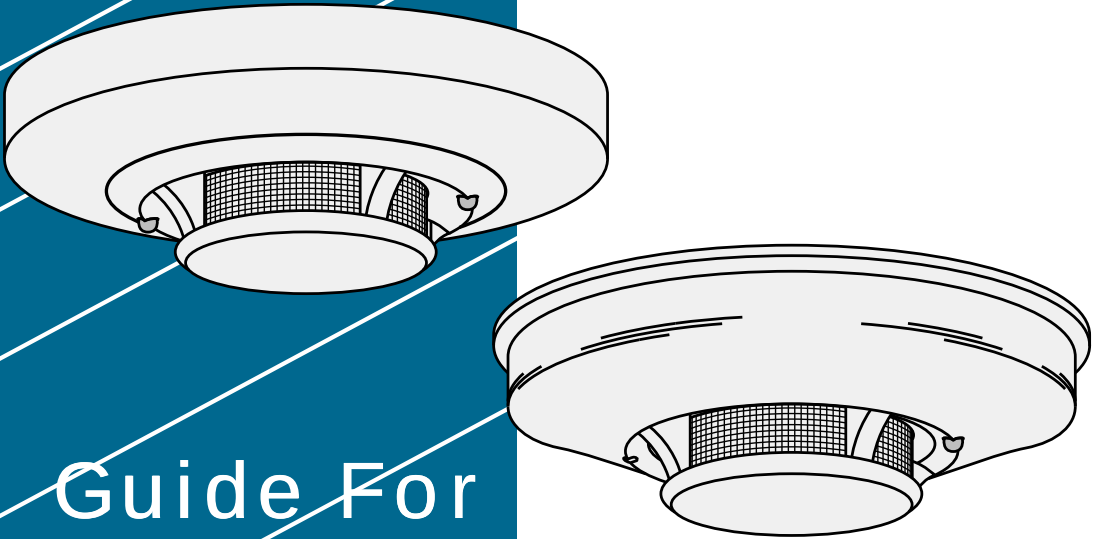




Guide For
Proper Use
Of

System
Smoke
Detectors



**SYSTEM
SENSOR®**

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FOREWORD

Studies have shown that in the United States the use of early warning fire and smoke detection systems has resulted in a significant reduction overall in fire deaths. The sooner a fire is detected, the better the chances are for survival.

A potential problem with smoke detectors is unwanted (nuisance) alarms that often result in people being desensitized to the alarm system or in severe cases disconnecting the system. This is an industry-wide problem that in most cases is caused by improper application, installation and maintenance of smoke detectors. It is hoped that the information in this guide will be used by those involved with the application, installation and maintenance of automatic fire alarm systems to minimize these problems.

INTRODUCTION

The purpose of this guide is to provide information concerning the proper application of smoke detectors used in conjunction with Fire Alarm Systems. It outlines basic principles that should be considered in the application of early warning fire and smoke detection devices. Operating characteristics of detectors and environmental factors, which may aid, delay or prevent their operation, are presented.

Fire protection engineers, mechanical and electrical engineers, fire service personnel, fire alarm designers and installers should find the contents both educational and informative.

Though this information is based upon industry expertise and many years of experience, it is intended to be used only as a technical guide. The requirements of applicable codes and standards, as well as directives of the Authorities Having Jurisdiction (AHJ's) should be followed. In particular, NFPA 72 for installation and testing of systems is a key element in the effectiveness of smoke detection systems.

SECTION I

GLOSSARY OF TERMS

ADDRESSABLE SYSTEM SMOKE DETECTOR

System smoke detectors, which in addition to providing alarm and trouble indications to a control unit, are capable of communicating a unique identification (address).

AIR SAMPLING-TYPE DETECTOR

A sampling-type detector consists of piping or tubing distribution from the detector unit to the area(s) to be protected. An air pump draws air from the protected area back to the detector through the air sampling ports and piping or tubing. At the detector, the air is analyzed for fire products.

ALARM (SIGNAL) INDICATING APPLIANCE

An electromechanical appliance that converts energy into audible or visible signal for perception as an alarm signal.

ALARM SIGNAL

A signal indicating an emergency requiring immediate action, such as an alarm for fire from a manual box, a waterflow alarm, or an alarm from an automatic fire alarm system, or other emergency signal.

ALARM VERIFICATION FEATURE

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

ANNUNCIATION

A visible and/or audible indication.

AUTOMATIC FIRE ALARM SYSTEM

A system of controls, initiating devices and alarm signals in which all or some of the initiating circuits are activated by automatic devices, such as smoke detectors.

CLASS A CIRCUIT (LOOP)

An arrangement of supervised initiating device, signaling line, or indicating appliance circuits that prevents a single open or ground on the installation wiring of these circuits from causing loss of the system's intended function.

CLASS B CIRCUIT (LOOP) (SEE ALSO CLASS A CIRCUIT)

An arrangement of supervised initiating device, signaling line, or indicating appliance circuits, which does not prevent a single open or ground on the installation wiring of these circuits from causing loss of the system's intended function.

COMBINATION SMOKE DETECTOR

A smoke detector that combines two or more smoke or fire sensing techniques.

DETECTOR COVERAGE

The recommended maximum distance between adjacent detectors or the area that a detector is designated to protect.

DRIFT COMPENSATION

The capability of a detector to automatically adjust its alarm sensitivity to compensate for any changes over time in the factory settings for smoke and/or fire detection.

END OF LINE DEVICE

A device such as a resistor or diode placed at the end of a Class B wire loop to maintain supervision.

END OF LINE RELAY

Device used to supervise power (usually for four-wire smoke detectors) and installed within or near the last device on the loop.

FIRE

A chemical reaction between oxygen and a combustible material where rapid oxidation results in the release of heat, light, flame and/or smoke.

FLAME DETECTOR

A device that detects the infrared, ultraviolet, or visible radiation produced by a fire.

FOUR-WIRE SMOKE DETECTOR

A smoke detector which initiates an alarm condition on two separate wires (initiating loop) apart from the two power leads.

HEAT DETECTOR

A device that detects abnormally high temperature or rate-of-temperature rise.

INITIATING CIRCUIT

A circuit which transmits an alarm signal initiated manually or automatically, such as a fire alarm box, smoke, heat, or flame sensing device, sprinkler waterflow alarm switch or similar device or equipment to a control panel or any similar device or equipment which, when activated, causes an alarm to be indicated or retransmitted.

INITIATING DEVICE

Any manually operated or automatically operated equipment which, when activated, initiates an alarm through an alarm signaling device.

INITIATING DEVICE CIRCUIT (LOOP)

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

INTELLIGENT (ANALOG, SMART) SYSTEM SMOKE DETECTOR

A system smoke detector capable of communicating information about smoke conditions at its location to a control unit. This type of detector typically communicates a unique identification (address) along with an analog signal, which indicates the level of smoke at its location.

IONIZATION SMOKE DETECTOR

An ionization smoke detector has a small amount of radioactive material that ionizes the air in the sensing chamber, thus rendering it conductive and permitting a current to flow between two charged electrodes. This gives the sensing chamber an effective electrical conductance. When smoke particles enter the ionization area, they decrease the conductance of the air by attaching themselves to the ions, causing a reduction in mobility. When the conductance is less than a predetermined level, the detector responds.

LIGHT SCATTERING

The action of light being reflected and/or refracted by particles of combustion for detection by a photoelectric smoke detector. The action of light being refracted or reflected.

LISTED

Equipment or materials included in a list published by an organization acceptable to the “authority having jurisdiction” and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The “authority having jurisdiction” should utilize the system employed by the listing organization to identify a listed product.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA administers the development and publishing of codes, standards, and other materials concerning all phases of fire safety.

NUISANCE ALARM

An alarm caused by everyday events such as cooking, cigarette smoke, dust, insects, etc.

OBSCURATION

A reduction in the atmospheric transparency caused by smoke usually expressed in percent per foot.

PARTICLES OF COMBUSTION

Substances (products that either remain at the site of burning such as ash, or scatter as volatile products) resulting from the chemical process of a fire.

PHOTOELECTRIC SMOKE DETECTOR

In a photoelectric light scattering smoke detector, a light source and a photosensitive sensor are so arranged that the rays from the light source do not normally fall on the photosensitive sensor. When smoke particles enter the light path, some of the light is scattered by reflection and refraction onto the sensor, causing the detector to respond.

PROJECTED BEAM SMOKE DETECTOR

In a projected beam detector the amount of light transmitted between a light source and a photosensitive sensor is monitored. When smoke particles are introduced into the light path, some of the light is scattered and some absorbed, thereby reducing the light reaching the receiver, causing the detector to respond.

RATE-OF-RISE HEAT DETECTOR

A device which will respond when the temperature rises at a rate exceeding a predetermined amount.

SMOKE DETECTOR

A device that detects the visible or invisible particles of combustion.

SPOT DETECTOR

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

STRATIFICATION

An effect that occurs when air containing smoke particles or gaseous combustion products is heated by smoldering or burning material and, becoming less dense than the surrounding cooler air, rises until it reaches a level at which there is no longer a difference in temperature between it and the surrounding air. Stratification can also be caused by forced ventilation.

SUPERVISION

The ability to detect a fault condition in the installation wiring, which would prevent normal operation of the fire alarm system.

THERMAL LAG

When a fixed temperature device operates, the temperature of the surrounding air will always be higher than the operating temperature of the device itself. This difference between the operating temperature of the device and the actual air temperature is commonly spoken of as thermal lag, and is proportional to the rate at which the temperature is rising.

TWO-WIRE SMOKE DETECTOR

A smoke detector which initiates an alarm condition on the same two wires that also supply power to the detector.

WIRELESS RADIO LINKER

A device which receives, verifies and retransmits binary coded low power radio frequency alarm and supervisory signals generated by smoke detectors and initiating devices.

WIRELESS SMOKE DETECTOR

A smoke detector which contains an internal battery or batteries that supply power to both the smoke detector and integral radio frequency transmitter. The internal power source is supervised and degradation of the power source is communicated to the control panel.

SECTION II

STANDARDS THAT APPLY

NATIONAL FIRE CODES

There are many code writing groups that publish standards for the proper application, installation, and maintenance of automatic smoke detectors. The principal code writing bodies and applicable standards which should be reviewed before specifying or installing automatic smoke detectors are:

National Fire Protection Association (NFPA)
Batterymarch Park
Quincy, MA 02269-9101

NFPA publishes codes and standards concerning all phases of fire protection. Among those which directly concern automatic smoke detectors are:

NFPA 70 — National Electrical Code

NFPA 72 — National Fire Alarm Code

NFPA 72 covers minimum performance, location, mounting, testing, and maintenance requirements of automatic fire detectors.

NFPA 90A — Standard for the Installation of Air Conditioning and Ventilating Systems

NFPA 92A — Smoke Control Systems in Malls, Atria, and Large Areas

NFPA 90A and 92A provides information for the use of smoke detectors in ducts of HVAC systems and smoke control systems.

NFPA 101 — Life Safety Code

NFPA 101 specifies the requirements for smoke detection in both new and existing buildings depending on the type of occupancy.

BUILDING CODES

Local and state building officials are organized into three independent regional building code organizations which write model building codes which become law when adopted by local and state governments. These codes also specify smoke detector requirements based on building type and occupancy. The three building official organizations are:

Building Officials and Code Administrators (BOCA)
4501 West Flossmoor Road
Country Club Estates, IL 60477-5795

BOCA's National Building Code is generally used throughout the northeast and Midwest regions of the United States.

