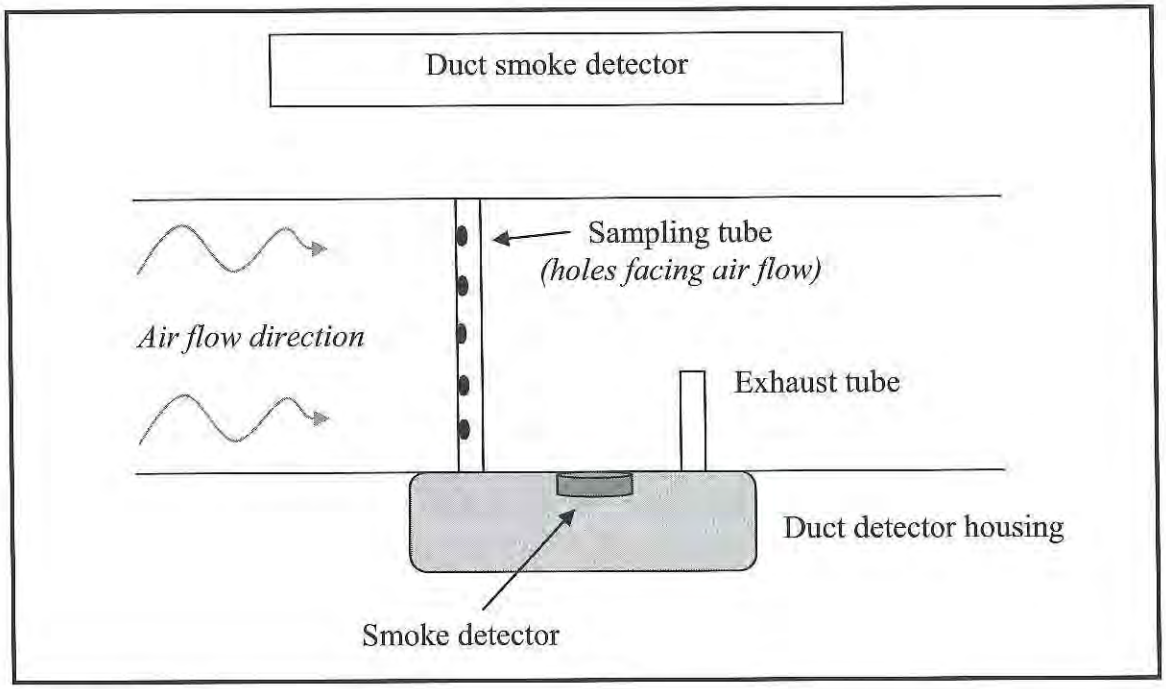
In Duct Smoke Detector

Photo courtesy System Sensor, p17.4

Duct detectors can be mounted in the duct, but are typically mounted outside the duct with sampling tubes penetrating the duct to sample the air as it passes. Detectors mounted in the duct must be rated to handle the air velocity that the air will reach in the duct. The detectors in either application must be listed for use as duct smoke detectors. They must sample air passing the sensor or the sampling tube at a high volume and be able to detect smoke in it.



Diagram, NTC, d17.5



Diagram, NTC, d17.6

Requirements for Equipment at the Protected Premise
The plans reviewer should be familiar with the basic requirements for the installed equipment at the protected premise. Fire alarm systems are permitted to share components with non fire alarm systems. It is common today for fire alarm systems / security systems to be combined. These combination control panels are acceptable according to NFPA 72® The National Fire Alarm Code®.

Fire pumps are required to be supervised by the fire alarm control panel. This means that all fire pump signals are supervisory signals not alarm signals. The waterflow is an alarm signal. The waterflow switch has already been tripped if the fire pump is running so there is no need for the fire pump to generate an alarm signal. Specifically the supervisory signals required from the fire pump are pump running, power fail, fail to start, and phase reversal.

Fire alarm systems are required to provide supervision for the conditions essential to sprinkler systems or suppression systems. These include things like air pressure, PIVs, OS&Ys and control valves.

Fire alarm systems are required to have at least 1 notification appliance on every floor when the purpose of the system is occupant evacuation. This requirement is not intended to limit the number of appliances per floor to just 1 device. The minimum is 1 device per floor. If additional devices are required in order to provide the proper audibility or visibility then those additional appliances must be added.

Modern fire alarm systems use relays for a number of different purposes. Some of those include damper shut down, elevator recall, and fan shutdown. The relays used to control these devices are required to be located within 3 feet of the controlled appliance at the point where it is being controlled. This requirement is in place to ensure that the circuit wiring from the fire alarm control panel to the relay is supervised. By making sure the relay is located within 3 feet of the controlled appliance, the chance of adverse conditions occurring on the circuit without notification are minimized.

Elevators are a source of contention in our industry. It is important for plans reviewers and AHJs to get familiar with the requirements. NFPA 72®, The National Fire Alarm Code®, specifically prohibits the installation of smoke detectors in elevator hoitsways. The code is specific on this subject because an elevator hoistway is not an appropriate environment for smoke detectors. Hoistways exceed the temperature limitations and they are particularly dusty and dirty. This environment will cause nuisance alarms. Smoke detectors in elevator hoistways will cause the responding firefighters to be dispatched on false alarms.

Some older elevator hoistways may have sprinkler heads installed. Older hoistways required the sprinkler head because the hoistway did not have adequate fire resistive protection. Modern requirements provide appropriate fire resistive protection for hoistways and sprinklers are not required there. For those older hoistways with sprinklers, a heat detector was also required to be located within 2 feet of the sprinkler head. The heat detector required a rating less that the sprinkler head. The job of the heat detector was elevator shutdown. Shutting down power to the elevator would prevent the sprinkler from dumping water on an electrically live elevator car. A problem arises with this for any person in the elevator car. They will likely be stuck in the elevator in a fire. In order to alleviate this, a smoke detector may be installed at the top of the hoistway. The purpose of the detector is to provide elevator recall prior to the shutdown of the elevator. This will permit any occupants to evacuate.

Smoke detectors may also be installed in the hoistway if the only purpose of the smoke detector is to activate smoke relief equipment for the elevator hoistway. Additional information on elevator recall and elevator shutdown may be found in Chapter 7 of this book.

Duct detectors are permitted to initiate an alarm signal or a supervisory signal. Duct detectors are not permitted to initiate a trouble signal. It is also required that electronic door locks release when a fire alarm signal is initiated and when primary power to the fire alarm control panel is lost.

Providing proper occupant notification is one of the most important functions of the fire alarm system. The plans reviewer must verify that all code requirements for notification are met. Chapter 6 of this book details the notification requirements for fire alarm systems.

Public Mode Audibility
Fire alarm system notification is required to be heard throughout the building. The notification appliances must be 15 db above the average ambient sound level, or 5 db above the maximum sound level which persists for 60 seconds or more. The maximum sound level for a notification appliance is 120 db. If the average ambient sound level exceeds 105 db, then visible appliances must be added. The standard evacuation signal is Temporal 3, in accordance with ANSI S3.41.

Private Mode Audibility
In some building occupancies, the building / life safety code may allow private mode notification. This provides notification at a constantly attended location, not throughout the building. Trained personnel then have the opportunity to verify the fire alarm signal before evacuation of the building. Hospitals and detention facilities are common examples of where private mode notification might be useful.

Audible devices are required to be mounted in a place where they will provide the best sound throughout the area. Specifically, audible devices must be at least 90 inchess above the finished floor (AFF) to the top of the device and a minimum of 6 inches down from the ceiling.

Visible appliances are required to flash with a minimum intensity level. The intensity requirements were set by ADA and adopted by NFPA 72®. The tables located in Chapter 6 of this book provide detailed information on room size and candela rating requirements. Visible appliances must actuate as a minimum of 1 flash per second and a maximum of 2 flashes per second.

Visible appliances are required to be mounted such that the entire lens is 80 inches or greater AFF and not more than 96 inches AFF. Strobes are required to be clear or nominal white in color. Strobes must be located within 15 feet of the end of corridors. Spacing of strobes in corridors cannot exceed 100 feet.

Synchronization is an important aspect of visible appliance operation. When more than 2 strobes are in any field of view, they must be synchronized. Strobes which are not in the same field of view do not require synchronization.

Most modern fire alarm systems are designed to communicate with a monitoring facility. Chapter 10 of this reference specifies the requirements for communications with the supervising station. The plans reviewer should check for several important aspects of this communication.

The DACT is required to have line seizure. This means in the event of a fire alarm signal, the communicator has the ability to seize the line and send its signal. The transmission of signals between the control panel and the supervising station must be completed within 90 seconds. The DACT is required to have two methods of communication (normally 2 telephone lines). Both communications channels require a

test signal every 24 hours. This requirement permits testing channel 1, then 24 hours later test channel 2. This alternating pattern will meet the requirement.

International Building Code® and NFPA 101® Life Safety Code®
NFPA 72® does not identify which buildings are required to have a fire alarm system installed. NFPA 72® does specify how a fire alarm system is required to be installed. The International Building Code®, or the NFPA 101® Life Safety Code®, identifies the specific requirements for each occupancy classification of buildings.

Photo courtesy IBC, p17.5

Photo courtesy National Fire Protection Association©, 2003 edition, p17.6

The IBC® and NFPA 101® are used to determine which building occupancies are required to have a fire alarm system. These codes are the source for when a fire alarm system is required. The plans reviewer must check the requirements of these codes in order to determine the specific requirements for the fire alarm system. Chapter 3 of this reference provides the fire alarm requirements for each type of building.

NFPA 70® National Electrical Code®

Photo courtesy National Fire Protection Association©, 2005 edition, p17.7

Wiring requirements for fire alarm systems are specifically detailed in the National Electrical Code®. Every fire alarm installation is required to comply with the requirements of the National Electrical Code. Every fire alarm installation requires appropriate wiring. Article 760 of the National Electrical Code® specifies the wiring

requirements for fire alarm systems. This article of the code identifies 2 types of fire alarm cable: Non Power Limited fire alarm cable and Power Limited fire alarm cable.

Power Limited fire alarm cable is the most common type used for fire alarm systems. Power limited is used for all low voltage fire alarm wiring. Non Power Limited fire alarm cable is virtually never used with today's fire alarm systems. Non Power Limited cable was used for old 110 volt fire alarm systems and circuits. Since these circuits are no longer used, neither is Non Power Limited fire alarm cable.

NFPA 70® details the requirements for wiring methods. This includes such things as conduit use and fill limitations, box fill requirements, classification of wiring, and proper methods for installing cable. This code is an important tool that everyone involved in fire alarm system design, installation and service should have readily available.

In addition to all of the requirements listed in the above codes, the submitted documents should have basic information included as well. Based on the diagram or drawing, the following information should be included:

All Drawing and Diagrams

1. Should be the same size
2. Should use the same scale
3. Should include North
4. Should have page number, revision, date and project name
5. Name and address of project, contractor, and building owner
6. Appropriate contact information (phone numbers) for key personnel
7. Building occupancy
8. Legend with symbol list

Riser Diagram

1. Should show all devices connected to each circuit
2. Device addresses if possible
3. It is a nice touch to show mounting height for devices used and conductor size for initiating and notification circuits

Fire Alarm Contract Drawings (Floor plan with fire alarm devices)

1. The floor plan of the building
2. The as built drawing cabinet location
3. Obstructions
4. Location of air supply and return registers and lighting fixtures
5. Ceiling heights and slopes
6. FACP, power supply and control equipment locations
7. Locations of all required initiating devices
8. Locations of all required notification appliances

9. Location of the disconnecting means
10. Location of all fire safety function devices
11. Wire type, conductor counts and approximate wire run locations
12. It is a nice touch to include the voltage drop and battery calculations as the last pages of the fire alarm drawings

Point to Point Drawings

1. Circuit wiring diagram
2. Typical device wiring

Equipment Specifications

1. Use a table of contents and associated tabs
2. Fire alarm control panel, power supply and annunciator cut sheets
3. Cut sheets on the initiating devices
4. Cut sheets for the notification appliances
5. System component cut sheets (modules, relays etc)
6. Operating instructions for the system.
7. Manufacturer's testing instructions.

Summary

The plans review process is a critical task in designing and installing effective fire protection. It is important that a thorough plans review be conducted by the fire alarm systems designer and the AHJ. Submitting professional drawings and documents is an important aspect in eliminating any confusion concerning the fire alarm system. We are expected to work with the AHJ, and the building owner to provide the most effective fire protection system.

Chapter 18

Listing Agency Requirements

The fire alarm industry is full of checks and balances to ensure that the equipment used and the manner it is installed meets stated requirements. Every device used in a fire alarm system or devices used for a life safety function performed by the fire alarm control must be suitable for its intended use. The suitability of a product for a specific application is determined by a testing, certifying, and listing organization. The acceptance of a product or service for an intended application is determined by the local authority overseeing the fire alarm project.

Authority Having Jurisdiction (AHJ)
The AHJ is the person or organization responsible for approving equipment, installation, and procedures involved in a fire alarm system. The AHJ may be the local electrical inspector, building inspector, fire marshal, or other approving authority or person. On larger projects, the AHJ may be a representative from the insurance company writing the policy on the project. Government projects may have an AHJ who is a government official or representative who oversees work done for the government. It is possible for a project to have multiple AHJs, all of whom must approve the equipment, installation, and procedures for the fire alarm system.

The term "approved" means acceptable to the AHJ. Technically, any "approvals" regarding fire alarm systems come from the AHJ.

Listing and Labeling
Product or service suitability is determined by the testing, certifying, and listing organization. Underwriters Laboratories (UL) is the most common organization. Other organizations exist, and some cater to regional or special application needs. The organization must conduct periodic testing of the manufacturing of the products or periodic evaluation of the services it approves. Products and services that have been tested and found to meet the requirements can be listed and labeled.

Listed means the product appears on a list published by the testing, certifying, and listing organization of all of the products or services found to meet the requirements of the listing agency. Labeled means that the equipment listed by the testing, certifying, and

listing organization has a label attached to it identifying that the product meets the requirements.

Codes

Codes specify where and how a system is to be installed and used. NFPA 101®, NFPA 5000®, and IBC® all determine when a fire alarm system is required and the type of system required. NFPA 70® determines how the fire alarm system and its auxiliary systems will be wired. NFPA 72® determines how and where the fire alarm devices will be installed.

2002 edition,p18.1

2003 edition, p18.2

Photos courtesy National Fire Protection Association©

2005 edition, p18.3

2003 edition, p18.4

Photo courtesy ICC

Standards

Standards fall into two categories: products and installation. Product standards specify how hardware must function and the conditions it must function under. UL268 (Standard on Smoke Detectors) describes the operating temperature range the detector must be able to function under, and how sensitive the detector must be.

Installation standards specify how the hardware must be installed. NFPA 72® specifies how smoke detectors must be spaced and under what circumstances they can be used.

Equivalency

Most of the standards in use in the fire alarm industry contain an equivalency clause. This clause allows the use of systems, methods, or hardware of equivalent or superior quality, effectiveness or safety that are different from those detailed in the standard. The AHJ decides whether the equivalent method or product is acceptable.

Fire alarm codes and standards are written in very general terms and reflect the minimum standards the system must meet. Equivalency allows the system designer to select products or applications that better meet the life safety intent of the system.

An example of equivalency would be using FPLR (riser) or FPLP (plenum) fire cable in standard, non-plenum horizontal cable runs. FPL (general purpose) cable is adequate for this application, but FPLR and FPLP exceed the requirements. Cable substitution is permitted and specified in NFPA 70®, so the substitution should be acceptable by the AHJ.

Product Testing

Before being released to the market, new fire alarm devices are tested by the manufacturer and by the listing organization(s) to make sure the product complies with the standards set for the product type. The standards are written by the two major testing laboratories (UL and FMRC), and any devices bearing their label and listing must meet those standards.

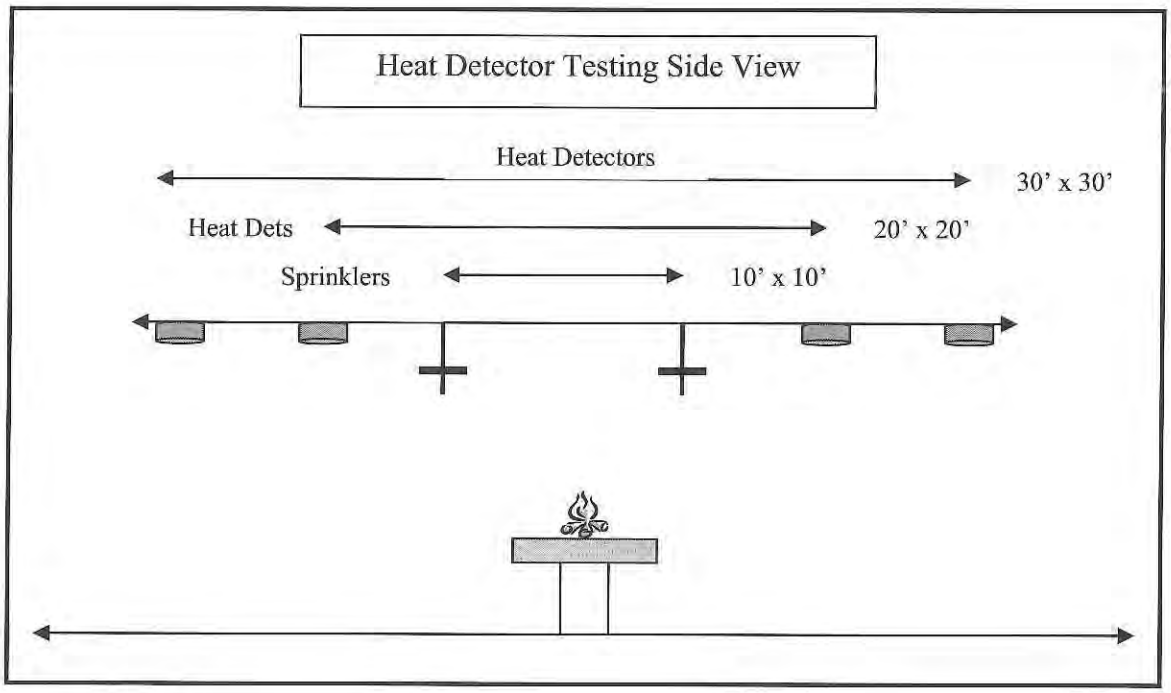
Photo courtesy UL, p18.5

Photo courtesy FM Global, p18.6

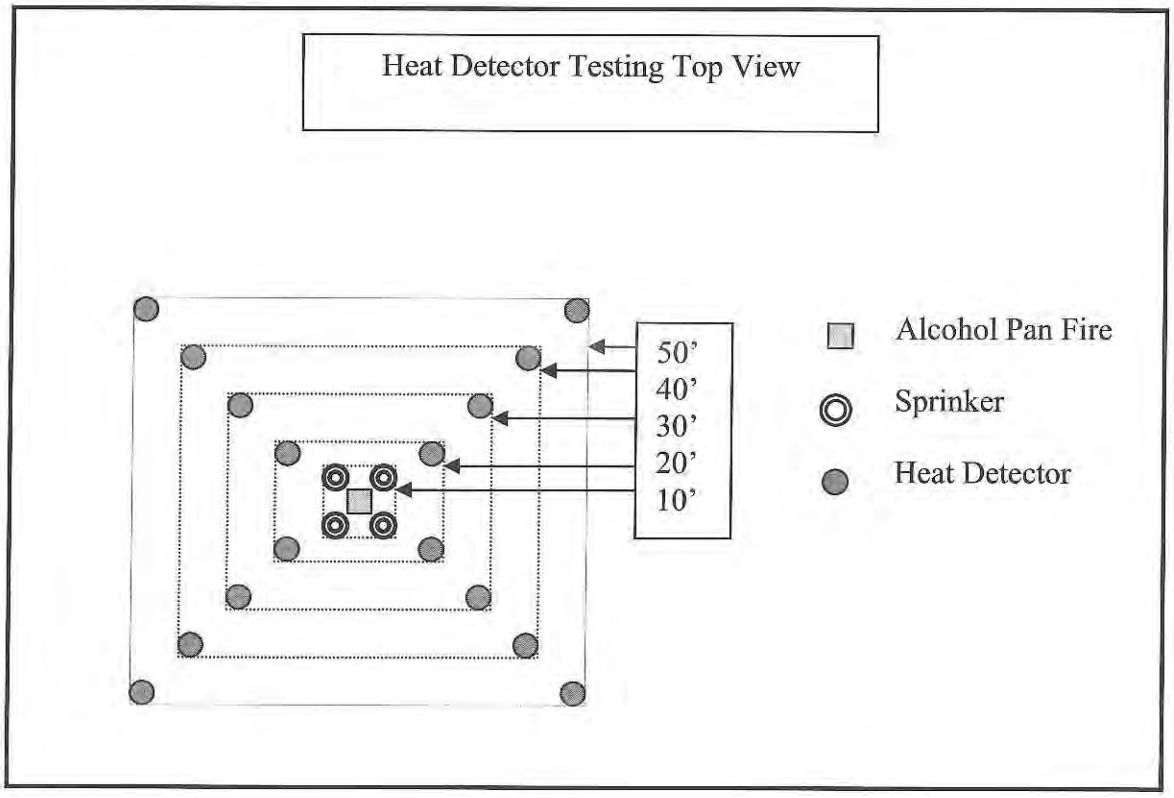
Once the product has been approved, listed, and labeled, product production is continually checked via unannounced manufacturing plant visits. The inspector compares production units to specifications of originally approved units to assure no variances occur. The system requires any changes to the product be approved by the testing organization before the changes be made on production units. Often, the listing/labeling agencies will not conduct the testing or follow up themselves, but rather the work is done by third party laboratories that test and inspect to the standards of the listing/labeling organization.

Heat Detector Testing

Heat detectors are tested by UL with an alcohol pan fire. They use 190 proof (95%) denatured alcohol in a pan positioned 3 feet above the floor. They install fire sprinklers rated at 160° in a square 10 x 10 foot pattern. They also install heat detectors in the room at 10' intervals. The test is based on the activation of the heat detector in comparison to the sprinklers. The heat detector which operates at the greatest distance from the fire prior to the sprinkler heads determines the listed spacing of the device. The test is based on a fire of sufficient size to activate the sprinklers within 2 minutes (+/- 10 seconds).



Diagram, NTC, d18.1



Diagram, NTC, d18.2

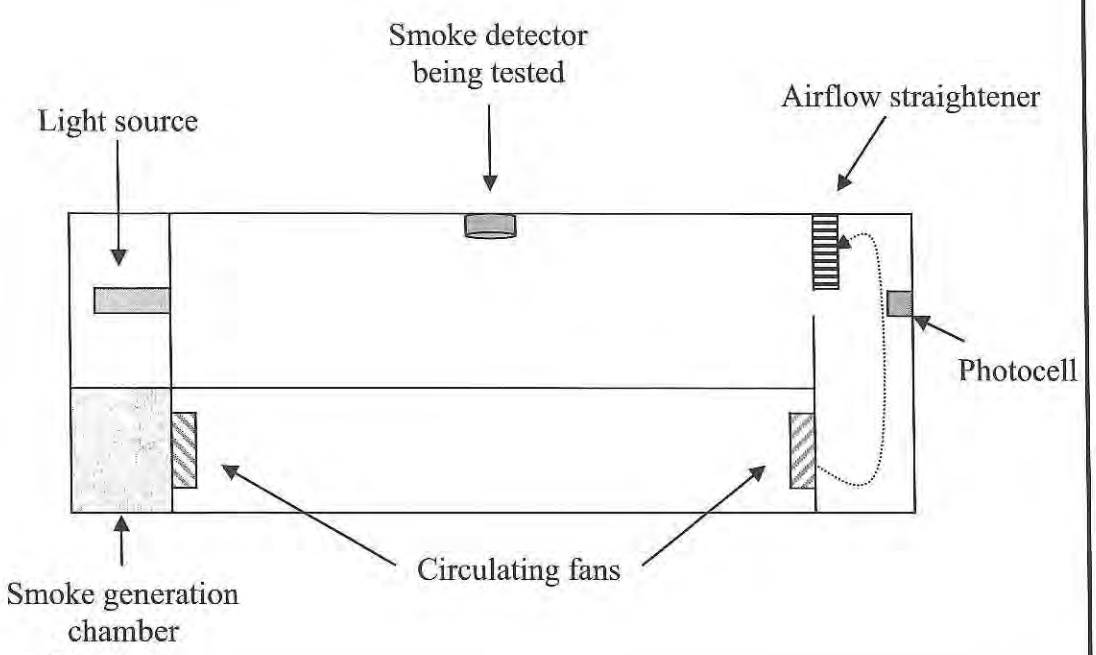
Smoke Detector Testing

Smoke detector testing is more involved than heat detector testing. Smoke detectors must detect visible and invisible particles of combustion. Smoke detectors typically respond much faster than heat detectors, so the test fire is smaller. Since different smoke detection technologies respond differently to different smoke particles from different fire types, UL has developed five test fires. Each fire produces a different type of smoke, and the detector being tested must detect all the smoke types.

The material that is burned to test the detectors produces various colors and types of smoke. *N*-heptane and polystyrene produce black smoke, wood and newspaper produce gray smoke, and wood burned using a hot plate produces a smoldering fire with gray smoke. These materials produce a broad sampling of the types of smoke that a fire can produce, and each detector type must respond to each type of smoke.

Smoke detectors are tested in a smoke box. The detector is mounted horizontally at the top of the upper chamber. Smoke is introduced into the lower chamber, circulated across and up through an airflow straightener, and directed into the detector. The smoke density is gradually increased until the detector responds. The point at which the detector responds is considered the sensitivity of the detector. Smoke density (obscuration) is measured by a light source projecting through the testing area to a photocell.

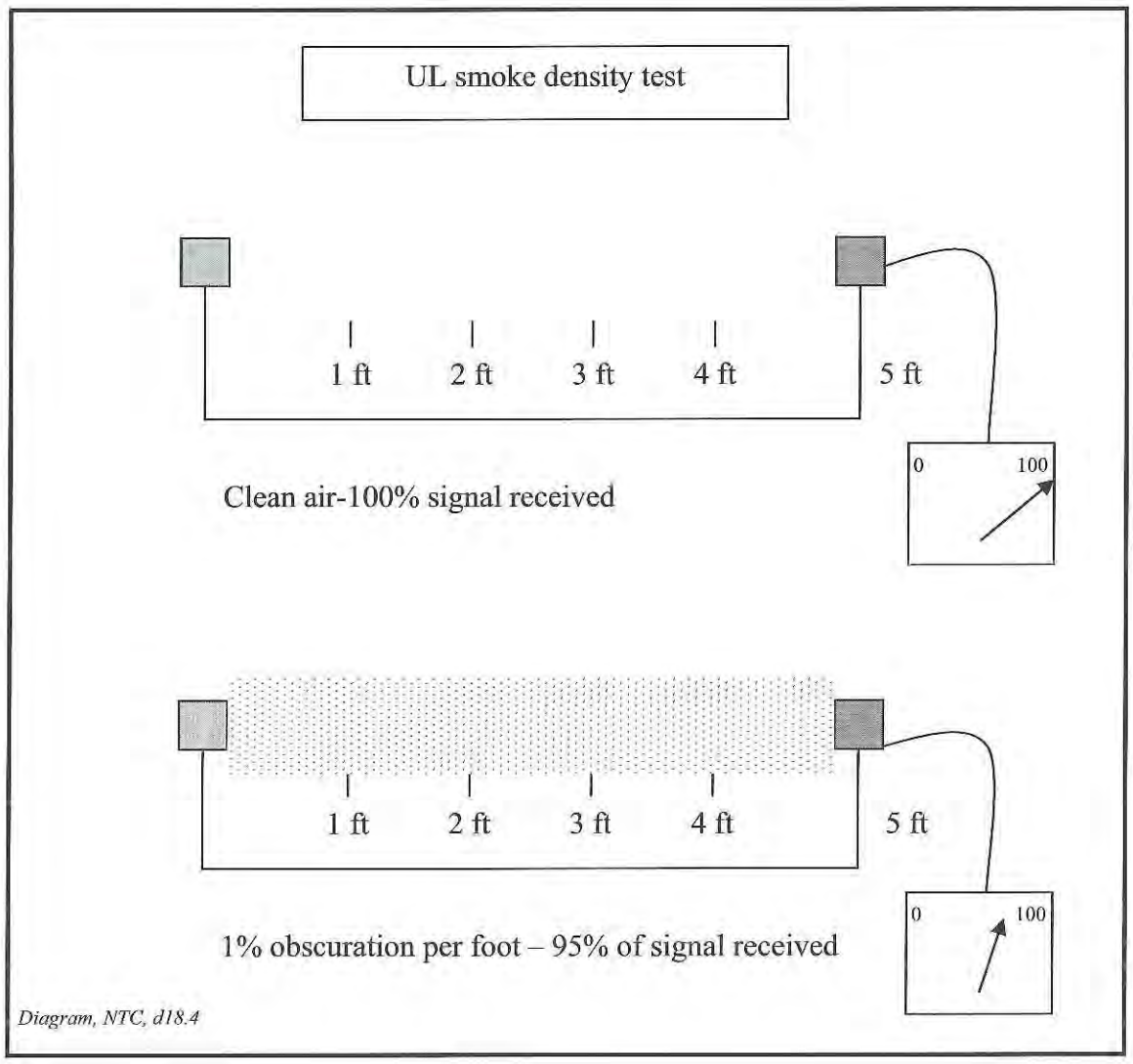
UL smoke detector testing in smoke box



Diagram, NTC, d18.3

Additional tests are conducted with the smoke approaching the detector from four different sides and also with the end facing the oncoming smoke. This is used to determine the least favorable position of smoke entry. The detector is then mounted in the fire test room with the least favorable smoke entry position directed towards the smoke source. Detectors used in the tests are set at the minimum production sensitivity (least sensitive). System powered detectors are connected to a power source at their rated operating voltage. Battery powered detectors are tested using a battery depleted to the level at which the unit gives a trouble signal.

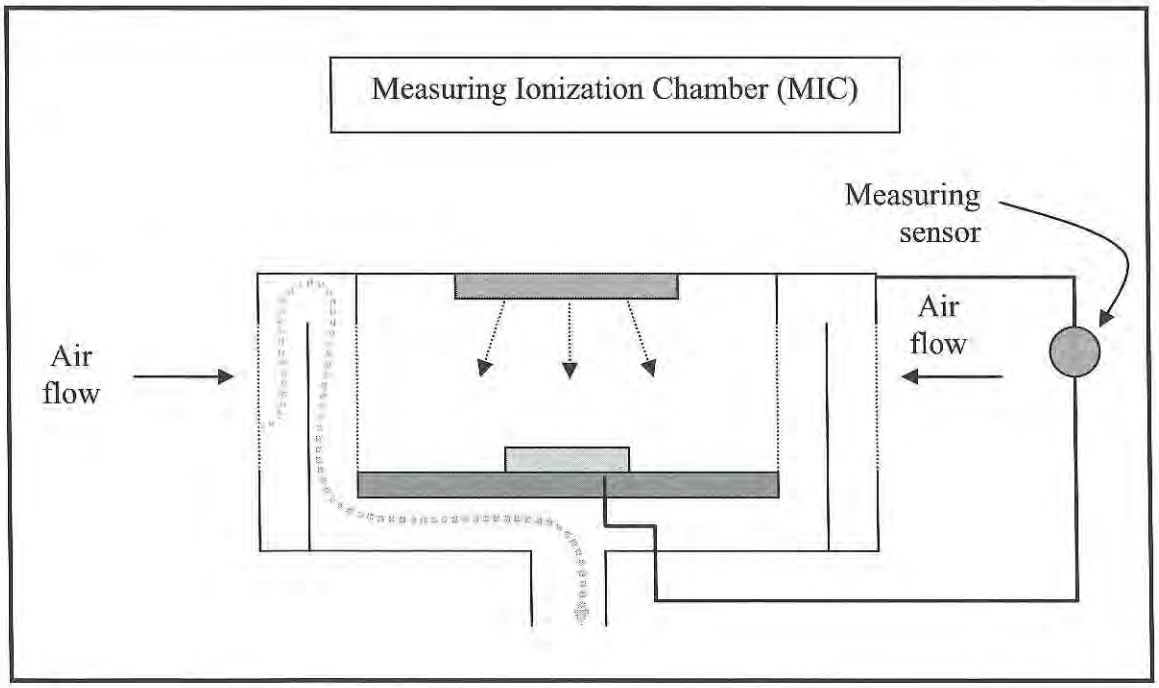
UL uses two different methods of measuring smoke density during fire room tests. The first method is photoelectric (PE), similar to a projected beam smoke detector. It uses a light source placed 5 feet from a receiver. The light power received before the test is measured and marked as 100%. As smoke enters the room the light is gradually obscured. The measurements from the five smoke tests are charted based on obscuration per foot versus time (seconds). The obscuration is charted per foot, but the room is tested based on 5 feet to give more accurate readings.



Diagram, NTC, d18.4

The second method used by UL is a measuring ionization chamber (MIC). This is the preferred device for testing ionization type smoke detectors. The MIC mimics the function of an ionization smoke detector, and when used with a light beam and a thermocouple helps measure the test fire to assure repeatable (standard) test fires are produced.

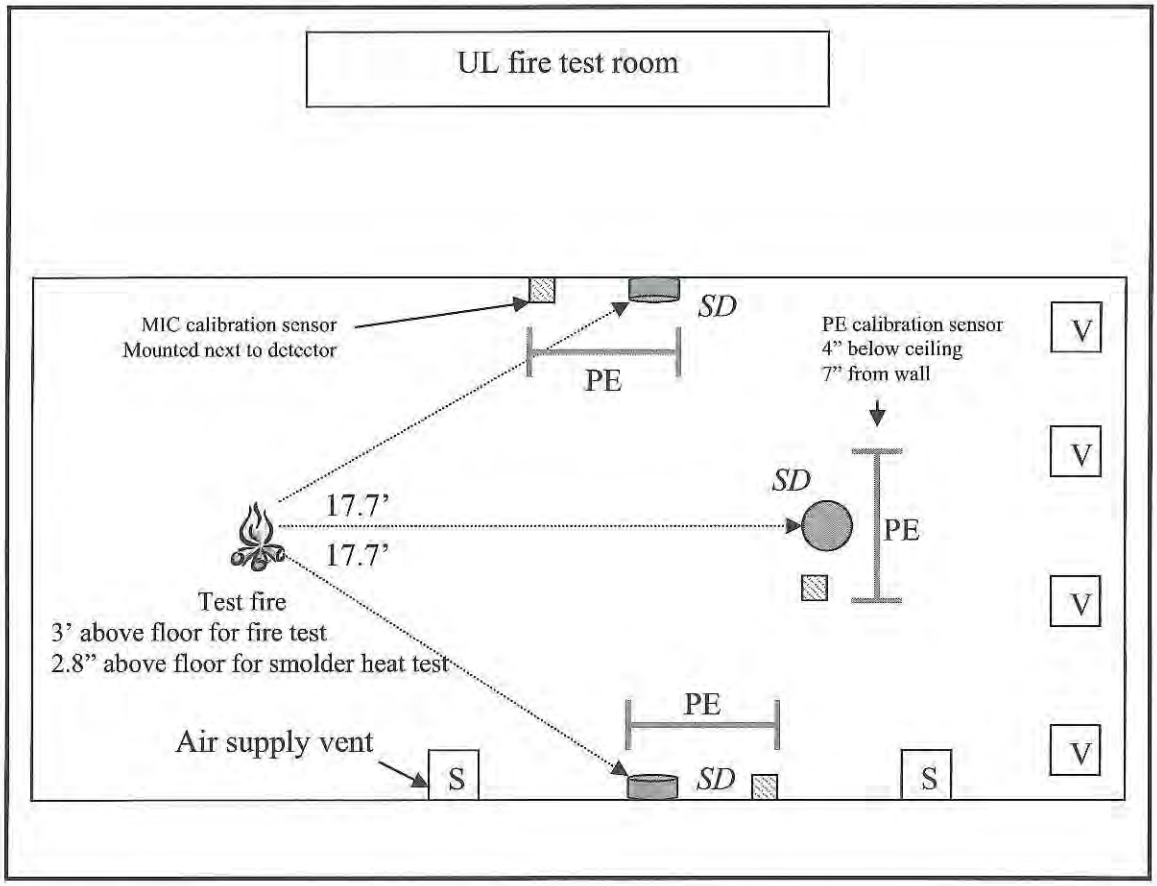
Air is drawn past the chamber mechanically, but is not drawn through the chamber since this would affect the stability of the readings. Smoke is drawn through the measuring chamber by diffusion. The current flow through the chamber is measured to determine the smoke density.



