Fire Alarm Systems

General

Fire alarm systems are required by the fire code, building code, state agencies, and as stipulations to an appeal.

Other Articles of the fire code require specific fire alarm applications for the more hazardous operations of occupancies not otherwise requiring fire alarm systems. The Building Code provides for smoke detection in areas where there are modifications for type or rating of building construction or modifications to egress.

Companies engaging in fire alarm installations in the City of Phoenix must hold a valid permit issued by the fire department.

Permits

Permits are required for fire alarm installations, including elevator recall, smoke detection, fire detection, general evacuation, visual indicating appliances, and special use systems. Permit fees are based on square footage of the protected area, number of buildings, and number of floors.

Fire alarm installations must be in accordance with NFPA 72-1996 Edition

Visual device placement

Visual devices must be installed in accordance with CABO/ANSI A117.1-1992, Section 4-26.2 and NFPA 72, Chapter 6, the adopted standard is more restrictive and offers more guidance about device placement.

Sprinkler System Monitoring

Where automatic fire alarm systems are required in fully sprinklered buildings, the sprinkler system water flow switch is sufficient to satisfy the automatic requirement.

Manual Fire Alarm Systems

Manual fire alarm systems consist of manual pull stations at every required exit and in intermediate locations so that travel distance to a station on a floor does not exceed 200 feet. Manual systems have alarm notification devices as required by Chapter 6 of NFPA 72.

A manual fire alarm system will have at least one automatic fire alarm device; a smoke detector located at the fire alarm control panel.

ANSI A117.1, 4.2.5.

Manual pull stations are mounted at 48 inches above the floor.

Locations Requiring Manual Fire Alarm Systems

Group A, Divisions 1, 2 and 2.1 Occupancies must have a manual fire alarm system unless the activation of the sprinkler system causes a prerecorded evacuation message.

If the assembly occupancy is part of an educational occupancy, the assembly portion may have alarms as required for the educational occupancy.

Educational occupancies with an occupant load greater than 50 must have a manual fire alarm system.

Aerosol Manufacturing

A manual fire alarm system shall be provided throughout an aerosol warehouse.

High Ignition Source Occupancies

Areas with product dryers or other significant ignition sources in wood manufacturing or processing must have a manual fire alarm system unless they are provided with an approved fire sprinkler system.

Definition-Organic coating. Liquid mixture of binders with flammable and combustible solvents spread in a thin film over a surface to produce a hard finish.

Organic Coating Operations

Organic coating manufacturing areas must be provided with a manual fire alarm system.

Emergency alarms must be yellow in color and labeled to identify purpose and to differentiate them from fire alarm manual pull stations.

Semiconductor Fabrication

Semiconductor fabrication facilities must have a manual fire alarm system. (Note: Additional hazardous materials emergency alarm systems are also required, but are not a part of the fire alarm system.)

Institutional occupancies regulated by the Department of Health Services must also conform to requirements of NFPA 101, Life Safety Code 1999 Edition.	**Health Care and Correctional Facilities**	Institutional Occupancies must have a manual and automatic fire alarm system. Jails, prisons, and other occupancies where persons are restrained are allowed to have manual pull stations only in staff-attended areas when they are supervising areas where manual pull stations would otherwise be required. Areas where the manual pull stations may be tampered with may have the pull stations locked as long as a staff member with keys is readily available to operate the pull station.
Residential smoke detectors must be powered by the building wiring and have battery backup. Detectors are required to sound an alarm audible in all sleeping areas. PCC 310.9 **The requirements are actually for 'smoke alarms' as defined in NFPA 72, "A single or multiple station alarm responsive to smoke."**	**Apartments, Hotels, Motels, Congregate Residences**	Hotels, apartments, and congregate residences are required by the Building Code to have smoke detectors located in sleeping areas. Arizona Revised Statutes §36-1637 requires smoke detectors in all new residential occupancies. Smoke detectors shall be wired together so that detectors sound an audible alarm in all sleeping areas.
To alleviate manual pull stations, Sprinkler system alarms must be capable of notifying residents within their units. This requires a fire alarm system.	**Multiple stories Multiple dwelling units**	Apartment houses three or more stories in height or containing 16 or more dwelling units require manual pull stations unless the buildings are fully sprinklered and activation of the sprinkler system causes a local alarm notifying all occupants.
This provision requires a fire alarm system.	**Hotels**	Hotels three or more stories in height or with 20 or more guest rooms require manual fire alarm systems unless the buildings are fully fire sprinklered and activation of the sprinkler system causes a local alarm notifying all occupants.
Definition-Congregate residence. Building or portion thereof containing facilities for living, sleeping and sanitation for occupancy of more than 10 unrelated persons. Examples: Shelter, convent, monastery, dormitory, fraternity or sorority house.	**Congregate Residences**	Congregate residences three or more stories or with an occupant load of 20 or more require a manual fire alarm system unless the buildings are fully fire sprinklered and activation of the sprinkler system causes a local alarm notifying all occupants.

Exceptions to manual fire alarm

Apartment houses, hotels or congregate residences need not have a manual fire alarm system if they are:

- Not over two stories in height;
- Have individual dwellings, attic spaces, and crawl spaces separated from each other and public or common areas by one-hour fire-resistive construction; and,
- Each unit has an exit directly to a public way, exit court or yard.