International Conference of Building Officials (ICBO)
5360 Workman Mill Road
Whittier, CA 90601-2298

ICBO's Uniform Building Code is generally used throughout the West and Southwest regions of the United States.

Southern Building Code Congress International (SBCCI)
900 Montclair Road
Birmingham, AL 35213-1206

SBCCI's Standard Building Code is generally used in the South and Southeast regions of the United States.

TESTING LABORATORIES

Testing laboratories test smoke detectors, control panels and other components of fire alarm systems to verify conformance with NFPA requirements and their own standards. Equipment that passes their tests are identified by a label.

Underwriters Laboratories, Inc. (UL)

333 Pfingsten Rd.	1655 Scott Blvd.
Northbrook, IL 60062	Santa Clara, CA 95050

1285 Walt Whitman Rd.	12 Laboratory Drive
Melville, NY 11747	P.O. Box 13995
	Research Triangle Park, N.C.

UL publishes an annual report listing fire protection equipment which bear the UL label. Its standards which apply to smoke detectors are:

- UL 217 — Single and Multiple Station Smoke Detectors
- UL 268 — Smoke Detectors for Fire Protection Signaling Systems
- UL 268A — Smoke Detectors for Duct Applications
- UL 864 — Standard for Control Units for Fire Protective Signaling Systems

Factory Mutual Research (FM)

1151 Boston-Providence Turnpike
P.O. Box 9102
Norwood, MA 02062

FM publishes an annual report listing fire protection equipment which bears its label.

There are other testing laboratories listed here that may provide similar services:

INDUSTRY PUBLICATIONS

- NEMA Guide for Proper Use of Smoke Detectors in Duct Applications
- NEMA Training Manual on Fire Alarm Systems
- NEMA Guide to Code Requirements for Fire Protective Signaling and Detection Systems

MANUFACTURER'S PUBLICATIONS

The manufacturer of the smoke detectors being used should be contacted for any published information on their products.

SECTION III

HOW SMOKE DETECTORS WORK

TYPES OF SMOKE DETECTORS

There are two basic types of smoke detectors in use today; ionization and photoelectric. The sensing chambers of these detectors use different principles of operation to sense the visible or invisible particles of combustion given off in developing fires.

IONIZATION SMOKE DETECTOR OPERATION

A typical ionization chamber consists of two electrically charged plates and a radioactive source (typically Americium 241) for ionizing the air between the plates. (See Figure 3-1.) The radioactive source emits particles that collide with the air molecules and dislodge their electrons. As molecules lose electrons, they become positively charged ions. As other molecules gain electrons, they become negatively charged ions. Equal numbers of positive and negative ions are created. The positively charged ions are attracted to the negatively charged electrical plate, while the negatively charged ions are attracted to the positively charged plate. (See Figure 3-2.) This creates a small ionization current that can be measured by electronic circuitry connected to the plates.

Particles of combustion are much larger than the ionized air molecules. As particles of combustion enter an ionization chamber, ionized air molecules collide and combine with them. (See Figure 3-3.) Some particles become positively charged and some become negatively charged. As these relatively large particles continue to combine with many other ions, they become recombination centers, and the total number of ionized particles in the chamber is reduced. This reduction in the ionized particles results in a decrease in the chamber current that is sensed by electronic circuitry monitoring the chamber. When the current is reduced by a predetermined amount, a threshold is crossed and alarm condition is established.

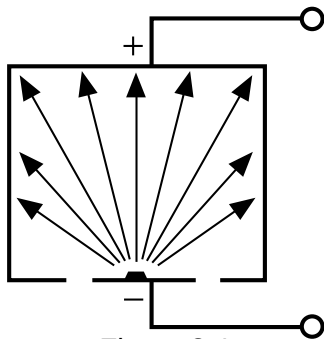


Figure 3-1
Particle Radiation Pattern

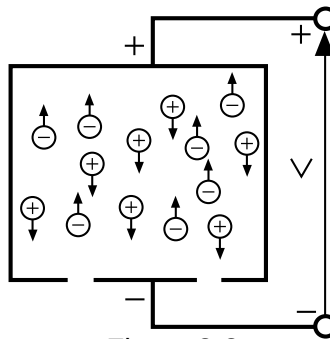


Figure 3-2
Ion Distribution

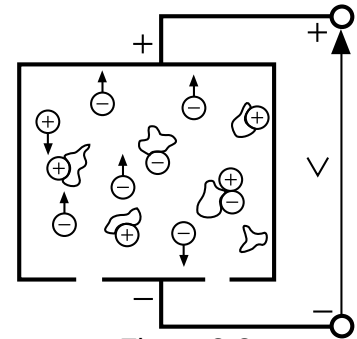


Figure 3-3
Ion and Smoke Distribution

Changes in humidity and atmospheric pressure affect the chamber current and create an effect similar to the effect of combustion particles entering the sensing chamber. To compensate for the possible effects of humidity and pressure changes, the dual ionization chamber was developed and has become commonplace in the smoke detector market.

A dual-chamber detector utilizes two ionization chambers; one is a sensing chamber that is open to the outside air. (See Figure 3-4). The sensing chamber is affected by particulate matter, humidity, and atmospheric pressure. The other is a reference chamber that is partially closed to outside air and affected only by humidity and atmospheric pressure, because its tiny openings block the entry of larger particulate matter including smoke. Electronic circuitry monitors both chambers and compares their outputs. If the humidity or the atmospheric pressure changes, both chambers' outputs are affected equally and cancel each other. When combustion particles enter the sensing chamber, its current decreases while the current of the reference chamber remains unchanged. The resulting current imbalance is detected by the electronic circuitry. (See Figure 3-5.)

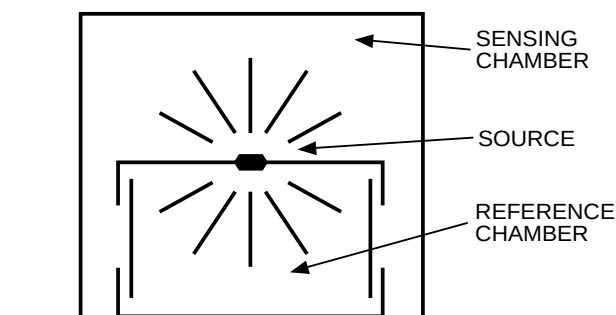


Figure 3-4
Dual Chamber

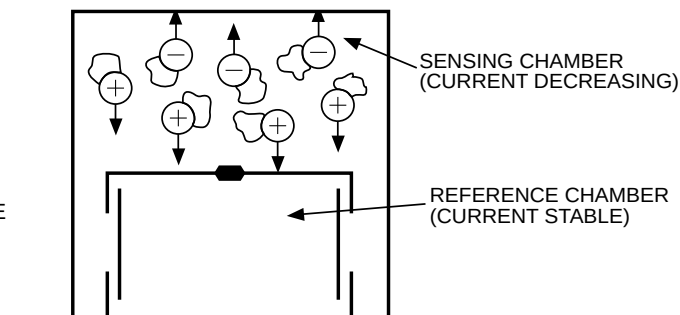


Figure 3-5
Dual Chamber with Smoke

There are a number of problems that can affect dual-chamber ionization sensors; dust, excessive humidity (condensation), significant air currents, and tiny insects can be misread as particles of combustion by the electronic circuitry monitoring the sensors. The more sensitive the detector calibration, the more likely it is that these problems will affect the detector performance and result in nuisance alarms.

PHOTOELECTRIC SMOKE DETECTOR OPERATION

Smoke produced by a fire affects the intensity of a light beam passing through air. The smoke can block or obscure the beam. It can also cause the light to scatter due to reflection off the smoke particles. Photoelectric smoke detectors are designed to sense smoke by utilizing these effects of smoke on light.

Photoelectric Light Obscuration Smoke Detector

One basic type of photoelectric detector, the light obscuration detector, employs a light source and a photosensitive receiving device, such as a photodiode (see Figure 3-6). When smoke particles partially block the light beam (Figure 3-7), the reduction in light reaching the photosensitive device alters its output. The change in output is sensed by the detector's circuitry, and when the threshold is crossed an alarm is initiated. Obscuration type detectors are usually of the projected beam type where the light source expands the area to be projected.

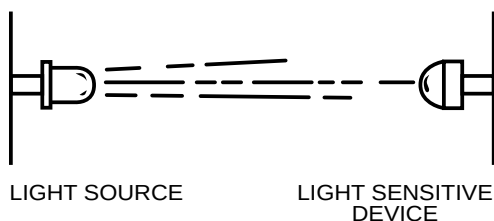


Figure 3-6
Light Obscuration Detector

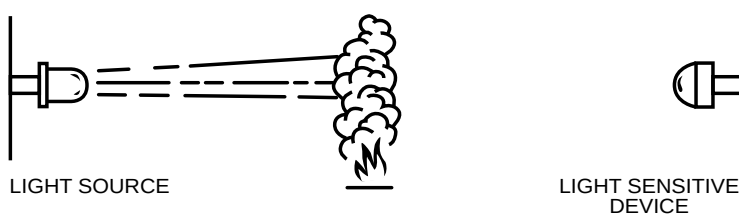


Figure 3-7
Light Obscuration Detector with Smoke

Photoelectric Light Scattering Smoke Detector

Most photoelectric smoke detectors are of the spot type and operate on the light scattering principle. A light-emitting diode (LED) is beamed into an area not normally "seen" by a photosensitive element, generally a photodiode. (See Figure 3-8.) When smoke particles enter the light path, light strikes the particles (Figure 3-9) and is reflected onto the photosensitive device causing the detector to respond.

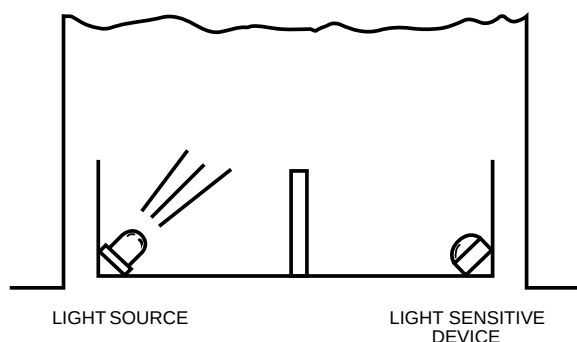


Figure 3-8
Light Scattering Device

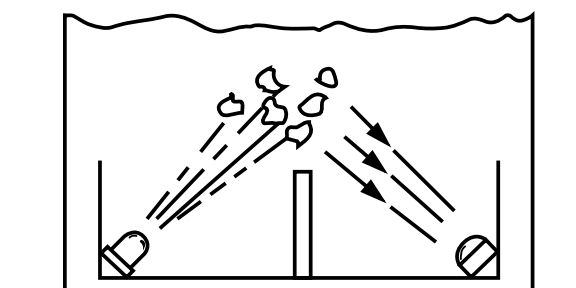


Figure 3-9
Light Scattering Detector with Smoke

SMOKE DETECTOR DESIGN CONSIDERATIONS

Smoke detectors are based on simple concepts, but certain design considerations need to be observed. They should produce an alarm signal when smoke is detected, but should minimize the impact of an unwanted signal which can arise from a variety of causes. In an ionization detector, dust and dirt can accumulate on the radioactive source and cause it to become more sensitive. In a photoelectric detector, light from the light source may be reflected off the walls of the sensing chamber and be seen by the photosensitive device when no smoke is present. The entrance of insects, dirt, drywall dust, and other forms of contamination into the sensing chamber can also reflect light from the light source onto the photosensitive device.