Diagram, NTC, d18.5

The five UL smoke detector test fires are conducted in a 36' x 22' room with a 10' ceiling. The detectors are placed on the ceiling and sidewall so they are 17.7 feet from the point on the ceiling directly over the test fire.

This test method is a pass or fail test only, not a spacing test, so the detectors do not need to be positioned at maximum spacing.

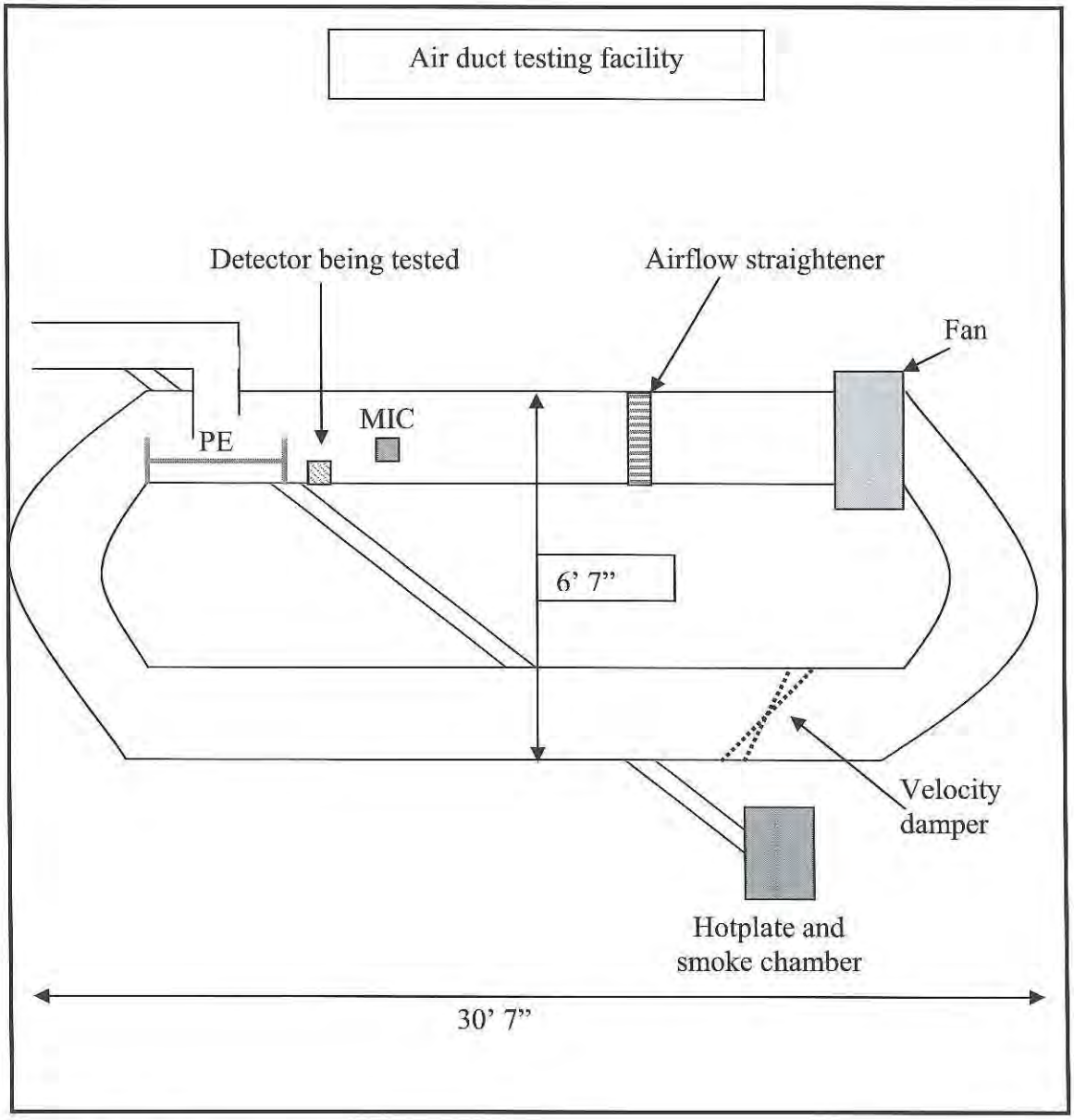


Diagram, NTC, d18.6

Duct Smoke Detector Testing

Duct smoke detectors are tested using an air duct facility. Detectors are installed the same way they would be mounted in the field in the air duct itself at a point where the duct is 1 foot square.

The detector is tested using two different sources: wood on a hot plate and *n*-heptane. The smoke is carried by air at various velocities and various build up rates. As with spot type smoke detector tests, this is a pass or fail test.



Diagram, NTC, d18.7

UL Smoke Detector Test Fire Information

Material	Fire Type	Minimum Detector Response Time
1.5 oz. shredded newspaper	Flaming	4 minutes
6 x 6 x 2.5 in. layered fir wood strips	Flaming	4 minutes
30 ml of *n*-haptane	Flaming	3 minutes
1 oz. Foam polystyrene-type packing material	Flaming	2 minutes
Ponderosa pine sticks over hot plate	Smoldering	70 minutes

Diagram, NTC, d18.8

UL Duct Detector Testing Smoke Parameters

Gray smoke (wood on a hot plate)

Duct air speed fpm	m/sec	No. of sticks used in test	Smoke buildup rate*
300	1.52	5	2.9 ± 0.5
1000	5.14	5	2.2 ± 0.8
2000	10.2	6	2.1 ± 0.5
3000	15.4	7	1.3 ± 0.4
4000	20.3	8	0.8 ± 0.2

*percentage per foot obscuration per minute

Diagram, NTC, d18.9

Black Smoke (*n*-heptane)

Duct air speed		Receptacle Size Diameter		Depth		Combustible (ml)	Smoke buildup rate*
fpm	m/sec	in.	mm	in.	mm		
300	1.52	3 3/8	85.7	1 7/8	47.6	30	4 ± 1.5
1000	5.14	3 3/8	85.7	1 7/8	47.6	30	4 ± 1.5
2000	10.2	3 3/8	85.7	1 7/8	47.6	30	4 ± 1.5
3000	15.4	4	101.6	2	50.8	40	4 ± 1.5
4000	20.3	4	101.6	2	50.8	40	4 ± 1.5

*percentage per foot obscuration per minute

Diagram, NTC, d18.10

% per foot	% per meter	OD per foot	OD per foot	% Light Transmission	
Gray Smoke					
4.0	12.56	0.0178	0.0583	81.5	Maximum
0.2	0.66	0.00087	0.0028	99.0	Minimum
Black Smoke					
10.0	29.26	0.0458	0.1504	59.0	Maximum
0.5	1.65	0.0022	0.0072	7.5	Minimum

*OD = optical density

Diagram, NTC, d18.11

Summary

Fire alarm installation and design requirements are interpreted and determined by the local authority having jurisdiction (AHJ). Device manufacturing and listing requirements are determined by the listing agency (UL, FM).

Automatic detectors are rigorously tested by various methods to ensure they meet the requirements of the listing agency and are suitable for use in automatic fire alarm systems.

Chapter 19

Performance Based Design

The prescriptive requirements of the code apply to almost all fire alarm systems installed in the US. When the prescriptive requirements of the code are not adequate, then performance based solutions are required to meet the fire protection needs of the building. Fire alarm technicians should recognize when performance based solutions are required. Some examples where performance based design may be required are:

1. High ceilings (more than 28ft)
2. Areas with high air movement
3. Areas where a faster response is required
4. Areas with highly combustible materials

The details in this chapter are based on Annex B, NFPA 72®, The National Fire Alarm Code®. Annex B is specifically designed to provide alternatives for property protection. Consult with a Fire Protection Engineer for performance based design alternatives for life safety. The performance based alternatives from Annex B and this chapter are not intended for the following areas:

1. Incipient or smoldering fire scenarios
2. Computer rooms
3. Switchgear or motor control rooms
4. Clean rooms
5. Storage vaults

Specific computer programs have been developed to perform the complex calculations needed for performance based design. Several companies offer such programs and fire protection engineers rely on them to predict the fire scenario for a particular building. Technician level work generally does not involve computations for performance based design.

This chapter is based on flaming fires which follow a generally predictable growth rate pattern. There are a few very important governing principles for performance based design.

1. The Nature of Fire is ALWAYS unpredictable.
2. Performance based design is ALWAYS used to increase the level of protection above the prescriptive requirements of the code.
3. Performance based design should only be done by qualified Fire Protection Engineers.

This chapter will provide information on some of the important concepts for performance based design. It is important to note, only a qualified fire protection engineer should use these principles to determine proper detector type, location and spacing for real world applications.

Performance based design is primarily based on the goals and objectives of the entire fire protection system for a building. Fire detection is only one piece of the puzzle. Other factors such as suppression, evacuation planning, administrative controls, fire fighter response, and occupant training are also important. If, for example, the goal is to detect a fire so that it can be extinguished before it consumes a particular room, fire fighter response may be an important consideration. If the fire fighter response is 4 minutes or 14 minutes can be an important consideration.

In terms of fire detection, the most important considerations are:

1. Listed spacing of the detector
2. Ceiling height
3. Detector time constant
4. Heat release rate
5. Time of fire growth

Listed Spacing
This term applies to heat detectors. Heat detectors are tested by FM Global, or Underwriters Laboratories to determine their listed spacing. The room used for this test has 160° sprinkler heads installed with a spacing of 10 feet between heads. The listed spacing of a heat detector is determined as the maximum distance from the fire to the point where the heat detector will actuate prior to any sprinkler head. Smoke detectors do not have a listed spacing. NFPA 72® permits a spacing of 30 feet between smoke detectors. Chapter 18 of this book covers listing procedures in detail.

Ceiling Height
The distance from the floor to the ceiling. It takes heat and smoke longer to reach and spread across a high ceiling. This becomes especially important for heat detectors when the ceiling height exceeds 30 feet. The critical point for smoke detectors is a ceiling height exceeding 28 feet. Ceiling heights below these marks are covered in the prescriptive requirements of the code.

Detector Time Constant
This is a measure of heat detector sensitivity. When the temperature at the ceiling reaches the threshold of a heat detector, the detector does not go into alarm

instantaneously. It takes some time for the sensing element to reach the temperature of the surrounding air. The detector time constant is a measure of the speed for this heat transfer. Annex B of NFPA 72®, The National Fire Alarm Code® provides a table for use by fire protection engineers conducting performance based design.

Listed Spacing	Temp 128 F	Temp 135 F	Temp 145 F	Temp 160 F	Temp 170 F	Temp 196 F
10 feet	400	330	262	195	160	97
15 feet	250	190	156	110	89	45
20 feet	165	135	105	70	52	17
25 feet	124	100	78	48	32	0
30 feet	96	80	61	36	22	0
40 feet	71	57	41	18	0	0
50 feet	59	44	30	0	0	0
70 feet	36	24	9	0	0	0
Listed Spacing	**FM All Temps**					
10 feet	196					
15 feet	110					
20 feet	70					
25 feet	48					
30 feet	36					
40 feet	0					
50 feet	0					
70 feet	0					

Diagram, NTC, d19.1

Heat release rate. This is the measurable production of heat from a fire. As a fire grows its rate of heat release increases. The benchmark for heat release rates is 1000 Btu / sec (1055 KW / sec).

This is an arbitrary benchmark. It is used to categorize fire growth. Fire growth rates can be determined through experimentation, or the power law fire growth model. Based on these, the following fire growth rates have been established.

Fire Growth Rate	Growth Time (Time to reach 1055 KW / sec)
Ultrafast	less than 75 seconds
Fast	75 seconds, up to & including 149 seconds
Medium	150 seconds, up to & including 399 seconds
Slow	400 seconds or longer

Diagram, NTC, d19.2

Annex B provides the fire protection engineer with heat release information on several common materials which may be involved in a fire scenario. These tables include:

1. Warehouse materials maximum heat release rates
2. Maximum heat release rates from fire detection institute
3. Unit heat release rates for fuels burning in the open
4. Furniture heat release rates

Warehouse materials.
Typical warehouse materials include stacked pallets, cartons, bottles, plastic parts and possibly fuel. All of these items are represented in the warehouse materials table.

The table includes the growth rate and the heat release density. Both of these are important for conducting performance based design calculations.

Maximum heat release rates from the fire detection institute.
This table provides typical heat release rates for standard types of objects including furniture and waste baskets. These heat release rates can be used for performance based design calculations.

Unit heat release rates for fuels burning in the open
This table includes the heat release rates for various fuel packages. It includes liquid fuels, and wood fuel packages of various sizes.

Furniture heat release rates.
There is a large variety of different types of furniture and density available for both residential and office type of environments. The heat release rates for typical furniture fuel packages are an important consideration in performance based design calculations.

Warehouse Materials

	Warehouse Material	Growth Time (sec)	Heat Release Density
			(kW / m2) (Btu / secft2)
1	Wood pallets stacked 1 1/2 ft	150-310 fast - medium	1248 / 110
2	Wood pallets stacked 5 feet	90-190 fast	3745 / 330
3	Wood pallets stacked 10 feet	80-110 fast	6810 / 600
4	Wood pallets stacked 16 feet	75-105 fast	10214 / 900
5	Mail bags filled 5 feet high	190 medium	397 / 35
6	Cartons stacked 15 ft high	60 fast	2270 / 200
7	Paper vertical rolls 20 ft high	15-28	
8	Cotton garments 12 ft racks	20-42	
9	Cartons on pallets 15-30 ft	40-280 fast - medium	
10	Paper products racks dense 20 ft	470 slow	
11	PE letter trays filled 5 feet	190 medium	8512 / 750
12	PE trash barrels 15 feet	55 fast	2837 / 250
13	FRP shower stalls in cartons 15 ft	85 fast	1248 / 110
14	PE bottles compartmented 15 ft	85 fast	6242 / 550
15	PE bottles cartons stacked 15 ft	75 fast	1929 / 170
16	PE pallets stacked 3 feet	130 fast	
17	PE pallets stacked 6 feet	30-55 fast	
18	PU mattress single horizontal	110 fast	
19	PE insulation board rigid 15 feet	8	1929 / 170
20	PS jars compartmented 15 feet	55 fast	13619 / 1200
21	PS tubes cartons 14 feet	105 fast	5107 / 450
22	PS toy parts cartons 15 feet	110 fast	2042 / 180
23	PS insulation board rigid 14 feet	7	3291 / 290
24	PVC bottles compartmented 15 ft	9	3405 / 300
25	PP tubes compartmented 15 ft	10	4426 / 390
26	PP / PE film in rolls stacked 14 ft	40	3972 / 350
27	Distilled spirits barrels 20 feet	23-40	
28	Methyl alcohol		738 / 65
29	Gasoline		2270 / 200
30	Kerosene		2270 / 200
31	Diesel Oil		2043 / 180
	Notes: PE polyethylene		
	PS polystyrene		
	PVC polyvinyl chloride		
	PU polyurethane		
	PP polypropylene		
	FRP fiberglass reinforced polyester		

Diagram, NTC, d19.3

Maximum Heat Release Rates from Fire Detection Institute

Materials	Approximate Values	Approximate Values
	kW	Btu / sec
Medium wastebasket with	105	100
milk cartons		
Large barrel w / milk cartons	148	140
Upholstered chair with	369	350
polyurethane foam		
Latex foam mattress	1265	1200
Furnished living room	4217-8435	4000-8000

Diagram, NTC, d19.4

Unit Heat Release Rates for Fuels Burning in the Open

Commodity	Heat Release Rate	Heat Release Rate
Flammable liquid pool	3291 / m2	290 / ft2 of surface
Flammable liquid spray	557 / lpm	2000 / gpm of flow
Pallet stack	3459 / m	1000 / ft of height
Wood or PMMA (verticle)		
2 feet high	104 / m	30 / ft of width
6 feet high	242 / m	70 / ft of width
8 feet high	623 / m	180 / ft of width
12 feet high	1038 / m	300 / ft of width
Wood or PMMA 9 (top horizontal)	715 / m2	63 / ft2 of surface
Solid polystyrene (verticle)		
2 feet high	218 / m	63 / ft of width
6 feet high	450 / m	130 / ft of width
8 feet high	1384 / m	400 ft of width
12 feet high	2352 / m	680 / ft of width
Solid polystyrene (horizontal)	1362 / m2	120 / ft2 of surface
Solid polypropylene (vertical)		
2 feet high	218 / m	63 / ft of width
6 feet high	346 / m	100 / ft of width
8 feet high	969 / m	280 / ft of width
12 feet high	1626 / m	470 / ft of width
Solid polypropylene (horizontal)	795 m2	70 / ft2 of surface
PMMA Polymethyl methacrylate (Plexiglass, Lucite, Acrylic)		

Diagram, NTC, d19.5

Furniture Heat Release Rates

Item Description / Mass	Growth	Fuel Fire Intensity	Virtual	Max Heat Release Rate
	Time in sec	(kW/sec2)/(Btu/sec3)	Time in sec	kW / btu per sec
Metal wardrobe 91.3 lb	50 fast	0.4220 / 0.4002	10	750 / 711
Chair (trial love seat) 64.4	400 slow	0.0066 / 0.0063	140	950 / 901
Chair initial 62.01 lbs	175 medium	0.0344 / 0.0326	110	350 / 332
Chair later 62.01 lbs	50 fast	0.4220 / 0.4002	190	2000 / 1897
Metal wardrobe 90 lb initial	250 medium	0.0169 / 0.0160	10	250 / 237
Metal wardrobe 90 average	120 fast	0.0733 / 0.0695	60	250 / 237
Metal wardrobe 90 later	100 fast	0.1055 / 0.1001	30	140 / 133
Chair 62.4 lb	350 medium	0.0086 / 0.0082	400	700 / 664
Chair 68.8 lb	400 slow	0.0066 / 0.0063	100	700 / 664
Chair 68.8 lb	2000 slow	0.0003 / 0.0003	150	300 / 285
Chair 42.3 lb	200 medium	0.0264 / 0.0250	90	800 / 759
Chair 63.9 lb	200 medium	0.0264 / 0.0250	360	900 / 854
Chair 30.9 lb	100 fast	0.1055 / 0.1001	70	1850 / 1755
Chair 64.4 lb	425 slow	0.0058 / 0.0055	90	700 / 664
Chair 61.3 lb initial	100 fast	0.1055 / 0.1001	100	2000 / 1897
Chair 61.3 lb later	60 fast	0.2931 / 0.2780	175	700 / 664
Chair 55.6 lb	60 fast	0.2931 / 0.2780	70	950 / 901
Chair love seat 87.3 lb	60 fast	0.2931 / 0.2780	145	2600 / 2466
Chair love seat 89.1 lb	80 fast	0.1648 / 0.1563	100	2750 / 2608
Chair sofa 113.5 lb	100 fast	0.1055 / 0.1001	50	3000 / 2845
Plywood wardrobe 151 lbs	35	0.8612 / 0.8168	20	3250 / 3083
Plywood wardrobe 150 lbs	35	0.8612 / 0.8168	40	3500 / 3320
Plywood wardrobe 79.4 lbs	40	0.6594 / 0.6254	40	6000 / 5691
Plywood wardrobe fire				
retardant interior initial	70 fast	0.2153 / 0.2042	50	2000 / 1897
Plywood wardrobe fire				
retardant interior later	30	1.1722 / 1.1118	100	5000 / 4742
Plywood wardrobe 149.1 lb	90	1.1722 / 1.1118	50	3000 / 2845
Plywood wardrobe fire				
retardant paint 81.14 lb	90 fast	0.1302 / 0.1235	30	2900 / 2751
Chair 62.48 lb	100	0.1055 / 0.1001	120	2100 / 1992
Chair 62.48 lb	45	0.5210 / 0.4941	130	2600 / 2466
Chair metal frame foam				
cushions 45.9 lb	170 medium	0.0365 / 0.0346	30	250 / 237
Easy chair 25.4 lbs	175 medium	0.0344 / 0.0326	90	950 / 901
Easy chair 34.57 lb	200 medium	0.0264 / 0.0250	50	200 / 190
Chair metal 36.42 lb	200 medium	0.0264 / 0.0250	120	3000 / 2845
Chair fiberglass 11.64 lb	120 fast	0.0733 / 0.0695	20	35 / 33
Molded plastic chair 24.82	275 medium	0.0140 / 0.0133	2090	700 / 664
Chair metal padded seat	350 medium	0.0086 / 0.0082	50	280 / 266
Diagram, NTC, 19.6				

Item Description / Mass	Growth	Fuel Fire Intensity	Virtual	Max Heat Release Rate
	Time in sec	(kW/sec2)/(Btu/sec3)	Time in sec	kW / btu per sec
Love seat metal with				
cushion 60.1 lb	500 slow	0.0042 / 0.0040	210	300 / 285
Chair wood cushion 24.7 lb	500 slow	0.0042 / 0.0040	50	85 / 81
Love seat wood with				
cushions 120.37 lb	350 medium	0.0086 / 0.0082	500	1000 / 949
Particleboard wardrobe				
120.33 lb	150 medium	0.0469 / 0.0445	0	1200 / 1138
Plywood bookcase 67.00	65 fast	0.2497 / 0.2368	40	25 / 24
Easy chair urethane 35.23	1000 slow	0.0011 / 0.0010	750	450 / 427
Easy chair 50.75 lb	76 fast	0.1827 / 0.1733	3700	600 / 569
Mattress & box spring				
137.48 lb initial	1100 slow	0.0009 / 0.0009	90	400 / 379
Mattress & box spring				
137.48 lb later	350 medium	0.0086 / 0.0082	400	500 / 474

Diagram, NTC, d19.7

Time of fire growth

This represents the time from the first flame to the point where the fire produces a heat release rate of 1000 Btu / sec (1055 KW / sec). The power law fire growth model is a specific formula which predicts how fast and large a fire will grow based on time. It shows the relationship that a fire grows faster and faster over time. The power law fire growth model follows this formula:

$$\text{Heat release rate} = \text{fire growth rate} \times (\text{time})^2$$

Annex B provides more detailed information on more advanced formulas for use by the fire protection engineer. All of the formulae are approximations. The reason for this is that the nature of fire is unpredictable. The calculations performed by the fire protection engineer will provide a simulated model of what could occur with an anticipated fire. The fact remains that a real fire may act in a very different way.

In real life, fire protection engineers do not perform (by hand) all of the calculations needed for a performance based design. Computer software is available which can take the variables into account and using fire model simulation help in determining an appropriate fire detection system using heat detectors or smoke detectors. Again, it is important to remember the unpredictable nature of fire. A computer generated solution is still only a guide and an actual fire may behave very differently.

For an example of how performance based design can be used to determine heat detector spacing, please refer to NFPA 72®, The National Fire Alarm Code® (2002 edition) pages 180-182 (B.3.3.6).

Performance based design for smoke detection systems are similar to that used for heat detectors, but it is more complicated. Smoke detectors have increased sensitivity to environmental factors and various types of detectors function differently for various types of smoke. Because of all the variables, computer generated solutions should be sought for the application of smoke detectors. Hand calculations are not practical.

Summary

It is important to remember the unpredictable nature of fire. Performance based design can be used to help in determining detection systems which provide a likely solution to the fire protection goals, but there is no guarantee. Performance based design falls into the scope of work for fire protection engineering and should be restricted to their purview.

Chapter 20

Principles of Smoke Movement in Buildings

The way in which smoke moves in and through buildings is an advanced concept in fire alarm detection systems. Understanding the principles of smoke movement in buildings will result in more effective fire alarm system design and safer buildings for the occupants. The major influences on smoke movement in buildings are:

1. Stack effect
2. Buoyancy
3. Expansion
4. Wind
5. HVAC Systems

Once the above influences are taken into account, the fire protection engineer can determine how best to manage the movement of smoke in the building. There are three primary ways in which smoke movement is managed in a building:

1. Compartmentation
2. Dilution
3. Pressurization

First, though, it is important to understand the nature of smoke. Smoke is produced by all fires in one form or another. Smoke is comprised of gases, solids and liquids which are airborne. A large part of the heat generated from a fire remains in the smoke plume and causes the smoke to expand and rise. Due to the temperature fluctuations, the smoke plume is turbulent and captures (entrains) much of the surrounding air. This entrainment can have the following effects:

1. Increase the volume and mass of the plume
2. Dilute the concentration of fire products
3. Cools the plume. The edges are cooler than the center

The amount of combustion products in the smoke plume is relatively small compared to the volume of air in the plume. Do not discount the deadly effects of the toxic gases

contained in smoke. Toxic gases can exist in sufficient quantity to cause death. In fact more people die from the effects of smoke than from the actual fire itself.

Smoke moves from areas of high pressure to areas of lower pressure. The temperature of smoke also determines how it will move. Hotter smoke will move toward the ceiling while cooler (and cleaner) smoke will move toward the floor. The farther the smoke moves from the source of the fire, the cooler the smoke becomes. As the smoke cools, it begins to act more like normal air. Also, as the particles in the smoke plume cool, they begin to coalesce (agglomeration). When the particles get large enough, they are deposited as soot.

Stack Effect

Stack effect can have a major influence on the movement of smoke through a building. It can be responsible for the wide distribution of smoke in high rise buildings. There are two types of stack effect: Normal stack effect and reverse stack effect.

Stack effect is caused by the difference in temperature inside the building compared with the temperature outside the building.

Building Height

Stack Effect

Temperature

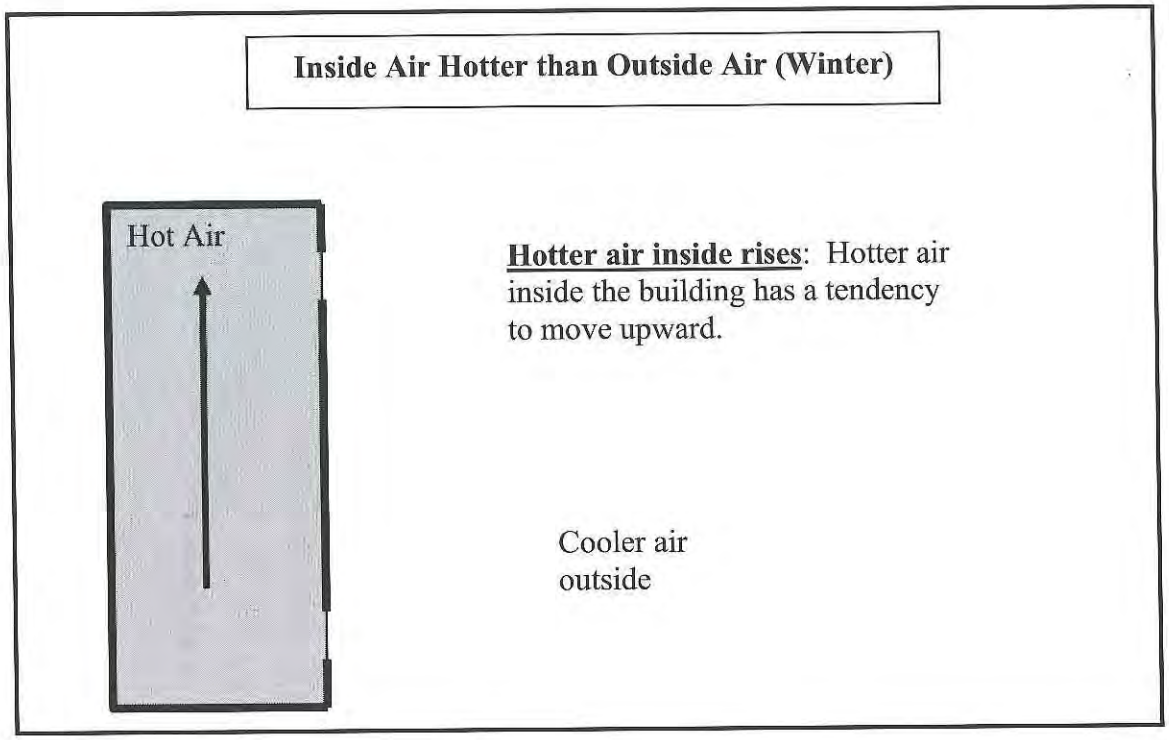
Buoyancy

Wind Effect

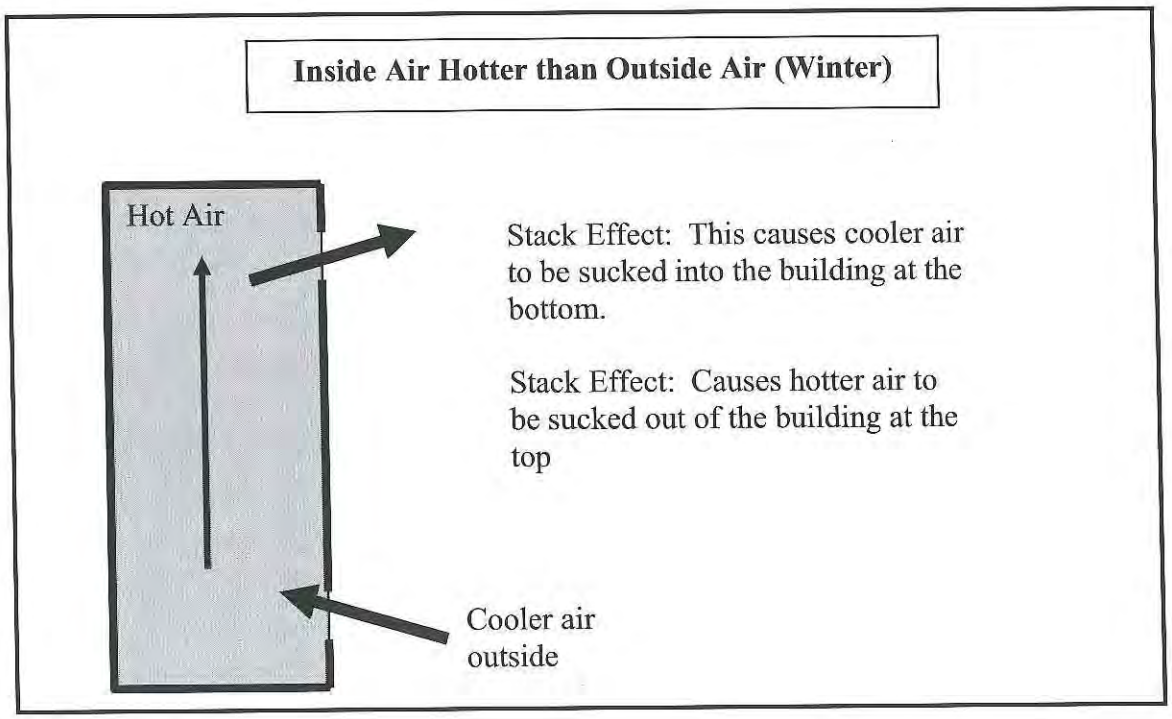
Expansion

Photo courtesy Taipei 101, World's Tallest Building, p20.1

When normal stack effect is present, the temperature outside of the building is lower than the temperature inside the building. When this condition exists, there is a strong movement of air from the floor to the ceiling. The strength of this stack effect movement is determined by the building height, air leakage, and the difference in the temperature. The diagrams on the next page illustrate this effect.



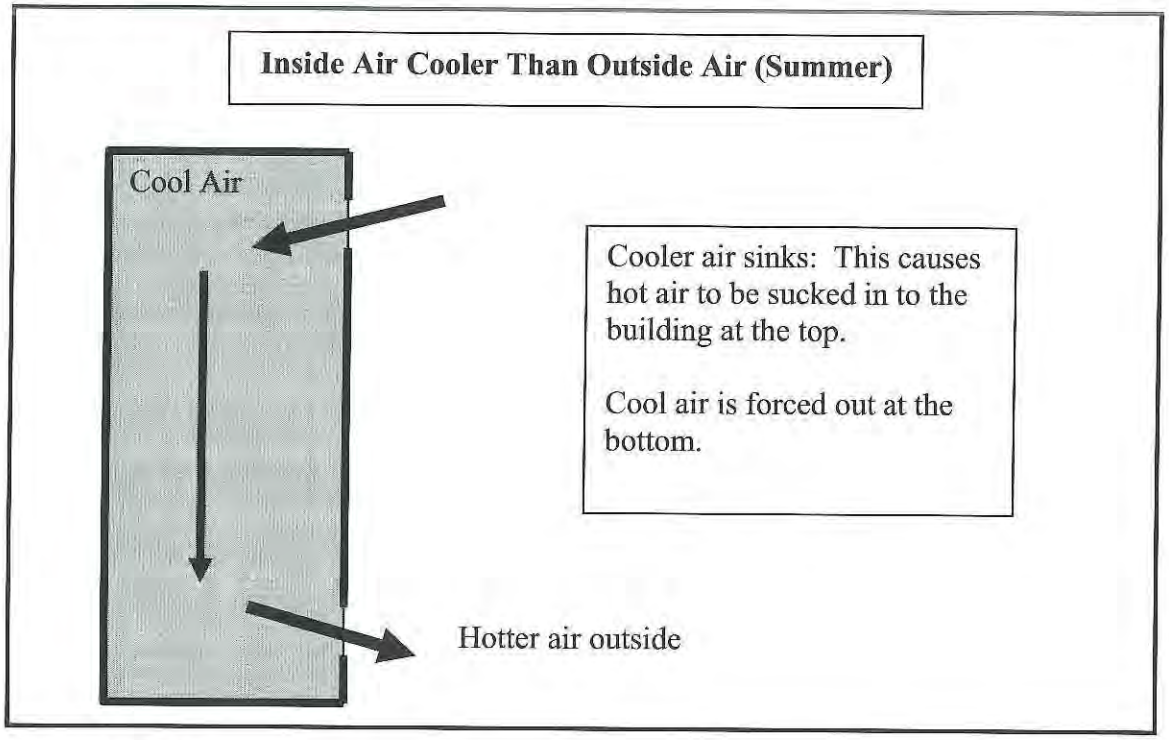
Diagram, NTC, d20.1



Diagram, NTC, d20.2

Reverse stack effect occurs when the temperature outside the building is greater than the temperature inside the building. With reverse stack effect air moves from the top of the

building to the floor. The influences for reverse stack effect are the same as for normal stack effect.