Locations Requiring Automatic Fire Alarm Systems

Smoke detectors located in areas subject to temperatures in excess of 100 degrees F must be listed for use in higher temperature locations.

Smoke detectors located in areas where there is substantial dust or airborne dirt must be suitable for the larger particles to which they will be exposed.
These detectors will require more frequent cleaning. Self-compensating detectors are the best choice for these locations.

Smoke detection connected to a fire alarm system is required in high-rise buildings with Group B and Group R, Division 1 Occupancies in the following locations:

- Mechanical equipment rooms;
- Electrical rooms;
- Transformer rooms;
- Telephone equipment rooms;
- Elevator machine rooms;
- Other similar rooms;
- Main return-air and exhaust plenum of each A/C system; and,
- At each connection to a vertical duct or riser serving two or more stories from a return-air duct or plenum of an A/C system.

Additionally, high-rise residential occupancies must have smoke detectors in all interior corridors serving an occupant load of 10 or more.

Fire Alarm Requirements by Occupancy

Assembly Occupancies

Assembly occupancies with an occupant load of 1,000 or more must be provided with the following:

- Voice communication system located in a protected space
- Approved prerecorded message activated by the fire alarm
- Audibility above ambient noise level
- Emergency power source conforming to 10-2, 1-5-2-5.
- Supervision of equipment (audio amplifiers, tone generator and two-way telephone circuits) 10-2, 1-5.8.5

Educational Occupancies

Arizona Administrative Code R4-34-1101, State Fire Code requires smoke detection in corridors in educational occupancies.

Smoke detectors are required throughout educational buildings not more than two stories in height where travel distance exceeds 75 feet but is less than 90 feet to a corridor or exit from a room.

Smoke detection

Smoke detectors are required in educational buildings not more than two stories in height when the travel distance from any location to an exit exceeds 150 feet but is not more than 175 feet.

Smoke detectors are required in educational buildings in intervening rooms through which occupants must pass to the exit access. Exception is for rooms used exclusively for mechanical or public utility service or rooms with an occupant load less than ten.

Institutional Occupancies

Smoke detectors are required at automatic-closing doors in smoke barriers of one-hour fire-resistive occupancy separations in institutional buildings. See MP 501.60
Smoke detectors are required in waiting areas open to corridors in institutional occupancies.

Institutional occupancies with patient sleeping rooms must be provided with single-station detectors, which cause a visual display in the corridor outside the room and a visual and audible signal at the nurses' station.

Jails and prisons must have smoke detection throughout resident housing areas, including sleeping areas and all common areas normally accessible to residents.

Residential Occupancies

Smoke detectors are required in hotels and apartments in interior corridors and common areas where the occupant load is ten or more.

Heat detectors are required in areas where smoke detection is inappropriate (temperatures above 100 degrees F, dusty or dirty areas) such as recreational rooms, laundry rooms, furnace rooms, and similar areas

Activation of an alarm system in an amusement building must be AUTOMATIC and must result in a visible means of egress from an amusement building.

Amusement Buildings

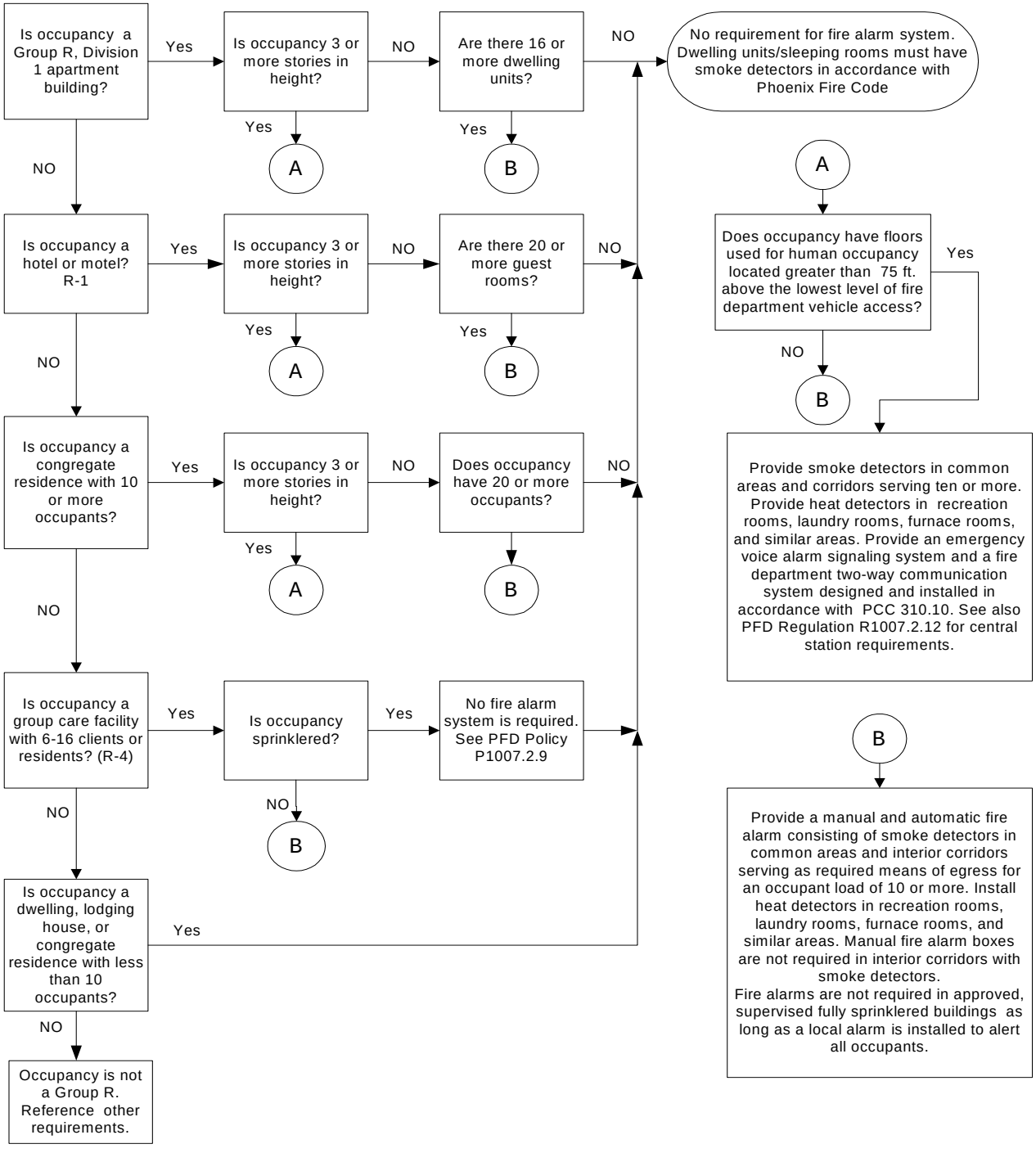
Amusement Buildings must be provided with an approved smoke-detection system connected to the fire alarm system. Activation of the fire alarm system must stop all confusing sounds and visual effects, activate approved directional exit markings, and illuminate the means of egress.