Electrical transients and some kinds of radiated energy can affect the circuitry of both ionization and photoelectric smoke detectors and be interpreted by the electronic circuitry to be smoke, resulting in nuisance alarms.

The allowable sensitivity ranges for both types of detectors are established by Underwriters Laboratories, Inc. and all are verified by their performance in fire tests. Regardless of their principle of operation all smoke detectors are required to respond to the same test fires.

CONSIDERATIONS IN SELECTING DETECTORS

The characteristics of an ionization detector make it more suitable for detection of fast flaming fires that are characterized by combustion particles in the 0.01 to 0.3 micron size range. Photoelectric smoke detectors are better suited to detect slow smoldering fires that are characterized by particulates in the 0.3 to 10.0 micron size range. Each type of detector can detect both types of fires, but their respective response times will vary, depending on the type of fire.

Because the protected buildings normally contain a variety of combustibles, it is often very difficult to predict what size particulate matter will be produced by a developing fire. The fact that different ignition sources can have different effects on a given combustible further complicates the selection. A lighted cigarette, for example, will usually produce a slow smoldering fire if it is dropped on a sofa or bed. However, if the cigarette happens to fall upon a newspaper on top of a sofa or bed, the resulting fire may be characterized more by flames than by smoldering smoke.

The innumerable combustion profiles possible with various fire loads and possible ignition sources make it difficult to select the type of detector best suited for a particular application. For more information, see paragraphs 5-3.3.1.1, 5-3.3.2.1, 5-3.3.3.1, and A-5-3.7.1.2, and tables A-5-3.7.1.1, A-5-3.7.1.2(a), and A-5-3.7.1.2(b).

SITUATIONS WHERE OTHER TYPES OF DETECTORS MAY BE USED

In certain circumstances where smoke detectors are unsuitable, special-purpose detectors, such as flame detectors, heat detectors, and other detection devices, may be suitable.

The application of these special types of detectors should be based on an engineering survey and used in accordance with the manufacturer's installation instructions provided.



SMOKE DETECTORS HAVE LIMITATIONS

Smoke detectors offer the earliest possible warning of fire. They have saved thousands of lives in the past and will save more in the future. Nevertheless, smoke detectors do have limitations. They may not provide early warning of a fire developing on another level of a building. A first floor detector, for example, may not detect a second-floor fire. For this reason, detectors should be located on every level of a building. In addition, detectors may not sense a fire developing on the other side of a closed door. In areas where doors are usually closed, detectors should be located on both sides of the door.

As already indicated, detectors have sensing limitations. Ionization detectors are better at detecting fast, flaming fires than slow, smoldering fires. Photoelectric smoke detectors sense smoldering fires better than flaming fires. Because fires develop in different ways, and are often unpredictable in their growth, neither type of detector is always best, and a given detector may not always provide significant advance warning of fires when fire protection practices are inadequate, nor when caused by violent explosions, escaping gas, improper storage of flammable liquids such as cleaning solvents, etc.

SECTION IV TYPICAL SYSTEM LAYOUT

ELECTRICAL SUPERVISION

The initiating circuits that connect smoke detectors to a control panel should be supervised so that a fault (trouble) condition that could interfere with the proper operation of the circuit will be detected and annunciated.

NOTE*: Refer to the fire alarm control panel manufacturer's operating manual to determine the ability of a specific initiating circuit to react in a "Class B" or "Class A" fashion.

CLASS B CIRCUITS

Class B circuits differentiate between short circuits across the loop (alarm) and opens on the loop (trouble). Supervision of this circuit is accomplished by passing a low current through the installation wiring and an end-of-line device. Increases or decreases in this supervisory current are monitored by the fire alarm control panel, and will cause alarm or trouble conditions, respectively, to be indicated. A single open in a Class B circuit disables all devices electrically beyond the open.

Smoke detectors that are connected to Class B initiating device circuits are generally categorized as either 2-wire or 4-wire detectors. Two-wire detectors derive their power directly from the same fire alarm control panel alarm initiating device circuit over which they report an alarm. Because of their dependency on the initiating circuit, 2-wire detectors should be tested and listed for compatibility to ensure proper operation.

Four-wire detectors are powered from a separate pair of wires, and generally apply an electrical short across the associated alarm initiating device circuit to transmit an alarm (Figure 4-1). Because they do not derive power from the alarm initiating device circuit, electrical compatibility is predicated upon the operating parameters of the power supply to which the detectors are connected. Supervision of the power to 4-wire detectors is made possible through the use of an end-of-line power supervision relay. When power is on, the relay contacts of the end-of-line relay are closed and connected in series with the end-of-line device beyond the last initiating device. Loss of power at any point in the supply circuit will cause the relay to de-energize and a trouble condition to occur.

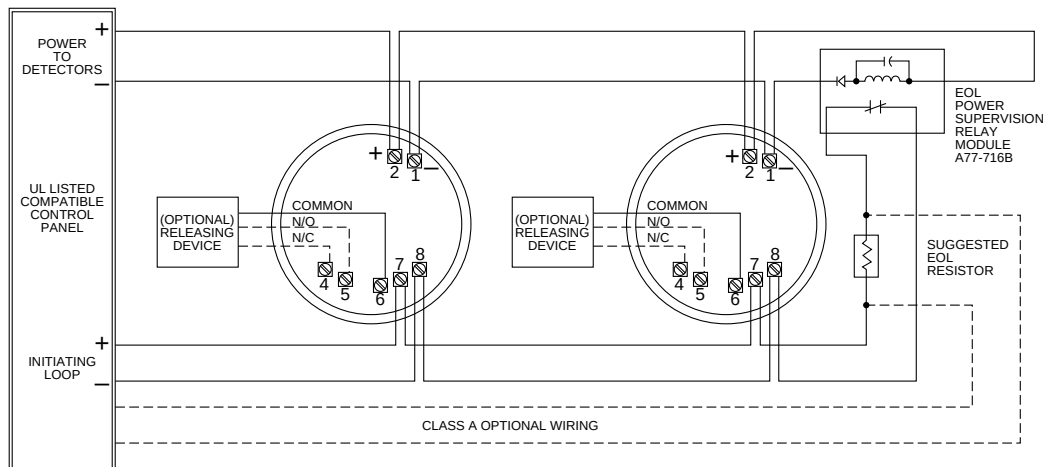


Figure 4-1
Four-Wire Detector Circuit

* NFPA 72 now classifies initiating device circuits by "Style" instead of "Class". Styles A, B, and C are examples of Class B circuits, Styles D and E are examples of Class A circuits.

CLASS A CIRCUITS

Class A circuits also differentiate between short circuits across the loop and opens on the loop. Supervision is accomplished by monitoring the level of current passing through the installation wiring and the end-of-line device, which in a Class A circuit is an integral part of the fire alarm control panel. Class A wiring must return to and be terminated in the control panel. This technique requires a minimum of four conductors to be terminated at the panel, and further requires that the fire alarm control panel is designed to monitor Class A circuits. The additional circuitry necessary for Class A supervision enables the control panel to “condition” the initiating circuit to monitor the initiating circuit from both ends when in a trouble mode due to an open fault on the loop. This “conditioning” ensures that all devices are capable of responding and reporting an alarm despite a single open at any point in the circuit.

The compatibility considerations that were detailed in Class B circuits apply with Class A as well. (Figure 4-2.)

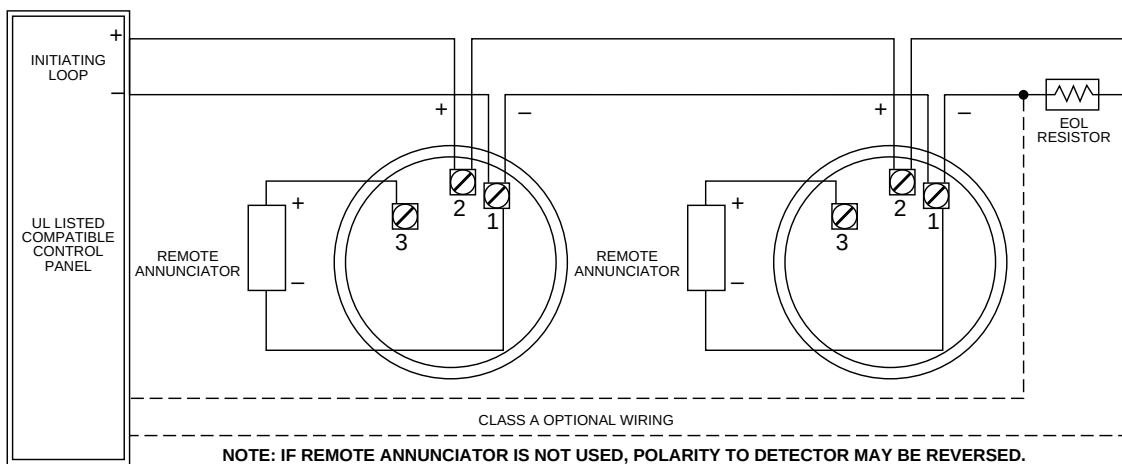


Figure 4-2
2-Wire Detectors – Class A Circuit

WIRELESS CIRCUITS

Wireless detectors and their internal transmitters derive their operating power from their internal battery or batteries and are listed by Underwriters Laboratories, Inc. in accordance with requirements of NFPA 72. Supervision of the internal battery power source is incorporated within the smoke detector circuitry. If the battery power source depletes to the threshold specified by Underwriters Laboratories, the smoke detector will sound a local alert and initiate a trouble signal once each hour for a minimum of seven days or until the battery or batteries are replaced.

The wireless initiating devices are supervised for removal by initiating a distinct trouble signal. Each wireless device also initiates a test transmission every hour to verify the reliability of the communication circuit. Any device failing to communicate is identified on the control panel every four hours.

GENERAL ZONING GUIDELINES

The faster the source of an alarm can be pinpointed, the faster action can be taken. Although formal rules for zoning are not given in fire protection codes, except for wireless devices where each smoke detector must be individually identified, it is always sensible to zone any system that contains more than a small number of detectors. Experienced detector installers and system designers recommend the following:

- Establish at least one zone on every protected floor.
- Zone natural subdivisions of a large building, such as separate wings on a single floor.

- Minimize the number of detectors in each zone. Fewer detectors on a zone will speed up locating the fire and simplify trouble shooting.
- Install duct detectors in different zones than open-area detectors for troubleshooting and locating purposes.

BUILDING CONTROL FUNCTIONS

Often smoke detectors are utilized to control ancillary equipment. Most detectors used in releasing service have auxiliary relay contacts which are directly connected to the system or device to be controlled. Care should be taken to ensure that detectors utilized in such a manner are approved for releasing service. A few of the typical applications are as follows:

- To control the flow of smoke in air handling and air conditioning systems.
- To release doors to contain smoke in a fire situation.
- To release locks to allow exit in a fire situation.
- To capture and recall elevators in a fire situation.
- To activate a suppression system.