Diagram, NTC, d20.3

Buoyancy

Hot gases produced by a fire have buoyancy. This is due to the fact that smoke has a reduced density. This effect can cause higher pressure areas to form in the smoke compartment. As this occurs, buoyancy can cause increased pressure in the smoke compartment. In tall buildings, this buoyancy effect can become quite significant.

In some cases fan powered and nonpowered smoke management systems may be employed to reduce the effects of buoyancy. These areas usually have a floor to ceiling height of at least 33 feet. These areas may include places like atria, covered shopping malls, sports arenas, and exhibition halls. The following approaches can be used to manage smoke in these larger spaces:

Smoke Filling

This approach assumes all occupants will be able to evacuate prior to the large volume space being filled with smoke.

Unsteady Clear Height with Upper Layer Exhaust

This approach exhausts smoke from the top of the building in order to delay the descent of smoke. This delay will allow occupants the time needed for evacuation.

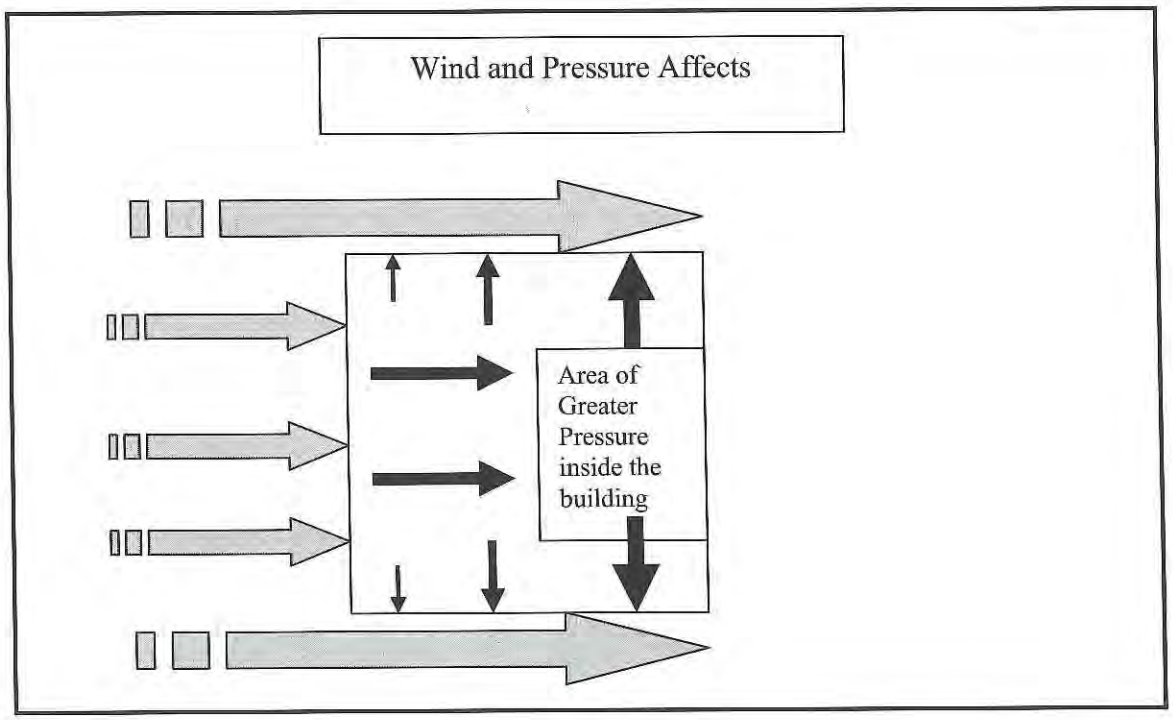
Steady clear height with upper layer exhaust. This approach exhausts smoke from the top of the building in such a volume equal to or greater than the rate of smoke production from the fire.

Expansion

Fires release energy which, in addition to buoyancy, can cause the movement of smoke due to expansion. Smoke compartments with one opening allow smoke to flow out of the opening and air to flow in. In enclosed smoke compartments, expansion will also increase pressure. The smoke compartment will become pressurized. Any opening will allow larger volumes of smoke to flow out of the smoke compartment.

Wind

The wind can exert pressures on buildings which may have an effect on smoke movement. The height of the building is important in determining how large this effect may be. The following diagram demonstrates how wind can affect pressure in the building. Consider this diagram as a view from above the building looking down on the roof.



Diagram, NTC, d20.4

The effects are:

1. Winward wall has an inward pressure
2. Leeward wall (away from the wind) has an outward pressure
3. The two side walls have an outward pressure

These pressures are the result of air moving over and around the building. A short building which is wide will have most of the air moving over the roof, with less moving around the sides.

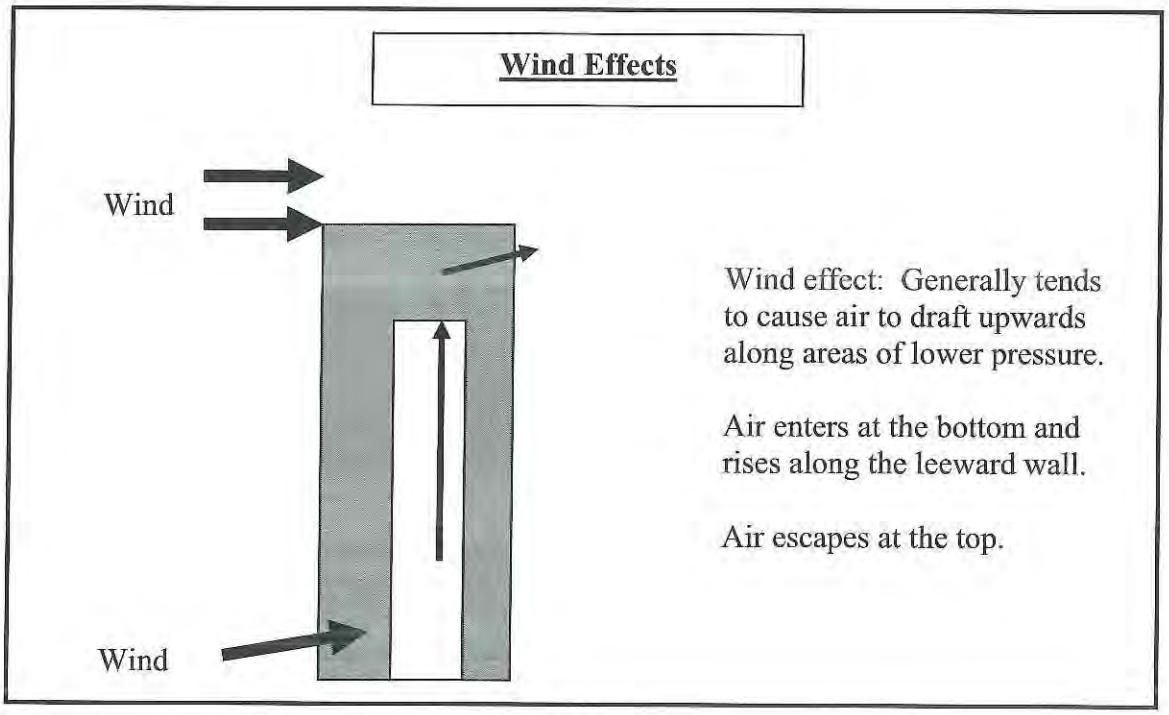
A tall building which is more narrow will have more wind moving around the sides and less air flow over the roof. The air velocities are the main cause of the amount and direction of pressure exerted upon the building.

The most important wind effects are as follows:

1. Velocity of the wind.
2. Wind velocity at the ground level (Ground Effect). The wind velocity at ground level is usually less than at higher elevations.
3. Buildings and other structures which can change wind conditions.

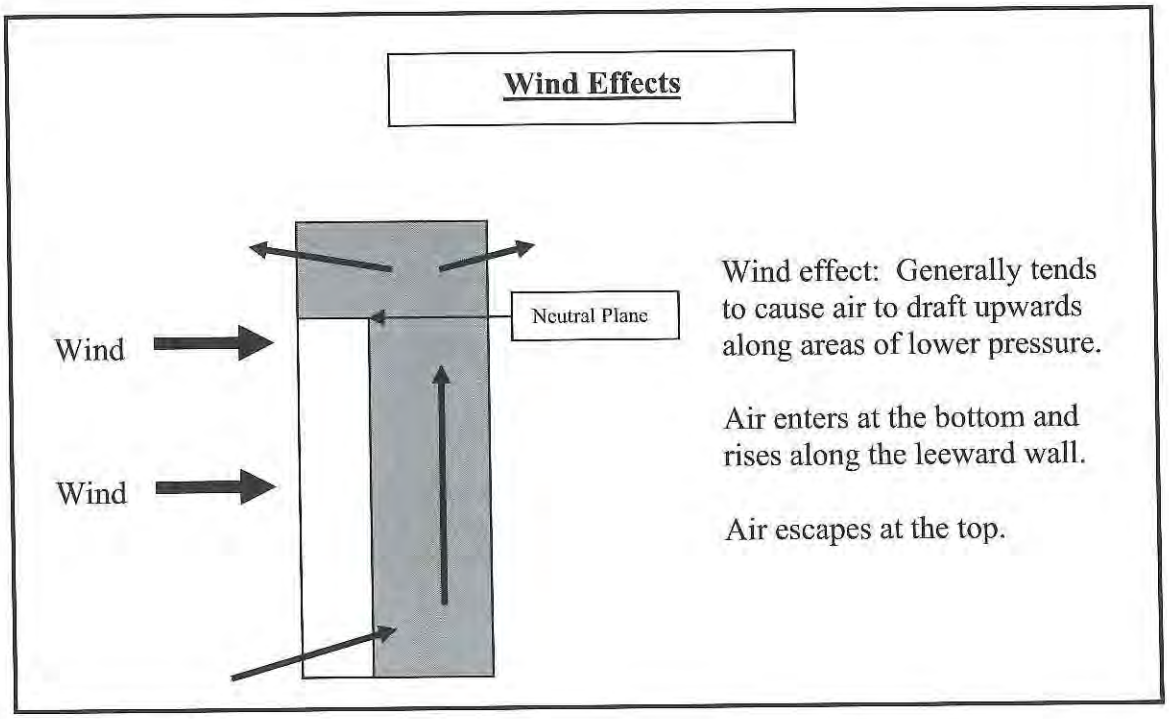
The effect of wind can change the air movement in a building. Consider a high rise with an open shaft at the roof. If a strong wind is present flowing over the roof, it can have a drawing effect.

This drawing effect can cause air to flow from lower levels in the building up toward the opening on the roof. The diagrams below demonstrate the effects wind can have on a tall building.



Diagram, NTC, d20.5

Horizontal pressure on the building can cause the neutral planes in the building to change. Positive wind pressure tends to cause the neutral plane to rise in elevation. Negative wind pressure causes the neutral plane to settle at a lower level.



Diagram, NTC, d20.6

HVAC Systems.
HVAC systems are typically shut down in the event of fire. Many professionals do this to prevent the HVAC system from transporting smoke to other parts of the building during a fire. Additionally, the HVAC system provides a source of fresh air (oxygen) to the location of the fire. For these reasons the HVAC system is normally shut down during a fire. This shut down does not prevent smoke movement through the ducts and shafts. The most important function of the HVAC shutdown is to stop the supply of fresh air to the fire source.

Smoke Management
The term smoke management includes the methods which can be used to modify smoke movement. The purpose of this is to provide clear routes for evacuation of occupants, movement of responding fire fighters and property protection. The ways this is accomplished include compartmentation, dilution and pressurization.

Compartmentation
Fire rated barriers, walls, partitions, floors and doors are proven effective tools for providing protection from the spread of fire. They also provide barriers to smoke movement. NFPA 101® and other codes may require the installation of smoke control

barriers including smoke doors and dampers. Smoke leakage can occur even when these items are in place. The full impact of such leakage depends on several factors including the toxicity of the smoke. This compartmenting of the smoke provides for effective protection for a certain time period, but not indefinitely.

Dilution

Smoke dilution or purging is accomplished by exhausting smoke from an area. Dilution can be used to maintain a relatively smoke free compartment. If adjacent compartments have higher levels of smoke, some leakage may occur. As long as the leakage is small in comparison to the exhausting ability of the compartment dilution can be effective.

Dilution can also be used by the fire department for removing smoke after a fire has been extinguished. Dilution has limited application. Some expectations may be unrealistic in terms of the effectiveness of dilution. HVAC systems used for dilution have relatively little effect on the dilution of smoke in a compartment. The reason for this is a fire produces large amounts of smoke compared to the transport capabilities of the HVAC system.

Pressurization

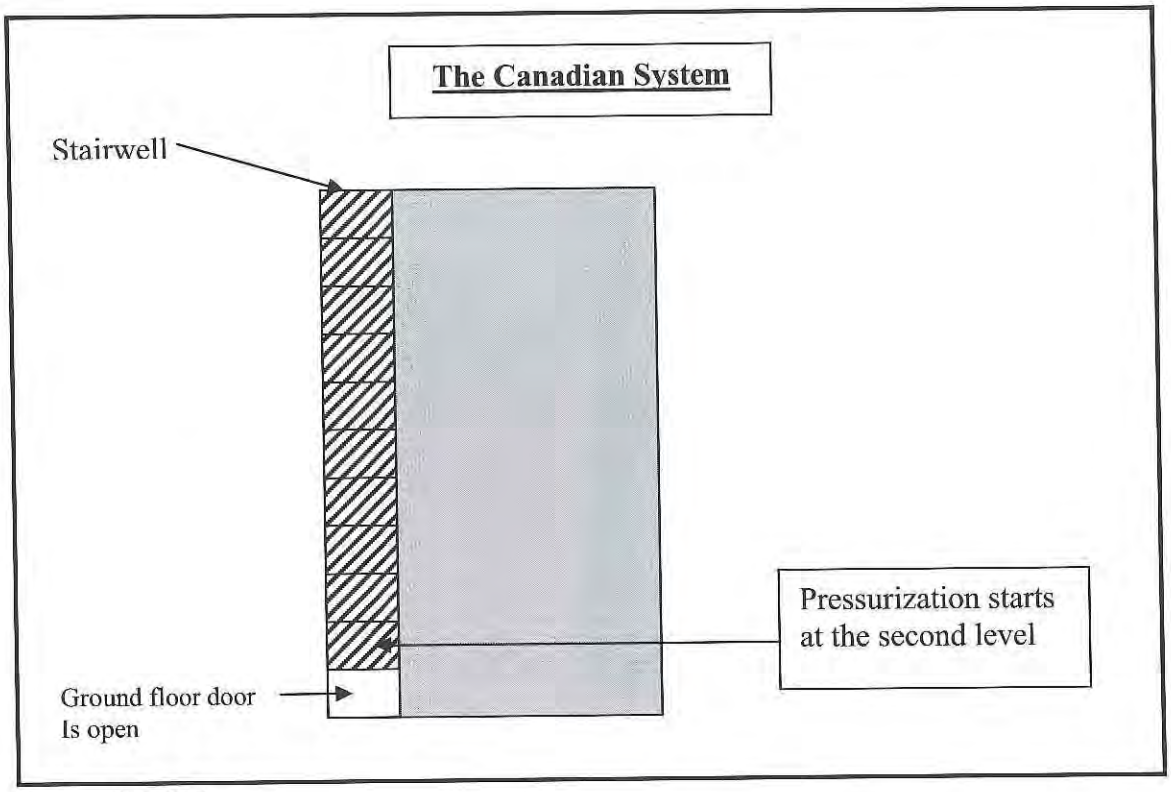
Pressurization produced by fans is a form of smoke control. Pressurization causes high velocity airflows around closed doors and construction cracks thus preventing smoke backflow through these openings. The most common use of pressurization systems are stairwells and zoned smoke control compartments.

Stairwell pressurization has as its goal to maintain a tenable environment in the area of occupant evacuation, namely the stairwell. A pressurized stairwell is designed to limit the amount of smoke which will enter the stairwell, not keep the stairwell smoke free. Pressurization system design must consider the three biggest factors in developing an effective system.

1. Pressure variances over the height of the stairwell
2. Large fluctuations in pressure due to the opening and closing of stairwell doors
3. The location of supply air inlets and fans

Pressure between the stairwell and the building will vary at different heights. The pressure variation at the 34th floor will be different than the pressure at the 3rd floor. This difference results from other shafts in the building and also imperfections in construction. All floors and walls are not air tight. Computer modeling can be used to predict these differences for a particular building.

The opening of a stairwell door can dramatically decrease the pressure throughout the stairwell. The door which has the single largest impact is the ground floor exterior door, because it is opened more than the other doors in the stairwell. This has been the source of design problems in the past. There is an over pressure relief system which has gained in popularity recently, referred to as the Canadian System.



Diagram, NTC, d20.7

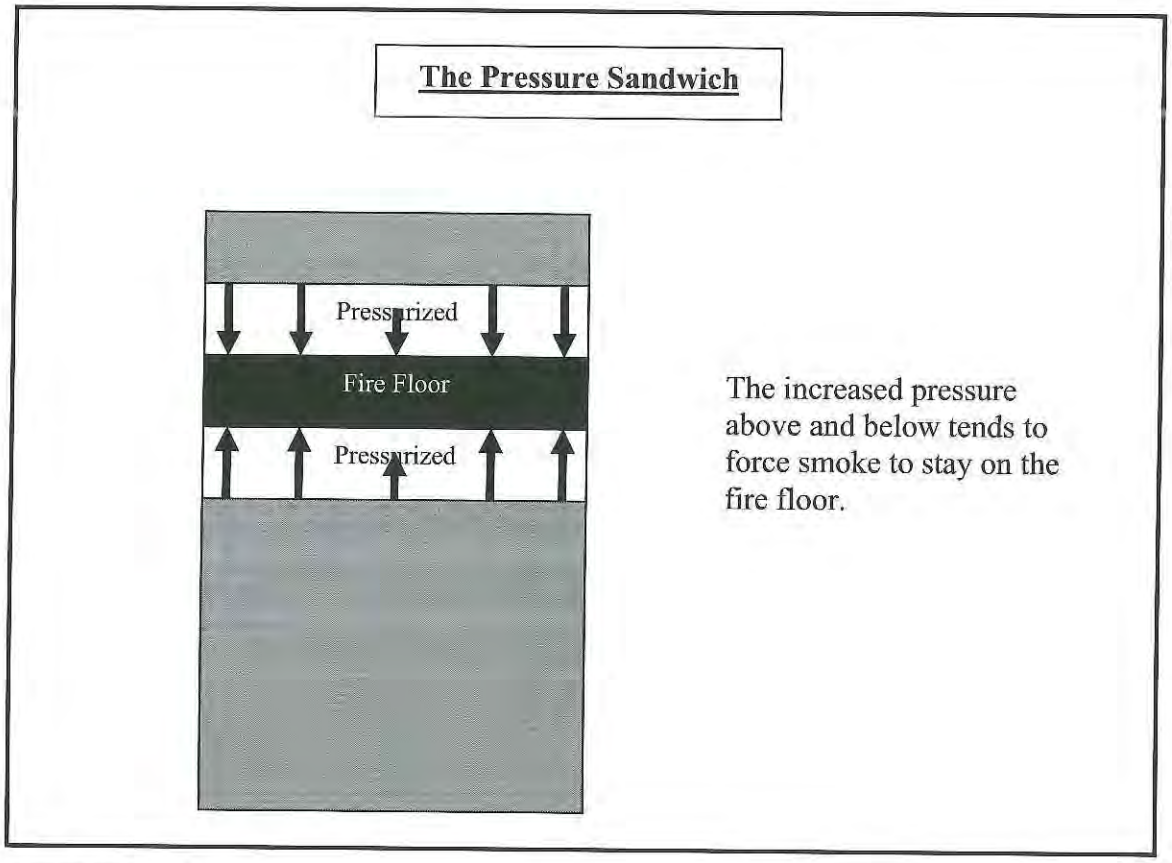
This pressurization system automatically opens the ground level exterior door when the system is in operation. This reduces the fluctuations caused by the ground level exterior door.

Additionally the pressurization system is designed to start pressurizing at the floor above the ground level exterior door. This forms a pressurization barrier which helps to maintain higher, more constant pressure throughout the stairwell.

Pressure Sandwich

Zoned smoke control (pressure sandwich) is another method of controlling smoke movement. This method exhausts smoke from the fire floor. The floor above and the floor below are pressurized to limit the movement of smoke from the fire floor.

The building can be divided into smoke zones by floor, by multiple floors or by a part of a floor. Mechanical fans can be used to produce the required pressurization in order to confine the smoke to its smoke zone.



Diagram, NTC, d20.8

One critical factor in using a zoned smoke control system is the proper identification of the location of the fire. The building fire alarm system and sprinkler system have to be zoned appropriately in order for this approach to be effective. Failure to properly identify the smoke zone may result in a pressurization configuration which will cause the fire to grow and spread more rapidly. Zoned smoke control is not intended to improve condition in the fire zone. Therefore, occupants should evacuate the fire zone as soon as possible.

Summary

Smoke control is an important aspect of fire protection engineering. There are many factors which can influence the movement of smoke in buildings. Wind effect, stack effect, buoyancy, and expansion are just a few. There are certain things which can be done to limit or control smoke movement such as pressurization. Using this to make the building a safer place is the goal of fire protection engineering.

Chapter 21

Fire Hazard Analysis

Fire safety programs have been developed in the past based on the professional judgments of experts. Today a more formal approach is starting to take hold. This new approach is based on engineering principals and is called Fire Hazard Analysis. Fire hazard analysis is part of a comprehensive risk analysis. Risk analysis is a tool used by insurance companies to determine the insurance rates of their clients. Risk analysis primarily considers monetary losses (property damage). Fire hazard analysis is focused on hazards to life and sometimes property.

A fire hazard analysis should only be conducted by a professional qualified with such methods. Normally a fire protection engineer will conduct a fire hazard analysis. There are specialized tools which the fire protection engineer uses to assist in the process such as computer modeling. The typical steps involved with a fire hazard analysis are:

1. Selecting a target outcome
2. Determining the scenarios of concern
2. Selecting the method of prediction
4. Evacuation calculation
5. Analyzing the impact of exposure
6. Examining the uncertainty

Selecting a Target Outcome
The most common target outcome for a fire hazard analysis is to sustain no fatalities of occupants. Providing fire fighters with a protected area might be another target outcome. The US Dept of Energy (DOE) requires a fire hazard analysis for all of their buildings. The objectives they list in DOE 5480.7a are:

1. Minimize the potential for fire
2. Prevent any release of radiological or other hazardous material which will threaten health, safety or the environment
3. Provide an acceptable degree of life safety for DOE and contractor personnel, and no undue hazards to the public from fire
4. Protect critical process control or safety systems from damage by fire

5. No interruption of mission critical processes
6. Limit property damage to acceptable levels ($150 million per incident)

An insurance company could wish to limit the maximum loss which affects the rates paid by the customer. A manufacturing facility would desire to limit the affect on production and shipping which might be caused by a fire. Other businesses may have a critical need to provide a safe and comfortable place for their customers. All of these are valid target outcomes for a fire hazard analysis.

Determining the Scenarios of Concern

The next step is to determine which fire scenarios could result in the unwanted outcomes. Past experience can play a big role in this. If fire scenarios have occurred before in similar buildings, they can be used as a model. Statistical information from a variety of sources can also help in determining the fire scenarios of concern.

Most major fire disasters have one thing in common. A series of failures caused the extent of damage. Because of this, it is helpful to analyze the worst case scenario. For example, the fire hazard analysis for the DOE, in one part, assumes that the automatic systems fail, and the fire department fails to respond.

This approach helps to identify those systems which are really important. For example, consider a building with a fire alarm system and a sprinkler system. If the fire alarm system fails, the activation of the sprinkler system can limit the damage of the fire and visa versa.

But if both systems fail, the resulting fire could be much more devastating. This methodology helps to identify the systems which are really critical to limiting the damage from a fire scenario.

Selecting Design Fires

Selecting relevant fires to compare with the fire protection design is very important to conducting an accurate fire hazard analysis. The purpose of the design fires is to provide a test for the effectiveness of the system. This comparison will reveal whether the design will effectively meet the goals. The design fire should be categorized by growth phase, steady burn phase, and decay phase.

It is important to select an appropriate growth rate for the design fire in order to accurately gauge the activation of the fire alarm or sprinkler system. Additionally, this is important in determining the start of occupant evacuation and the point of initial exposure of occupants.

For most flaming fires, their growth can be simulated using the power law growth formula. This formula identifies the predictable nature of flaming fires based on a stable source of fuel. Fires are classified by the speed with which they reach a heat release rate of 1055 KW / sec. The following table details these categories:

Fire Growth Rate	Growth Time (Time to reach 1055 KW / sec)
Ultrafast	less than 75 seconds
Fast	75 seconds, up to & including 149 seconds
Medium	150 seconds, up to & including 399 seconds
Slow	400 seconds or longer

Diagram, NTC, 21.1

Slower growth curves are fueled by thicker and heavier solid objects like solid wood furniture. Medium growth curves are typical of objects with a lower density such as upholstered furniture and full mail bags. Thin combustible items make up the fuel package for fast fires, such as paper, cardboard, and stacks of pallets. Ultrafast growth rates are typical of flammable liquids.

If the fuel package is a highly mixed collection of fuels, it is appropriate to select a medium growth curve for the fire hazard analysis. That is, as long as none of the fuels is a highly flammable item. The power law growth formula represents a relatively large stable flame for the fuel. If the ignition source is small, an incubation period may be required prior to the flame being stable enough to apply the power law growth formula. This can result in a slower response time from the fire alarm system than what the design may have predicted.

Steady Burning

The heat release rate will go into a steady burning phase when all the surface area of the fuel is burning. In most cases, the steady burning phase will occur at a post flashover level. Post flashover fires can be controlled by controlling the ventilation to the fire. This is advantageous because it is relatively easy to specify sources of air. Fires which reach steady burn in pre flashover are less common and are fuel controlled.

Decay

As the fuel is consumed by the fire, the burn rate decreases. An engineering approximation indicates the decay rate as the inverse of the growth curve. In other words, fast growth fuels decay fast and slow growth fuels decay slow. It is assumed that decay begins approximately when 20% of the original fuel is left. Additionally, decay will occur even in the presence of an activated sprinkler system. Although the decay will occur much more quickly, it will still take place.

Selecting Appropriate Methods of Prediction

There are at least 62 models and calculation methods which could be applied to fire hazard analysis. Because the nature of fire is unpredictable, choosing the methods best suited to the application is very difficult. Some basic methods of hand calculation tend to provide useful data for many fires, but when public safety is at stake, solely using hand calculation methods may not be appropriate. When public safety is a primary concern, actual fire models (or appropriate testing) should be used. Computer generated fire models can provide more accurate and detailed information for the fire hazard analysis. It is also possible for computer modeling to take into account other factors like adjacent

rooms, ventilation concerns, additional fuel packages, flashover etc. The model should consider all of these things or the result could be over estimating the conditions in the room of origin and under estimating the conditions in other rooms.

Heat transfer calculations are another aspect of the model which should be considered. While they may take up a great deal of computer time, they are necessary for accurate results.

When it comes to fire hazard analysis, it is important to select a computer model which is rigorously tested and has a history of documented results. This is important for code compliance and litigation. The model should come with a comprehensive technical guide which describes in detail the physics, chemistry, assumptions and limitations of the model.

It should also provide an accuracy comparison between the results from the model and actual experimental data. Public exposure and review are necessary for the model to have credibility. ASTM publishes a Standard Guide for Documenting Computer Software for Fire Models (ASTM E1472-92). Computer model documentation should comply with this standard.

The data entered into the computer model directly affect the results the model produces. If the input data is incorrect, the data generated by the model will be incorrect. Properly specifying the fire is the most important piece of input data for the computer model.

Secondly, specifying the sources of air supply to the fire location. This includes open doors, windows, cracks behind doors etc. Most large fires are ventilation controlled (post flashover) making the sources of air supply important for correct predictions. Ignition characteristics of secondary fuel items and heat transfer to ceilings and walls are also significant. The fire hazard analysis should include a listing of these values and how they were determined.

Performing an Evacuation Calculation

This is a very important step in the overall fire hazard analysis. It is important for evacuation to occur prior to the existence of untenable conditions. Evacuation calculations can be done by hand or by computer modeling. The calculations for evacuation are easier than the calculations for predicting the fire. Computer models still hold an advantage in accuracy and time savings over hand calculations. There are several factors which influence evacuation time. Some of the more significant considerations are:

1. Time for detection and notification
2. Time it takes for occupants to decide to take action
3. Time for movement out of the building

When the building has a large population of occupants, computer models are preferred to hand calculations. Congestion can occur at stairwells, crowded conditions can slow the

evacuation and smoke definitely can play a major role in evacuation time. A computer model is quicker and more accurate at predicting the evacuation time.

Analyzing the Impact of Exposure

Computer models, again, are the preferred method for analyzing the impact of exposure. There are a few products available which perform this analysis and provide reasonable results. Toxicology, heat and exposure time are all important considerations. Assessing the impact of exposure to sensitive equipment is more difficult due to lack of experimental data.

Accounting for Uncertainty

The intent of the fire hazard analysis is to provide a worst case scenario. Therefore, fire protection engineers generally believe that an additional safety factor is not needed. However, in terms of the evacuation calculation, it is recommended that an uncertainty factor of 2 be used. This should account for the unknown variability in any population. If for instance, the evacuation calculation predicted an evacuation time of 12 minutes, we would use the uncertainty factor of 2, making the time 24 minutes.

The fire hazard analysis should include a section regarding uncertainty. It should address the data used and the sensitivity of the results. Also, it should include the assumptions made in the fire hazard analysis. This narrative should also include the appropriateness of the calculation models used.

Sometimes a computer model or calculation can produce a result which seems contrary to common sense. If this happens, the model is probably wrong. If the solution seems to be logical, it probably is correct. It is important to note, the nature of fire is unpredictable. We can make a guess using the most sophisticated tools available, but in the end, an actual fire may behave in a drastically different fashion.

Summary

Engineering level work for fire alarm systems includes performance based design, principles of smoke movement in buildings and fire hazard analysis. These concepts are to a large degree, our attempt to predict the unpredictable. They provide us with tools which can be used to generally predict certain situations. And as a result, provide a better fire protection solution for the protection of property and life. Remember the 3 rules:

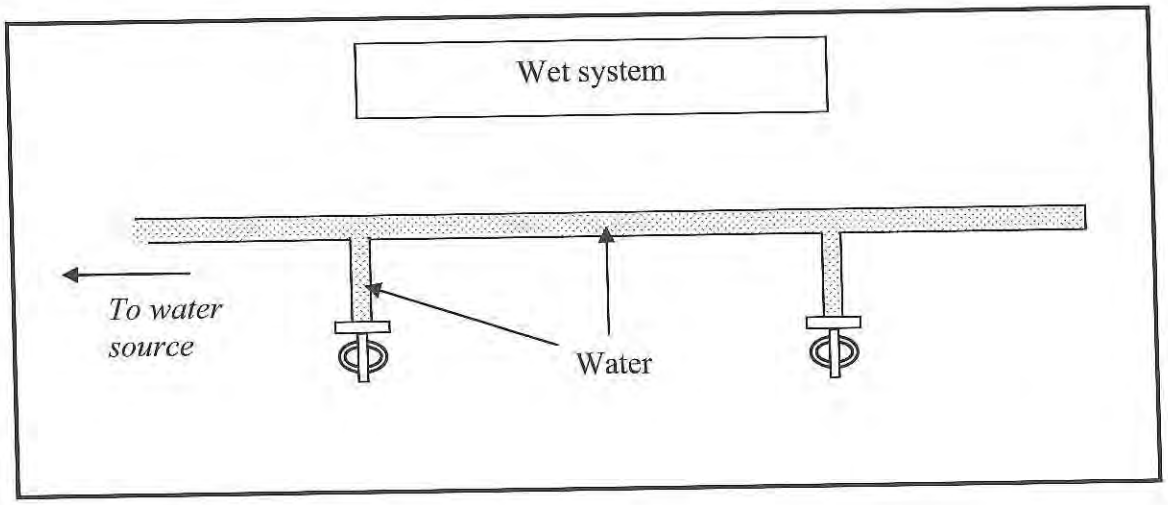
1. The Nature of Fire is ALWAYS unpredictable.
2. Performance based design is ALWAYS used to increase the level of protection above the prescriptive requirements of the code.
3. Performance based design should only be done by qualified Fire Protection Engineers.

Chapter 22

Extinguishing Systems

When automatic extinguishing systems and fire alarm systems are installed in the same building the extinguishing system is should be supervised by the fire alarm system. The fire alarm system monitors the extinguishing system for activation and off-normal conditions. Automatic detectors may also be used to activate the extinguishing system. There are many types of extinguishing systems, some of which are discussed below.

Wet Systems
Wet systems have pipes that are connected to a water source and permanently fixed with water under pressure. The pipes are terminated in sprinkler heads, which have heat actuated valves on them. When a sprinkler head is activated (usually by melting an element or causing a glass vial fixed with liquid to break) the water is released. These systems are automatic; meaning when they detect fire, they activate. Wet systems can cause water damage to the facility they are protecting. They are typically not used in environments where freezing is a concern (frozen pipes can burst).



Diagram, NTC, d22.1

Preaction Systems

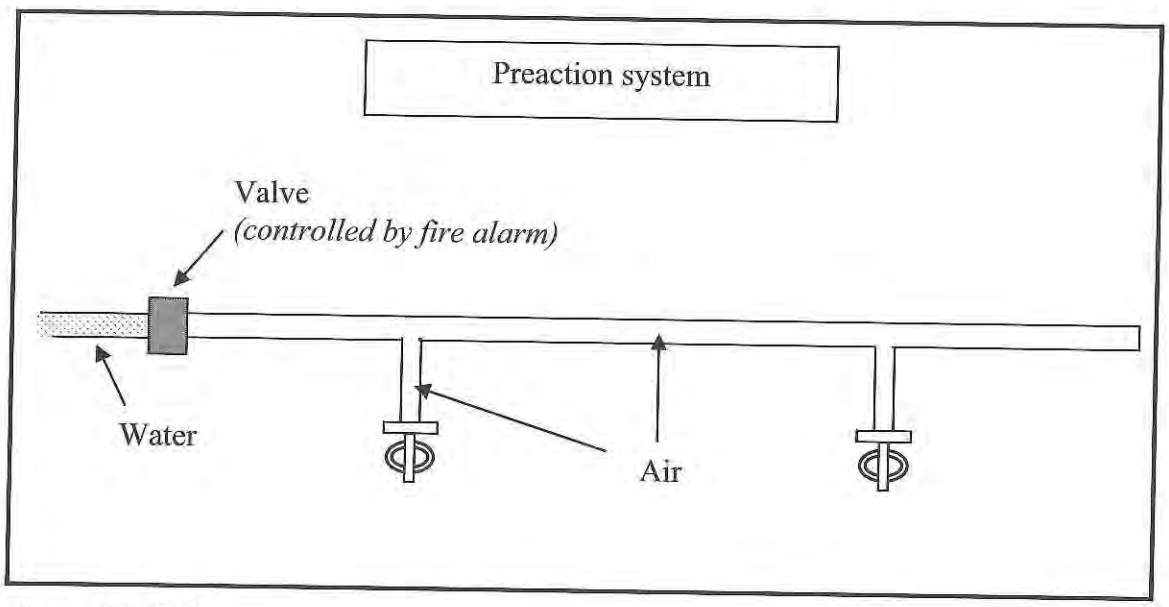
A preaction system differs from a wet system. Preaction system piping is charged with air under pressure, not water. A valve prevents water from flowing into the piping.