For purpose of amusement buildings, smoke detection system response consists of:

- Two or more smoke detectors or,
- An alarm verification zone or,
- Activation of the automatic fire sprinkler system or other approved fire-detection device (heat detectors, etc.

Residentail Occupancy Fire Alarm Requirements Flowchart

R-1 Hotel, motel, or congregate residence with more than 10 occupants.
R-2 Not used
R-3 Dwelling, lodging house, or congregate residence with 10 or less occupants
R-4 Residential Group Care with 6-16 ambulatory, unrestrained clients /residents (not including staff).



Public address system

A public address system may serve as the fire alarm in an amusement building.

Communication System or Special Requirement

In addition to an automatic fire alarm system, **High-rise buildings** must be provided with emergency voice alarm-signaling systems.

Definition – area of refuge PCC 1102

Area of refuge is an area with direct access to an exit or an elevator where persons unable to use stairs can remain temporarily in safety to await instructions or assistance during emergency evacuation. Areas of refuge are not required in open parking garages. Areas of refuge must be provided at the fourth level and above.

Emergency voice alarm-signaling system

Voice systems must be activated by the operation of any automatic fire detector or sprinkler or water-flow device.

Voice instructions must be heard in the following locations:

- Elevators
- Elevator lobbies
- Corridors
- Exit stairways
- Rooms and tenant spaces exceeding 1,000 sq. ft.
- Dwelling units in apartment houses
- Hotel guest rooms or suites, and
- Areas of refuge (PCC 1104.2.5.)

Emergency communications must be provided in areas of refuge above the fourth level.

Phoenix Fire Department Policy P1303

High-rise evacuation notification

Fire alarm evacuation must occur on the floor of emergency, and one floor above and one floor below the emergency floor. If interior convenience stairs connect floors, all such floors must be considered as one floor. Fire operations may require modification of this policy.

A central control point to monitor an emergency situation and communicate with building occupants is an important feature of a high-rise building.

Central Control Stations in High-rise Buildings

A central control station not less than 96 sq. ft. with a minimum dimension of 8 feet, must be provided in new and existing high-rise buildings. Station must be separated from the remainder of the building by a one-hour fire-resistive occupancy separation. The central control station must contain:

- Voice Alarm

- Public Address System
- Fire department communication panel
- Fire-detection and fire annunciator panels
- Annunciator to identify location and status of elevators
- Status indicators and controls for air-handling systems
- Controls to unlock stairway doors simultaneously
- Sprinkler valve and water flow detector display panels
- Emergency and stand-by power status indicators
- Telephone with controlled access to public system for fire department use
- Fire pump status indicators
- Current, legible, building plans showing:
- Typical floor plan
- Detail of building core
- Means of egress
- Fire-protection systems
- Firefighting equipment locations and type
- Fire department access
- Permanent partitions
- Rooms and doorways
- Exterior wall openings that can be used for smoke ventilation
- Elevator locations
- Stairway locations
- Location of main shutoff for fire protection systems
- Electrical service entrance
- Water service and shutoff and area served by shutoff
- Gas service and shutoff and area served by shutoff
- Steam service and shutoff and area served by shutoff
- Telephone numbers and names of key building personnel for 24 hour response

Plan submittals must conform to the Arizona Fire Marshal/AZAFAA joint standards for fire alarm plans.