Spacing and placement requirements for detectors used in releasing service may be different from detectors used in conventional open area applications. It is recommended that 4-wire detectors be used in these situations because depending on the control panel and detectors used, more than one detector relay on a circuit may not receive enough power from the 2-wire circuit to operate during alarm.

SMOKE DETECTOR INSTALLATION

Wiring Installation Guidelines

All fire alarm system installation wiring should be installed in compliance with Article 760 of NFPA 70, the National Electrical Code (NEC) the manufacturer's instructions and the requirements of the authority having jurisdiction.

Typical Wiring Techniques

The primary rule of installation wiring is:

“Follow the Manufacturer’s Instructions”

This rule cannot be overemphasized. The requirement for electrical supervision of the installation wires and their connections to initiating devices makes fire alarm system installation wiring very different than general wiring.

A manufacturer's installation wiring drawing routes wires and shows connections in a certain manner to accommodate supervision requirements. Any variance from the manufacturer's drawings might cause a portion of a circuit to be unsupervised and, if an open or short circuit fault occurred, it could prevent the circuit from being able to perform its intended function without giving the required trouble indication.

The rules of supervision are not very complex, however, unless an installer is experienced in fire alarm system installations, he or she would not likely be familiar with them.

Smoke detector manufacturer's installation drawings will show how their detectors are to be connected into a system. However, a manufacturer's drawings may not show how devices located on the same floor, but served by a different riser (vertical wiring run), should be connected. The following diagrams should be considered as typical initiating device circuits utilizing smoke detectors. They are

offered to illustrate proper and improper installation wiring and termination techniques. Since there are always exceptions to typical installation drawings, experienced installers use the primary rule of installation wiring: Follow the manufacturer's instructions, and meet the local codes.

Figure 4-3 illustrates improper wiring of smoke detector "A". This wiring method is referred to as "T-tapping." This common installation error is made in riser wiring as well as single floor wiring. The smoke detector may operate properly under alarm conditions, however, if it becomes disconnected from the installation wiring loop beyond the T-tap it would not cause a "trouble" condition to occur.

NOTE: T-tapping may be permitted with some "intelligent" fire alarm systems. Refer to manufacturer's recommendations.

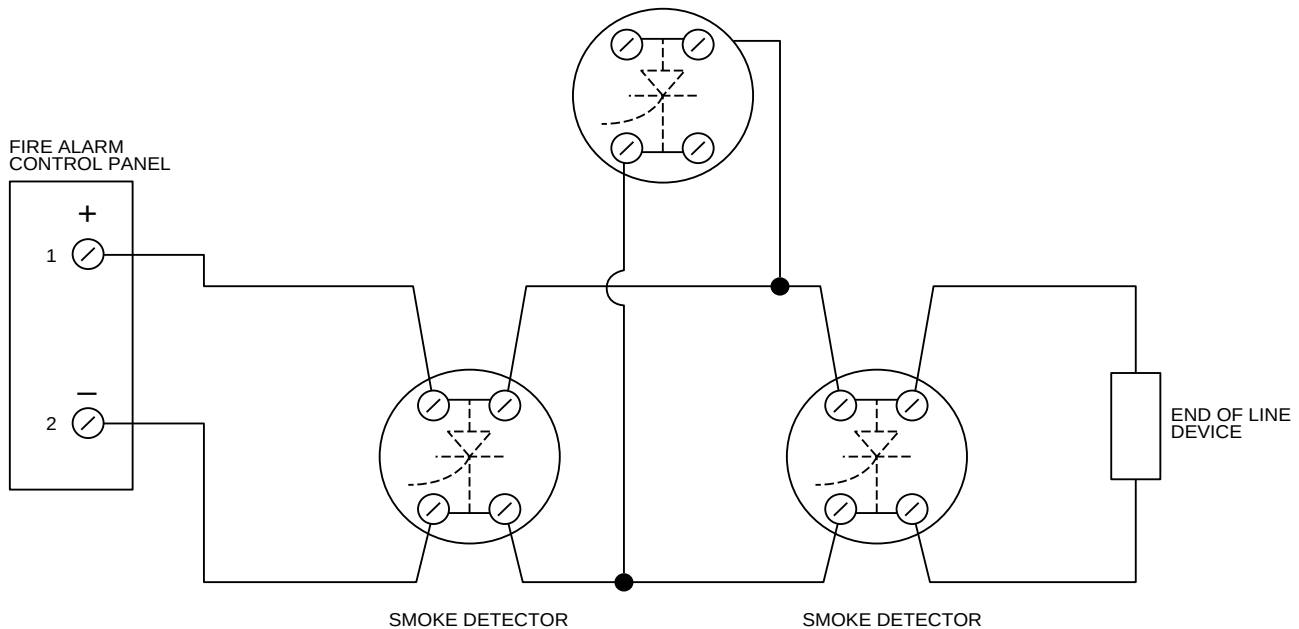


Figure 4-3
Incorrect Wiring Method

Figure 4-4 illustrates the correct installation wiring method for smoke detectors. None of the connections can be broken without opening the circuit, causing loss of supervision, and the fire alarm control panel to indicate trouble.

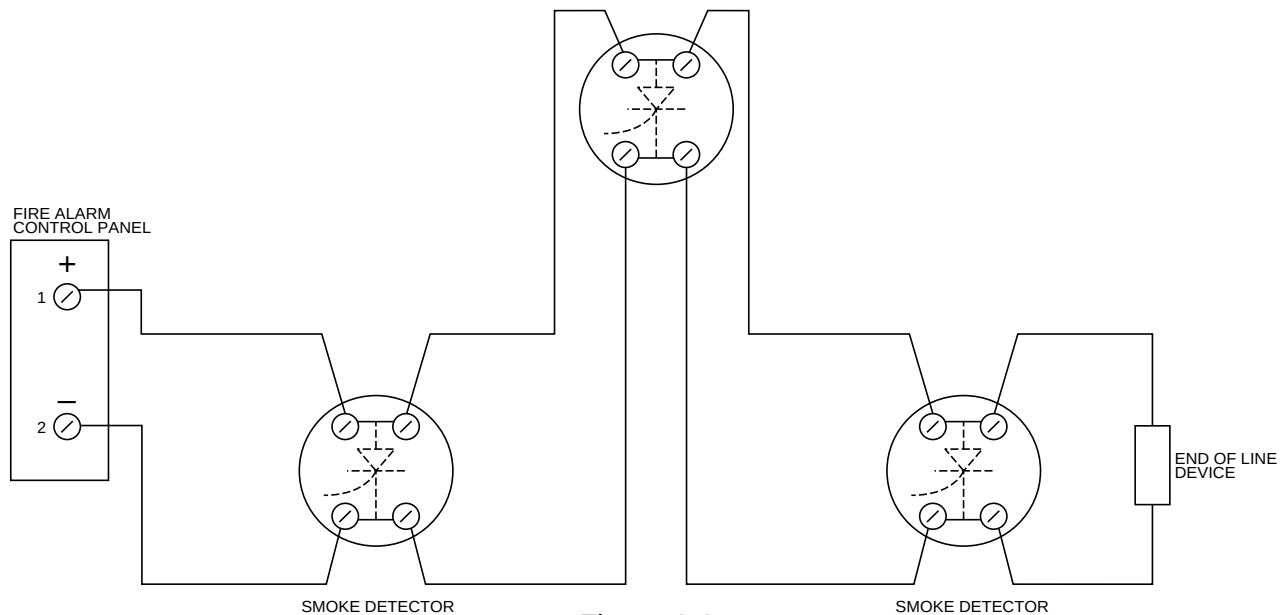


Figure 4-4
Correct Wiring Method

Smoke detectors should be connected to supervised installation wiring in a manner that ensures electrical supervision of the device. Removal of a detector from its associated initiating circuit should cause the loop to open, resulting in a trouble condition. The required termination at the smoke detector may involve either screw terminals or wire pigtails. Regardless of the method utilized, removal of the smoke detector or a single installation wire must open the initiating circuit and result in a trouble signal at the control panel.

Screw termination of either side of the initiating circuit may require only one or two screws. Figure 4-5 is an example of proper termination when one screw terminal is used. Note that the installation conductor has been cut before termination. This assures full supervision to the smoke detector.

Figure 4-6 details common connection errors. In both examples, removal of the smoke detector does not open the initiating circuit. The fire alarm control panel will not recognize a trouble condition, and the detector that has been deliberately or inadvertently disconnected will be disabled.

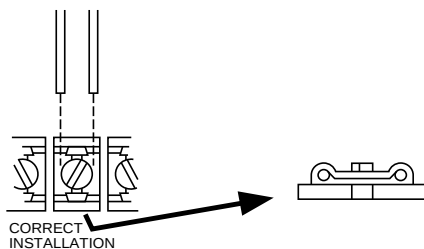


Figure 4-5
Proper Termination

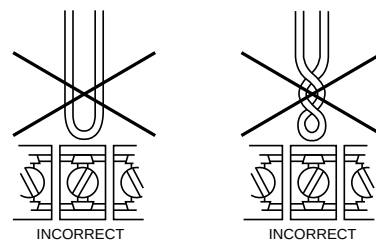


Figure 4-6
Improper Termination

Figure 4-7 is an example of properly connected smoke detectors provided with pigtails. This method of termination supervises all wiring to the point at which it connects to the detector.

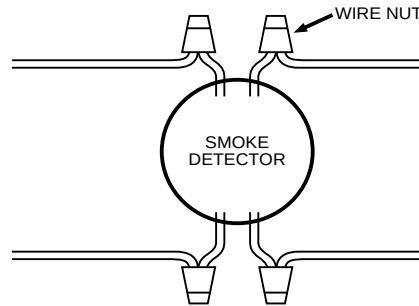


Figure 4-7
Pigtail Connections – Correct Wiring Method

Figure 4-8 shows an incorrect pigtail connection. This is a form of T-tapping discussed earlier. Note that the conductor between the wire nut (or splice) and the detector is unsupervised, and could be cut or disconnected without resulting in a trouble signal.

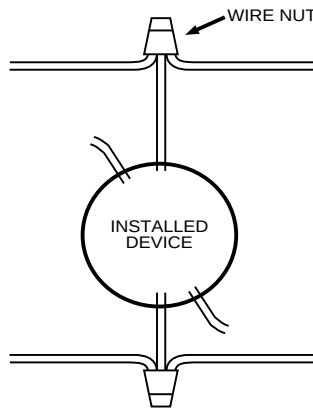


Figure 4-8
Pigtail Connections – Incorrect Wiring Method

Wireless Systems

Wireless smoke detectors do not require any field wiring as the power for the initiating devices is contained and incorporated within the device. Removal of a wireless smoke detector initiates a distinct trouble signal. Follow the instructions in the manufacturer's installation manual for wireless systems.

INSTALLATION DO'S AND DON'TS

DO

- Verify that 2-wire smoke detectors to be used have been tested and listed for compatibility with the equipment to which they are connected. If necessary, contact the manufacturer for this information.
- Locate any end-of-line devices electrically at the end of the circuit, beyond all initiating devices.
- Use caution when utilizing 2-wire detectors with integral relays, because they may require more power than the initiating device circuit can supply. This could result in the inability of the relay to control auxiliary equipment to which it is connected.
- When using wireless detectors, follow the manufacturer's installation instructions to assure proper radio communication between the smoke detector and the control panel.