Preaction systems are always used in conjunction with fire alarm systems. The fire alarm system uses smoke detectors which respond to a fire more quickly than the sprinkler heads. When a smoke detector actuates, the fire alarm system opens a valve which permits water to fill the sprinkler system piping.

Then, when a sprinkler head actuates the water is already in a position to be discharged on the fire. The sprinkler system has a constant source of water which flows to the actuated sprinkler heads. The water is distributed directly into the area where the source of the fire exits.

Preaction systems may be used in areas where freezing pipes are a concern. Generally preaction systems are used in areas where the prevention of water damage is important. These areas may include facilities with record storage or storage of valuable items.

The benefit which preaction systems offer is the requirement for alarm detection from two technologies prior to the discharge of water. This dual aspect of preaction systems provides a more reliable system of fire detection. If both the fire alarm system and the extinguishing system detect a fire condition, it is likely to be a real fire.

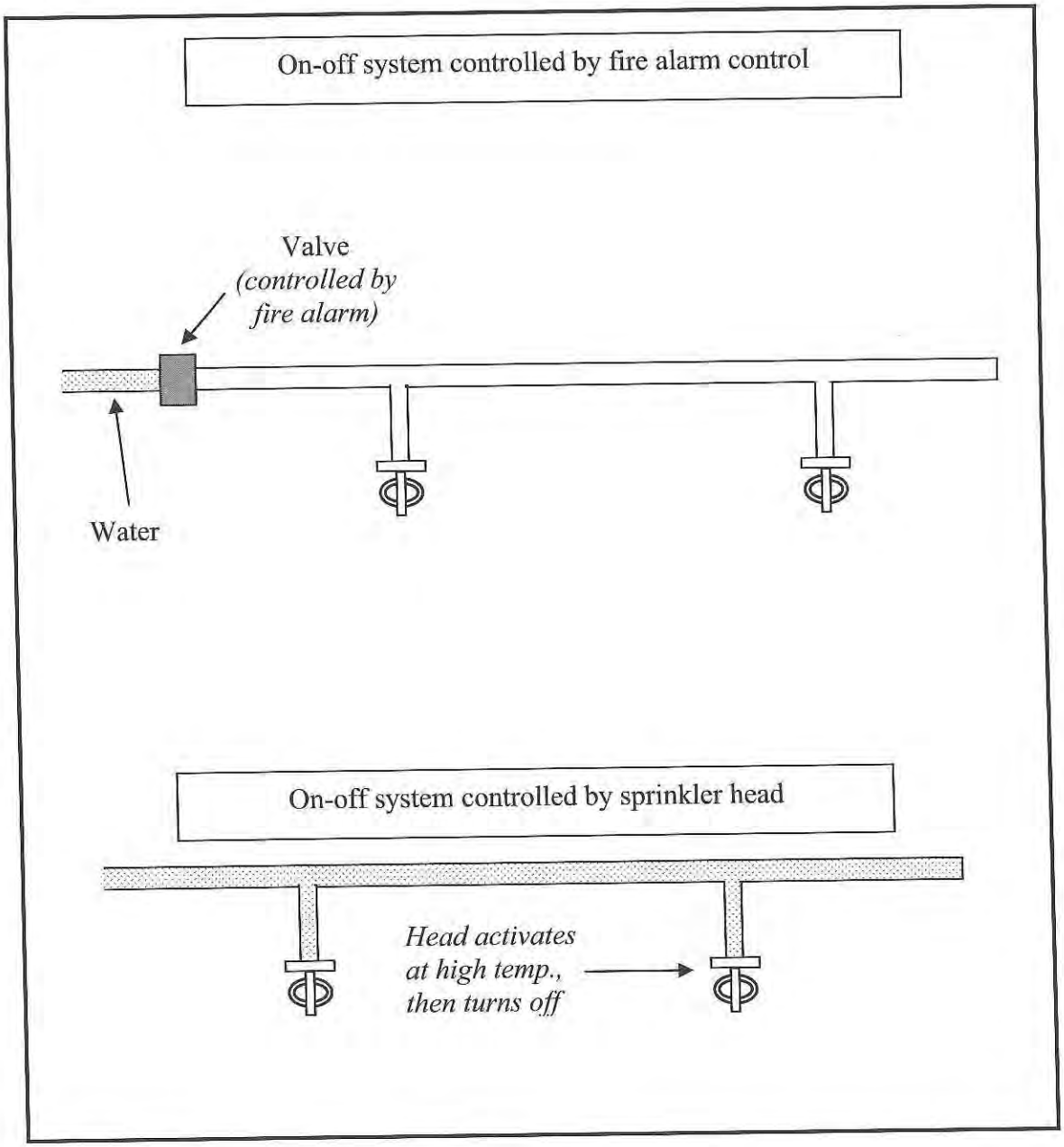


Diagram, NTC, d22.2

On-Off Systems

On-off systems are similar to preaction systems, except that the fire alarm system shuts off the water when the extinguishing system is no longer needed. The fire alarm control opens the valve to allow water into the system when a predetermined temperature is reached, and closes it again when the temperature returns to normal.

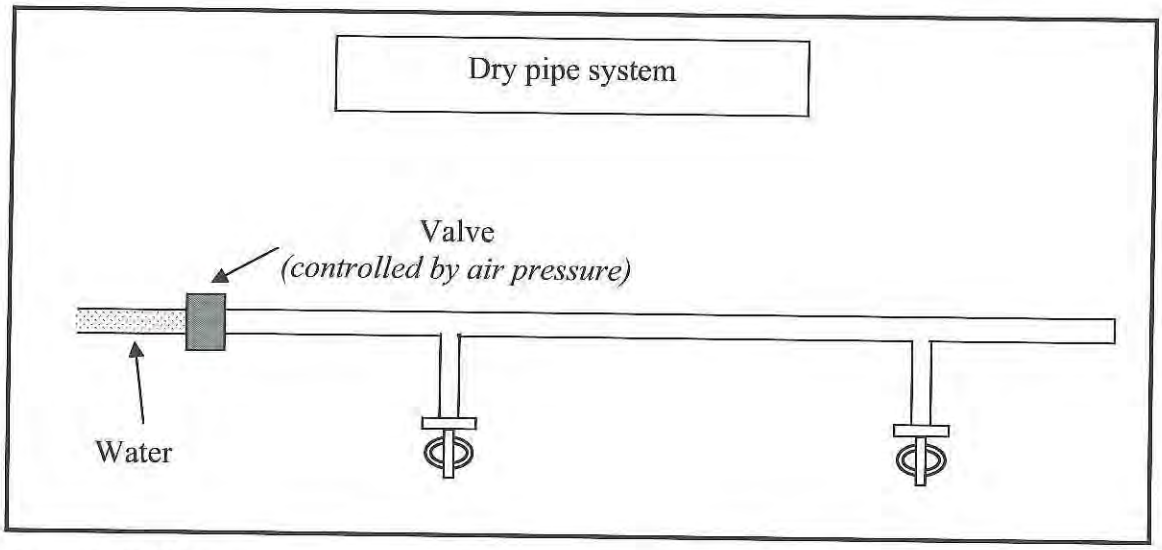
Another variation of the system uses a wet pipe system with on-off sprinkler heads. The heads themselves control the water flow directly. Since on/off systems control the flow of water they are less likely to damage critical items.



Diagram, NTC, d22.3

Dry Pipe System

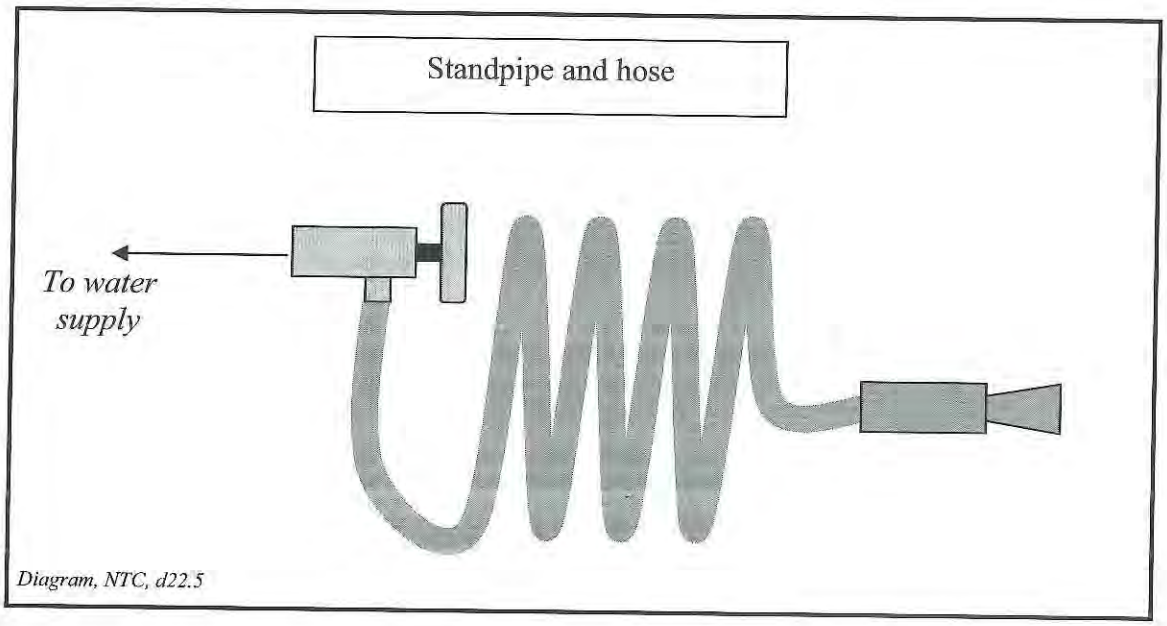
Dry pipe systems are like pre-action systems but the valve is not controlled by the fire alarm system. The piping contains pressurized air that holds a water valve closed. When a sprinkler head is activated, the air pressure is released and the valve opens, allowing water to flow out of the open sprinkler head. There is a delay, because the air has to be expunged prior to the discharge of water. Dry pipe systems can protect areas prone to freezing, but the water supply must be protected from freezing as well.



Diagram, NTC, d22.4

Standpipe and Hose System

Standpipe and hose systems provide piping in a building with hoses connected to it for emergency use by the building occupants, trained staff, or the fire department. This type of system is typically installed as a compliment to an automatic system.

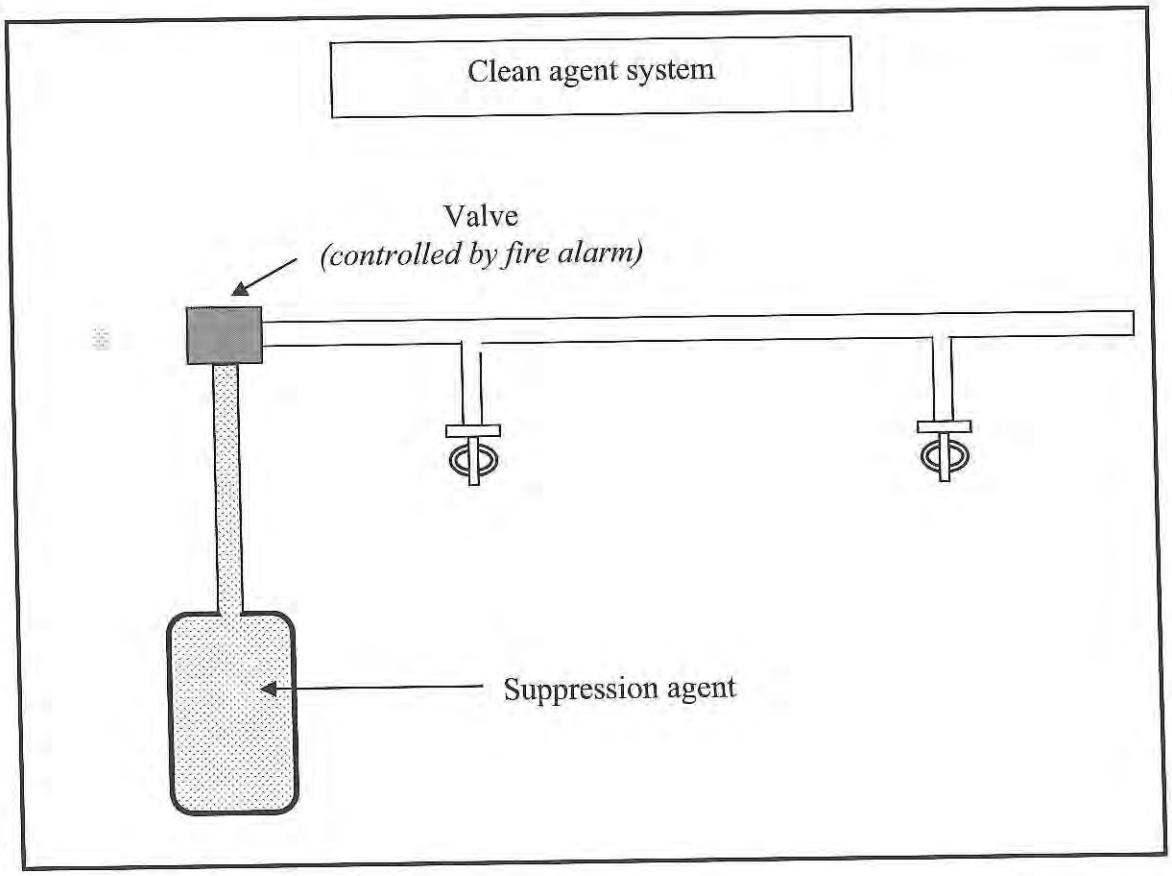


Diagram, NTC, d22.5

Clean Agent System

Extinguishing gas under pressure is fed through piping and out heads when the system is activated by automatic detector operation or manual initiating device operation. The chemical agent helps inhibit the reaction of fuel and oxygen, thus choking out the fire.

The fire alarm system, which must be properly listed for releasing service, usually incorporates a delay circuit to allow the release of the agent to be aborted. Older systems used Halon, but since Halon has been banned due to environmental concerns, newer chemicals have been developed. Clean agent systems are popular because they generally do not damage the material they are protecting.



Diagram, NTC. D22.6

Carbon Dioxide System

Carbon dioxide systems work the same way as clean agent systems, but use carbon dioxide to extinguish the fire. The carbon dioxide reduces the amount of oxygen available to the fire. This oxygen reduction also requires that personnel be evacuated before system activation to avoid suffocation. These systems are used for service and utility areas. They are effective on surface fires, but are not very effect in suppressing deep-seated fires in ordinary combustibles.

Dry Chemical System

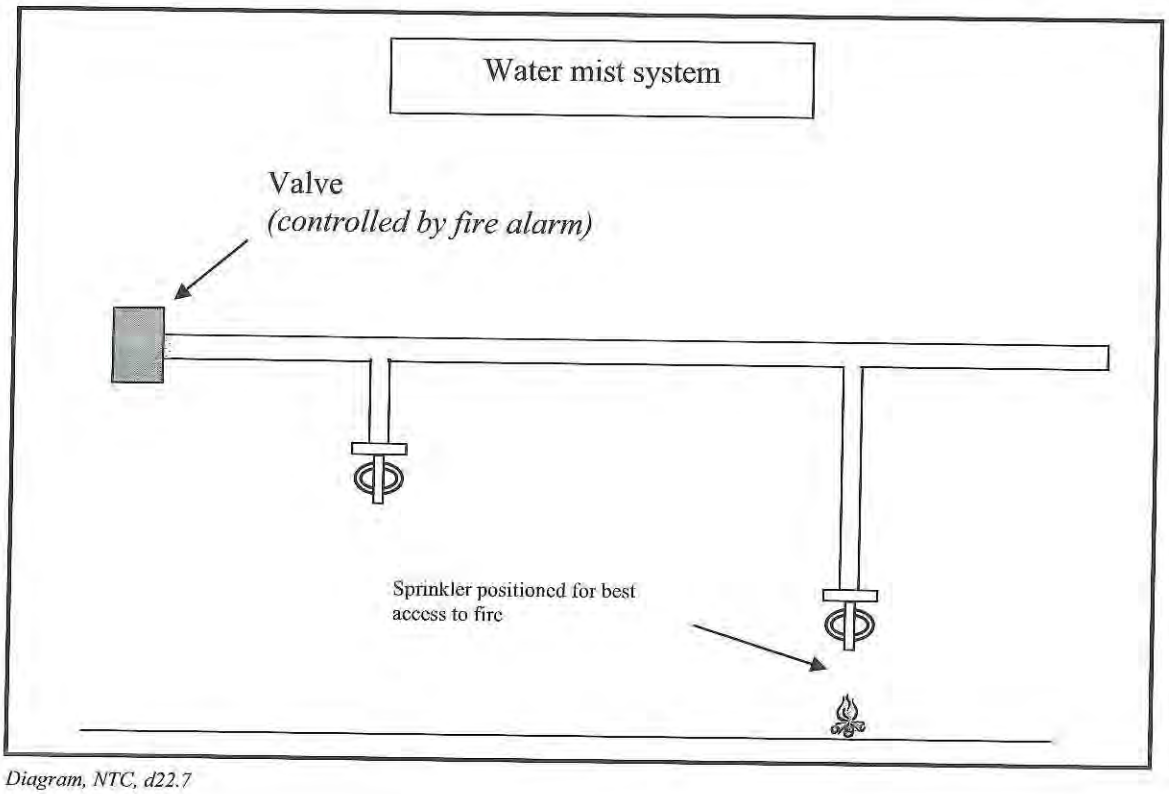
Dry chemical systems work in the same way as clean agent systems, but use dry chemical powder released directly by the sprinkler head. Dry chemical extinguishing is common in range hood and duct systems. Unfortunately, it leaves powder all over the area, so it must be cleaned up. These systems should not be used in areas that are normally occupied. Like Carbon Dioxide Systems, they are effective for surface fires, but less effective for deep-seated fires.

High Expansion Foam System

High expansion foam systems release an expanding foam agent that floods the area and displaces vapor, heat, and smoke. The foam stops the fire by reducing the free movement of oxygen to feed the fire. These systems are not normally used in occupied areas because the foam may make egress difficult by blocking vision or impairing breathing. These systems also require clean up after the discharge because they leave a residue.

Water Mist System

Water mist systems use high pressure or special nozzles to produce a water mist to suppress the fire. Water mist systems are only effective on some types of fire, but they do cause significantly less water damage than conventional water systems. They must be designed carefully to allow the water to reach the fire, instead of being pushed away by fire flumes or air pressure. These systems are usually activated by smoke detectors.



Diagram, NTC, d22.7

Extinguishing System Monitoring

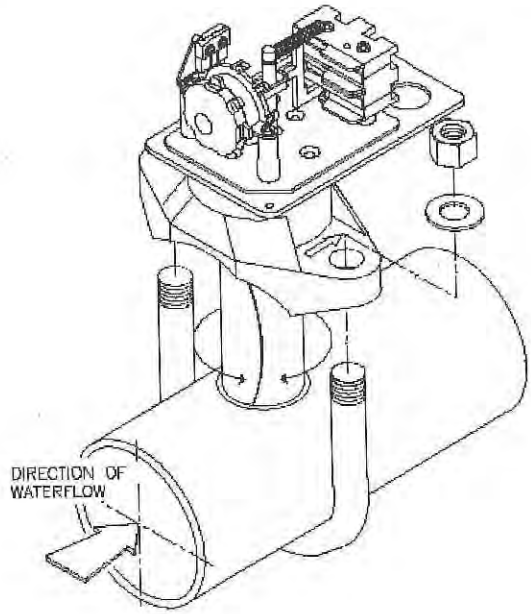
Extinguishing systems installed in the same building as fire alarm systems should be monitored for alarm and off-normal (supervisory) conditions. The type of device used to monitor the system depends upon the type of system. The device used to monitor system waterflow or tamper must be tamper resistant. This is often accomplished with a special security screw. Any junction boxes outside the building that the device connects to must also be similarly tamper resistant.

Waterflow

Waterflow devices monitor waterflow or pressure change in the sprinkler system piping. Vane type waterflow devices attach to the sprinkler piping and have a plastic vane that extends into the pipe. When water is flowing through the pipe the vane is pushed forward, activating a switch in the device housing. Vane-type waterflow switches are typically only used on wet pipe systems.

Photo courtesy Potter, p22.1

Diagram, Potter, d22.8



Dry pipe systems are usually monitored using water pressure switches. The sudden loss of water pressure when a head is activated closes contacts on a pressure switch. The switch is typically installed in the retard chamber. The chamber helps compensate for short duration water and pressure surges so they do not cause an alarm condition in the pressure switch.

Photo courtesy Potter, p22.2

Both types are connected to an initiating zone on the fire alarm control. NFPA 72® permits a maximum of 5 waterflow switches to be connected to single initiating circuit.

Waterflow devices are required to activate within 90 seconds of operation of even a single head connected down line of the device. The 90 second delay, or retard, is required to prevent false alarms from waste, surges, and variable pressure. Sprinkler systems connected to a city water supply are prone to sudden pressure drops and surges. The delay is usually built into the device itself in the form of an adjustable pneumatic retard.

Supervisory

Supervisory switches monitor the extinguishing system for off-normal conditions that may affect the proper operation of the extinguishing system. Supervisory switches monitor systems for proper valve position, air pressure, water level, water temperature, fire pump status and room temperature.

NFPA 72® allows a maximum of 20 supervisory devices to be connected to a single circuit. Supervisory devices must initiate a separate and distinct signal at the control panel and remote annunciators, and must restore when the device is reset (unless approved by the AHJ).

Valve Supervision

Valves control the water supply to the sprinkler system. They control the water coming from the water source, and they control the water as it is distributed to different parts of the sprinkler system. The valves exist so that the system can be shut off in the event of a malfunction, and so that the system may be serviced.

Valves are monitored because they may be intentionally or unintentionally shut off, depriving the sprinkler system of its water and rendering it ineffective. The type of valve determines the type of tamper switch that must be used.

Outside Stem and Yolk (OS&Y) Valves
OS&Y valves are hand operated gate valves with a screw thread stem that travels into a yolk. As the wheel is turned, it closes the valve. The switch typically straddles the valve and the sensing rod rests in a groove filed into the stem. As the valve stem rotates, the rod is pushed out of the groove and operates contacts.

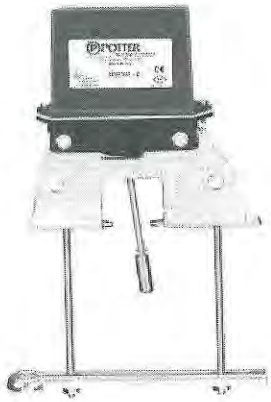
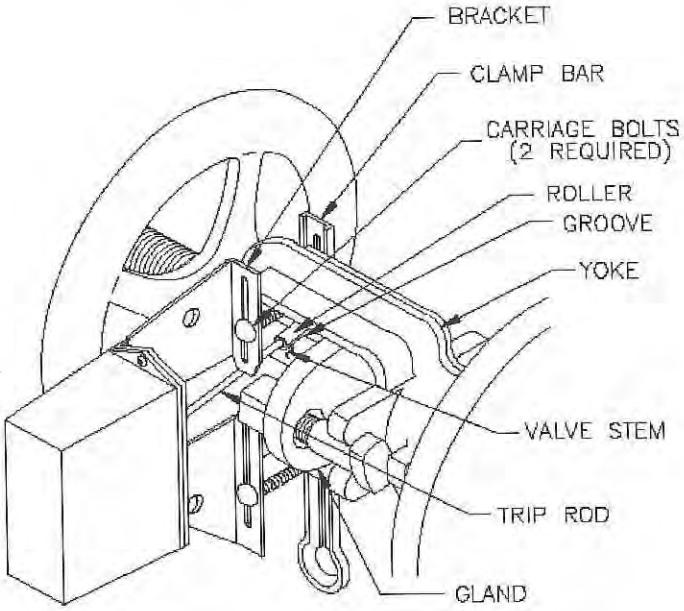


Photo courtesy Potter, p22.3

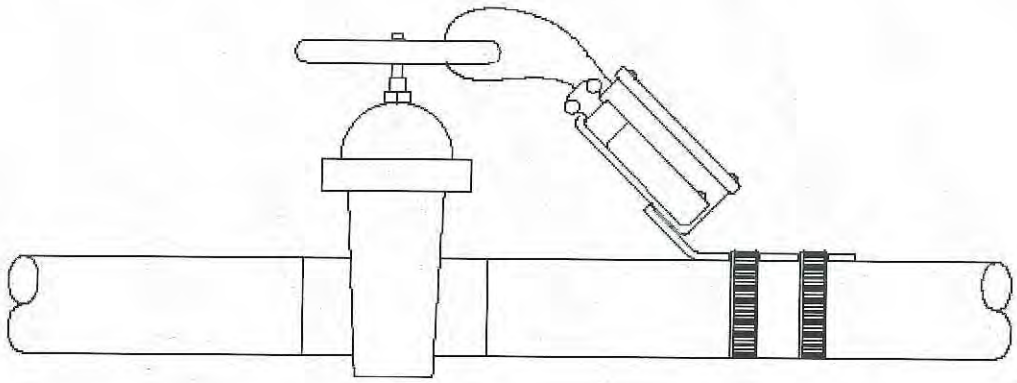


Diagram, Potter, d22.9

Plug Type Switch

Some OS&Y valves do not lend themselves to standard switch installation. For these applications a plug type switch may be used. A plug type switch consists of a housing with a wire coming out of one side and terminating in a plug at the other end. The wire is looped through the valve and cut to length so that rotating the valve will disconnect the plug. The cable and plug are electrically supervised so that cutting the cable also results in a signal.

Photo courtesy Potter, p22.4

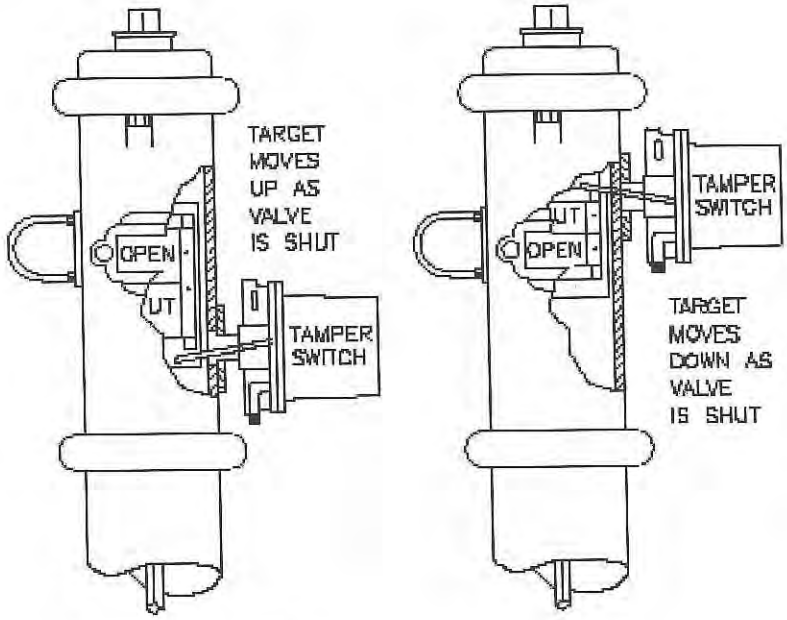


Diagram, Potter, d22.10

Post Indicator Valves (PIV)

PIVs are below ground valves that have an actuator and indicator above the ground. The indicator, or target, is viewable through an opening in the post. The indicator shows whether the valve is open or closed. The switch attaches to the post and a rod extended into the assembly rests on the indicator. As the indicator moves up or down (when the valve is opened or closed), the rod moves and operates contacts.

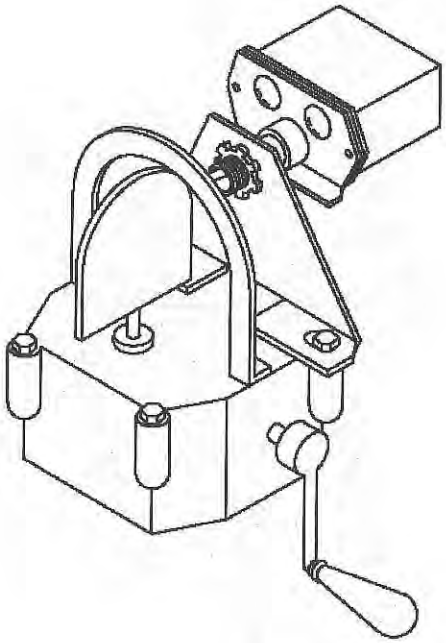
Photo courtesy Potter, p22.5



Diagram, Potter, d22.11

Butterfly Valves

Butterfly valves are compact and lightweight gear operated valves with an external position indicator. Turning a hand wheel or crank handle rotates a disk in the sprinkler pipe. The same switch used for PIVs is used to monitor this valve type. The rod extends into the valve and rests on the disk. As the disk moves, the rod is pushed and operates contacts.



Diagram, Potter, d22.12

Lever Operated Ball Valves

This type of valve is operated by rotating a lever handle one quarter turn. They are typically installed on pipes, pressure alarm devices or foam additive supply lines to make servicing the system easier. They may be monitored by an external switch triggered by lever handle movement, or the switch may be integrated into the ball valve assembly itself.

Photo courtesy Potter, p22.6

Pressure Supervision

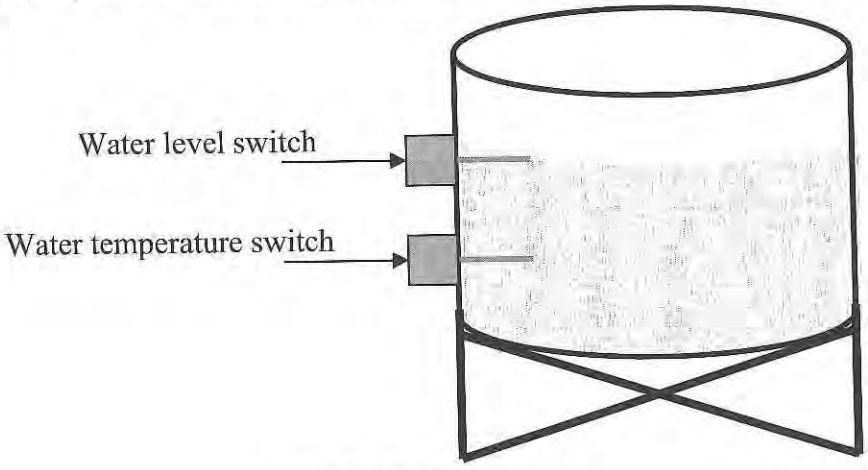
Sprinkler systems can be monitored for air and water pressure. Air pressure is a supervisory condition. Water pressure is an alarm condition. Dry pipe system require that the air pressure in the pipes be monitored. Low air pressure in the pipes due to an air leak or compressor failure could result in a valve opening, the system taking on water, and a waterflow false alarm. Air pressure supervisory switches should signal when the pressure changes 10 psi above or below normal.

Photo courtesy Potter, p22.7

Water pressure alarms monitor the wet sprinkler portion of a dry pipe system. The actuation of a water pressure switch will generate an alarm signal. A loss of water pressure indicates the flow of water in a dry pipe system. Water pressure switches should signal when the pressure changes 10 psi above or below normal.

Water Tank Supervision

Facilities with an on site water tank for the sprinkler system should also have the tank monitored. The tank should be monitored for water level and temperature (if appropriate). The water level and temperature switch both attach to the side of the tank and extend a sensor into it. The water level switch has a float, which rises and falls based on water level. A change of 3 inches higher or lower should result in a supervisory signal. Water temperature of 40° or less could mean the tank is on its way to freezing, and should also result in a supervisory signal.



Diagram, NTC, d22.13

Water Temperature Switch

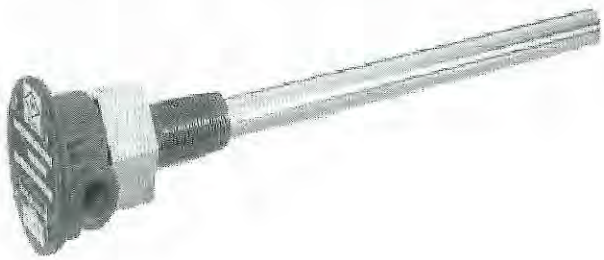


Photo courtesy Potter, p22.8

Water Level Switch

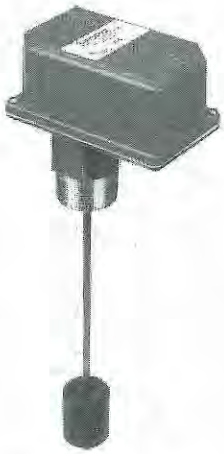


Photo courtesy Potter, p22.9

Room Temperature Supervision

Room temperature supervisory switches monitor the temperature of rooms protected by sprinkler systems to prevent frozen pipes. The switch typically activates at 40°, and resets when the temperature rises above 40°.