Plan Review Required

Plans for fire alarm systems must be submitted for review and approval prior to installation. The following information is required on drawings submitted for review.

General Requirements – all sheets

- All sheets must be the same size, 24” x 36” preferred.
- All sheets to same scale, 1/8” minimum (except site plan)
- Drawing number and revision numbers and dates
- Name and address of project
- Name, address and phone number of installing contractor
- Seal and signature of an Arizona Registrant if a public building or point-to-point voltage drop calculations are used.
- Reviewed by section on the title block
- Compass points on all sheets with buildings, including site plan
- Sheet title
- Key plan
- Plans must be clear and legible and suitable for photocopying

Title sheet

- Name and address of building owner
- Name and telephone number of installation company contact
- Name and address of general contractor, if applicable
- Name and address of electrical contractor, if applicable
- Area in square feet of each building and total of all buildings
- Occupancy type
- Type of system – fire alarm, conventional, addressable, wireless, analog addressable, Class A, Class B
- List of applicable codes and their editions, fire code, building code, NFPA 72, NFPA 70, UMC, Elevator
- Approving agencies, name and telephone numbers
- Sequence of operation
- Wiring method
- Contractor notes with reference to this project
- Fire department notes with reference to the project

The term “Class A” comes from an earlier NFPA (71) standard for municipal fire alarm systems. The wiring method is called a McCullough loop.

This loop is basically a single telephone line that is linked from site to site with a transmitter at each site. When the alarm is tripped at that site, the transmitter signals a series of signals (similar to a telegraph key). This way the person at the other end can tell which site on the loop sent the signal. Later versions of this system had the receiver using ballpoint pen refills on a strip of paper .The pen continually rests on the paper, but when a signal is sent in, the pen jumps up on the paper creating a series of blips in the lines that can be read.

On the same telephone looped line you could have as many transmitters as you had possible combinations of blips. For example a 1-1-1 could be easily differentiated from a 2-2-2. But also there are lots of other combinations possible, such as 1-1-2, 1-2-1 and 2-1-1 and so on. Also, the number of times the sequence repeated also provided information.

Some United States eastern city fire departments used this system for their pull-boxes. If a citizen pulled a signal box, then a signal would be sent identifying from where it was sent.

Fire Alarm System Wiring Information for plan reviewers and inspectors

Fire alarm systems are unique low voltage systems because system wiring and connections to devices must be supervised. Circuit supervision is either direct current or multiplex. Direct current supervision is used on smaller fire alarm systems while the use of multiplex is reserved for larger systems. Most fire alarm systems installed are addressable with analog devices. Each device is recognized by the fire alarm control panel through programming of the device or a module connected to the device. A unique address is assigned to every device on an initiating circuit. The devices are polled by the fire alarm control panel to determine their condition.

The most troublesome portion of the fire alarm installation is the wiring. Proper installation of wire and cable is an art as well as a science in that time and care must be taken as the conductors are pulled through conduit, attached to the structure or terminated at the devices. Correctly installed field wiring is a mandatory requirement for a successful final inspection.

Direct Current Circuit Theory

Direct current flows at the same amplitude from negative to positive potential.

Ohm's Law defines the relationship between resistance, voltage and current in a direct current circuit. It states that voltage in a circuit is the product of the circuit's resistance times the current flowing through the circuit.
Or,

V (volts) = R (ohms) x I (amps)

If you know two of the values in the equation, you can calculate the third.

To find resistance when current and voltage are known:

$$R = \frac{V}{I}$$

To find current when resistance and voltage are known:

$$I = \frac{V}{R}$$

Alternating Current Circuit Theory

Alternating current does not flow constantly from negative to positive potential. It alternates at 60 Hz (cycles per second), changing direction 60 times a second (nominal). Its amplitude goes from +120 volts down to zero, then to –120 volts and back up through zero and to +120 volts. It does this sixty times a second.

Because the current is not at the same amplitude at all times, Ohms law is not directly applicable. An alternating current circuit has resistance and reactance. The total opposition to the flow of alternating current is called **impedance**.

Direct current continuity supervision is straightforward in that it requires a continuous supervisory current flow from the fire alarm control panel through the supervisory circuit device (resistor or relay) and back to the fire alarm control panel. Any interruption in this current results in a supervisory signal, trouble signal, or an alarm, depending on the type of circuit and the type of interruption.

A conductor is broken, cut or detached from a device, an open will result. If there is a short across a device, an alarm condition is created. Another form of short is a ground fault where a conductor is in contact with the grounding path. This occurs when wire or cable insulation is scraped or cut or when liquid enters a conduit. An electrical path to ground causes system trouble and malfunction. This condition is difficult to troubleshoot and may cause intermittent problems or complete circuit failure.

Three illustrations follow to demonstrate the three conditions, normal, alarm and trouble on an initiating device circuit (IDC). The same operation occurs on the notification alarm circuit for opens and shorts. The exact operation is governed by the style of circuit as described in NFPA 72, Chapter 3.