- Observe polarity when required.
- Protect detectors against contamination during construction or renovation.
- Carefully follow the manufacturer's installation instructions.

DO NOT

- T-tap smoke detectors or circuit conductors, except when specifically permitted by the manufacturer as part of an intelligent/addressable system.
- Loop uncut installation conductors around screw terminations.
- Exceed the maximum resistance permitted for the initiating device system.

WIRING AND SYSTEM CHECKOUT

As required for all installation wiring of fire alarm systems, check the detector loop wiring for grounds, short circuits, and open faults before the system is placed into operation. Each detector should be tested in accordance with the manufacturer's instructions.

When using wireless detectors, verify the radio signal transmission strength in accordance with the installation manual.

After all detectors have been installed, test the complete system to ensure that no wiring faults exist, and that all parts of the system operate as intended. A complete system checkout consists of testing each detector at its installed location and following the panel manufacturer's instructions for system checkout. Also, refer to NFPA 72 for additional information.

SECTION V PROPER DETECTOR PLACEMENT AND SPACING APPLICATIONS AND PROBLEM SITES*

WARNING DETECTOR PLACEMENT IS CRITICAL TO EARLY WARNING FUNCTIONS

Where To Place Detectors

To provide effective early warning of a developing fire situation, smoke detectors should be installed in all areas of the protected premises. Total coverage as defined by NFPA 72¹ should include all rooms, halls, storage areas, basements, attics, lofts, and spaces above suspended ceilings including plenum areas utilized as part of the HVAC system. In addition, this should include all closets, elevator shafts, enclosed stairways, dumbwaiter shafts, chutes and other subdivisions and accessible spaces.

Fire detection systems installed to meet local codes or ordinances may not be adequate for early warning of fire. Some codes or ordinances have minimum objectives such as capturing elevators or preventing circulation of smoke through the HVAC systems instead of early detection of fire.

A user should weigh the costs against the benefits of installing a complete fire detection system when any detection system is being installed. The location, quantity and zoning of detectors should be determined by what objectives are desired rather than the minimum requirements of any local codes or ordinances.

Detectors may be omitted from combustible blind spaces when any of the following conditions prevail:

- Where the ceiling of a concealed space is attached directly to the underside of the supporting beams of a combustible roof or floor deck.
 - Where the concealed space is entirely filled with noncombustible insulation. (In solid joisted construction, the insulation need only fill the space from the ceiling to the bottom edge of the joist of the roof or floor deck.)
 - Where there are small concealed spaces over rooms, provided the space in question does not exceed 50 square feet (4.6 square meters).
 - In spaces formed by sets of facing studs or solid joists in walls, floors, or ceilings where the distance between the facing studs does not exceed 6 inches (15 cm).
- Detectors may also be omitted from below open grid ceilings where all of the following conditions are met:

- The openings of the grid are at least $\frac{1}{4}$ inch (6 mm) in the smallest dimension.
- The thickness of the material does not exceed the smallest of the grid openings.
- The openings constitute at least 70% of the area of the ceiling material.

Detectors are usually required or recommended underneath open loading docks or platforms and

¹Section 5-1.3.4

*The guidelines in this section of the manual are adapted from Standards published by the National Fire Protection Association, Quincy, Massachusetts, U.S.A. These standards include NFPA 72, National Fire Alarm Code; NFPA 70, "National Electrical Code", Article 760; and NFPA 90A, "Installation of Air Conditioning and Ventilating Systems".

their covers, and in accessible underfloor areas in buildings without basements. Detectors may be omitted from combustible blind spaces when any of the following conditions prevail:

- The space is not accessible for storage purposes, it is protected against the entrance of unauthorized persons, and it is protected against the accumulation of windblown debris.
- The space contains no equipment or structures (such as steam pipes, electrical wiring, ducts, shafts, or conveyors) that could potentially ignite or conduct the spread of fire.
- The floor over the space is tight.
- Nonflammable liquids are processed, handled, or stored on the floor above the space.

“Total coverage”, as defined in NFPA 72, is the definition of a complete fire detection system. In some of the specified areas of coverage, such as attics, closets, under open loading docks or platforms, a heat detector may be more appropriate than a smoke detector. Careful consideration should be given to the detector manufacturer's instructions and the following recommendations in this guide.

In general, when only one detector is required in a room or space, the detector should be placed as close to the center of the ceiling as possible. Central location of the detector is best for sensing fires in any part of the room. If a center location is not possible, it may be placed no closer than 4 inches from the wall, or if listed for wall mounting, it may be mounted on the wall. Wall-mounted detectors should be located approximately 4 to 12 inches (10 to 30 cm) from the ceiling to the top of the detector, and at least 4 inches (10 cm) from any corner wall junction. (See Figure 5-1.)

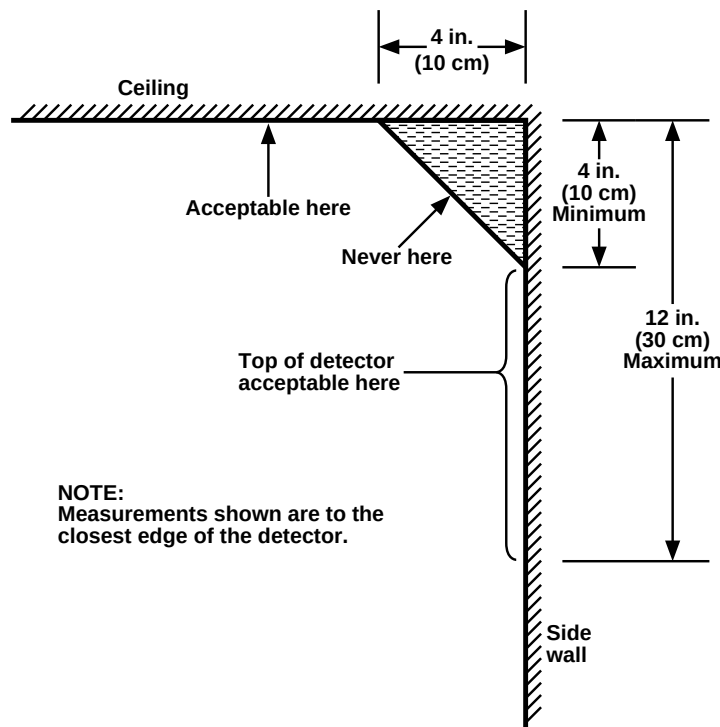


Figure 5-1
Wall Mounted Detector

When air supply and/or air return ducts are present in a room or space, the detector(s) should be placed in the path of the air flow toward the return air duct. (See Figure 5-2.)

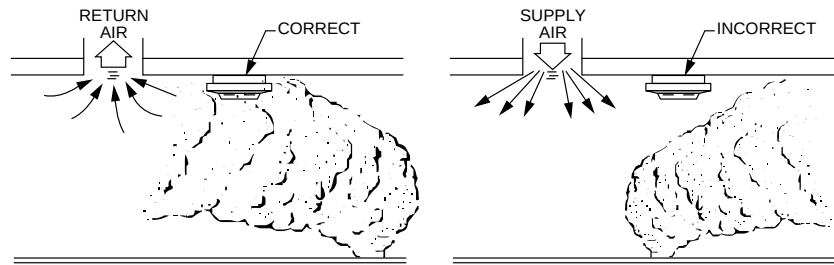


Figure 5-2
Detector Placement – Air Supply and/or Return Ducts

Smoke tests are helpful in determining proper placement. Special attention should be given to smoke travel directions and velocity, since either can affect detector performance.

Placement of detectors near air conditioning or incoming air vents can also cause excessive accumulation of dust and dirt on the detectors. This dirt can cause detectors to malfunction and cause nuisance alarms. Detectors should not be located closer than 3 feet from an air supply diffuser.

Spot type detectors, in properly engineered systems, may also be placed in return air ducts, or in approved duct detector housings designed for this application. Although duct detectors are not a substitute for open area detectors, they can provide an effective method of initiating building control functions to prevent smoke from being transported from the fire area to other parts of a building.

Where NOT To Place Detectors

See Table A-5-3.7.1.1 in NFPA 72.

One of the major causes of nuisance alarms is improper placement of detectors. The best way to avoid nuisance alarms is to not install detectors in environments that can cause them to malfunction. Examples are given below:

- In excessively dusty or dirty areas, such as feed rooms, steel mills, etc. Dust and dirt can accumulate on the detector's sensing chamber and make it overly sensitive, or block the air entrances to the sensing chamber and make the detector less sensitive to smoke. Be especially careful to avoid areas where fumigants, fog or mist-producing materials, or sweeping and cleaning compounds are used. These substances may cause nuisance alarms.
- Outdoors, in stables, open storage sheds, or other open structures affected by dust, air currents, or excessive humidity and temperature.
- In damp or excessively humid areas, or next to bathrooms with showers. Water droplets can accumulate inside the sensing chamber and make the detector overly sensitive. A tremendous amount of humid air is produced during a hot shower. The moisture in this humid air can enter the sensing chamber as water vapor, then cool and condense into droplets that can cause a false alarm.
- Elevator lobbies — do not place over ash trays or where people will smoke while waiting for the elevator.
- In very cold or very hot environments, or in unheated buildings or rooms where the temperature can fall below or exceed the operating temperature range of the detector. At temperatures below 0°C (32°F), ice crystals or condensation can appear inside the sensing chamber and make it overly sensitive or cause a false alarm. At temperatures above the operating range of the detector (greater than 49°C or 120°F), its internal components may not function properly.

- In or near areas where combustion particles are normally present, such as in kitchens or other areas with ovens and burners; in garages, where particles of combustion are present in vehicle exhausts; within 15 feet (4.5 meters) of any type of furnace, hot water heater, or gas space heater; or in welding shops or other types of work areas where some form of combustion is used in the activity normally conducted in that area. When a detector must be located in or adjacent to such an area, a heat detector may be appropriate.
- In air streams passing by or through kitchens. Air often enters a residence or a residential unit of an apartment building through cracks around the front and/or back doors. If the air return is in the bedroom hallway or in the bathroom, and if air from the kitchen easily enters the air stream going from the door to the air return, combustion particles from cooking can cause nuisance alarms. Install detectors so that they protect the bedrooms, but so they are out of the airstream.
- In or near manufacturing areas, battery rooms, or other areas where substantial quantities of vapors, gases, or fumes may be present. Strong vapors, like excessive humidity, can make detectors overly sensitive or less sensitive than normal. In very large concentrations, gases heavier than air, such as carbon dioxide, may make detectors more sensitive, while gases lighter than air, such as helium, may make them less sensitive. Aerosol particles may collect on detector chamber surfaces and cause nuisance alarms.
- Insect-infested areas. If insects enter a detector's sensing chamber, they can cause a false alarm. Take proper insect eradication procedures before installing detectors in such a location. If spraying is done, do not allow insect spray to enter the detectors.
- Near fluorescent light fixtures. Electrical noise generated by fluorescent light fixtures may cause unwanted alarms. Install detectors at least 1 foot (.3 meters) away from such light fixtures.

Underwriters Laboratories (UL) has three standards for smoke detectors: one for duct detectors, UL 268A; one for single and multiple station detectors, UL 217; and one for systems type detectors, UL 268. Detectors should only be used for the applications for which they are specifically listed.