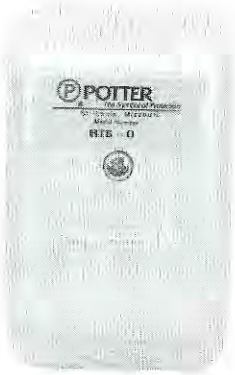


Photo courtesy Potter, p22.10

Fire Pump Supervision

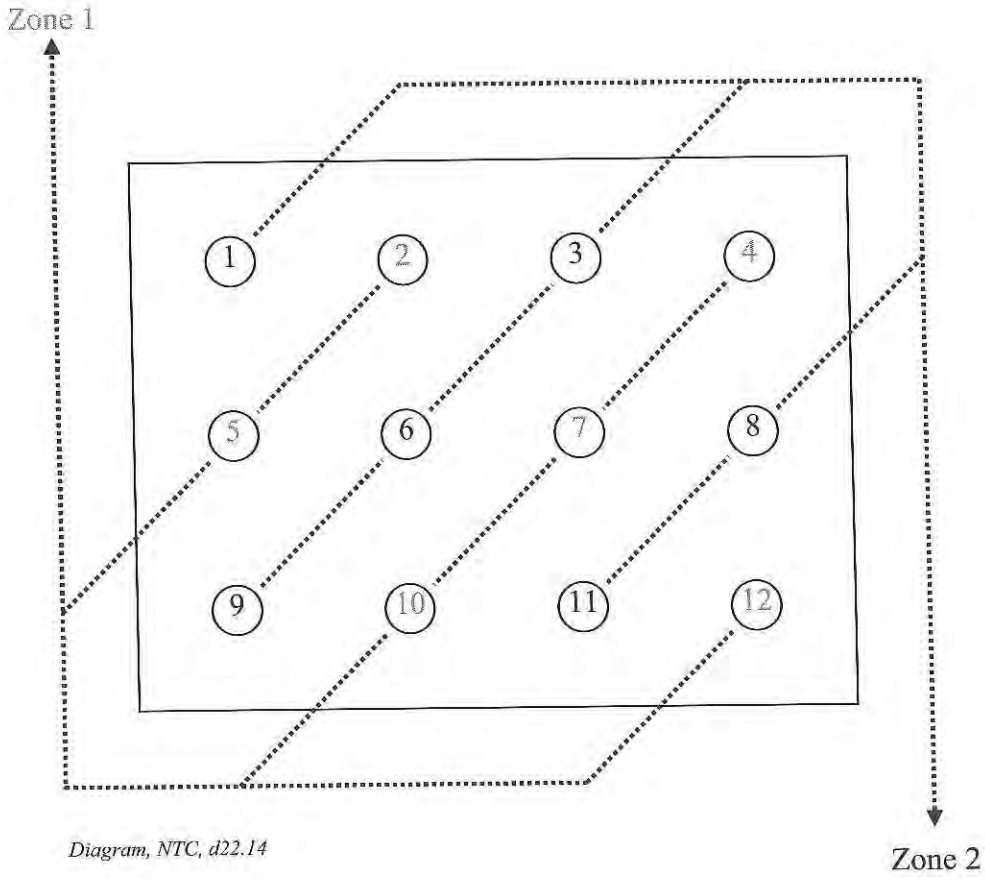
Fire pumps must be supervised to the degree required by the local AHJ. All fire pump signals are required to be supervisory signals. The pump should be supervised for power on the pump side, so that blown fuses or circuit breakers will be indicated. If multiple phase power is used, all phases must be supervised. Additionally pump running and fail to start should be supervised. All the pump supervisory signals should be separate, except those for engine-drive high temperature, low oil, overspeed shutdown, battery failure, and failure to start. These can have a common signal.

Detector Controlled Extinguishing Systems

Automatic fire detectors are often used to actuate extinguishing systems. Preaction, deluge, and clean agent systems are often activated by automatic detector operation. The detectors are connected to a fire alarm control specifically listed for releasing service. The control monitors the detectors and controls the audible and visual alarm indicators. It also controls the relays or solenoids that control the release of the extinguishing agent. Depending upon the application, the system may also have a time delay to allow the release of the extinguishing agent to be aborted.

Cross Zoning

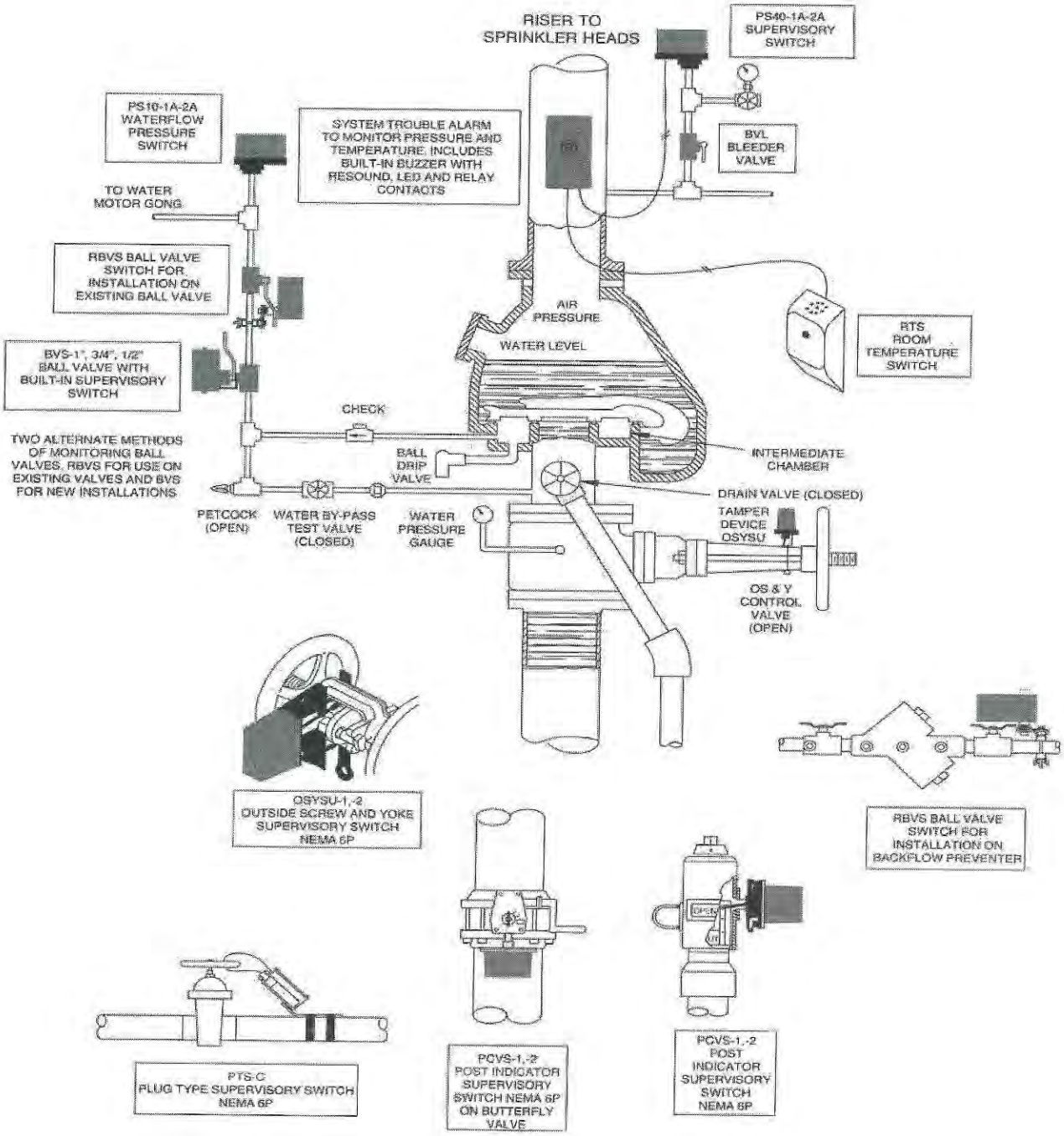
Some extinguishing systems require automatic detectors to be cross zoned. Cross zoning uses detectors in the same area wired to two different initiating circuits. At least one detector on each circuit must alarm before the panel will go into alarm and release the extinguishing agent. This prevents false alarms by a single detector from releasing the agent. The two zones may contain the same or different type of detectors.



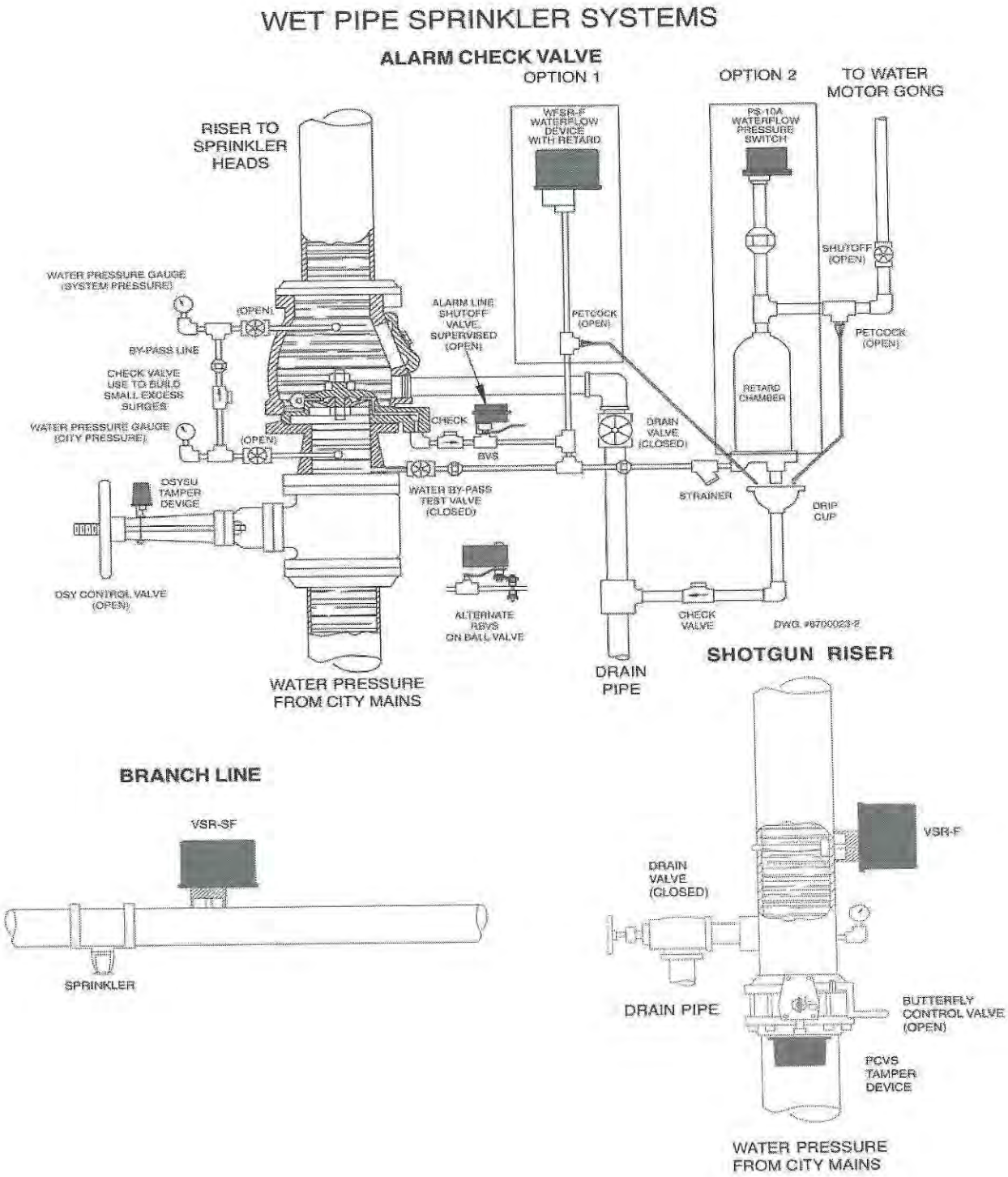
Diagram, NTC, d22.14

Detectors 2, 4, 5, 7, 10, and 12 are on zone 1. Detectors 1, 3, 6, 8, 9, and 11 are on zone 2. If any detector (or detectors) on *either* zone go into alarm by themselves the extinguishing system is not activated. If a detector (or detectors) on *both* zones go into alarm the extinguishing system is activated.

DRY PIPE VALVE SYSTEM WATERFLOW ALARM INSTALLATION

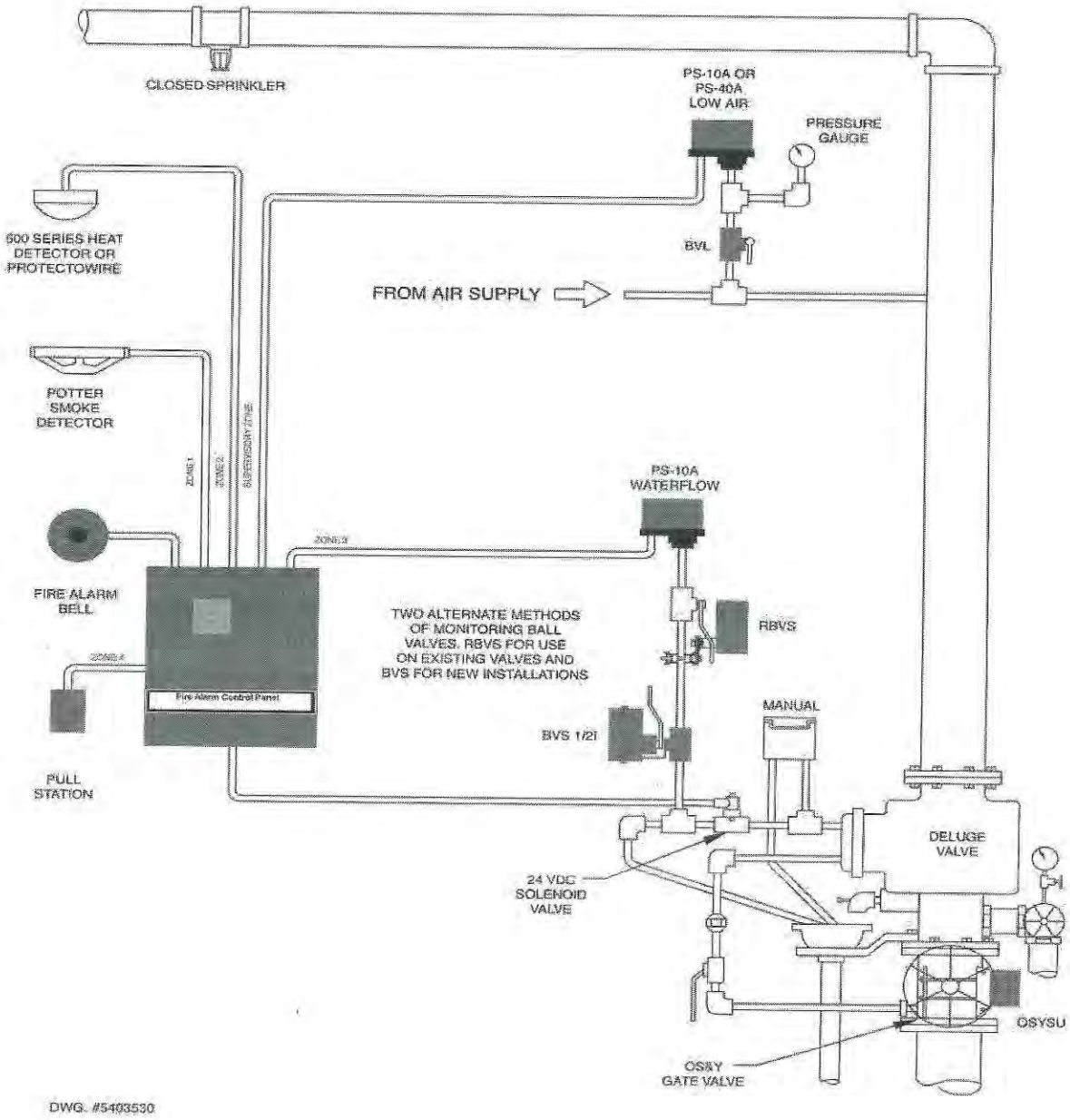


Diagram, Potter, d22.15



Diagram, Potter, d22.16

PRE-ACTION DELUGE SYSTEM
SINGLE ZONE/ELECTRIC CROSS ZONE



Diagram, Potter, d22.17

Summary

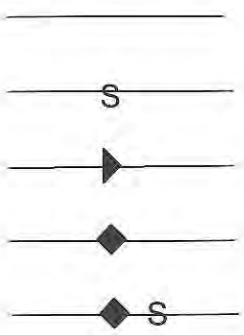
Extinguishing systems come in various types and are installed based on the specific needs and environments of the application. NFPA 101® requires extinguishing systems to be monitored by the fire alarm system in installations where both systems are installed.

Appendix A

Fire Alarm Symbols

NFPA 170® (Standard for Fire Safety Symbols®) lists the industry standard symbols for use on fire alarm drawings. Even though these are the industry standards, not all fire alarm system drawings will use these symbols. The symbol key of the drawings should always take precedence when reviewing the drawings. The symbol key for the drawings should only be used with the drawings it pertains to, as different designers may use different symbols. The symbol key of the drawings should be the only source used when doing take-offs and device counts from the drawings.

Walls
Walls are symbolized by a line. Modifications to the line are used to indicate the wall's fire and smoke ratings.



Wall (basic)

Smoke barrier wall

½-hour fire-rated wall

1-hour fire-rated wall

1-hour fire rated/smoke barrier wall

Additional diamonds (◆) indictate additional hours of fire rating. Portions of diamonds (½ or ¾) indicate ½ or ¾ hour fire wall ratings.

Openings

E	Elevator in combustible shaft
E	Elevator in non-combustable shaft
E	Open hoistway
	Stairs in combustable shaft
	Stairs in fire-rated shaft

Fire Alarm and Suppression Basic Shapes

Major Elements

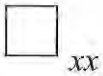
	Automatic detector/actuating system
	Manual station/actuating systems
	Control panel (type/function inside box)
	Portable fire extinguisher (type/function inside triangle)
	Fire fighting equipment (type/function inside shape)

Control Panel

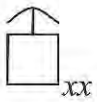
Control panels and associated control units are designated by a rectangle. The letters inside the rectangle indicate the control panel type or function. Letters outside the lower right corner of the rectangle indicate the suppression agent released (if applicable).

Control panel	Supression *(if any)*
FACP	Fire alarm control panel
FSA	Fire system annunciator
FTR	Fire alarm transmitter
ESR	Elevator status/recall
FAC	Fire alarm communicator
MIC	Remote microphone for voice evacuation
FCS	Fire command system
FACU	Fire alarm control unit
SAP	Sprinkler alarm panel
DGP	Data gathering panel
FSCP *xx*	Fire system control panel with suppression release (*xx* = released agent) HL- Halon, CO_2 – carbon dioxide, DC – dry chemical, FO – foam, WC – wet chemical, CA- clean agent, WM- water mist, DL- deluge sprinkler

Initiating Devices/Input Modules

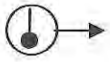


Manual station (xx – feature/function)
P – pull station
Suppression functions:
HL – Halon, CO_2 – carbon dioxide, DC – dry chemical, FO – foam WC – wet chemical, CA – clean agent, WM- water mist, DL-deluge, PRE - preaction
Other:
MB- master box, DK – drill key



Abort switch (xx – feature/function)
Same as above for manual station
Also: EPO – emergency power off

Heat detector (xx – type)
R – rate of rise, F – fixed, R/F – rate of rise/fixed combo, R/C – rate compensation



Line-type heat detector

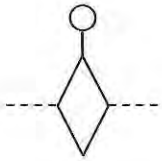
Smoke detector (xx – type)
P- photoelectric, I – ionization, BT – beam transmitter, BR – beam receiver, ASD – air sampling smoke detector

Smoke/heat detector

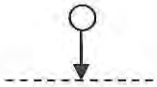
Smoke detector for duct

Flame detector
(F –flame, UV- ultraviolet, IR – infrared,
UV/IR combo ultraviolet/infrared, VR – visible radiation)

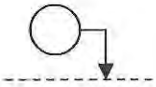
Gas detector



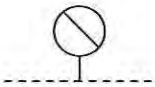
Flow switch



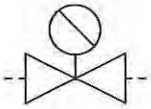
Pressure switch



Level switch



Tamper detector



Valve tamper

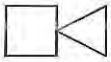
High temperature switch

Low temperature switch

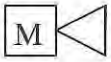
Addressable input module

Fire service telephone
(A – accessible, J – jack, H – handset)

Notification Appliances/Output Modules



Speaker/horn



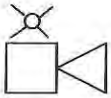
Minihorn

xx

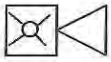
Bell (xx – type)
V – vibrating, VS – vibrating/strobe, G – single stroke,
GS – single stroke/strobe, T –trouble, C – chime

Light (strobe, lamp, indicator)

Rotating beacon



Horn and light as separate assembly



Horn and light as one assembly

RTS

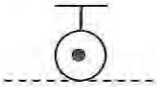
Remote alarm indicator and test switch

AOM

Addressable output module

R

Output relay



Door holder

Suppression System Components

Water system components (shading indicates wet system)

Foam agent

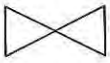
Dry chemical

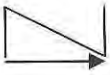
Gaseous agent

Nozzle (use on pipe or other symbol)

Pressure (used on detector, tank or other symbol)

Switch


Valve


Check Valve

Tamper

Heat detector

Flow detector

1-hour fire rating

Sprinkler/Water

Public water main

Private water main

Riser

Valve (general)

Post-indicator valve

Key-operated valve

OS&Y valve

Indicating butterfly valve

Non-indicating valve

Check valve

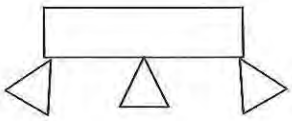
Pressure regulating valve

Pressure relief valve

Float Valve

Meter

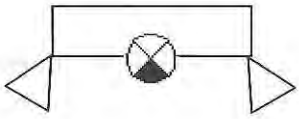
Emergency Lighting & Exit Signs



Emergency light, battery powered
(number of lamps indicated)

Illuminated exit sign, single face
(arrow indicated direction)

Illuminated exit sign, dual face



Combined battery powered emergency light and
illuminated exit sign

Exit lighting

Appendix B

Electronics for Fire Alarm Systems

Basic electronic principles control the operation of fire alarm systems. Ohm's law is the driving force behind using electronic systems for fire detection. Ohm's law determines the electrical requirements and limitations for fire alarm detection and notification circuits. This chapter will relate the relevance of Ohm's law to the technician's role in fire alarm system design and installation.

Ohm's Law

Benjamin Franklin discovered electricity with his kite. Well, this is not exactly true. Electricity was known to exist long before Benjamin Franklin's kite experiment. Benjamin Franklin is credited with identifying the 3 components of electricity. Those components are:

1. Voltage.
2. Current.
3. Resistance.

George Simon Ohm (1787-1854) was a German scientist and he discovered the relationship between these 3 components. This mathematical relationship is Ohm's law. The formula used to express the relationship between Voltage, Current and Resistance is as follows:

Voltage = Current x Resistance

OR

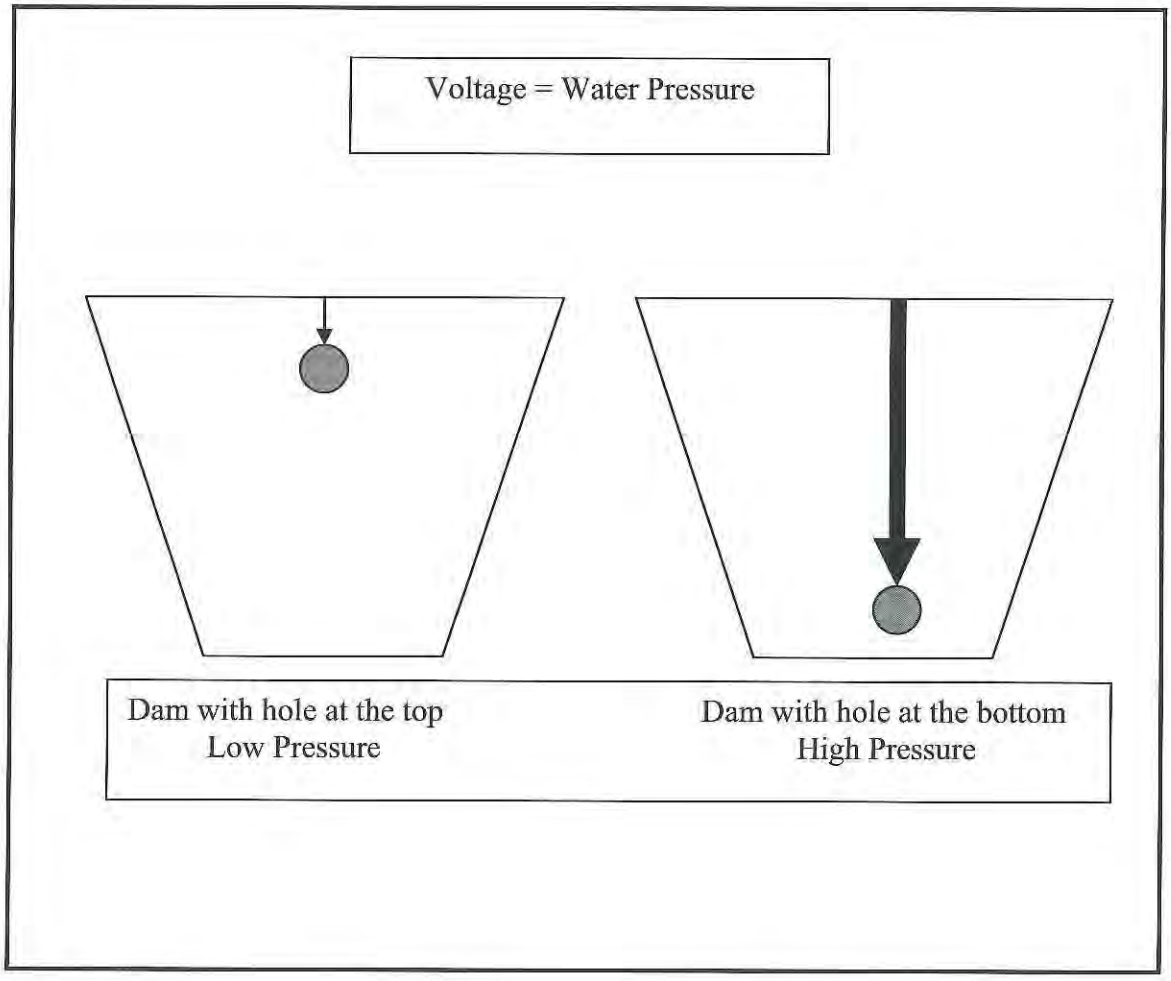
$$E = I \times R$$

Where

E = Voltage (Electromotive Force)
I = Current (Intensity of Current Flow)
R = Resistance (Resistance to Current Flow)

Voltage

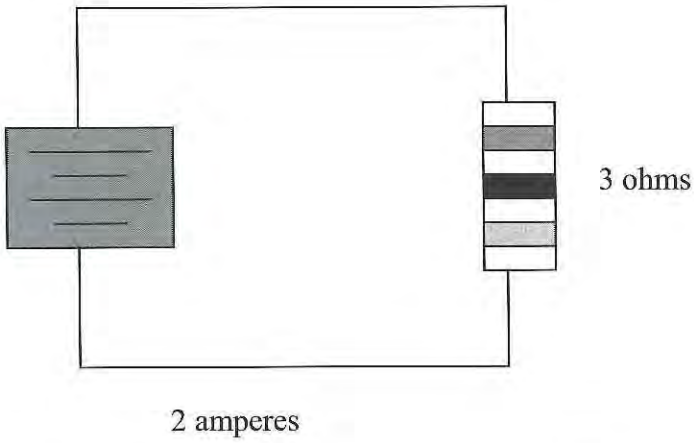
Voltage is also called electromotive force. It is the measure of the pressure required to push current through the circuit. This pressure is frequently compared to water pressure in order to illustrate its effect. Consider a dam with two holes. The first hole is at the very top of the dam. The second is at the bottom of the dam.



Diagram, NTC, db.1

It is easy to see the effect of increased pressure. The water leaking from the hole at the top of the dam just dribbles out. The water leaking from the hole at the bottom of the dam has a significantly greater force due to pressure. Voltage works in a similar way. Examples are on the following pages:

Voltage Example 1



Calculation Box

Solve for E

E = ?
I = 2 amperes
R = 3 ohms

E = I x R

Fill in the Values:

E = 2 x 3 = 6 volts

Ohm's Law Box

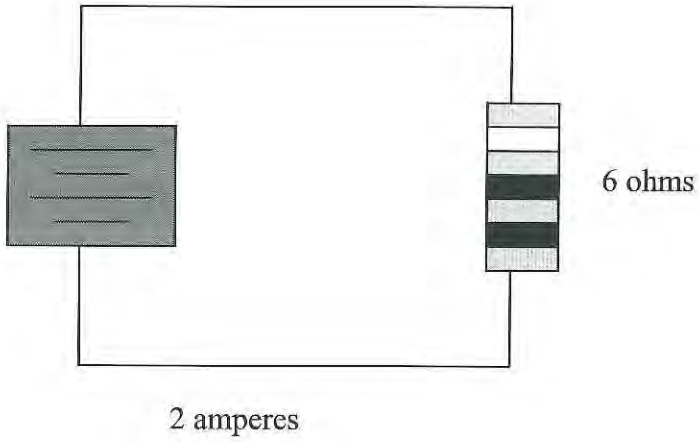
E = I x R

I = E ÷ R

R = E ÷ I

Diagram, NTC, db.2

Voltage Example 2



Calculation Box

Solve for E

E = ?
I = 2 amperes
R = 6 ohms

Fill in the Values

E = 2 x 6 = 12 volts

Ohm's Law Box

E = I x R

I = E ÷ R

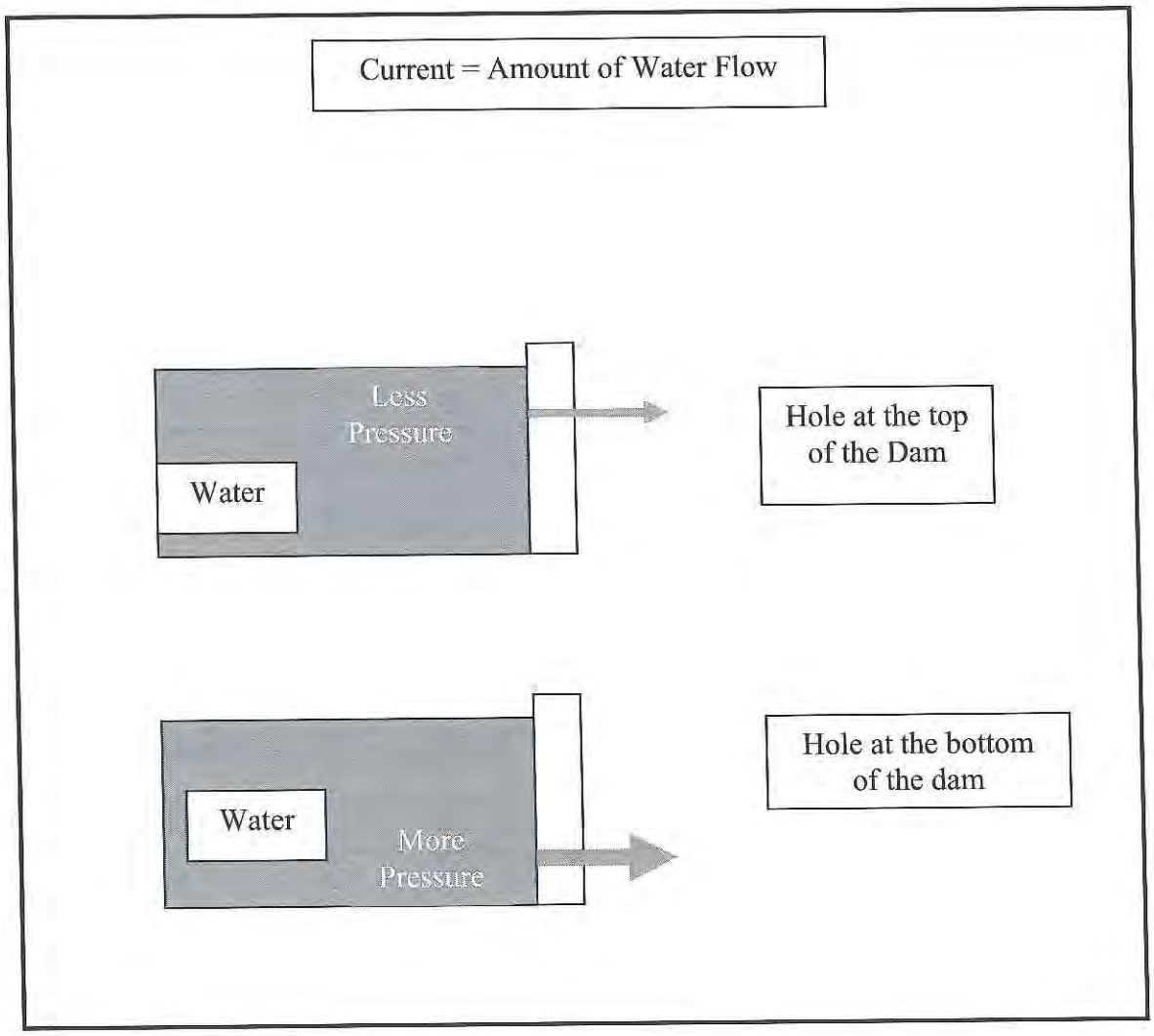
R = E ÷ I

Diagram, NTC, db.3

Current

Current is the flow of electrons through a conductor. The symbol used for current is I. This represents the Intensity of the current and it is measured in amperes. The measure of current is based on the quantity of electrons which flow through the conductor. One ampere is equal to 6.24×10^{18} electrons which flow through a given point in one second.

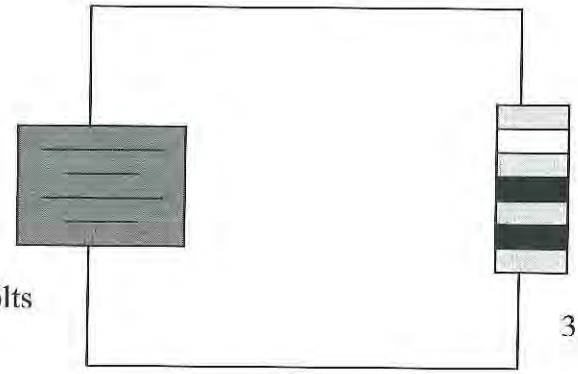
The flow of water can be used to help understand current. Consider the dam with two holes. Voltage is represented by the pressure exerted on the water. The hole at the bottom of the dam has a great deal more pressure than the hole at the top of the dam. The water which flows through the hole is the current.



Diagram, NTC, db.4

More water will flow from the bottom hole because it has more pressure. More current will flow through a circuit which has a higher voltage. Using Ohm's law, current can be calculated when the values of voltage and resistance are known.

Current Example 1



Calculation Box

Solve for I

E = 6 volts
I = ?
R = 3 ohms

Fill in the values

6 = I x 3, (divide each side by 3)

I = 6 ÷ 3 = 2 amperes

Ohm's Law

E = I x R

I = E ÷ R

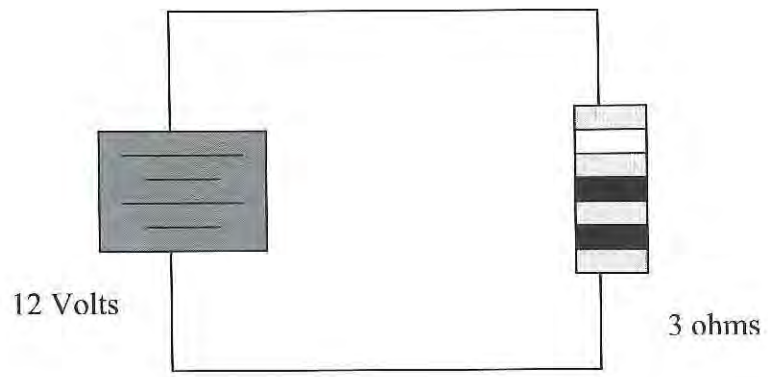
R = E ÷ I

Diagram, NTC, db5

This example shows that the relationship detailed by Ohm's law holds for current flow. With 6 volts and a resistance of 3 ohms, our current flow is limited to 2 amperes. Making a simple change to the voltage can have a dramatic effect on current flow in the circuit.

What would happen if we increased the voltage to 12 volts? The next example will demonstrate the effect.