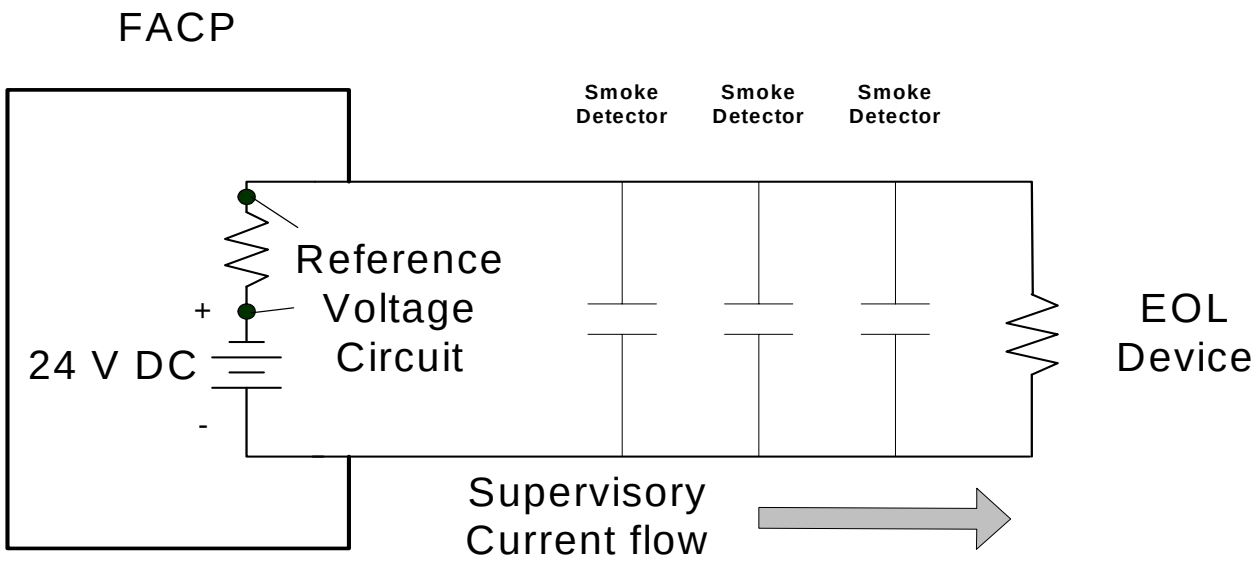
Signaling Line Circuit-
A circuit or path between control devices or transmitters.

Initiating Line Circuit-
A circuit carrying signals from alarm initiating devices, i.e., smoke detectors, heat detectors, manual pull stations, etc.

Notification Appliance Circuit-
A circuit carrying signals from horns, strobes, chimes, etc.

Circuit Styles

Tables 3-5, 3-6, and 3-7.1 in NFPA 72 define the operating parameters of each style of alarm signaling, initiating and indicating circuit.

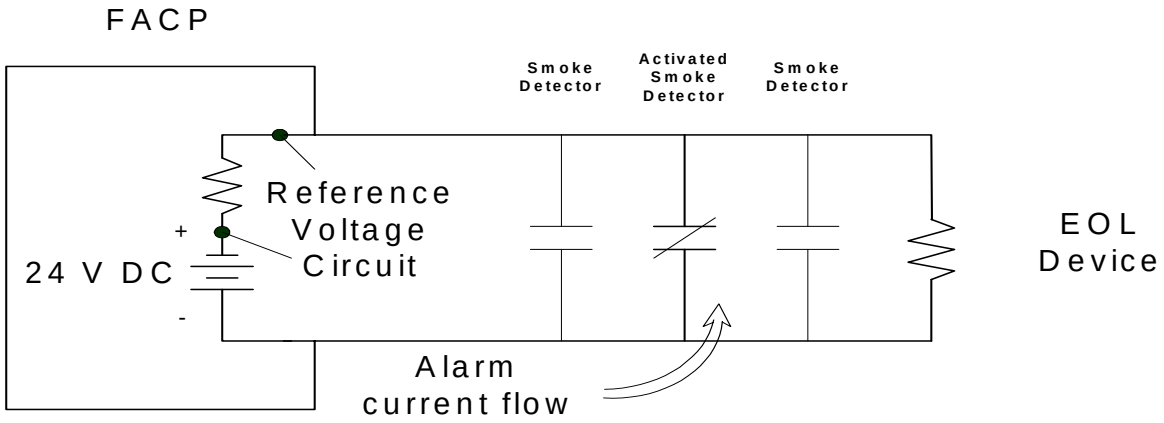


Current flows through reference circuit and end-of-line device. Reference voltage circuit must have a voltage predetermined by the manufacturer based on the circuit design. The 24 volts from the battery are dropped over the reference circuit and the end-of-line device.