The 1991 NFPA 101 Life Safety Code notes in Section 7-6.2.9, that single station smoke detectors shall sound an alarm only within an individual living unit or similar area and shall not actuate the building protective signaling and control system. Section 7-6.1.5 states, "All systems and components shall be approved for the purpose for which installed."

In addition to possible code noncompliance, the following deficiencies would exist in a series of residential smoke detectors, connected in a system mode:

- Since the system is not supervised, vandals or others could disconnect a detector or the entire system, leaving a building without protection. The residents would be unaware of this serious life threatening condition.
- Residential detectors do not latch in alarm. In other words, the detector self-resets. One detector in alarm will sound all the detectors connected together. It would be difficult to identify or locate a specific detector that initially put the system into alarm after the alarm condition was cleared.

System detectors latch in alarm. They do not reset until power is momentarily disconnected. This makes it convenient to identify the location of a detector that caused the control panel to alarm. In addition, system detectors are specifically designed to connect to a panel. Two-wire detectors require a UL compatibility review to verify that the detector and panel operate together. A typical life safety fire protection system for an apartment complex would be to use system detectors and manual fire alarm stations in the hallways and common areas of the complex and residential single station type detectors and heat detectors in the individual apartments. The system detectors, manual stations and heat detectors would be connected to a control panel, sound a general alarm and automatically notify the

proper authorities that a fire condition exists. The residential detectors located in the apartments would be interconnected only within the individual living quarters of each apartment. These residential units would sound an alarm only in the apartment where a fire started.

DETECTOR SPACING

General Spacing Guidelines

Some fire protection codes specify detector spacing on a given center-to-center distance between detectors under ideal conditions. These spacings are based on rooms with smooth ceilings with no physical obstructions between the contents being protected and the detectors. Moreover, they are also based on a maximum ceiling height, and on the assumption that the value and the combustible nature of the contents of the room to be protected do no warrant greater protection or closer spacing.

If we assume a typical center distance spacing guideline is 30 feet (9.0 meters), how do we determine whether a given room or space can be protected by a single detector? Figure 5-3 shows four detectors spaced horizontally and vertically 30 feet (9.0 meters) apart. Detectors B and D, however, are more than 30 feet apart. Clearly, detector spacing can exceed the given 30 foot spacing and still comply with the code if any source of combustion is within 21.2 feet (6.4 meters) of the horizontal projection of a detector, and if no more than 900 square feet (82.8 square meters) are being protected by one detector.

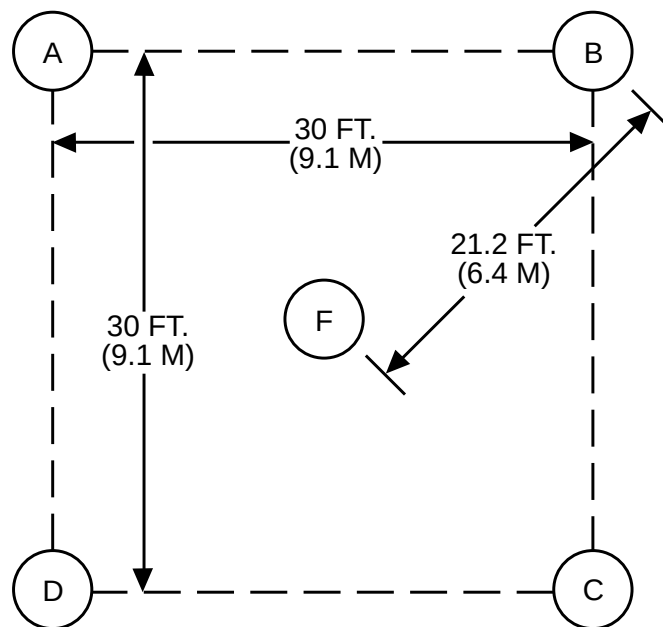


Figure 5-3
Typical Detector Spacing

To determine what coverage patterns are permissible within the 30 foot spacing, start by tracing a circle with a radius of 21.2 feet. Keeping in mind the fact that most rooms and areas to be protected are rectangular or square in shape, any square or rectangle that fits within the circumference of the circle may be protected by one detector. (See Figure 5-4.)

Rectangle A = 10' × 41' = 410 sq. ft.
B = 15' × 39' = 585 sq. ft.
C = 15' × 39' = 740 sq. ft.
D = 15' × 39' = 850 sq. ft.
Listed Spacing = 15' × 39' = 900 sq. ft.

For SI Units: 1 ft. = 0.305 m.

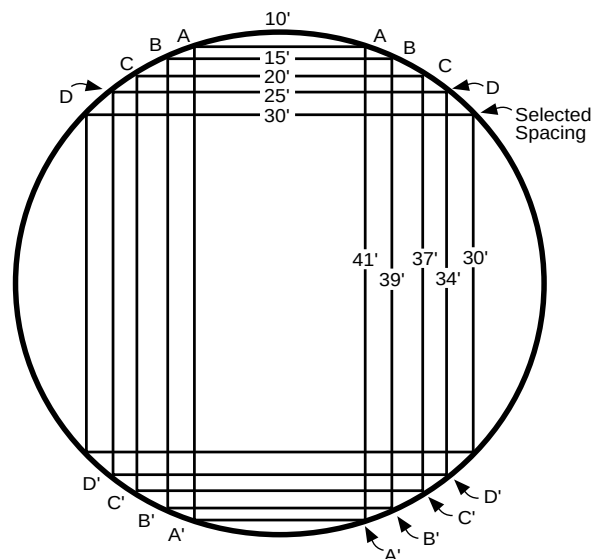


Figure 5-4
Detector Coverage Patterns

In other words, if a diagonal through the center of the room is no greater than the diameter of the circle, or 42.4 feet (12.8 meters), one detector can be used under ideal conditions. Figure 5-5 shows how a length of hallway can be protected by only two detectors under ideal conditions

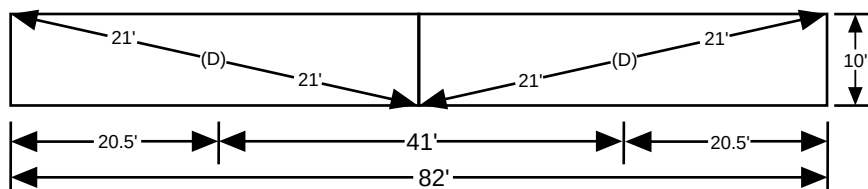


Figure 5-5
Detector Placement in Hallways

Special Spacing Problems

The ideal conditions upon which code guidelines are based do not exist in the majority of buildings. Detector installers usually have to deal with a variety of problems, such as uneven ceilings or ceilings crossed by beams and joists; storage racks and partitions that obstruct the path of smoke toward detectors; air stratification due to uninsulated roofs, peaked or sloped ceilings, or localized heating or cooling from heating, ventilating, and air conditioning systems; and extensive variability in the value and combustion characteristics of building contents. The following are suggested techniques for dealing with some of the special detector spacing problems:

- Uneven ceilings or ceilings crossed by beams and joists. Ceiling beams less than 8 inches (20 cm) in depth may be considered equivalent to a smooth ceiling, because of the “spill-over” effect of smoke. When ceiling beams are more than 8 inches (20 cm) in depth, the movement of heated air and smoke may be slowed by the pockets or bays formed by the beams. Therefore, detector spacing perpendicular to the joists or beams should be reduced from the ideal spacing. If beams exceed 18 inches (45 cm) in depth and are more than 8 feet (2.5 meters) apart, each bay should be treated as a separate area requiring at least one detector.
- High storage racks. Multi-level storage racks present special problems for early fire detection. Developing fires, especially smoldering fires, on the lower levels of the racks may not be sensed rapidly by ceiling mounted detectors. Upward convection of smoke can be slowed or blocked by

goods stored on the upper levels of the racks. Multi-level fire detection is required. Detectors should be installed on the ceiling above each aisle and on intermediate levels of the racks adjacent to alternate pallet sections, shown in NFPA 72, Appendix A-5-3.7.5. A consultant's judgement may be required for specific installations.

- **Partitions.** Partitions and many types of large, tall equipment standing on the floor can block the flow of smoke toward detectors. Any partition or similar obstruction that is less than 18 inches (45 cm) from the ceiling should be treated as a side wall dividing the area protected.
- **Air Stratification.** Air stratification in a room may keep air containing smoke from reaching ceiling-mounted detectors. Three conditions are known to accentuate air stratification: when a layer of hot air exists under a poorly insulated roof heated by the sun, cooler air will stratify the hot air layer at the ceiling; when a layer of cold air exists under a poorly insulated roof cooled from the outside by cold air, the heated air is cooled as it reaches the cold air layer; or when a heating, ventilating, or air conditioning (HVAC) system creates artificial hot or cold air layers in a room, the layers may affect the flow of smoke to the detectors.
- **Uninsulated Roofs.** Uninsulated roofs present special placement problems. Air movement toward ceiling detectors is not impeded when the outside temperature is cool, but stratification can occur when outside temperature is warm or hot, or when the roof is heated by the sun on bright, sunny days. Although true thermal barriers are not present in many installations, smoke tests should be run in factories or warehouses with metal roofs on warm sunny days to determine whether such a thermal barrier exists.
- **Peaked or Sloped Ceilings.** Peaked or sloped ceilings can foster air stratification. Codes may specify spacing detectors by using horizontal spacing from the peak of the roof or ceiling. For instance, if the specified distance from the peak is 3 feet (1 meter), the distance is measured on the base of the right triangle formed by a vertical line dropped from the peak of the roof, with the roof incline as the hypotenuse. Additional detectors are installed on the selected spacing, using the horizontal distance, not the distance along the incline of the ceiling. (See Figure 5-6.)

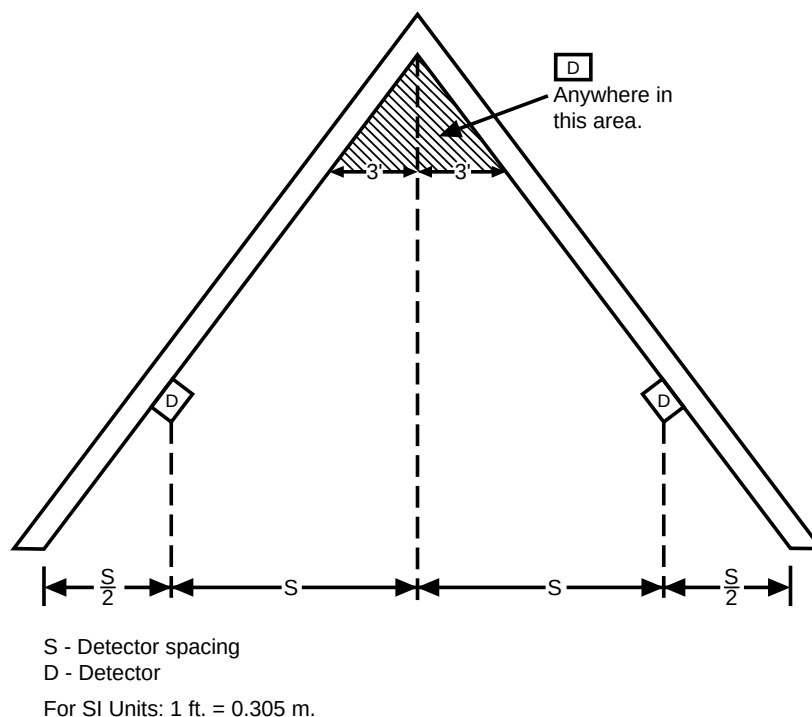


Figure 5-6
Detector - Spacing Layout - Sloped Ceilings (peaked type)

- Alternate Detector Mounting. Mounting alternate detectors up to 3 feet below the ceiling can increase detection of small or smoldering fires when the possibility of air stratification exists. Figure 5-7 illustrates such an installation. Specific designs for such an alternate detection should be based upon an engineering survey.