Current Example 2



Calculation Box

Solve for I

E = 12 volts
I = ?
R = 3 ohms

Fill in the values

12 = I x 3, (divide each side by 3)

I = 12 ÷ 3 = 4 amperes

Ohm's Law Box

E = I x R

I = E ÷ R

R = E ÷ I

Diagram, NTC, db.6

In the first current example, there was 2 amperes flowing in the circuit. Increasing the voltage directly affects current flow. When the voltage was doubled to 12 volts, our current flow was doubled as well. Our current increased from 2 amperes to 4 amperes.

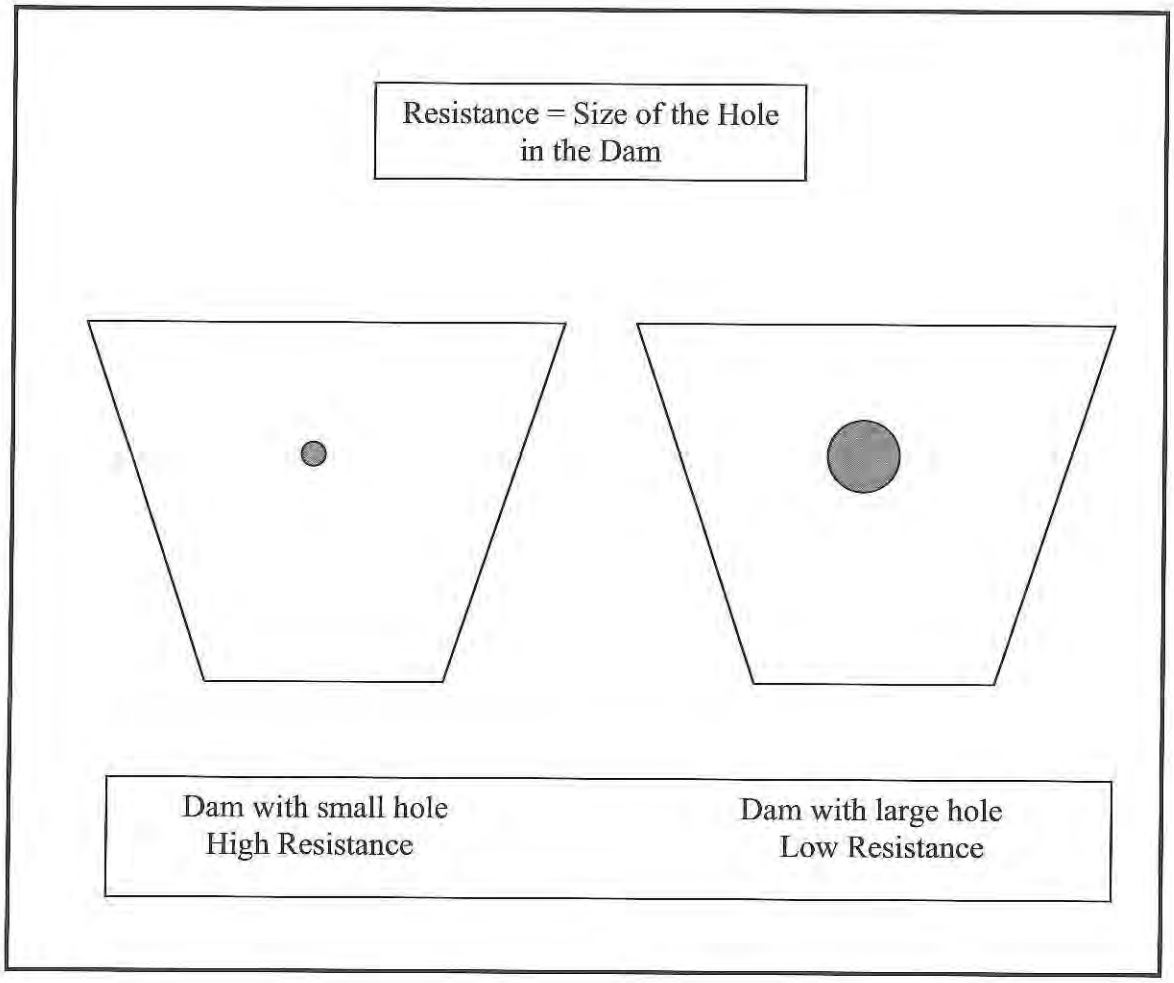
This significant affect is put to use with fire alarm system notification appliance circuits. Rather than using 12 volt circuits, most fire alarm systems use 24 volt circuits. This

permits more current to flow to the notification appliances. It allows more devices on a single circuit.

Resistance

The symbol for resistance is R. Resistance is the opposition to current. Resistance is measured in ohms. Water can be used to help illustrate how resistance affects the flow of current. Consider a dam with two holes.

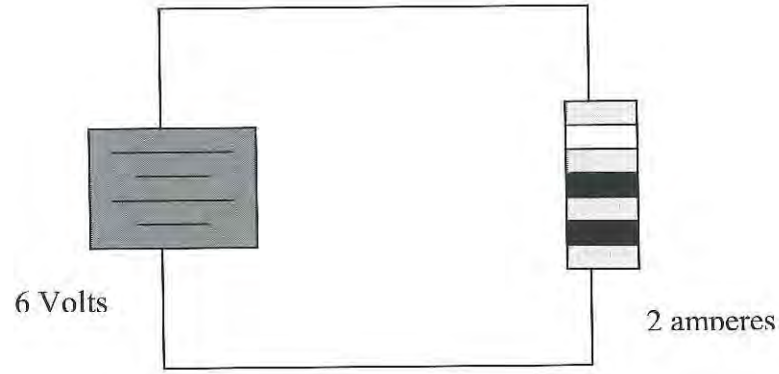
This time, both holes are located at the center of the dam. The difference is their size. The first hole is very small. The second hole is very large. The holes themselves represent resistance.



Diagram, NTC, db.7

The smaller hole represents greater resistance and less current is allowed to flow. The large hole represents less resistance and greater current is allowed to flow. In a real circuit, resistance is usually a load. A horn for example, is a load for a notification circuit. The smoke detectors represent a load for an initiating device circuit.

Resistance Example 1



Calculation Box

Solve for R

E = 6 volts
I = 2 amperes
R = ?

Fill in the values

6 = 2 ÷ R, (divide each side by 2)

R = 6 ÷ 2 = 3 ohms

Ohm's Law Box

E = I x R

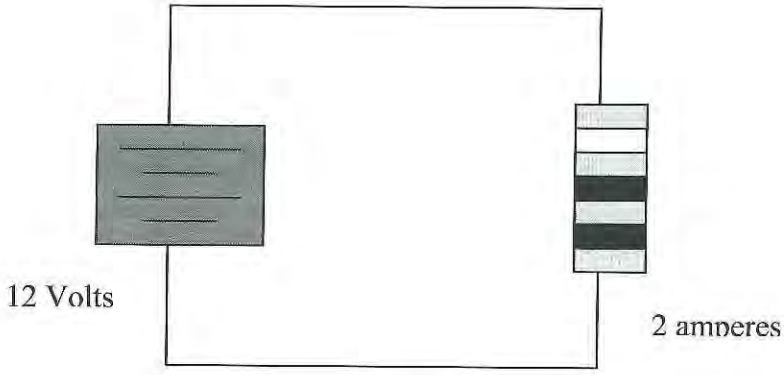
I = E ÷ R

R = E ÷ I

Diagram, NTC, db.8

Resistance can play an important role in current flow as well. The greater the resistance, the lower the current flow. Resistance is used in fire alarm systems as the primary method for providing circuit supervision.

Resistance Example 2



Calculation Box

Solve for R

E = 12 volts
I = 2 amperes
R = ?

Fill in the values

12 = 2 x R, (divide each side by 2)

R = 12 ÷ 2

R = 6 volts

Ohm's Law Box

E = I x R

I = E ÷ R

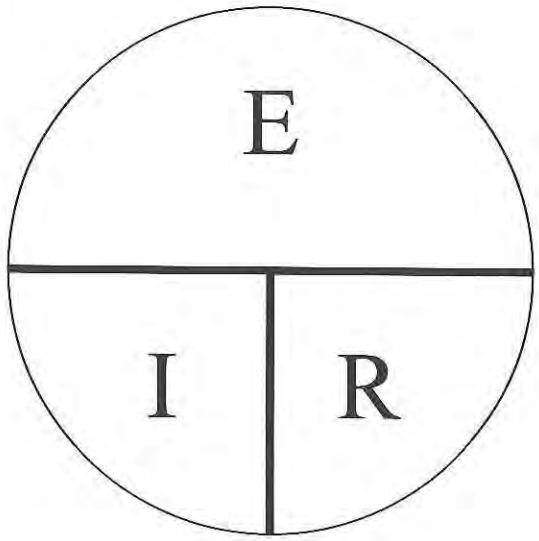
R = E ÷ I

Diagram, NTC, db.9

Ohm's Law Chart

A circular chart can be used to help remember Ohm's law. The chart appears below:

Ohm's Law Circle



Cover the value needed. Perform the function indicated

Diagram, NTC, db.10

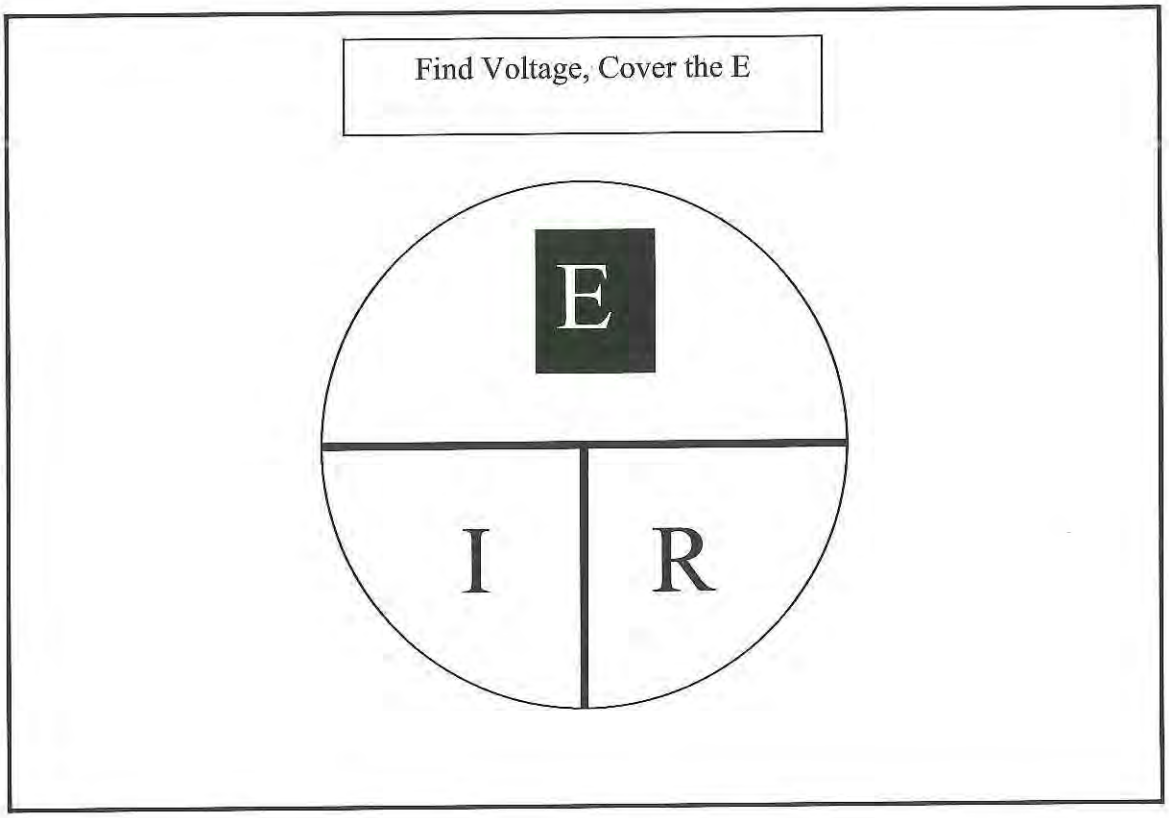
Using the Ohm's law chart is very easy. Simply cover the value needed, and then perform the indicated mathematical function with the other two values. This method works for any of the three values represented in ohm's law.

It can be applied for finding voltage.

It can be applied for finding current.

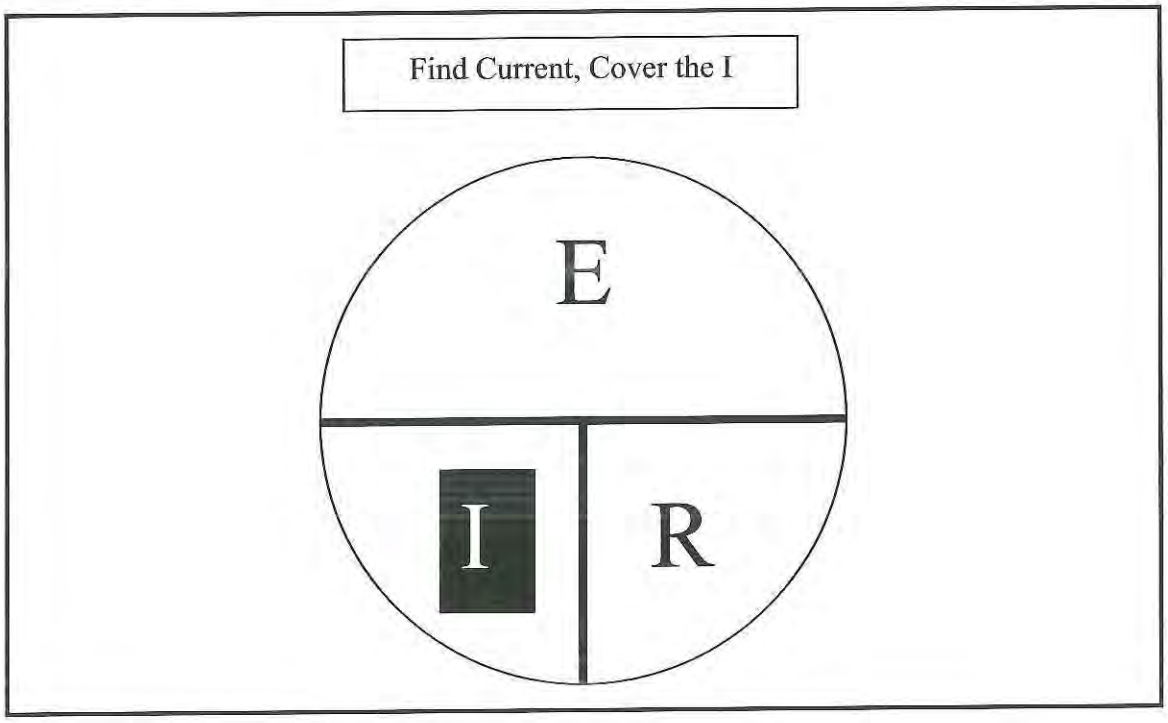
It can be applied for finding resistance.

In order to find Voltage, simply cover the symbol for voltage E. Then perform the indicated mathematical function.



Diagram, NTC, db.11

Just multiply the values to get the voltage. **E = I x R**

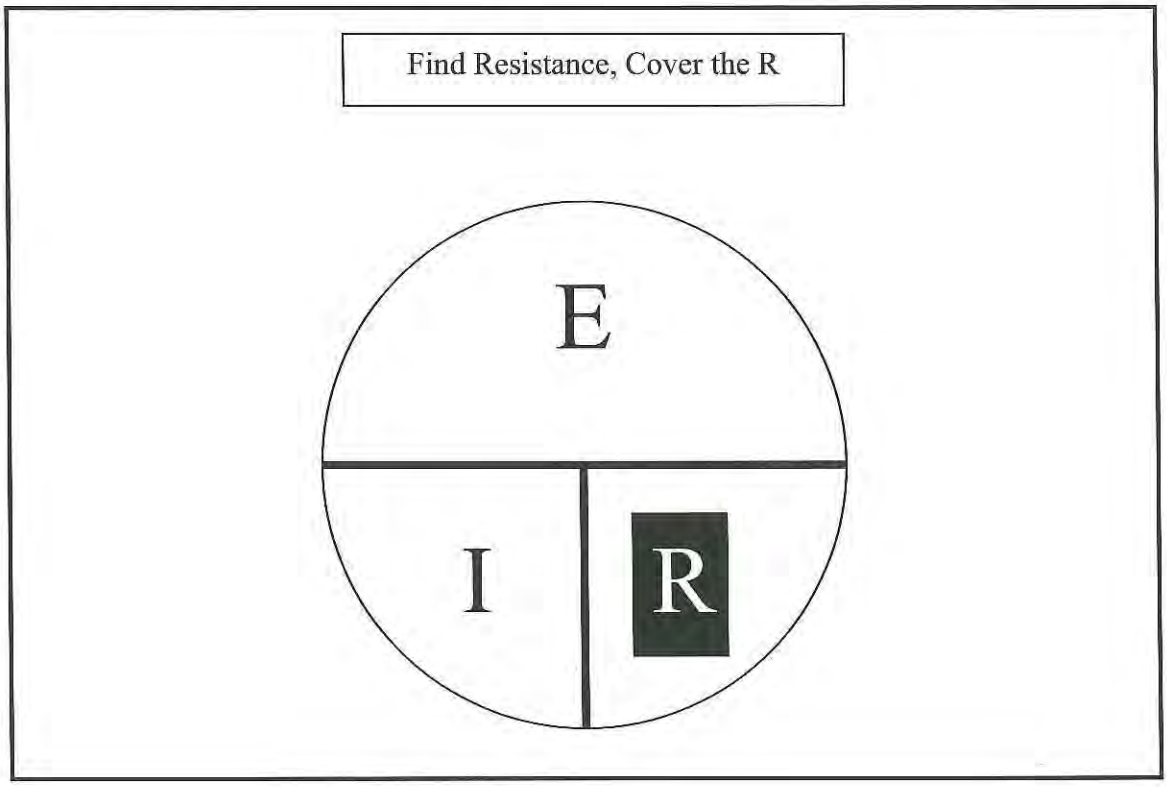


Diagram, NTC, db.12

The two remaining values are E ÷ R. Just divide the values to get the current.

I = E ÷ R

In order to find Resistance, simply cover the symbol for resistance R.



Diagram, NTC, db.13

The two remaining values are E ÷ I. Just divide the values to get the resistance.

R = E ÷ I

All of the formulas

Voltage	E = I x R
Current	I = E ÷ R
Resistance	R = E ÷ I
Power	P = E x I

Diagram, NTC, db.14

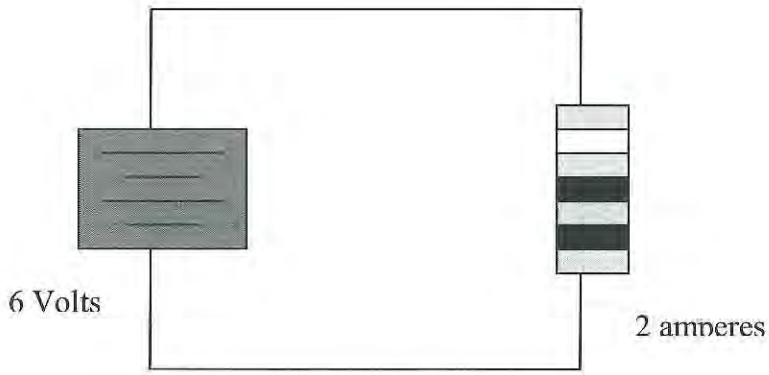
Power

An expansion of Ohm's law provides a formula for calculating power. The power formula was discovered by James Watt. Power is expressed in watts. The power law is:

$$P = E \times I$$

Wattage is a measure of work. One watt is equal to 1 volt moving 6.24×10^{18} electrons in 1 second. The formula for calculating power is easy to apply.

Power Example 1



Calculation Box

Solve for P

P = ?
E = 6 volts
I = 2 amperes

Fill in the values

P = 6volts x 2amps

P = 12 VA or watts

Ohm's Law / Power Law

$E = I \times R$

$I = E \div R$

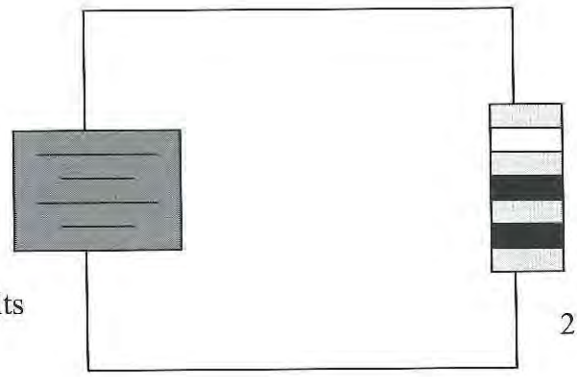
$R = E \div I$

$P = E \times I$

Power is expressed in watts
Or VA

Diagram, NTC, db.15

Power Example 2



Calculation Box

Solve for Power

P = ?
E = 12 volts
I = 2 amperes

Fill in the values

P = 12volts x 2amps

P = 24 VA or watts

Ohm's Law / Power Law

E = I x R

I = E ÷ R

R = E ÷ I

P = E x I

Diagram, NTC, db.16

The Correct Unit of Measure

Using the proper unit of measure is critical to applying the formulas for electricity. Prior to doing any calculations make sure your values are using the correct unit of measure. The correct units of measure are:

Value	Symbol	Correct Unit of Measure for Calculation
Voltage	E	Volts
Current	I	Amperes
Resistance	R	Ohms
Power	P	Watts

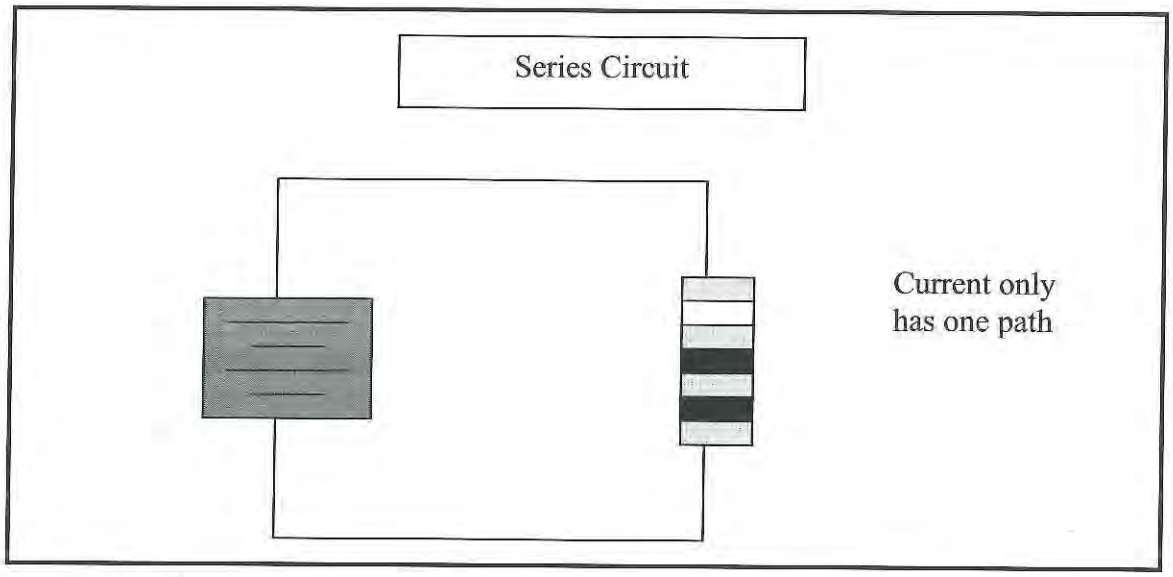
Diagram, NTC, db.17

Mega	Kilo	Unit	Milli	Micro	Pico
1,000,000 Volts	1,000 Volts	1 Volt	.001 Volts	.000001 Volts	.000000001 Volts
1,000,000 Amps	1,000 Amps	1 Ampere	.001 Amps	.000001 Amps	.000000001 Amps
1,000,000 Ohms	1,000 Ohms	1 Ohm	.001 Ohms	0.000001 Ohms	0.00000001 Ohms

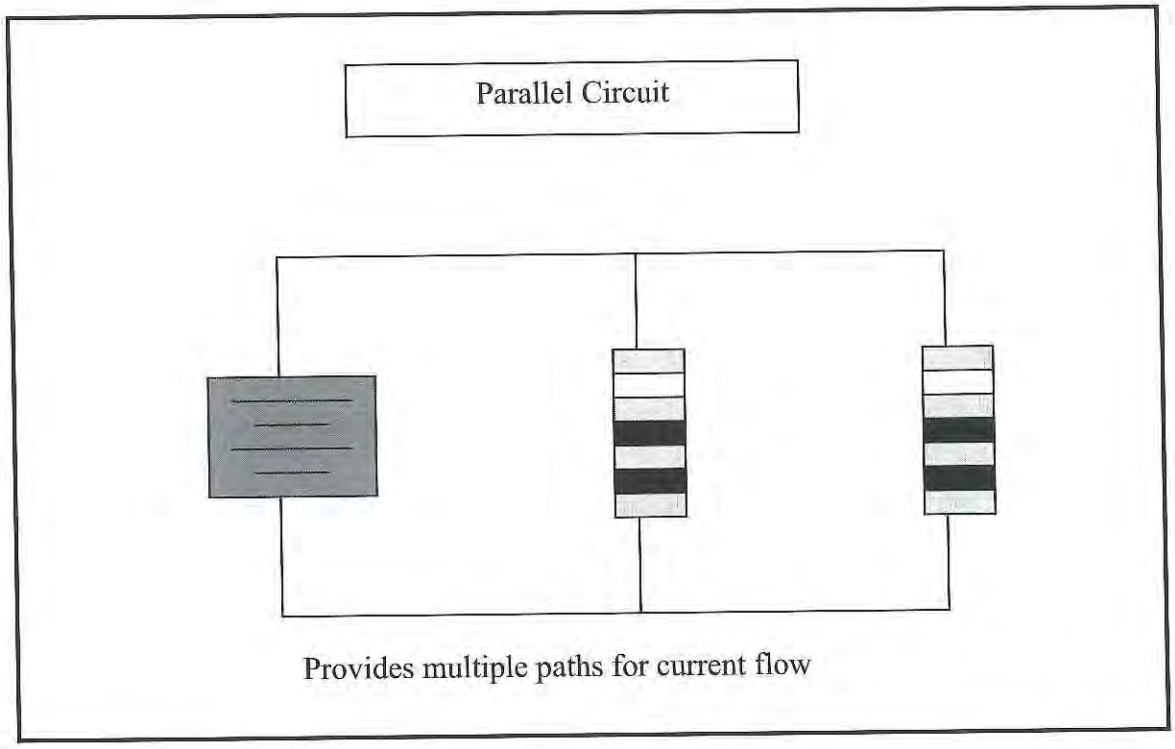
Diagram, NTC, db.18

Types of Circuits

There are two categories of circuits. The first category is Series circuits. Series circuits offer only one continuous path for current to flow. The second category is a parallel circuit. Parallel circuits provide multiple paths for current flow.



Diagram, NTC, db.19



Diagram, NTC, db.20

There are several significant differences in the way these two types of circuits perform. They both have advantages and disadvantages. In fire alarm systems specifically, and low voltage systems generally both types of circuits are common.

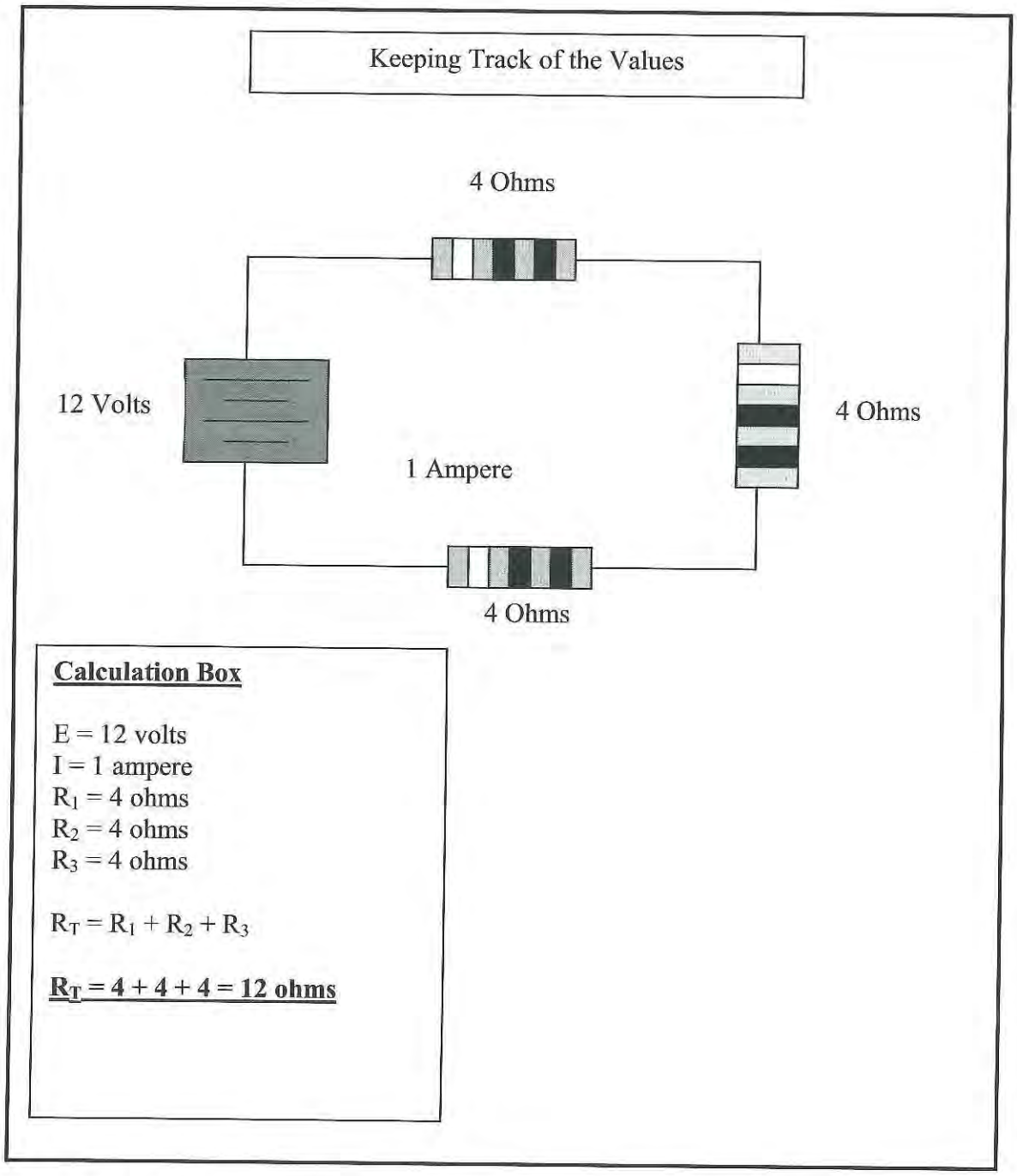
Series circuits are simple. There is only one path for current flow. Following ohm's law for series circuits is clear cut. Series circuits have three very important rules which govern how they perform.

1. Voltage in Series is additive
2. Current in Series is constant
3. Resistance in Series is additive

Parallel circuits are more complex. There are multiple paths for current flow. All parallel circuits can be dissolved down to a simple series circuit. Doing this makes them easier to work with. There are 3 very important rules which govern how parallel circuits perform.

1. Voltage in Parallel is constant
2. Current in Parallel is additive
3. Resistance in Parallel is less than the value of the smallest resistor

It is important for industry professionals to know theses rules for series and parallel circuits.



Diagram, NTC, db.21

As more resistors are added to a circuit, it becomes more challenging to keep track of all the values. We will use a simple and proven method to keep track of multiple values.

Listing all these can get confusing. There is a method that can be employed to more easily track and calculate the values from the circuit. This method is referred to as the PEIR table. The PEIR table for the values of the circuit is:

PEIR Chart

Load	Power	E (at load)	I (at load)	R (at load)
R_1	4 watts	4 volts	1 amp	4 ohms
R_2	4 watts	4 volts	1 amp	4 ohms
R_3	4 watts	4 volts	1 amp	4 ohms
R_T	12 watts	12 volts	1 amp	12 ohms

Diagram, NTC, db.22

The circuit has 3 loads. Each of those loads is represented by a resistor. Remember the rules of series circuits.

Voltage is additive — The voltage at each resistor can be calculated by using Ohm's law E = I x R. E = 1 x 4. E = 4 volts

Total voltage equals the addition of the voltage values at each of the resistors. $E_T = 4 + 4 + 4 = 12$ volts

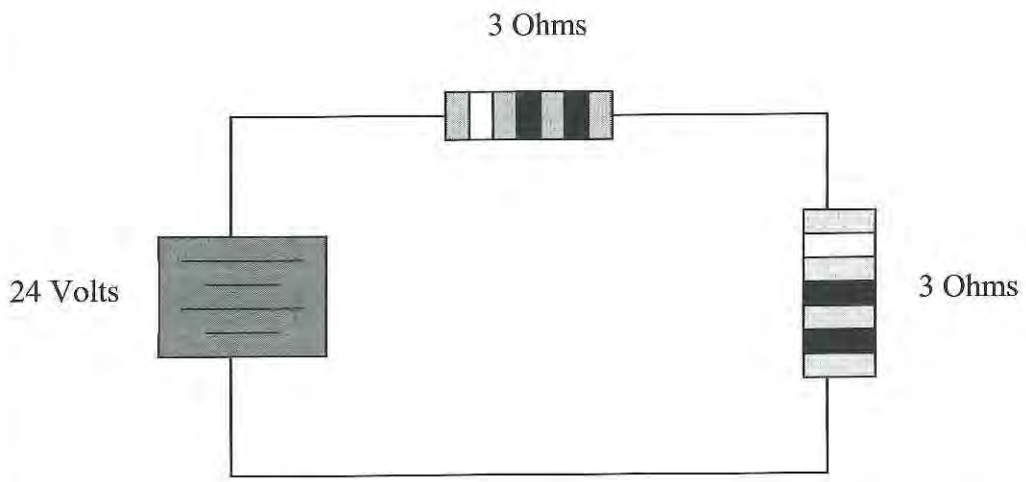
Current is constant — Current in a series circuit is constant at all points.

Resistance is additive — The total resistance is equal to the sum of all the resistors. $R_T = 4 + 4 + 4 = 12$ ohms.

The PEIR Chart provides a neat and orderly method for keeping track of all of the loads and their associated values. The PEIR Chart is a valuable tool. It can be used for voltage drop calculations and other important circuit calculations relating to fire alarm systems.

This technique works for both series and parallel circuits. In order to make parallel circuits more manageable, it is a good idea to convert them to a basic series circuit.