Illustration 1- Normal Initiating Device Circuit (IDC)

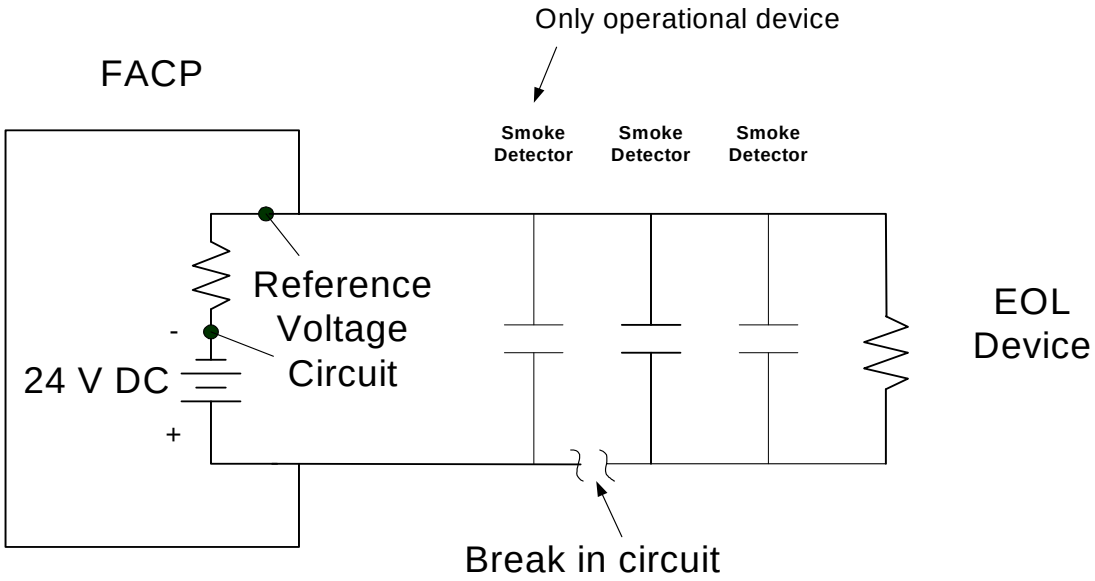
The circuit above indicates a zone of three smoke detectors. As long as the circuit wiring is in a normal condition the supervision voltage across the voltage reference circuit is a fraction of the voltage at the supply because of the voltage drop across the end-of-line resistor (EOL).

If a device such as a smoke detector or manual pull station activates (shorts), the current then flows through the device and most of the voltage is dropped across the voltage reference circuit. When this occurs, an alarm condition exists and the fire alarm control panel will send current through the audible and visual devices to cause an alarm. This condition is illustrated below.



Circuit in alarm - Current flows through smoke detector in alarm. All voltage is dropped across reference circuit and no voltage is dropped across the end-of-line device.

Illustration No. 2-Short (Alarm) on the IDC



Circuit with open - No current is flowing through End-of-Line device.
All voltage is dropped across reference circuit.
Only device before break can send a signal to panel.

Illustration 3 – IDC in Trouble Condition

When there is break in the field wiring, an open condition exists. No current is flowing in the circuit and as a result, there is no voltage drop across the EOL device. The voltage across the reference circuit increases. The fire alarm control panel sees the change in voltage drop and reports a trouble condition.

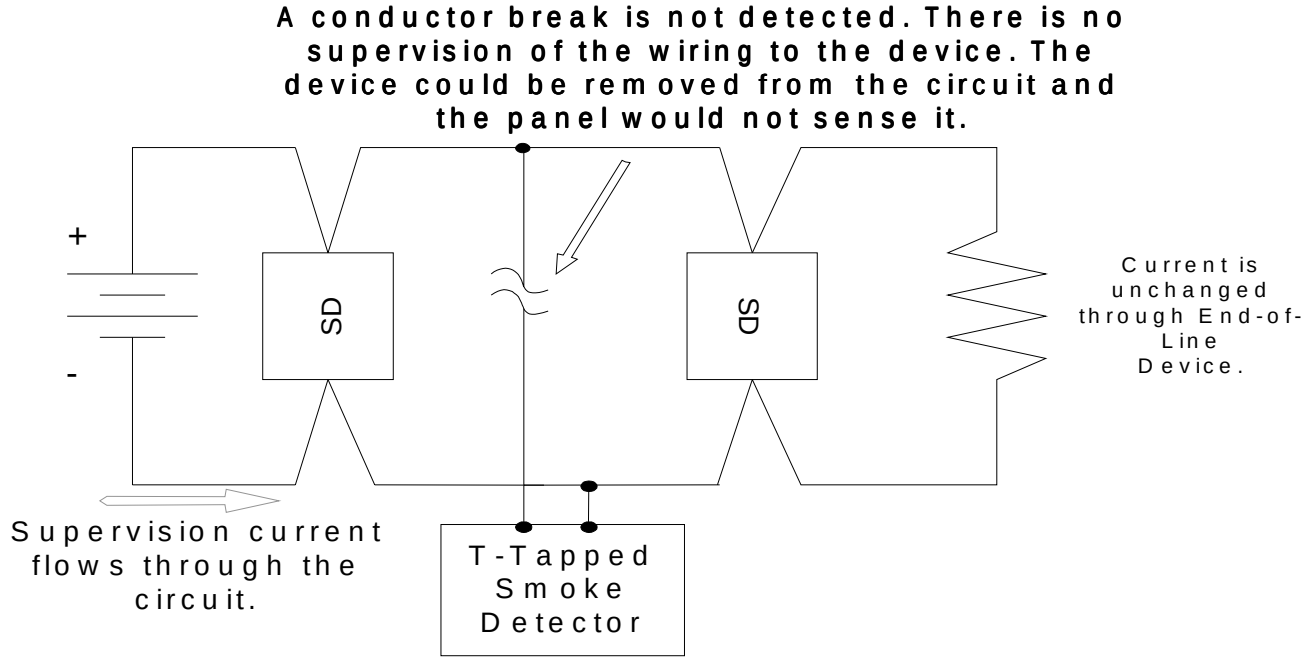
The same wiring configuration problem can be found on notification circuits as well.