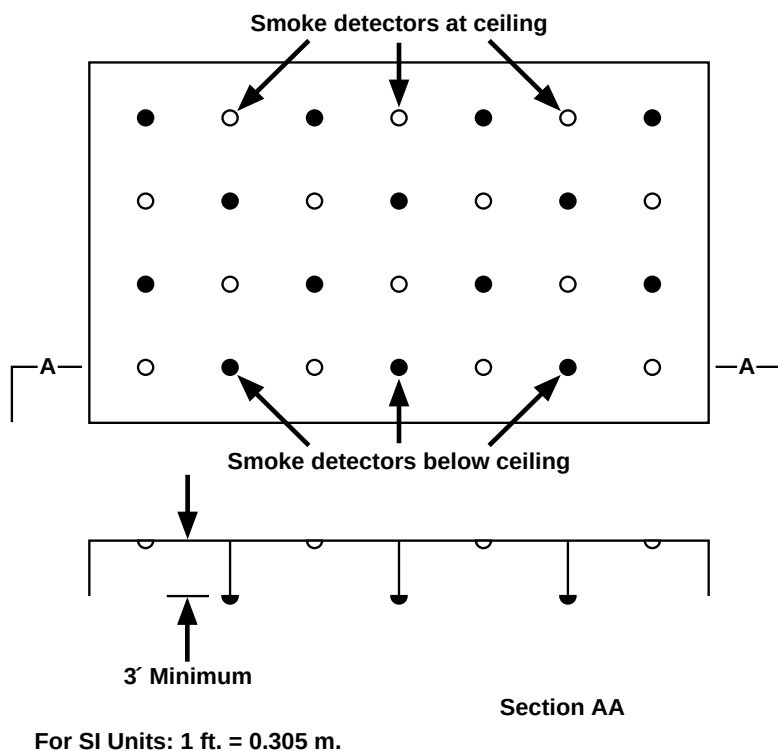


Figure 5-7
High Ceiling Area

- Heating, ventilating, and air conditioning (HVAC) effects on air flow and air stratification should be determined and considered when planning detector placement. In rooms where forced-air ventilation is present, detectors should not be located where air from supply diffusers could dilute smoke before it reaches the detector. Detectors should be located in the air flow toward air-return openings. This may require additional detectors, because placing detectors only near return air openings may leave the balance of the area with inadequate protection, especially when the Heating, Ventilating, and Air Conditioning (HVAC) system is not operating.
- Detectors placed in an above-ceiling air handling space should not be used as a substitute for open-area protection, because smoke may not be drawn into the air handling space when the ventilating system is shut down. The detector will be less responsive to a fire condition in the room below than a detector located on the ceiling of the room below due to dilution and filtering of the air in the air handling space before the smoke reaches a detector. (See the discussion of detector placement in **Where To Place Detectors** [Section V]).
- Burn characteristics and the value of contents influence the spacing of detectors and the amount of protection provided in a specific room or area. See Appendix B of the NFPA 72 for more detailed information on spacing of detectors under special applications. Likewise, if the contents are especially valuable, for example, sophisticated and expensive machinery or irreplaceable records, detectors should be placed closer together.

DETECTORS IN AIR-HANDLING AND AIR CONDITIONING SYSTEMS

See NEMA Guide for Proper Use of Smoke Detectors in Duct Applications and NFPA 72, National Fire Alarm Code for more specific information.

DETECTORS IN ABOVE CEILING PLENUM AREAS INCLUDING PLENUMS UTILIZED AS PART OF THE HVAC SYSTEM

Detectors should be placed in plenum areas (above ceiling air handling space) in addition to the open area detectors installed in the open areas below and duct detectors installed in the ducts. Plenum detectors are required to be listed or tested and approved for the air velocities within the environment in which they are to be installed.

Detectors placed in plenums MAY NOT be used as a substitute for open-area protection, because smoke may not be drawn into the plenum when the ventilating system is shut down, and when the system is operating, the detector may be less responsive to a fire condition in the room below than will a detector located on the ceiling of the room below. This may be due to blockage, dilution, and filtering of the air prior to its arrival at the detector location in the plenum area.

Since the air circulating through the plenums is usually at higher velocities than would be prevalent in the room below, detector spacing should be reduced.

Also, the dilution of the smoke in plenum spaces is an important consideration when utilizing smoke detectors rated for higher velocities. Therefore, plenum detectors should be utilized to detect fire in the plenum but should never be utilized as a substitute for duct detectors and open area detectors.

Maintenance requirements of detectors exposed to unusual velocities (above 300 fpm) are generally increased due to the excessive dirt buildup and contamination present in these environments.

SECTION VI TESTING, MAINTENANCE AND SERVICE OF DETECTORS

CAUTION

Smoke detectors are sophisticated electronic devices that need periodic testing and maintenance. To maintain the integrity of any fire alarm system, it is important to have a qualified person periodically test the system.

Smoke detectors are designed to be as maintenance-free as possible. However, dust, dirt, and other foreign matter can accumulate inside a detector's sensing elements and change its sensitivity. They can become either more sensitive, which may cause unwanted alarms, or less sensitive, which could reduce the amount of warning time given in case of a fire. Both are undesirable. Therefore, detectors should be tested periodically and maintained at regular intervals. Follow closely the manufacturer's specific recommended practices for maintenance and testing. Also refer to Appendix B of NFPA 90A and NFPA 72, Chapter 7.

TYPICAL INSPECTION, TEST, AND MAINTENANCE PRACTICES

Detectors should be given a visual inspection at installation and at least twice a year. This ensures that each detector remains in good physical condition and that there are no changes that would affect detector performance, such as building modifications, occupancy hazards, and environmental effects. Notify the proper authorities that the smoke detector is undergoing maintenance, and therefore the system will temporarily be out of service. NOTE: Disable the zone or system undergoing maintenance to prevent unwanted alarms and possible dispatch of the fire department.

Use a high power vacuum cleaner and remove dust from the detector by placing the nozzle as close as possible to the openings in the outside housing. A nozzle with a brush attachment will assist in dust removal. Some detectors can be removed for more thorough cleaning; refer to the manufacturer's recommended procedure for details.

Test each detector's sensitivity per the manufacturer's recommended procedure within one year after installation and every alternate year thereafter.

Test each detector functionally in place annually, as detailed in NFPA 72 1993 (Chapter 7).

If a detector's sensitivity is within specifications, nothing further needs to be done to the detector. If the detector's sensitivity is outside specifications, replace the detector or follow the manufacturer's recommended procedure.

Restore zone or system at the completion of testing.

Notify the proper authorities that testing has been completed and the system is again operational.

Refer to paragraph 7-4.1 of NFPA 72 for additional information.

To assure that each smoke detector is within its listed and marked sensitivity range it should be tested using either:

- A calibrated test method, or
- The manufacturer's calibrated sensitivity test instrument, or
- Listed control equipment arranged for the purpose, or
- Other calibrated sensitivity test method acceptable to the authority having jurisdiction.

Detectors found to have a sensitivity of 0.25 percent/ft. obscuration or more outside the listed and marked sensitivity range should be cleaned and recalibrated or replaced.

Exception: Detectors listed as field adjustable may be either adjusted within the listed and marked sensitivity range, cleaned and recalibrated, or replaced.

Restore the zone or system at the completion of testing.

Notify all the persons contacted at the beginning of the test that testing has been completed and the system is again operational.

Some individuals rely on an aerosol chemical spray to test the sensitivity of a detector. This can give unsatisfactory results since an aerosol chemical spray does not accurately test detector sensitivity. NFPA 72-1993, Chapter 7, Section 7-3.2.1 notes that, "The detector sensitivity shall not be tested or measured using any device that administers an unmeasured concentration of smoke or other aerosol into the detector." The duration of spray, distance between the detector and the aerosol container, angle of discharge, and different environmental conditions can produce random results. In addition, many aerosols leave an oily residue. Over a period of time, this oily residue can attract dust or dirt which can make a detector more sensitive and result in nuisance alarms.

Be sure to follow the manufacturer's recommendation on test gas, aerosol or smoke.

SECTION VII

TROUBLESHOOTING TECHNIQUES

WHAT TO DO ABOUT NUISANCE ALARMS

No detection system is impervious to nuisance alarms. Statistically, as the system size and the total number of detectors increases, the total number of nuisance alarms per year tends to increase. Historical experience in a given installation or data on similar-sized buildings with similar utilization patterns can provide a basis for a rough indication of how many nuisance alarms are probable during a 12 month span; however, no two installations are identical.

In small- to moderate-sized detection systems protecting relatively combustion-free environments, like office buildings, more than one or two nuisance alarms per year would be unusual. In more adverse environments, such as laboratory or manufacturing facilities where fumes, vapors, solvents, and combustion processes are present, more frequent alarms can be anticipated. In very adverse environments, one alarm per month might not be considered excessive.

After the first year, which serves as a shakedown period, it should be possible to arrive at some reasonable expectation for probable alarms from the system. After that, any unexpected change in alarm frequency or distribution indicates a problem that should be investigated. The best way to monitor alarm frequency and distribution is to maintain an alarm log.

Some manufacturers of automatic fire alarm systems offer an alarm verification feature that delays an alarm signal for a period of time (maximum 60 seconds). This feature can contribute to the reduction of nuisance alarms.

Make sure that the fire alarm equipment featuring alarm verification has been approved for alarm verification by Underwriters Laboratories, Inc.

REASONS FOR NUISANCE ALARMS

Nuisance alarms can result from a wide variety of causes, including:

- Improper locations in environments where they will not operate properly because of temperature extremes; excessive dust, dirt, or humidity, excessive air flow rates, or the normal presence of combustion particles, vapors, gasses or fumes in the air streams surrounding the detectors.
- Improper installation where the detector wiring is not protected from interference from fluorescent lights, induced currents and noise in adjacent wiring systems, radio-frequency transmissions, and other types of electromagnetic effects.
- Inadequate maintenance that results in the accumulation of dust and dirt on the detector's sensing chambers over a period of time.
- Seasonal effects, such as alarms that occur during the reactivation of the building heating system after an extended summer shutdown as the dust accumulated on the heating coils is burned.
- Incidental to building maintenance, such as accidental triggering of a detector's magnetic test switch (such as by touching it with a magnetic screwdriver), or the introduction of plaster dust from drywall repairs or other powder-like debris into a detector's sensing chamber because the detector was not shielded from dirt during drilling, sawing, or sanding operations nearby.
- Induced current effects from lightning storms.
- Infestation from insects small enough to enter the detector's sensing chamber.
- Vandalism or mischievous acts. Detectors set off as a prank have been found to be a major problem in dormitories.