PEIR Chart Example 1



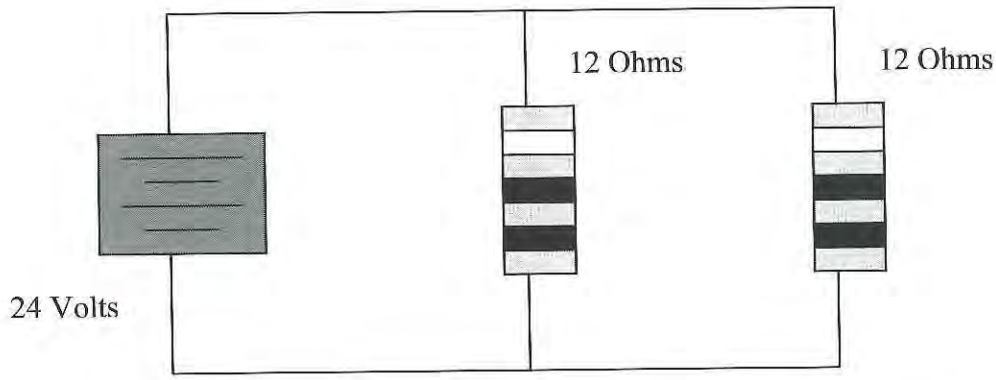
Load	Power	E (at load)	I (at load)	R (at load)
R_1				3 ohms
R_2				3 ohms
R_T		24 volts		

Calculate Total Resistance $R_T = R_1 + R_2 = 3 + 3 =$ **6 ohms**
Calculate Current $I = E \div R = 24 \div 6 =$ **4 amperes**
Current is constant at all points in the series circuit

Load	Power	E (at load)	I (at load)	R (at load)
R_1	48 watts	12 volts	4 amps	3 ohms
R_2	48 watts	12 volts	4 amps	3 ohms
R_T	96 watts	24 volts	4 amps	6 ohms

Diagram, NTC, db.23

PEIR Char Parallel Example 1



Load	Power	E (at load)	I (at load)	R (at load)
R_1		24 volts		12 ohms
R_2		24 volts		12 ohms
R_T		24 volts		

Voltage is constant in parallel circuits
Calculate the total resistance $1/R_T = 1/R_1 + 1/R_1 + 1/R_2 = 1/12 + 1/12$
$1/R_T = 2/12$ $R_T = 6$ ohms

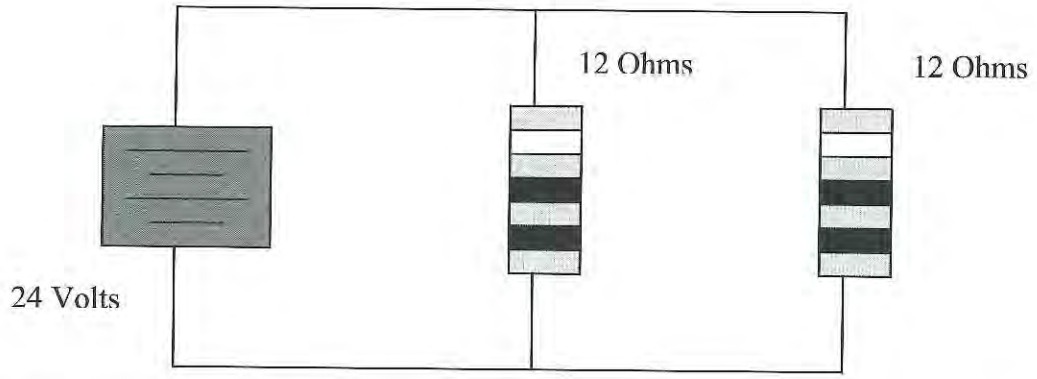
Load	Power	E (at load)	I (at load)	R (at load)
R_1	48 watts	24 volts	2 amps	12 ohms
R_2	48 watts	24 volts	2 amps	12 ohms
R_T	96 watts	24 volts	4 amps	6 ohms

Diagram, NTC, db.24

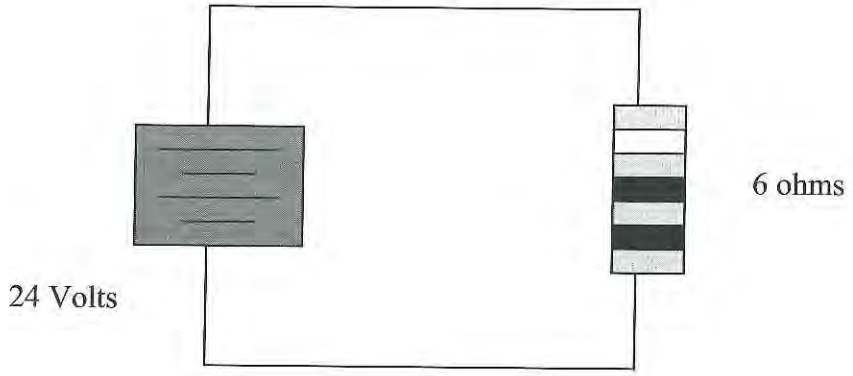
In order to make things easier, a parallel circuit can be represented by a simple series circuit. For example, the two circuits below can be considered basically equivalent:

Break It Down to the Simple Form

All parallel circuits can be broken down to a simple series circuit. Consider the parallel circuit below. It can be represented by a simple series circuit. The

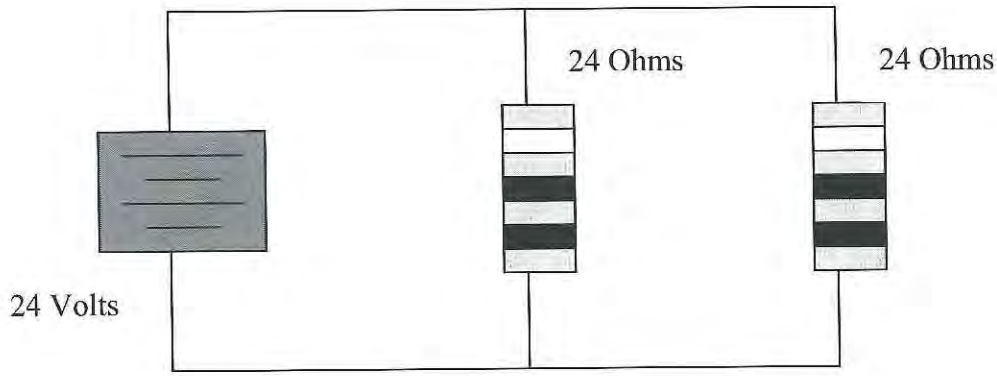


The series circuit below works essentially the same as the parallel circuit above. Two 12 ohm resistors in parallel work the same as one 6 ohm resistor in series.



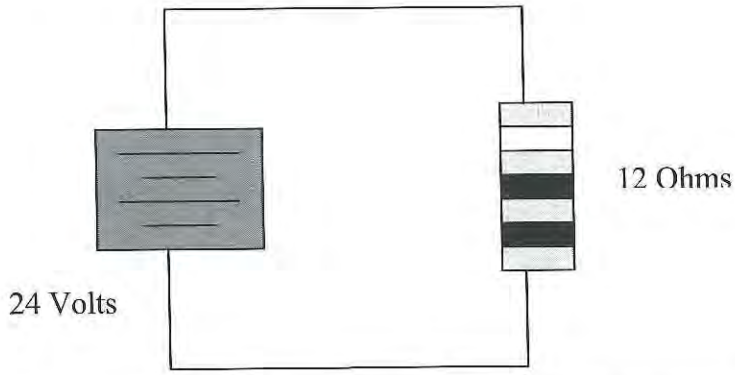
Diagram, NTC, db.25

Parallel Circuit Example 2



Calculate total Resistance $1/R_T = 1/R_1 + 1/R_2 = 1/24 + 1/24 = 2/24$

$1/R_T = 2/24$, **R_T = 12 ohms**

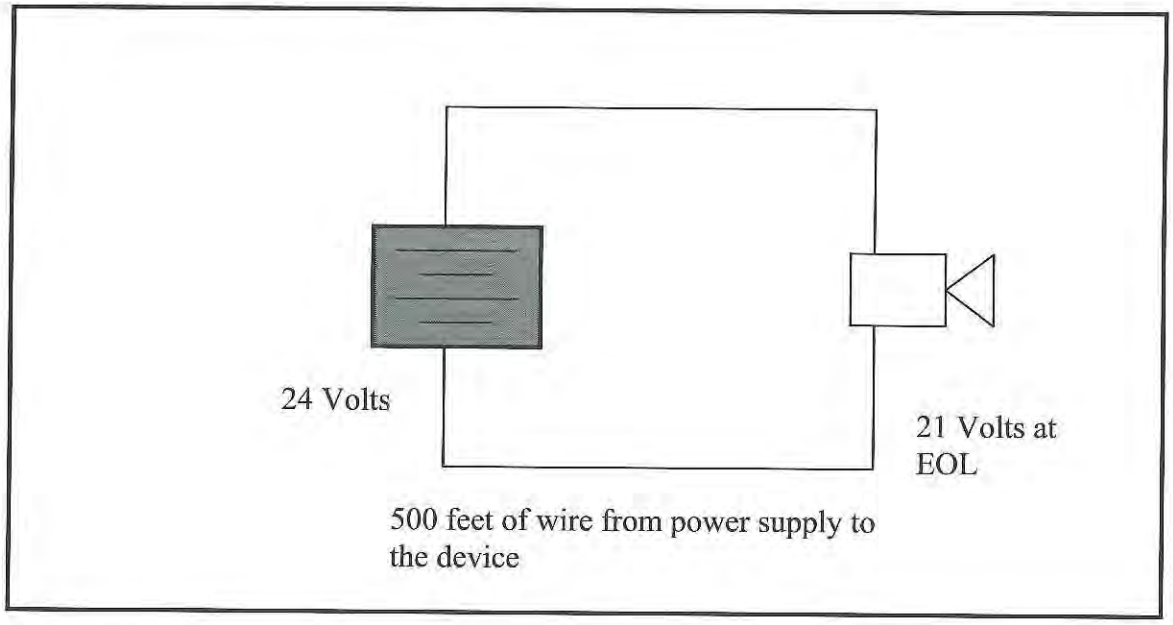


Load	Power	E (at load)	I (at load)	R (at load)
R_1	24 watts	24 volts	1 amp	24 ohms
R_2	24 watts	24 volts	1 amp	24 ohms
R_3	48 watts	24 volts	2 amps	12 ohms

Diagram, NTC, db.26

Voltage Drop Calculations:
Using Ohm's Law for Fire Alarm System Design
The primary application of Ohm's law for fire alarm system design is voltage drop calculations. Voltage drop calculations are a required submittal for fire alarm systems. These calculations ensure there is adequate voltage and current for all devices on a fire alarm circuit. The actual wiring used in a circuit acts as a resistor in the circuit. The smaller the wire size, the greater the resistance. For short wire runs, this resistance is negligible. For longer runs, it can become quite significant. Voltage drop calculations determine the effects of that resistance.

Consider the following circuit



Diagram, NTC, db.27

What is the proper wire size for the circuit listed above?

a. 16 awg
b. 14 awg
c. 12 awg
d. 10awg

For this problem, all the information needed is here. The rule for voltage in series provides:

Voltage in a series circuit is additive.

$E_{total} = E_{device} + E_{wire}$

$24 = 21 + E_{wire}$

$E_{wire} = 24 - 21 = 3$ ohms
Now look at the chart below and find the wire size for which 1000' has 3 ohms or less wire resistance.

1000" coated solid wire with a total resistance of 3 ohms or less

Wire Guage AWG	Wire Type	Coated Wire Resistance per 1000'	Uncoated Wire Resistance per 1000'
18	Solid	8.08	7.77
18	Stranded	8.45	7.95
16	Solid	5.08	4.89
16	Stranded	5.29	4.99
14	Solid	3.19	3.07
14	Stranded	3.26	3.14
12	Solid	2.01	1.93
12	Stranded	2.05	1.98
10	Solid	1.26	1.21
10	Stranded	1.29	1.24

Diagram, NTC, db.28

This is an excerpt of the chart found in Ugly's Electrical Reference, page 65.

The answer here is 12 AWG.

Software is available now which allows voltage drop calculations to be made via computer rather than by hand.

Basic Electronics
There are some electronic components which technicians should have some familiarity with. Technicians used to be responsible for conducting component level service down to the board level. Now equipment is plug and play. Technicians simply replace the malfunctioning device. Some common component definitions are:

Capacitance: The electrical characteristics which permits the storage of electrical energy in the electrostatic field between conductors. The amount of charge that can be stored by a capacitor is measured in farads.

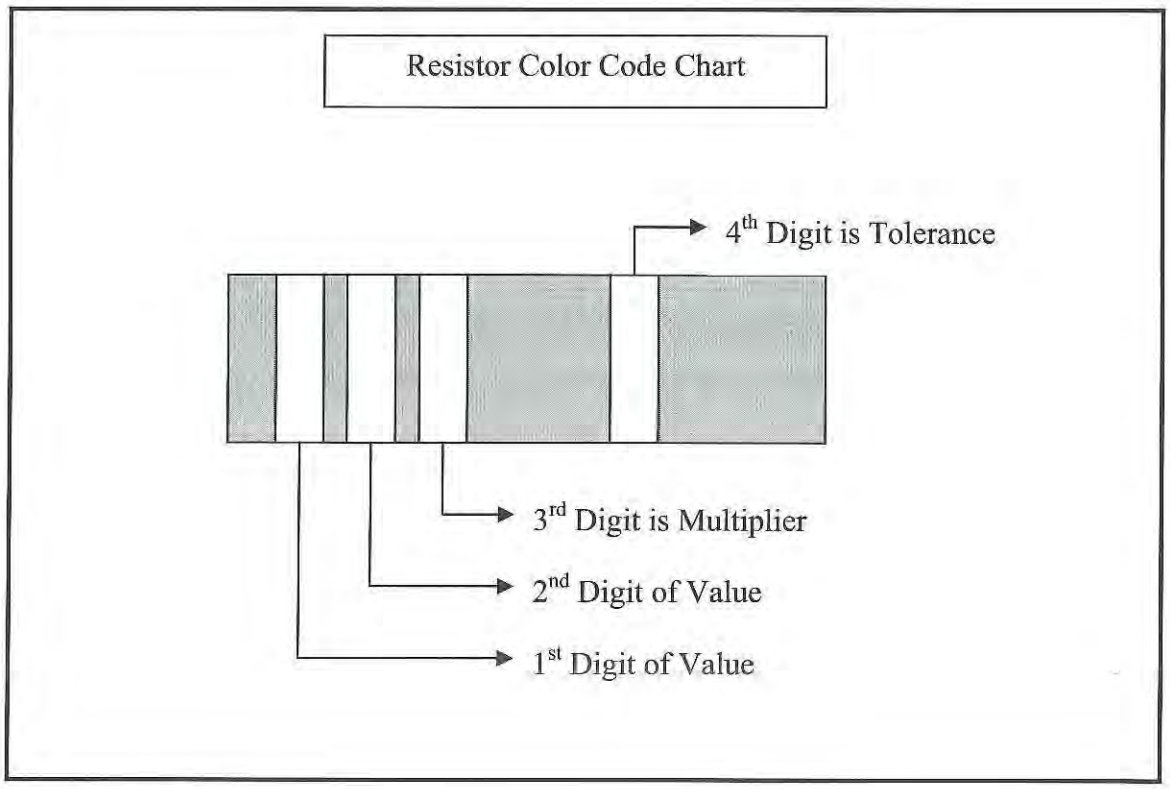
Capacitor: Two conductors separated by an insulator or dielectric to store a charge.

Cathode: The general name of any negatively charged electrode such as the negative side of a diode or electrical cell.

Cathode Ray Tube: A tube used in television sets and oscilloscopes where the electron beam is capable of being deflected to produce a visible pattern.

Diode: A semiconductor device that has a PN junction. Usually diodes permit the flow of electrons in one direction but not in the other direction. Not all diodes work this way however.
Transistor: A semiconductor made from germanium or silicon with leads 3 leads called emitter, collector, and base. Transistors are made to conduct by forward biasing an emitter base junction.

Resistor Color Code
All resistors are provided with a color code. It is easy to determine their value using a meter. The color code can also be used. The resistor color code values are as follows:



Diagram, NTC, db.29

1st digit. This is the actual number used for the first digit of the resistor's value.
2nd digit. This is the actual number used for the second digit of the resistor's value.
3rd digit. This is the multiplier.
4th digit. This is the tolerance of the resistor. The values of resistance may have some variance due to manufacturing.

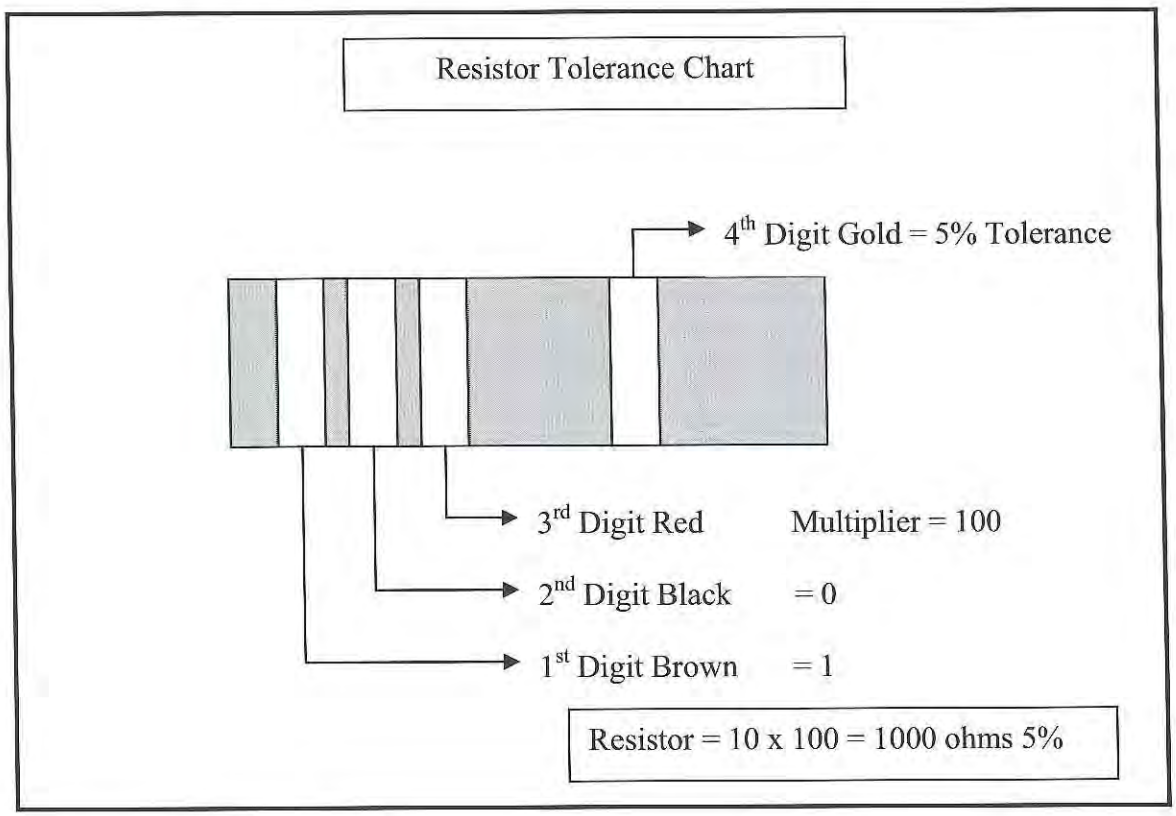
Color	1st Digit	2nd Digit	Multiplier
Black	0	0	1
Brown	1	1	10
Red	2	2	100
Orange	3	3	1,000
Yellow	4	4	10,000
Green	5	5	100,000
Blue	6	6	1,000,000
Violet	7	7	10,000,000
Gray	8	8	100,000,000
White	9	9	1,000,000,000

Diagram, NTC, db.30

Tolerance

Gold band	±5%
Silver band	±10%
No color	±20%

Determine the value of the resistor



Diagram, NTC, db.31

Speaker Power Loss Calculation

Some fire alarm systems use speakers for audible notification. Voltage drop can have an effect on the sound level for speakers. This can be determined using the speaker power loss calculation. Speaker power loss should be kept at 1 db or less. Evax Systems provides automated speaker power loss software on their website www.evax.com.

Summary

Electronics and basic electricity are very important to fire alarm systems. It is important for technicians to understand the basics of electronics and electricity. Knowing and being able to use Ohm's law will help technicians understand the critical design requirements for fire alarm systems as they relate to wire size, power supply requirements and equipment selection.

Appendix C

Documentation for Fire Alarm Systems

There are two primary documents which are required for all fire alarm systems. They are the Record of Completion and the Inspection and testing form.

The record of completion is a document which is required for every new fire alarm installation. There are 10 parts to this document. Parts 1, 2, and 4 thru 10 are required to be completed after the system is installed and prior to the acceptance test. Part 3 is required to be completed after the actual acceptance test is complete. A copy of this document is required to be provided to the building owner, the AHJ and the fire alarm system contractor should keep a copy. This document is required to be signed by a representative of the installation company and by the AHJ.

There are 2 very important parts of the record of completion. The document requires the building owner to have a program for future testing and inspections in place. Most building owners do not have employees trained to do testing and inspections. In those cases the code permits testing and inspections to be contracted to a service company. The contract information is required to be annotated on the front page of the record of completion, then again in section 10 of the document. Your company should always secure this contract prior to the acceptance testing. The second very important part of this document is located in section 10 as well. This is the Deviations from referenced NFPA standards section. If the installation and design of the system deviate from the requirements of the code, such deviations should be annotated here. If the AHJ requires a deviation from code, make sure it is noted in section 10 of the record of completion. This will provide your company with the documentation needed in the event of future litigation.

The inspection and testing form is also very important. Routine testing and inspection of the fire alarm system is required by NFPA 72® The National Fire Alarm Code®. This form has to be filled out and attached to the record of completion after the acceptance test has been completed. Then every future test or inspection requires the completion of the form. This record proves that proper service has been performed on the system. Additionally it is an important source of recurring revenue for your company.

Both forms are included in this Appendix.

Fire Alarm System
Record of Completion

Name of Protected Property:_____

Address:_____

City:_____ State:_____ Zip:_____

Rep of protected property:_____ Phone (_____)_____

Authority Having Jurisdiction:_____

AHJ Address:_____

City:_____ State:_____ Zip:_____

AHJ phone number:(_____)_____

Installation company_____

Installation company phone number:(_____)_____

Installer:_____ Phone:(_____)_____

Equipment Supplier:_____

Service Organization:_____

Location of As Built Drawings:_____

Location of operation and maintenance manuals:_____

Location of test reports:_____

Contract for testing and inspections IAW NFPA 72, #_____

Effective Date of Contract:_____ Expiration:_____

System Software, Operating System revision:_____

Site Specific Software revision date:_____

Revision completed by:_____ Firm:_____

1. Type of System or Service (please check all that apply)

_____Local System, *NFPA 72, Chap 6* (all systems shall comply with Chapter 6)

Monitored Systems

_____Remote Station, *NFPA 72, Chap 8* (most common type of fire alarm system)

_____Proprietary Station, *NFPA 72, Chap 8* (under 1 ownership, requires runner)

_____Central Station, *NFPA 72, Chap 8* (requires UL or FM inspection and runner)

Prime contractor (central station only)_____

Name of monitoring station_____

Address of monitoring station_____

City_____State_____Zip_____

Monitoring station phone number (_____)_____

Phone number of additional monitoring stations (_____)_____
(sometimes signals are sent to additional receivers for trouble or supervisory)

Retransmission (who the monitoring station calls ie fire dept, communications center)

Retransmission address_____

City_____State_____Zip_____

Phone number for public fire service comm. Center (_____)_____

Means of signal transmission from protected premise to monitoring station

_____Digital Communicator _____Two Way Radio

_____One Way Radio _____Multiplex (Derived Channel)

_____McColloh _____Other

_____Auxiliary System, *NFPA 72, Chap 9,* (rarely used today)

Connection: _____Local energy _____Shunt _____Parallel telephone

Phone number for receipt of signals (_____)_____

2. **Record of System Installation** (fill out after installation is complete and wiring has been checked for opens, shorts, ground faults and improper branching, but prior to conducting operational acceptance tests)

This system has been installed in accordance with NFPA standards and all wiring has been tested satisfactorily.

Inspected by_____ Date_____

Date in service_____

This system complies with the following

_____NFPA 72, Chapter 1 Administration

_____NFPA 72, Chapter 2 Referenced Publications

_____NFPA 72, Chapter 3 Definitions

_____NFPA 72, Chapter 4 Fundamentals

_____NFPA 72, Chapter 5 Initiating Devices

_____NFPA 72, Chapter 6 Protected Premise

_____NFPA 72, Chapter 7 Notification Appliances

_____NFPA 72, Chapter 8 Supervising Station Fire Alarm Systems

_____NFPA 72, Chapter 9 Public Fire Alarm Reporting Systems

_____NFPA 72, Chapter 10 Testing and Inspections

_____NFPA 72, Chapter 11 Residential Fire Alarm Systems and Equipment

_____NFPA 70, Article 760 Fire Alarm System Wiring

_____Manufacturer's Instructions

_____Other Codes_____

Signature of Inspector listed above_____

Date_____

Organization_____

3. **Record of System Operation** Inspection Testing Form Required to be attached to this document)

All operational features and functions of this system have been tested and found to be operating properly in compliance with NFPA Standards.

Tested by_____Date_____

This system complies with the following

_____NFPA 72, Chapter 1 Administration

_____NFPA 72, Chapter 2 Referenced Publications

_____NFPA 72, Chapter 3 Definitions

_____NFPA 72, Chapter 4 Fundamentals

_____NFPA 72, Chapter 5 Initiating Devices

_____NFPA 72, Chapter 6 Protected Premise

_____NFPA 72, Chapter 7 Notification Appliances

_____NFPA 72, Chapter 8 Supervising Station Fire Alarm Systems

_____NFPA 72, Chapter 9 Public Fire Alarm Reporting Systems

_____NFPA 72, Chapter 10 Testing and Inspections

_____NFPA 72, Chapter 11 Residential Fire Alarm Systems and Equipment

_____NFPA 70, Article 760 Fire Alarm System Wiring

_____Manufacturer's Instructions

_____Other Codes_____

Signature of Inspector listed above_____

Date_____

Organization_____

4. **Signaling Line Circuits** (Addressable Circuits, see NFPA 72, table 6.6.1)

Number of Signaling Line Circuits connected to system_____

Class of SLC_____ Style of SLC_____

5. **Alarm Initiating Devices and Circuits** (see NFPA 72, table 6.5)

Number of Initiating Device Circuits connected to system_____

Class of IDC_____ Style of IDC_____

Manual Initiating Devices (pull stations)

Quantity of Noncoded (most common)_____ Coded (rarely used today)_____

Quantity of Addressable pull stations_____ Transmitters_____

Automatic Detectors (please select the type of coverage required by NFPA 101) (circle type of coverage)

Complete Partial Selective Nonrequired

Smoke Detectors

Number of Photo_____ Number of Ion_____ Addressable_____

Duct Detectors

Number of Photo_____ Number of Ion_____ Addressable_____

Heat Detectors

Number of Fixed Temp_____ Number of Rate of Rise_____

Number of Combination FT/RR_____ Addressable_____

Number of Rate Compensation Heat Detectors_____

Sprinkler Waterflow Devices

Quantity of Noncoded_____ Coded_____ Addressable_____

Alarm Verification Feature _____Enabled _____Disabled _____Seconds

Other initiating devices_____

6. Supervisory Signal Initiating Devices and Circuits

Guard's Tour _____Coded Stations _____Noncoded Stations

Compulsory guard's tour system with _____transmitter stations and intermediate stations

Sprinkler System (indicate number of devices)

Number of valve supervisory switches _____

Number of building temperature points _____

Number of site water temperature points _____

Number of site water supply level points _____

Electric Fire Pump (circle appropriate answer)

Fire pump power supervision	Yes	No
Fire pump running supervision	Yes	No
Fire pump phase reversal supervision	Yes	No

Engine Drive Fire Pump (circle appropriate answer)

Selector in auto position supervision	Yes	No
Engine control trouble supervision	Yes	No
Fire pump running supervision	Yes	No

Engine Driven Generator (circle appropriate answer)

Selector in auto position supervision	Yes	No
Control panel trouble supervision	Yes	No
Transfer switch supervision	Yes	No
Engine running supervision	Yes	No

Other supervisory functions_____

7. Annunciators

Number of Annunciators_____ Type_____

Location of Annunciators_____

_____

8. Alarm Notification Appliances and Circuits

Emergency Voice / Alarm Communications

Quantity of Voice / Alarm channels_____Single_____Multiple_____

Quantity of speakers_____Quantity of speaker zones_____

Quantity of telephones included_____Quantity of Jacks_____

Notification Appliance Circuits (see NFPA 72, table 6.7)

Quantity of NAC Circuits_____

Class of NAC_____ Style of NAC_____

Indicate the quantity of each of the following

Strobes _____

Horns _____

Horn / Strobes _____

Speakers _____

Speaker / Strobes _____

Chimes _____

Chime / Strobes _____

Bells _____

Other Devices _____

Other Devices / Strobes _____

9. System Power Supplies

Fire alarm control panel nominal voltage_____ Current Rating_____

Overcurrent protection Type_____ Current Rating_____

Secondary (Standby) Storage Battery_____Amp-hour rating_____

Calculated capacity to drive system in hours_____

Engine driven generator used for secondary Yes No

Location of fuel storage_____

Emergency system used as backup to primary power Yes No
(NFPA 70, article 700 describes requirements for Emergency Systems)

10. Comments

Frequency of routine testing and inspections if other than in accordance with NFPA

_____

System Deviations from NFPA Standards_____

_____

Signature for Installation Contractor_____

Title_____Date_____

Signature for Alarm Service Company_____

Title_____Date_____

Signature for Central Station_____

Title_____Date_____

Upon satisfactory completion of the acceptance test witnessed by the AHJ

Signature for Authority Having Jurisdiction_____

Title_____Date_____

Inspection and Testing Form

Date_____ Time_____

Service Organization

Name_____

Address_____

City_____ ST_____ Zip_____

Representative_____

License_____

Telephone (_____)_____

Property Name

Name_____

Address_____

City_____ ST_____ Zip_____

Owner Contact_____

Telephone (_____)_____

Monitoring Entity

Contact_____

Telephone (_____)_____

Monitoring Acct Ref#_____

Approving Agency

Contact_____

Telephone (_____)_____

Type Transmission

_____Digital Communicator

_____McColloh

_____Multiplex (Derived Channel)

_____Radio

_____Reverse Polarity

_____Other _____

Control Unit Manufacturer_____ Model_____

Software Revision_____ Last Revision Date_____

Date of Last Service_____

Alarm Initiating Devices & Circuit Information

Device	Quantity	Circuit Style
Manual Fire Alarm Box	_____	_____

Device	Quantity	Circuit Style
Photo Detector	_____	_____
Ion Detector	_____	_____
Duct Detector	_____	_____
Heat Detector	_____	_____
Waterflow Switch	_____	_____
Supervisory Switch	_____	_____
Other_____	_____	_____

Alarm Verification feature (circle) Enabled Disabled

Alarm Notification Appliances and Circuit Information

Device	Quantity	Circuit Style
Horns	_____	_____
Strobes	_____	_____
Bells	_____	_____
Speakers	_____	_____
Chimes	_____	_____
Horn / Strobes	_____	_____
Speaker / Strobes	_____	_____
Chime Strobes	_____	_____
Other_____	_____	_____

Number of NAC Circuits_____

Are all circuits monitored for integrity? (circle) Yes No

Supervisory Signal Initiating Devices and Circuit Information

Device	Quantity	Circuit Style
Building Temperature	_____	_____
Site Water Temperature	_____	_____
Site Water Level	_____	_____
Fire Pump Power	_____	_____
Fire Pump Running	_____	_____
Fire Pump Auto Position	_____	_____
Fire Pump or Auto Controller Tbl	_____	_____
Generator in Auto Position	_____	_____
Switch Transfer	_____	_____
Generator Engine Running	_____	_____
Other_____	_____	_____

Signaling Line Circuit (see NFPA 72, table 6.6.1)

Quantity_____ Style_____

System Power Supplies

Primary (main) Power Nominal Voltage_____ Amps_____

Overcurrent Protection Type_____ Amps_____

Location_____

Disconnecting Means Location_____

Secondary (standby) Type_____ AH Rating_____

Calculated capacity in normal operation (in hours)_____

Type of Generator (if used)_____Fuel Location_____

Type of Battery (circle)

Sealed Lead Acid Lead Acid

Nickel Cadmium Dry Cell

Other_____

Standby system used as backup (if used instead of secondary power supply)

_____ Emergency System (NFPA 70, Article 700)

_____ Legally Required Standby System (NFPA 70, Article 701)

_____ Optional Standby System (NFPA 70, Article 702)

Prior To Any Testing

Notification

Monitoring Entity Person_____ Time_____

Building Occupants Person_____ Time_____

Building Management Person_____ Time_____

Other_____ Person_____ Time_____

AHJ Notification of Impairments_____ Time_____

System Tests and Inspections (P= pass, F = fail)

Device Type	Inspection	Test	Comments
Control Unit	_____	_____	_____
Interface Equipment	_____	_____	_____
Lamps / LEDs	_____	_____	_____
Fuses	_____	_____	_____
Primary Power	_____	_____	_____
Trouble Signals	_____	_____	_____

System Tests and Inspection (P = pass, F = fail)

Device Type	Inspection	Test	Comments
Disconnect Switch	_____	_____	_____
Ground Fault	_____	_____	_____
Secondary Power			
Battery Condition	_____	_____	_____
Load Voltage	NA	_____	_____
Discharge Test	NA	_____	_____
Charger Test	NA	_____	_____
Specific Gravity (lead acid only)		_____	_____
Transient Suppressor	_____	NA	_____
Remote Annunciator	_____	_____	_____
Notification Appliances			
Audible	_____	_____	_____
Visible	_____	_____	_____
Speakers	_____	_____	_____
Voice Clarity	NA	_____	_____

Initiating and Supervisory Device Tests and Inspections
(P = pass, F = fail)

Serial #	Location	Inspection	Test	Factory Setting	Measured Setting

Comments _____

Emergency Communications Equipment
(P = pass, F = fail)

Device Type	Inspection	Test	Comments
Phone Set	_____	_____	_____
Phone Jacks	_____	_____	_____
Off Hook Indicator	_____	_____	_____
Amplifiers	_____	_____	_____
Tone Generators	_____	_____	_____
Call in Signal	_____	_____	_____
System performance	_____	_____	_____

Interface Equipment (relays for fire safety functions)

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Special Hazard Systems

_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Special Procedures_____

_____

Comments_____

_____

_____

Supervising Station Monitoring

Signal Type	Test	Time	Comments
Alarm Signal	_____	_____	_____
Alarm Restoral	_____	_____	_____
Trouble Signal	_____	_____	_____
Supervisory Signal	_____	_____	_____
Supervisory Restoral	_____	_____	_____

Notification Testing is Complete

Notification

Monitoring Entity Person_____ Time_____

Building Occupants Person_____ Time_____

Building Management Person_____ Time_____

Other_____ Person_____ Time_____

System restored to normal operation Date_____ Time_____

The following did not operate properly_____

_____

_____

This testing was performed in compliance with applicable NFPA standards

Name of Inspector_____Date_____Time_____

Signature_____

Name of Owner or Representative_____

Date_____Time_____

Signature_____

Appendix D

Metric Conversion

To convert from Measurement #1 to Measurement #2 multiply by Factor #1
To convert from Measurement #2 to Measurement #1 multiply by Factor #2

Examples:
1. Convert 300 centimeters to yards. Multiply Factor #1 (0.010936) times 300 (Measurement #1) to get Measurement # 2.: 0.010936 x 300 = 3.28 yards
2. Convert 5 kilometers to feet. Multiple Factor #2 (3280.84) times 5 (Measurement #2) to get Measurement #1: 3280.84 x 5 = 16,404.2 feet

Factor #1	Measurement #1	Measurement #2	Factor #2
43,560	Acre	Foot	0.000022956
0.0015625	Acre	Square Mile	640
0.0328084	Centimeter	Foot	30.48
0.3937	Centimeter	Inch	2.54
0.010936	Centimeter	Yard	91.44
0.000000785398	Circular Mil	Square Inch	0.000001273239
0.000507	Circular Mil	Square Millimeter	1973.525
0.06102374	Cubic Centimeter	Cubic Inch	16.3870165
0.028317	Cubic Foot	Cubic Meter	35.13467
0.0003048	Foot	Kilometer	3,280.84
0.3048	Foot	Meter	3.28084
0.0001894	Foot	Mile	5280
0.0022046	Gram	Pound	453.592
0.0254	Inch	Kilometer	39,370
25.4	Inch	Millimeter	0.03937
1093.61	Kilometer	Yard	0.00009144
0.000621	Meter	Mile	1,609.344
1.0936	Meter	Yard	0.9144
1760	Mile	Yard	0.00056818
0.224809	Newton	Pound (force)	4.44822
0.155	Square Centimeter	Square Inch	6.4516
0.092923	Square Foot	Square Meter	10.76391
0.386102	Square Kilometer	Square Mile	2.589988

Temperature Conversions

Fahrenheit to Celsius: 0.555 x (F° - 32)
Celsius to Fahrenheit: (1.8 x C°) + 32

Appendix E

What is NICET?