Beware of more than two conductors in a wire nut or terminal on a device. This is an indication of T-tapping.

Conventional Fire Alarm Wiring Problems

Below is an example of what can happen when a conventional fire alarm system is not properly wired. Illustrated below is a T-tapped wiring configuration. The device at the bottom of the circuit is electrically not in the circuit. The circuit senses neither a short nor open in the wiring to the device or the device itself because there is another path with less resistance for the current to travel.

T-Tapped Fire Alarm Initiating Circuit (Conventional)



Class A Fire Alarm Circuit

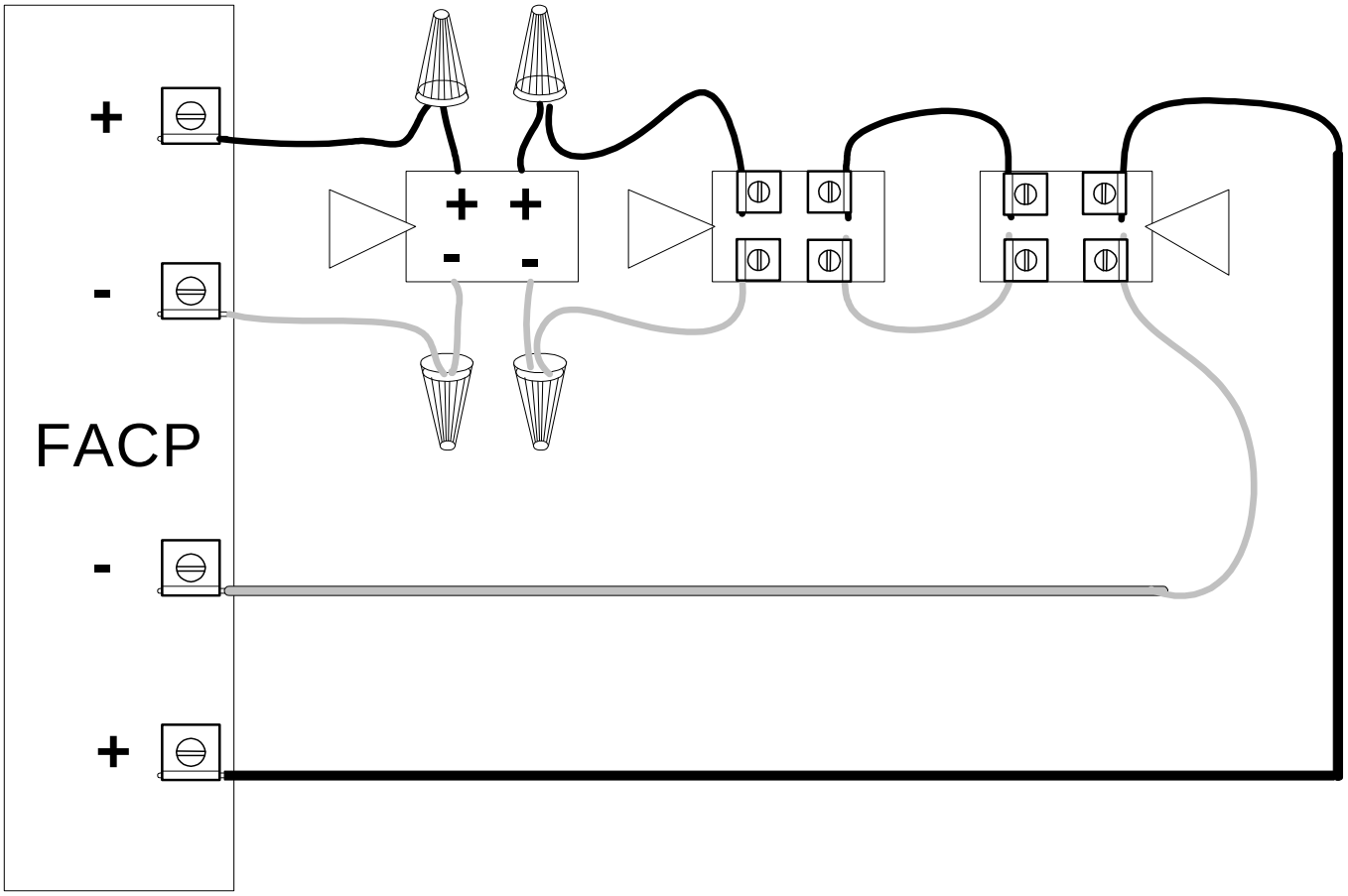
A **Class A** fire alarm system allows operation of a circuit when one of the devices in the circuit is physically removed from the circuit wiring or there is a break in the conductor continuity. This wiring method is required in buildings under the jurisdiction of the State Fire Marshal.