In a worst-case example, a pattern of repeated alarms and/or small fires in a particular area may indicate a serious deficiency in safety practices that should be promptly corrected. In less obvious cases, patterns are indicated by repeated alarms in the same or adjacent zones with similar probable causes, or repeated alarms in the same zone that occur at about the same time of day, or time of year.

EFFECTS OF LOCATION OR ENVIRONMENT

Check for the effects of location and environment. Review the information in this guide **Where To Place Detectors** and **Where NOT to Place Detectors** to determine whether the detector's location or its environment is potentially causing the nuisance alarms. Also, refer to the installation manual for further information.

One often overlooked source of problems is the placement of detectors where air streams carry smoke or chemical fumes from some areas of an installation past detectors in other areas unrelated to the source of the contaminants. Diagnosing problems of this kind requires that air movements into the problem area, especially near the ceiling, be carefully checked and their sources be determined. Experienced heating, ventilating, and air conditioning (HVAC) engineers or contractors usually have the training and specialized equipment (flow meters, etc.) to conduct such a study. In very difficult cases, a full scale smoke test may be required to solve the problem.

Conversely, strong air streams near air inlet ducts, etc., can also prevent a detector from signaling an alarm when a fire is present by blowing smoke away from the detector heads.

INSPECT DETECTOR FOR DIRT AND REVIEW MAINTENANCE

If the Alarm Log indicated that after several months or a year with a fairly stable alarm rate, there is a gradual increase in the frequency of nuisance alarms, this is usually an indication that the detectors in the system should be cleaned.

NFPA standards require and smoke detector manufacturers recommend that all detectors be visually inspected twice a year.

Clean the detectors at least once a year, or more frequently if environmental conditions warrant it. See the section on **Detector Testing and Maintenance** in this guide for more details.

In cases where the probable cause of a number of alarms appears to be dust or dirt on the detectors, detector maintenance schedules should be reviewed to determine the dates when the detectors were last cleaned and tested. If the detectors are due or overdue for maintenance, scheduling and performing the recommended cleaning and testing should eliminate the problem.

If the problem resulted from a temporary overall increase in airborne dust due to nearby construction, scheduling a one-time special cleaning for all the detectors in the system will alleviate the problem. If the problem is confined to one or two zones and is the result of higher dust levels in particular area, scheduling the detectors in those areas for more frequent maintenance and cleaning may prevent the development of similar alarm problems in the future.

EFFECTS OF OTHER SYSTEMS ON ALARM SYSTEM WIRING

In checking for the effects of other systems on the alarm system wiring the Alarm Log may be very valuable in helping to pinpoint relationships among apparently causeless alarms. One important fact that can be obtained from an Alarm Log is the beginning date for a rash of apparently causeless alarms that may or may not be grouped around one particular zone. The sudden onset of such a group of alarms may result when an addition or change in the alarm system or in another electrical or electromechanical system in the building affects the detectors or the alarm system circuitry.

Systems that can affect the alarm system include: other security systems; walkie-talkie; mobile telephones; heating, ventilating, and air conditioning controls; elevator call systems; remote control equipment (door closers, etc.); and even the installation of microwave antenna. If the alarm pattern

supports the possibility of some kind of interference with a fairly definite initiation date, all equipment changes made in the building immediately prior to or concurrent with the beginning of the development of the alarm pattern should be reviewed. In addition, the wiring layouts of the alarm system and any recent building or system modifications should be compared to make sure that the spacing and/or shielding required to protect the alarm system wiring from other potentially interfering electrical systems was maintained.

MISCELLANEOUS CAUSES OF NUISANCE ALARMS

Isolated alarm causes such as a maintenance person accidentally triggering an alarm by touching a detector with a magnetic screwdriver can be ignored, except to periodically remind maintenance personnel to be careful when working around detectors.

Steps should also be taken to protect detectors from dust whenever maintenance requires sawing, sanding, drilling, or other dust-producing operations in the vicinity of the detector heads to prevent nuisance alarms due to the dust getting into the detector sensing chambers. In new construction applications drywall dust contamination affects all types of smoke detectors. To help overcome this problem, it is strongly recommended that installation of detector heads be delayed until after drywall installation is completed or to protect detector heads from dust contamination.

If alarms occur whenever the heating system is turned on after an extended shutdown, due to the accumulated dust burning off as the system components heat, the detector system can be turned off for a short period while the heating system is activated and checked out, or the start-up of the heating system can be scheduled for an evening, weekend or other off-hours period to minimize the effects of alarms on regular daytime activities.

Not all nuisance alarms are caused by dirt, interference or other effects on the detectors. If the control panel shows an alarm but no detectors in the zone are indicating an alarm condition, the possibility of interference or a failure of a control panel component should also be investigated.

RESPONSIBILITIES OF DETECTOR OWNERS AND INSTALLERS

The owners of smoke-detector-equipped fire alarm systems are responsible for maintaining the integrity of the detection system. This can be accomplished by:

- Maintaining an Alarm Log and training appropriate personnel to properly maintain the system as described above in the section titled **What To Do When Nuisance Alarms Occur**.
- Maintaining a Detector Maintenance Log that records inspection, testing and cleaning data for each detector in the system. (Refer to **Section VI – Testing, Maintenance and Service of Detectors** for information on recommended testing and maintenance intervals and procedures, and a sample Detector Maintenance Log page.)
- Maintaining a complete file of information on the alarm system in a readily accessible location. This file should include specifications and installation instructions for the detectors, control panel, and auxiliary devices, wiring diagrams and wire location information, and the manufacturer's recommendations for isolating the detection system wiring from other electrical wiring to prevent interference and nuisance alarms.
- Making certain that maintenance personnel or contractors working on the building's electrical systems are given copies of the alarm system wiring layout and locations so that potential interference from other wiring systems can be prevented by proper insulation and spacing during installation.
- Keeping accurate records of installation and modifications to all other building electromechanical systems that could cause interference with the alarm system, including updating schematics, wiring layouts, and wiring location information whenever changes are made, so that problems can be promptly found and eliminated.

- Making a record of everything done during investigation of a series of alarms, indicating a problem exists. If assistance must be sought from the installer or manufacturer, there will be an indication of the tests that have already been done by the owner's personnel.

These services can be provided by qualified outside organizations.

The installers of smoke detector equipped alarm systems are responsible for providing the owners with the necessary information and training so that their personnel can maintain the integrity of the alarm system. These responsibilities should include:

- Providing copies of the specifications and installation instructions for the detectors, control panel, and auxiliary devices; wiring diagrams and wire location information; and the manufacturer's recommendations for isolating the detection system wiring from other electrical wiring to prevent interference and nuisance alarms.
- Verifying that the alarm system installation meets all applicable code requirements.
- Completely testing a newly installed, expanded, or modified alarm system to ensure that all components are working properly.
- Providing troubleshooting assistance to the owners for a specified break-in period after installation in case problems develop.
- Helping the owner set up appropriate Detector Maintenance and Alarm Logs for the system.
- Providing initial instruction and training to the owner's personnel or outside organization which will be monitoring and maintaining the system.
- Providing troubleshooting assistance if nuisance alarm problems cannot be solved satisfactorily by the owner's personnel or outside organization.

WHERE TO GET HELP IF THE SOURCE OF NUISANCE ALARMS CAN'T BE FOUND

In the event a series of unexplained nuisance alarms and/or a review of the Alarm Log indicates that a problem situation exists, the owner should conduct the initial investigation to find a solution. If the owner's personnel are unable to determine the cause for the alarms, the installer or representative of the manufacturer should be contacted to help pinpoint the problem.

Manufacturers can be contacted by phone for additional suggestions. If factory assistance is needed, a factory engineer may be able to explain the source of the problem with data from your Alarm Log, complete description of your alarm system including detector model numbers, make and model number of the control panel and other components, and a complete summary of all aspects of the problem that have already been checked.

SYSTEM SENSOR SERVICES

THE SYSTEM SENSOR WARRANTY

System Sensor smoke detectors are covered under the following **Three-Year Limited Warranty**:

"System Sensor warrants its System Smoke Detectors to be free from defects in materials and workmanship under normal use and service for a period of three years from the date of manufacture as indicated by the date code stamped on each product. System Sensor makes or assumes no other express Warranty, obligation or liability for its system smoke detectors. No agent representative, dealer, or the employee of the Company has the authority to increase or alter the obligations of this Warranty. The Company's obligation under this Warranty shall be limited to repair or replacement of any part of the detector which is found to be defective in materials or workmanship under normal use and service during the three year period commencing with the date of manufacture. After phoning System Sensor (1-800-SENSOR2) for a return authorization number, send defective units postage prepaid to System Sensor, Repair Department, 3825 Ohio Avenue, St. Charles, IL 60174. The Company shall not be obligated to repair or replace units which are found to be defective because of damage, unreasonable use, modification, or alterations occurring after the date of manufacture, or units that are not properly maintained. The duration of any implied warranty, including that of merchantability or fitness for any particular purpose, shall be limited to the period of three years commencing with the date of manufacture. In no case shall the Company be liable for any consequential damages for breach of this or any other warranty, express or implied whatsoever, even if the loss or damage is caused by the Company's negligence or fault.

Customer shall be solely responsible for determining suitability for use, including compatibility with other equipment. System Sensor shall in no event be liable in this respect. Customer agrees that if the products sold hereunder are resold, customer will include in the contract for resale, provisions which limit recoveries against System Sensor in accordance with this section."

UL LISTING AND OTHER AGENCY APPROVALS

System Sensor Smoke Detectors are submitted for approval by Underwriters Laboratories, Inc. (UL), Underwriters Laboratories of Canada (ULC), the California State Fire Marshal (CSFM), and Factory Mutual (FM).

CUSTOMER SERVICE CENTERS

Detectors needing cleaning, testing, repair, or replacement can be sent to the addresses listed below after calling the Repair Department for a Return Authorization Number:

or, in Canada to:

System Sensor
Repair Department
RA # _____
3825 Ohio Avenue
St. Charles, IL 60174
Telephone: (708) 377-6363
FAX: (708) 377-6495

System Sensor Canada
6581 Kitimat Road, Unit #7
Mississauga, Ontario
Canada L5N 2T5
Telephone: (905) 812-0767
FAX: (905) 812-0771

OTHER SYSTEM SENSOR SERVICES

- System Sensor Field Sales Engineers can provide technical support from the factory.
- System Sensor Customer Service Department provides cleaning and calibration of smoke detectors.



WORLDWIDE MANUFACTURING AND DISTRIBUTION

System Sensor
3825 Ohio Avenue
St. Charles, Illinois 60174, USA
Telephone: (630) 377-6580
Fax: (630) 377-6495

System Sensor
Pittway Tecnologica S.p.A.
Via Caboto, 19
34147 Trieste, Italy
Telephone: 39 40 9490 111
Fax: 39 40 382137

System Sensor Far East
Rm 903, Tower A, New Mandarin Plaza
14 Science Museum Road
TST East, Kowloon, Hong Kong
Telephone: 852-2191-9003
Fax: 852-2736-6580

System Sensor Europe, Ltd.
Horsham Gates III, North Street
Horsham, West Sussex RH13 5PJ
United Kingdom
Telephone: 44 1403 276500
Fax: 44 1403 276501

System Sensor Canada
6581 Kitimat Road
Unit #7
Mississauga, Ontario
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Telephone: 905-812-0767
Fax: 905-812-0771

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