NICET stands for the National Institute of Certifying Engineering Technologies. NICET develops and administers exams for engineering certifications in more than 30 fields, including construction, utilities, sound systems, and fire alarm systems. After being accepted by NICET for testing, NICET maintains applicant records.

NICET also verifies work experience and references. If certification is achieved, NICET maintains the certification records and helps assure the applicant's knowledge remains current via continuing education.

The Importance of NICET Certification
NICET certification is a nationally recognized, cross-industry recognized certification standard. Many states and municipalities are adopting NICET certification as a requirement to install and service fire alarm systems. NFPA 72® (The National Fire Alarm Code®) recognizes NICET certification as a qualification to install and service fire alarm system specifically in two places (Chapter 4, 4.3.3 and Chapter 10, 10.2.2.5).

Many employers are requiring NICET certification as a condition of employment or for advancement. NICET certification belongs to the person who is certified, not his employer, so it is also a resume builder.

Certification
NICET offers Technologist and Technician certifications. Technologist certification is intended for persons who have a bachelor's degree in engineering technology from an approved program. Technician certification is intended for field personnel, and does not have any education requirements. Technician certification is intended for persons who install, maintain, test, and inspect fire alarm systems. Technician certification is based upon your work experience and your ability to successfully pass a test on different aspects of fire alarm systems based on what NICET considers to be essential to your level of experience.

Program Detail Manual
The Program Detail Manual contains the information needed to apply for NICET certification. It defines the requirements for certification a different levels, describes the work elements (knowledge areas) that appear on the certification exam, and a lot of other information about NICET certification. This should only be used for a general overview only.

You are strongly encouraged to download the most recent copy of the Program Detail manual from NICET's website, www.NICET.org, as this information is subject to change.

A copy of the Program Detail manual may be request by mail from NICET, but there is a charge and NICET requires pre-payment by check before they will mail the manual.

Certification Levels
NICET offers certification in Fire Alarms in four levels:

Level I
Entry-level certification for technicians with minimal work experience.

Level II
Recommended 6-18 months of experience.

Level III
Recommended 5 year of experience.

Level IV
Recommended 10 years of work experience, plus supervision of a major project.

Work Elements
NICET exams are broken into work elements. Work elements are a series of 5-15 multiple-choice questions on specific fire alarm or fire alarm-related subjects. You must pass at least 60% of the questions in order to pass the work element.

Work Elements and Certification Levels
Certification at different levels requires passing work elements at that level, and work elements from previous levels for higher certifications. Elements are classified as General or Special. Each level of certification has a requirement for the number of elements in General or Special classification that must be passed. Level III and IV certifications require even more of the General and Special elements from the lower levels to be passed in order to achieve these certifications. General work elements are further classified as Core and Non-Core. Core elements are required to be passed to achieve certification at a particular level.

Work Element Requirements
The number of passed work element requirements for all levels:

Level I
Level I – General - 6
Level I – Special – 2
Total 8

Level II
Level I – General - 6
Level I – Special – 2
Level II – General – 18
Level II – Special – 4
Total 30

Level III
Level I – General - 9
Level I – Special – 3
Level II – General – 24
Level II – Special – 6
Level III – General – 11
Level III – Special – 1
Total 54

Level IV
Level I – General - 9
Level I – Special – 3
Level II – General – 26
Level II – Special – 6
Level III – General – 15
Level III – Special – 1
Level IV – General – 6
Level IV – Special – 2
Total 68

Core Elements for Level III and Level IV
Note how the required number of core elements rises on Level III and Level IV certifications. Passing ALL core elements for the lower levels is required for certification at these levels. All Level III and IV core elements are required to be passed for certification at these levels.

Work Element 31011
"Basic Metric Units and Conversions" is a Level I General element, but it must be passed for certification at Level II and above.

Passed and Failed Work Elements

Once you pass an element you do not have to test on it ever again as long as your certification remains current and active. If you fail a work element, you may retest on it on a future exam. You must wait 140 days from the time you failed an element until you can test on it again. If you fail an element three times you will be blocked from testing on it a forth time for a period of 2 years from the date you first tested (failed) it.

Personal Tally

It is your responsibility to keep track of what elements you have tested on, and whether you have passed or failed them. NICET includes a tally sheet with its Program Detail Manual. We recommend you keep this tally sheet in a safe place. For a fee, NICET will provide you with a tally sheet from their records if you lose your copy.

Preparing For NICET Certification

National Training Center offers many resources to help you prepare for NICET certification. NTC offers live NICET certification classes and on-line classes, NFPA code books, and reference books (including Chuck Notes, a "Cliff Notes" version of .

Visit our website at www.NationalTrainingCenter.net for more information!

Appendix F

Sample Battery Calculation

Battery Calculation

Standby

Device Type	Number of Devices		Current (Amps)		Total Current (Amps)
Main Circuit Board	1	X	0.123	=	0.123
Remote Annunciator	1	X	0.006	=	0.006
Relay Module	0	X		=	0
2-wire Detector Heads	10	X	0.005	=	0.05
4-wire Detector Heads	2	X	0.005	=	0.01
SUM COLUMN FOR STANDBY LOAD				=	0.189

Alarm

Device Type	Number of Devices		Current (Amps)		Total Current (Amps)
Main Circuit Board	1	X	0.255	=	0.255
Remote Annunciator	1	X	0.05	=	0.05
Relay Module	0	X		=	0
4-wire Detector Heads	2	X	0.23	=	0.46
Notification Appliances	10	X	0.101	=	1.01
SUM COLUMN FOR LOAD IN ALARM				=	1.775

Total

Standby Load Current (Amps)	0.189	X	Required Standby Time in Hours (24 or 60 Hrs.) 24	=	4.54
Alarm Load Current (Amps)	1.775	X	Required Alarm Time in Hours (5 minutes = 0.084) 0.084		0.15
Add Standby and Alarm Load for Required Ampere Hour Battery					4.69
Multiply by the Derating Factor of 1.2 Total Ampere Hours Required				=	5.63

Central Station Fire Alarm System	A fire alarm system that reports to a constantly attended approved monitoring station where, upon receipt of signal, the signal is recorded and appropriate action is taken.
Channel	A path of signal transmission between two or more locations. May be wire, radio, or other means.
Chime	A single stroke or vibrating type signal device that produces a pleasant, non-alarming, musical-type tone.
Circuit	Conductors or a radio channel and associated equipment used to perform a function in association with the fire alarm system.
Circuit Interface	Device that interfaces one or more initiating device circuits (IDC) to a signaling line circuit (SLC) and allows the central supervising station to monitor the status of each initiating device circuit.
Circuit Performance	The performance of a circuit under adverse (fault) conditions.
Clean Agent Extinguishing System	Supression system that uses extinguishing agent under pressure to flood the area with a fire-inhibiting chemical. Causes minimal damage to protected items.
Cloud Chamber Smoke Detector	An air sampling type detector that draws air into a humidifier and looks for condensation of water onto smoke particles.
Code	A specification for the circumstances in which fire protection is required.
Coded Signal	A pulsed signal transmitted in a predetermined format, usually repeated three times (rounds), with a minimum of three pulses per round.
Coded Radio Fire Alarm Box	Municipal fire alarm boxes that report via radio frequency instead of hardwire connection.
Combination Detector	A detector that responds to one or more fire signatures (heat, smoke, flame, etc) or uses more than one operating principle to detect the fire.
Combination System	A fire alarm system with components shared in with other non-fire systems. The function of the non-fire components cannot interfere with the function of the fire alarm components. Example: burglar alarm, paging.
Communications Channel	A signaling channel having two or more termination locations and the capacity to handle the type of signals used for communication.
Computer Aided Dispatch (CAD)	A system that provides relevant data (address,

	hazards, equipment status) to the dispatcher.
Contiguous	Sharing and edge or boundary, connected.
Control Unit	A device that furnishes and supervises power to the fire alarm system, receives signals from initiating devices, transmits signals to notification appliances, and supervises all wiring associated with the system.
Conventional System	A system that does not identify individual initiating or control devices.
Delayed Egress	A door lock system that delays unlocking for 15 (or up to 30 seconds) after activation. The lock device must sound a local alarm, and unlock immediately upon fire alarm activation or loss of power.
Delinquency Signal	A signal indicating a need for action in regard to guard supervisory service.
Deluge Extinguishing System	Open sprinklers attached to a water supply with a valve controlled by the fire alarm system.
Derived Channel	A signaling line circuit that uses the local leg of the public switched telephone network (PSTN) as a active multiplex channel while still allowing the leg to be used for normal telephone communications.
Design Drawings	Drawings submitted along with specification indicating the intended design of the fire alarm system for review and approval by the AHJ.
Digital Alarm Communicator System (DACS)	A system which transmits signals from a digital alarm communicator transmitters (DACT) over the public switched telephone network (PSTN) to a digital alarm communicator receiver (DACR).
Digital Alarm Radio System (DARS)	A system which transmits signals from a digital alarm radio transmitters (DART) through the radio channel or radio network to a digital alarm radio receiver (DARR).
Dual Action	A device that requires two separate physical actions to activate it.
Dry Chemical Automatic System	Suppression system that uses a dry chemical powder under pressure to flood the area with a fire-inhibiting chemical. Causes minimal damage to protected equipment, but requires clean up.
Dry Pipe Automatic Sprinkler	An extinguishing system with piping with air under pressure. When a sprinkler head is activated the air pressure drops and a valve opens to allow water to flow.

Dual Control	The use of two different routes or methods to control one communications channel.
Electrical Metal Tubing (type EMT)	Unthreaded, thinwall, circular raceway for the protection and routing of cables.
Electrical Nonmetallic tubing (Type ENT)	A nonmetallic, corrugated, circular racewayfor the protection and routing of cables.
Elevator Recall	The recall of elevators to safe levels and/or operating modes in the event of a fire.
Emergency Controls	Controls designed to operate emergency systems.
Emergency Forces Notification	Notification to a Proprietary, Remote or Central Station of fire alarm signals
Emergency Systems Generator	Backup power system for a building. It provides power to the most important building systems which have a direct impact on life safety
Emergency Lighting	Lighting system connected to an Emergency Systems Generator which illuminates routes of egress from the building (usually has batteries in addition)
Emergency Voice/Alarm Communication System	A system that provides voice (manual or automatic) evacuation instructions and voice communications in the event of a fire.
Enclosure	Case or housing that prevents tampering or damage
End of line relay (EOLR)	A powered relay device used to supervise 4-wire type detectors. When the power to the relay is cut, the relay opens the detection circuit to cause a trouble.
Engine Driven Generator	Power source which uses a motor to generate electricity. The motor may use gasoline, diesel fuel or natural gas
Equivalent Facilitation	Devices or systems which provide the same level of protection or greater
Evacuation Signal	A signal used to alert the building occupants to leave the building during an emergency.
Extinguishing System	A system designed and installed to delay or extinguish the harmful effects produced by a fire. This includes Sprinkler and Suppression systems
Factory Mutual (FM Global)	A testing agency for fire alarm equipment. They maintain a list of equipment which passes certain standards.
False Alarm	An alarm resulting from anything other than what the device was intended to detect.
Fault	An open, ground, or short that prevents the fire alarm system from operating properly.

Fiber Optics	Transmission of signals by pulsing light over glass fibers.
Fire Alarm System	Initiating and notification devices connected to a control unit installed so that they produce an alarm signal in the event of a fire.
Fire Barrier Door	A door normally held open during normal operation of the building. In the event of a fire the door is closed to maintain the integrity of a fire barrier
Fire Command Station	A specific location in the building where Voice Evacuation, annunciation and other control functions are located. This is the place fire fighters use to direct fire fighting operations in the event of a fire.
Fire Model	An anticipated scenario used for fire protection planning. Fire models are developed based on previous fires in similar buildings, test fires and software computer modeling. This provides a possible fire scenario for design purposes. Always expect drastically different results from a real fire. Fire is upredictable.
Fire Pump	A motor (electrically or diesel fueled) used to pump water from the water tank to the sprinkler system.
Firefighters Smoke Control Station (FCFS)	A control station (normally collocated with the Fire Command Center) designed specifically to provide fire fighters with the capability of managing smoke control devices to assist in fighting the fire.
Fixed Temperature Heat Detector	A detector that goes into alarm condition when it reaches a specific temperature. May be restorable or non-restorable.
Flame Detector	A detector that detects the infrared, ultraviolet, or visible radiation produced by a fire.
Flexible Metal Conduit (Type FMC)	Normally used for short runs to connect a box to another box or device.
Four-Wire Detector	A detector the receives power and transmits alarm signals over separate pairs of wires.
Frequency Division Multiplexing	Signal transmission method that allows more than signals to be transmitted on the same channel by transmitting each signal on a separate frequency or combination of frequencies.
Fusible Link Heat Detector	Detectors which are activated when the temperature at the detector reaches a predetermined level that melts a metallic link holding back a spring loaded contact. The link

	must be replaced for the detector to be reset.
Gas Sensing Fire Detectors	Detectors which operated when they sense combustion gases from fires.
Generator	Power source which uses a motor to generate electricity. The motor may use gasoline, diesel fuel or natural gas
Ground	The earth. Metal parts are connected to earth for the purpose of directing lightning and other high voltage surges into the ground and away from electrical / electronic circuits.
Ground Fault	A condition when the resistance between a conductor and the electrical ground reaches an unacceptably low level.
Grounding Electrode	The rod or plate which is in direct contact with the ground and has sufficient surface area contact.
Guard's Tour Supervisory Service	Using the fire alarm system to monitor the progress of a guard on routine patrol through a facility. The guard is required to check in at predesignated points usually at a specific time.
Halon Extinguishing Systems	A very effective fire suppression agent which is no longer used due to environmental concerns.
Heat Detector	A detector when operates when it sense heat at a specific level, or a specific temperature rise within specific time frame.
Heat Release Rate	The rate at which a fire releases heat energy. The arbitrary point where a fire reaches 1000 Btu/sec or 1055 KW/sec
High Air Movement	Any area where the rapid movement of air could interfere with a detection device's ability to detect the fire. Normally this applies to areas with more than 7.5 air changes per hour.
High Expansion Foam System	A suppression system which floods the affected area with expanding foam effectively choking out the fire.
High Rack Storage	Storage areas with open or closed rack systems with multiple levels normally exceeding 25 feet in height
High-Rise Building	Any structure where the highest story is more than 75' from the level of fire fighter access. This is used because the maximum extension of a fire fighter's truck ladder is 75'
Horn	An audible device that produces sound by vibrating a flexible surface when voltage is applied to it.
Hotel	A specific occupancy classification where

	multiple rooms (usually 16 or more) can be rented for short term use.
Household Fire Alarm System	A fire alarm control and associated equipment specifically listed for residential use.
Hunt Group	A group of associated telephone lines arranged so that incoming calls are automatically directed to an open line
Impairments	Any malfunction of the fire alarm system. Typically if the impairment affects more than 10% of the system and / or persists for more than 8 hours, notification to the building owner and the AHJ should be completed.
Infrared Flame Detector	A detector what detects infrared energy produced by a fire.
Initiating Device	A manual or automatic that causes alarm or supervisory indication at the fire alarm control panel when it is activated.
Initiating Device Circuit (IDC)	The circuit to which manual or automatic initiating devices are connected, where the panel does not indicate the device initiating the signal.
Interconnection	Refers to the connecting of multiple smoke alarms or fire alarm control units.
Intermediate Metal Conduit (type IMC)	A steel threadable raceway designed for the protection and routing of cables and conductors. It is specifically designed for use as an equipment grounding conductor when appropriate connectors and fittings are used.
Ionization Smoke Detector	A smoke detection device which operates on the principle of reduced current in an ionization chamber. Smoke entering the chamber reduces the flow of current and generates an alarm signal.
Joist Construction	Solid joists project more than 4" from the ceiling and are spaced 3' or less center on center.
Labeled	Equipment that bears the label, marking, or other identification of a testing organization acceptable to the AHJ.
Legally Required Standby Generator	A standby power system which provides power to a building. Legally required standby provides power to those building systems which have an indirect effect on life safety. For fire alarm systems legally required standby is used to provide power to supervising station receiving equipment.
Life Safety Code (NFPA 101)	When used for fire alarm system requirements, this code identifies which building occupancies

	require a specific type of fire alarm equipment.
Line Type Heat Detector	A heat detection device which is normally run in cable trays. It is capable of detecting along its entire length.
Listed	Equipment in a list published by a testing organization acceptable to the AHJ.
Load Side	A description used to identify the devices or systems which are connected to a power supply. Typically for fire alarm system purposes, load side is represented by the fire alarm control panel and all associated equipment. The supply side is represented by the breaker box from which the power for the system is derived.
Local Alarm System	A system that sounds a local alarm at the protected premises in response to manual or automatic system operation.
Local Energy Auxiliary System	An auxiliary fire alarm system where control panel, initiating devices, and associated equipment that trip a municipal transmitter or master box this is electrically isolated from the municipal system circuit.
Low Power Radio	This term refers to wireless fire alarm equipment like a wireless smoke detector which transmits to a control. This is not a communications method used to send signals to a monitoring facility.
Master Box	A municipal fire alarm box that can also be operated by remote means (fire alarm connection).
McCulloh Circuit	A transmission technology which uses an automated form of Morse code to send signals.
Measuring Ionization Chamber (MIC)	A specific chamber used by testing agencies (UL and FM Global) for testing Ionization type smoke detectors.
Metal Clad Cable (Type MC)	Factory assembly of conductors enclosed in a armor of interlocking metal tape, or a smooth or corrugated metal sheath
Monitoring	Generally refers to the monitoring of fire alarm signals by a supervising station.
Multichannel Capability	The capability of providing live voice instructions to certain areas, while providing recorded or evacuation instructions to other areas.
Multimode Fiber	Fiber that allows light to travel down in multiple paths.
Multiple Station Station Smoke Alarm	A smoke alarm which is capable of being interconnected with other smoke alarms. If one

	goes into alarm, all interconnected smoke alarms sound the evacuation signal.
Multiplexing	A signaling method that allows multiple signals to use the same signal path (simultaneously or sequentially) and allows each signal to be identified separately at the receiving end.
Municipal Communications Center	Building or part of building that houses central operating part of municipal fire alarm system. Usually where testing, switching, receiving, and power supply equipment is located.
Municipal Fire Alarm Box	A manually operated transmitter that send signals to the municipal communications center.
Municipal Transmitter	A remotely operated transmitter that sends signals to the municipal communications center.
Nameplate	A place where device information is stamped or printed directly on the device itself.
National Electrical Code (NEC) (NFPA70)	The code which governs all wiring for fire alarm system wiring and all electrical work.
National Fire Alarm Code (NFPA 72)	The code which details the installation of fire alarm equipment.
National Fire Protection Association (NFPA)	An association dedicated to producing the most comprehensive codes and programs to reduce the damage and loss of life due to fire
National Institute for Certification in engineering Technologies (NICET)	A certifying agency. NICET develops and administers certification testing for the fire alarm industry.
Non Required System	A system which has no requirement by any code for installation.
Noncoded	Signal that is transmitted continuously.
Noncontiguous	Not physically connected or touching.
Nonmetallic-Sheathed Cable (Type NM)	Factory assembly of two or more insulated cables having an outer sheath of nonmetallic material. Commonly called Romex®.
Nonpower Limited	As applied to fire alarm systems, generally refers to 120 volt or greater fire alarm equipment and wiring. Not used with modern fire alarm installations. Voltage is limited to 600 V and current is not limited for these systems.
Nonrestorable Heat Detector	A heat detector that must be replaced or have it's detection element replaced after it has been activated.
Notification Appliance	An audible or visual signal that indicates an alarm, trouble, or supervisory condition.
Notification Appliance Circuit	Circuit connected directly to notification appliances.
Occupancy Classification	A method for identifying buildings based on use.

	This is useful in determining fire alarm system requirements.
One Way Telephone	A telephone which does not provide the user with the option of dialing multiple numbers. When the handset is picked up, the telephone only dials one number.
On-Off Automatic Sprinkler System	A sprinkler system which stops flowing water when the signature of fire is no longer detectable. Fire alarm systems are used to control the shutoff valve or the sprinkler may have specially designed heads for this purpose.
Optical Fiber	Glass fiber that allows signals to be sent though it in the form of pulsed light.
Outside Stem and Yolk (OSY)	A control valve for a sprinkler system which uses a circular hand wheel to open or close the valve.
Overcurrent Protection	Protection provided to an electrical circuit in order to stop current flow above a certain threshold. This is in place to protect the load side equipment. For fire alarm systems overcurrent protection shall not exceed 20 amps.
Paging System	A system that pages person(s) through voice communication loudspeakers, coded audible or visual signals, or lamp annunciators located throughout the premises.
Parallel Telephone System	A telephone system using individually wired circuits for each box.
Peaked Ceiling	Any ceiling which slopes in more than one direction.
Permanent Visual Record	Generally refers to a requirement for a paper record or report. Some AHJs may accept computer storage media as meeting this requirement.
Photoelectric Smoke Detector	A smoke detector that works on light scattering (spot type) or light obscuration (beam type) detection principle.
Placard	Used to identify an installation as meeting the requirements of a listing agency. Required to be individually serial numbered and issued by UL or FM Global.
Plenum	Any area used as an environmental air return
Positive Alarm Sequence (PAS)	A method which provides for investigation (up to 180 seconds) of an alarm signal prior to evacuating the building.
Post Indicator Valve (PIV)	A sprinkler valve which is located underground and uses a post above ground to open or close

	the valve. A square or hex screw head is used with a wrench to change valve position.
Power Limited	Circuits where voltage and current are limited. Commonly used for modern fire alarm systems
Power Supply	Refers to the fire alarm control's power output or additional power boosters used for notification circuits. Also refers to secondary power sources.
Preaction Automatic Sprinkler System	Closed sprinklers attached to piping that contains air (may or may not be under pressure) and connected to a water source controlled by the fire alarm system.
Presignal	A method used to provide human control for fire alarm signal evacuation. A human being decides whether to evacuate the building or not. The fire alarm signal must be transmitted immediately to the fire dept.
Pressure Switch	A sprinkler monitoring switch that responds to high or low air or water pressure on the system.
Prime Contractor	The contractor who holds the actual contract with the customer for Central Station Service.
Private Mode	A notification mode designed only to notify the those associated with emergency action of a fire alarm signal.
Proprietary Fire Alarm System	Fire alarm systems that serve contiguous or noncontiguous properties under one ownership and monitored by a central station located at the property.
Public Fire Alarm Reporting Systems	Fire alarm systems which are municipally owned and connected to a local fire dept or communications center.
Public Fire Service Communications System	The system used to receive reports of fire from fire alarm systems or other sources. Such reports are then sent to the appropriate responding fire dept.
Public Mode	A notification mode designed to notify everyone in the building of a fire emergency.
Public Switched Telephone Network (PSTN)	Standard telephone service
Raceway	Enclosed channel to hold wire. Example: conduit
Radiant Energy Sensing Fire Detector	A line of sight device designed to detect the fire signature of radiant energy in the form of flame and spark / embers.
Radio Alarm Repeater Station Receiver (RARSR)	An RF repeater station.
Radio Alarm Supervising Station	A radio receiver located at the supervising

Receiver (RASSR)	station.
Radio Alarm System (RAS)	The components which comprise a communicating 1 way or 2 way RF radio system.
Radio Alarm Transmitter (RAT)	The 1 way or 2 way radio located at the fire alarm control panel location.
Rate Compensation Heat Detector	A heat detector that respond to the temperature of the surrounding air, no matter how fast or slow the rate of temperature rise.
Rate of Rise Heat Detector	A heat detector that responds to rapid temperature rise (about 15° in one minute). Usually used in conjunction with fixed temperature detectors.
Record Drawings	These are the final drawings of the system as it actually was installed
Records	Reports of system signals, testing and inspections.
Rectifier	An electrical device that converts AC voltage to DC.
Redundancy	Having 2 or more systems which perform the same function. In the event one system fails, the other takes over the job.
Remote Annunciator	An annunciator which is located at a place other than the control panel.
Remote Station Fire Alarm Systems	A fire alarm system that reports alarm, trouble, and supervisory signals to a remote monitoring location over supervised dedicated circuits.
Response Time Index	A measure of the time from which a fire signature appears until the detection device actually indicates an alarm condition
Restorable Heat Detector	A heat detector that automatically resets itself after operation when the temperature drops below it's operating point.
Retard	A delay in indicating a signal
Rigid Metal Conduit (Type RMC)	A threaded galvanized steel raceway. RMC is the thickest and heaviest of the conduits and is suited for indoor and outdoor use, direct burial and it is zinc coated both inside and out.
Ripple Through Multiplex	An old style of active multiplexing where devices are not individually addressed and they are connected in series. The control sends a start signal and each device responds in turn. T-tapping is not permitted
Riser	A vertical run between floors. Also may indicate a large water supply pipe for a sprinkler system
Riser Diagram	A diagram which depicts all circuits on the fire

	alarm system with typical devices.
Room Temperature Switch	A supervisory switch used with sprinkler system to monitor the temperature of a room protected by the sprinklers (to prevent frozen pipes).
Runner Service	Employees of a central station available to physically visit a protected premise. The employees are not part of the required number of operators for the central station, and must maintain constant radio contact with the central station.
Sealed Pneumatic Line Type Detector	A line type heat detector which uses a sealed tube with hydrogen gas. When a section of the tube is heated, pressure in the tube is increased initiating an alarm.
Sequential Counting Multiplex	A type of active multiplexing where the devices are connected in parallel and are individually addressed. The control sends a start signal and the first device responds. The control sends a start signal and the second device responds.
Shed Ceiling	A ceiling which slopes in one direction only.
Shunt Auxiliary Alarm System	A municipal system with a circuit extending into the protected property to interconnect to the actuating device. When operated, the system shunts the trip coil of the transmitter, which can then transmit without requirement of any local power (energy).
Signaling Line Circuit (SLC)	A circuit in which multiple input and output signals are transmitted and received.
Single Action	A device requiring only a single physical action to activate it.
Single Station Smoke Alarm	A smoke alarm which is self contained and does not have the ability to be interconnected.
Singlemode Fiber	Fiber optic cable that only allows light to travel down a single path.
Sleeping Area	Any area where the intended use is sleeping.
Smoke Alarm	A single or multiple station alarm which contains a detection element, control and sounder.
Smoke Barrier Door	A door normally held open during normal operation of the building. In the event of a fire the door is closed to maintain the integrity of a fire barrier
Smoke Damper	A damper used to control and / or stop the spread of smoke.
Smoke Detector	An automatic detector that detects visible or invisible particles of combustion.

Spark/Ember Detector	A detection device specifically geared to detect the radiant signature emitted from spark / embers.
Speaker	A notification appliance which is characterized by setting (tapping) the speaker at a specific power level. The circuitry which produces the sound is remotely located from the speaker.
Special Knowledge	A procedure which is not intuitive. A process which requires special knowledge to initiate.
Special Locking Arrangements	Locking arrangements which usually include delayed egress.
Specifications	Pre bidding documents which detail the requirements for the fire alarm system.
Spot Type Detector	A smoke or heat detector which is designed to be located and mounted in one location. As compared to a line type detector
Standards	Product standards specify how a piece of equipment must function. Installation standards specify how equipment must be installed.
Standpipe and Hose	A prepositioned water pipe and hose system used for extinguishing a fire.
Stratification	The level at which smoke stops rising. Stratification can occur in multiple story buildings and high ceiling areas.
Strobe Light	A visible notification appliance.
Subcontractor	A contractor hired to do a specific job. In fire alarm systems, the fire alarm company could be subcontracted by the electrical or general contractor.
Supervision	Monitoring of a circuit or device in which a trouble signal is generated by the control panel if a fault exists that would prevent normal operation of the circuit or device.
Supervisory Service	A service provided to monitor performance of guard tours, operational condition of sprinkler systems, and other systems related to property and life safety.
Supervisory Signal	A signal that indicates a need for action in a system monitored for supervisory service.
Supply Side	The source of power for the system. In fire alarm systems, this is the connection from the breaker box to the fire alarm control panel.
Survivability	The ability of the parts of a fire alarm system to survive during a fire emergency.
System Detector	A smoke or heat detector which is specifically designed to be connected to a fire alarm panel.

Tamper Switch	A switch that monitors a system or device for proper operating position and secure condition.
Thermistor Heat Detector	A heat detector which activates based on increasing resistance when the temperature rises.
Thermoelectric Effect Heat Detector	The effect on a thermocouple or thermopile device which increases voltage with an increase in temperature.
Transmitter	A device to which initiating device(s) are connected. The device transmits signals to the supervising station or supervising receiving device indicating the status of the device or circuit.
Trouble Signal	An audible and/or visual indication of an off-normal condition (open, ground) on a circuit or device connected to the fire alarm system.
Trunk Facility	Part of signaling line circuit (SLC) connecting two or more leg facilities to the supervising station.
Two Way Telephone System	A supervised voice communication system providing private voice communication between the fire command center and remote locations.
Two-Wire Detector	A detector that receives power (if required) and initiates alarms on the same pair of wires.
Ultraviolet Flame Detector	A flame detector which detects ultraviolet signatures in the 0.17 – 0.30 microns.
Underground Feeder Cable (Type UF)	Cable listed for use in direct burial, wet, dray, and corrosive environments
Underwriters Laboratories (UL)	The most prominent listing agency for fire alarm equipment.
Visible Signal	A signal that alerts occupants to system status by illuminating itself.
Water Mist System	An extinguishing system which uses water mist to suppress and / or extinguish the fire.
Waterflow Switch	A device that monitors sprinkler systems for activation by monitoring the flow of water through the pipe. The device must activate during the flow of water equal to or greater than waterflow from the smallest orifice on the system.
Wet Pipe Sprinkler System	A sprinkler system which the piping is charged which water.
Wireless	Communication between a wireless device and a the fire alarm control panel. Also called low powered wireless
Wiring	The connection means between devices and the control. Fire alarm systems use Fire Power

	Limited cable (FPL)
Zone	Generally refers to a specific device or circuit used for fire alarm initiating purposes. Zones are restricted to a single floor, building, area of no greater than 22,500 square feet and areas with a dimension no longer than 300 feet.

Bibliography

NFPA 10 Standard for portable extinguishers
NFPA 11 Standard for low expansion foam
NFPA 11a Standard for medium and high expansion foam
NFPA 12 Standard for carbon dioxide systems
NFPA 12a Standard on halon 1301
NFPA 13 Standard for Sprinkler systems
NFPA 13d Standard for sprinkler systems in 1 & 2 family dwellings
NFPA 13r Standard for sprinklers in residential bldg up to 4 stories
NFPA 14 Standard for installation of standpipe systems
NFPA 15 Standard for water spray fixed systems
NFPA 17 Standard for dry chemical systems
NFPA 20 Standard for stationary pumps
NFPA 25 Standard for inspection, testing, maintenance of water based systems
NFPA 37 Standard for installation of engines and gas turbines
NFPA 54 National fuel gas code
NFPA 58 Liquified petroleum code
NFPA 70 National Electric Code
NFPA 80 Standard for fire doors and windows
NFPA 90a Standard for the installation of AC and ventilating systems
NFPA 90b Standard for installation of warm air heating and AC systems
NFPA 92a Recommended practice for smoke control
NFPA 92b Guide for smoke management in malls, atria and large areas
NFPA 101 Life Safety code
NFPA 111 Standard on stored electrical energy and standby power systems
NFPA 170 Standard for life safety symbols
NFPA 601 Standard for security services in fire loss prevention
NFPA 780 Standard for the installation of lightning protection
NFPA 1221 Standard for installation maintenance and use of communications systems
NFPA 5000 Building Construction and Safety Code
ANSI A-58.1 Building code requirements for minimum design
ANSI S1.4a Specifications for sound level meters
ANSI S3.41 Audible emergency evacuation signal
ANSI/ASME A17.1 Safety code for elevators and escalators
ANSI/IEEE C2 National Electrical Safety Code
ANSI/UL 217 Standard for single station smoke alarms
ANSI/UL 268 Standard for System smoke detectors
ANSI/UL 827 Standard for safety central station for watchman fire alarm supervisory svc
ANSI/UL 985 Standard for household fire control units
ANSI/UL 1971 Signaling devices for hearing impaired
International Building Code 2003 edition
Fire Alarm Signaling Systems 2003 edition
Fire Protection Handbook
SFPE Handbook

Corporate Contributors

National Training Center, Inc. would like to thank the following manufacturers for their contributions and support in putting this book together. They have provided a great deal of important and significant information in the production of this book.

Honywell Ademco	www.security.honeywell.com
Honywell Firelite	www.firelite.com
Bosch Security	www.us.bosch.com
Bosch Fire	www.boschsecurity.us
Edwards Signaling Tech	www.edwards-signals.com
Commercial Products Group	www.cpglifesafety.com
Gentex	www.gentex.com
System Sensor	www.systemsensor.com
Wheelock	www.wheelockinc.com
West Penn Wire	www.westpenn-cdt.com
Belden Cable	www.belden.com
Evax Systems	www.evax.com
Building Reports	www.buildingreports.com
Altronix	www.altronix.com
Potter	www.pottersignal.com
Stealth Labs	www.stealthlabs.com
Labor Saving Devices	www.lsdinc.com
Thermotech	www.thermotechheatdetectors.com
Detector Electronics	www.detronics.com
Spectrex	www.spectrex-inc.com
Protectowire	www.protectowire.com
Notifier	www.notifier.com
Safety Technology International	www.sti-usa.com
Dorma	www.dorma-usa.com
Vision Systems	www.vesda.com
FM Global	www.fmglobal.com
Underwriter's Laboratories	www.ul.com

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