Class B wiring allows a circuit to operate only to the point of circuit malfunction. Devices beyond the open in the circuit will not activate. This is only true for conventional fire alarm systems.

NFPA 72
Chapter 3
Device wiring to circuit

The following illustrations show proper wiring of several styles of notification appliance circuits. Notification appliance circuits (NAC) are described in Table 3-7.1. From these tables, the style of circuit can be determined; Class A or B. Addressable fire alarm systems allow operation of all devices on a loop even if one becomes inoperative. However, unless the wiring is in a loop without T-taps and has appropriate physical separation between the outgoing and incoming sides of the loop, a true Class A configuration does not exist.

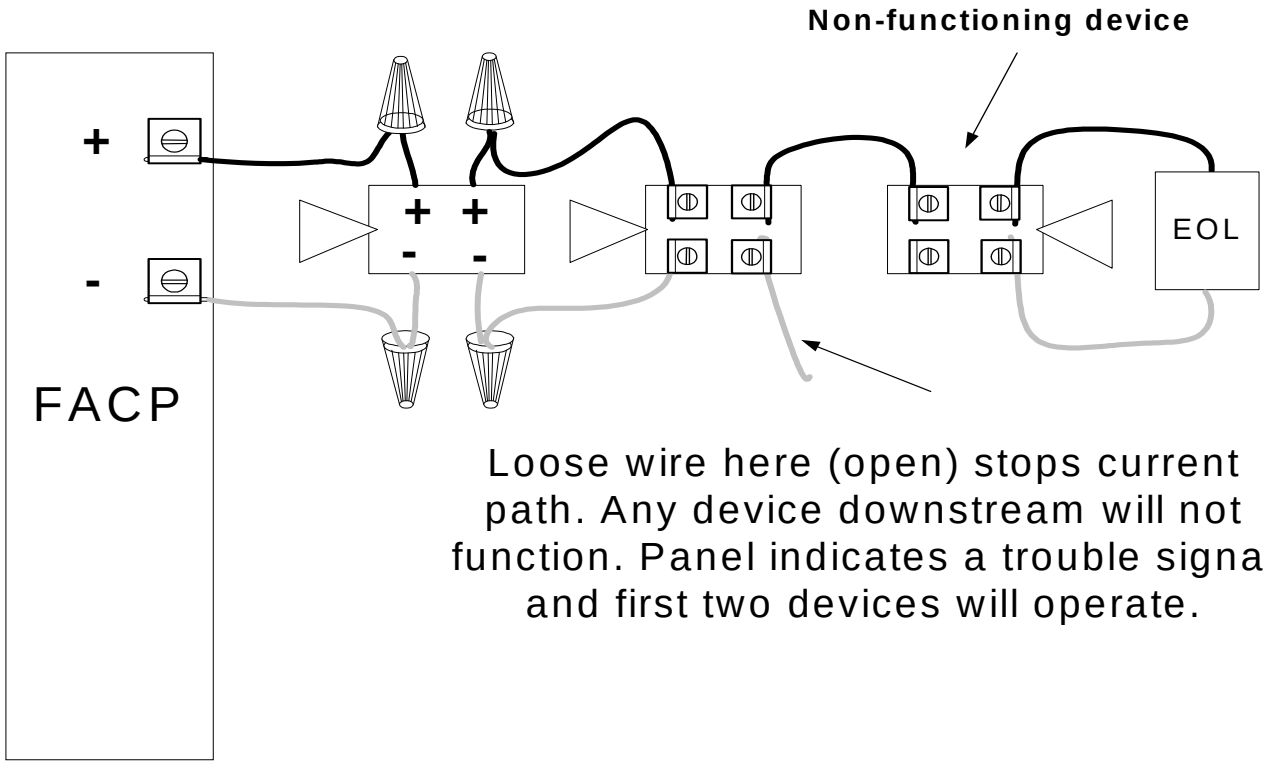
Class A Conventional, Style Z, Notification Appliance Circuit (NAC)



Style Z is the only style that allows an alarm during trouble on the circuit. The alarm occurs during an open or ground condition but not during a wire-to-wire short.

Class B circuits for alarm notification are listed as W, X or Y. Style W circuits show a trouble for an open, ground, or wire-to-wire short. There is no alarm capability on the circuit with any of these conditions. Style X shows trouble under the same conditions and has alarm capability only during an open abnormal condition. Style Y shows trouble under all three abnormal conditions but shows an alarm only during a ground with trouble on the circuit.

Class B Conventional, Style Y Notification Appliance Circuit



Loose wire here (open) stops current path. Any device downstream will not function. Panel indicates a trouble signal and first two devices will operate.

It is not as easy to improperly wire an addressable system, as it is a conventional fire alarm system circuit. The data loop over which polling signals are sent can be a shielded or non-shielded twisted pair of conductors, as required by the manufacturer. Devices may be T-tapped without negating the supervision of the circuit.

Addressable System

An addressable system does not use EOL devices. Instead, each device has an address. The fire alarm control panel sends a signal to each device address and waits for that device to reply. When no reply occurs, a trouble condition is signaled. When a short is sensed during polling, an alarm occurs. Polling appears constant but is done in very short increments of time. Normal condition occurs when the device replies to the panel with an appropriate signal.

An example of an addressable system schematic is shown below.