FIRE ALARM SYSTEM FUNDAMENTALS

In Accordance with NFPA 72

(Fire Alarm and Signaling Code)

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EQUIPMENTS

10.3 Equipment.

10.3.1 Equipment constructed and installed in conformity with this Code shall be listed for the purpose for which it is used.

What Exactly this listing means ?

What is Listing & Listing Requirements

- A Global Safety Consulting and Certification Company.
- UL in one of the several companies approved to perform safety testing by US federal agency Occupational Safety and Health Administration (OSHA)

What is Listing & Listing Requirements

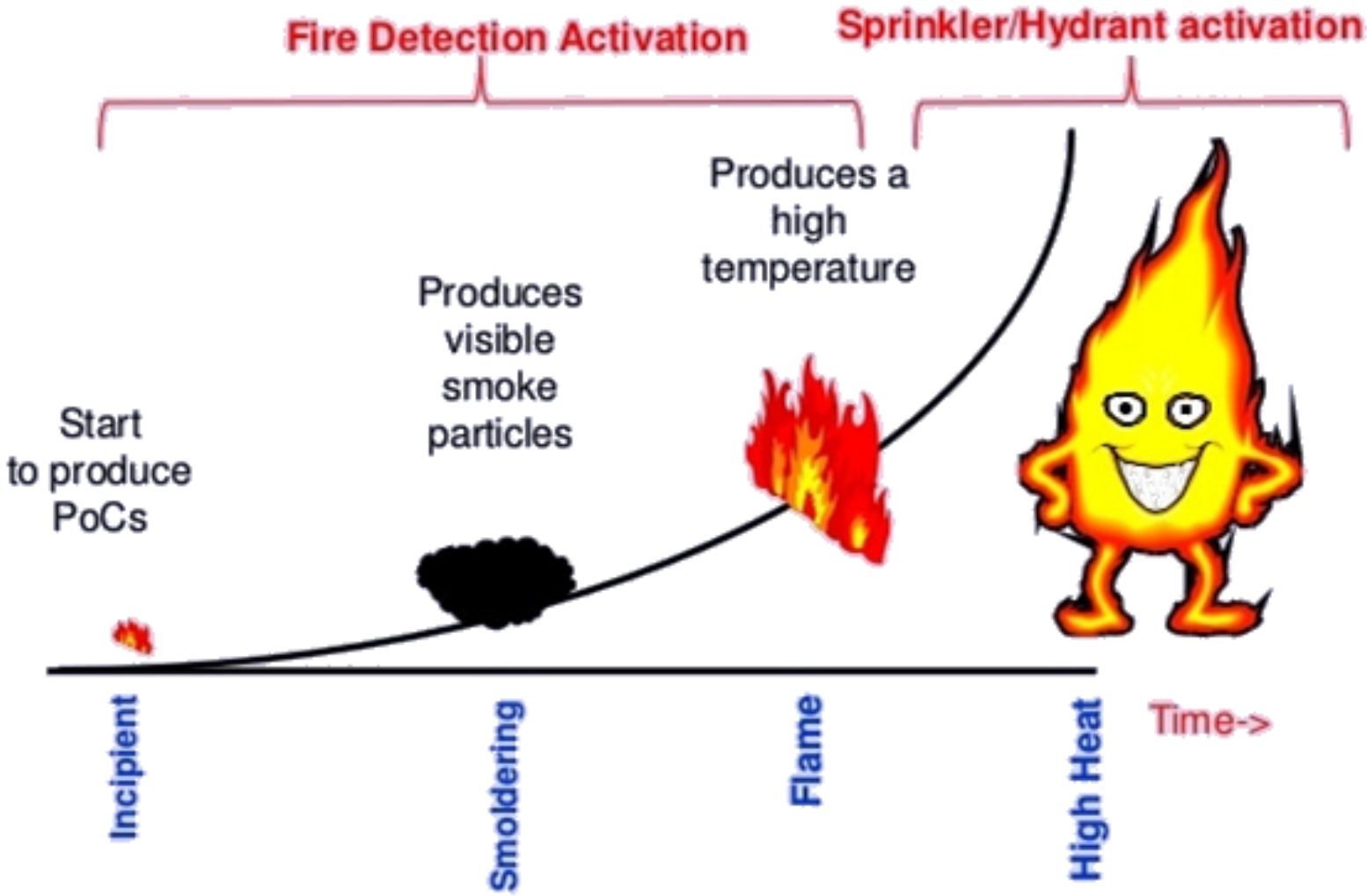
- This means that equipment must be listed for specific fire alarm system application for which it is used.
- Furthermore, equipment must be installed & used in accordance with the provisions of listing and with the manufacturer's published instructions, which are usually included as the basis of equipment listing.
- The manufacturer's instructions should be consulted as a starting point for any listing issues that may arise.
- The listing agency and associated product listing directories published by the listing agency are the additional sources to be consulted.

Role of FM Global

FM Global accepts equipment, Materials & services for approvals testing based upon two general principles :

1. They must be useful to the end of property conservation by preventing, limiting, or not causing damage under the conditions of the approval.
2. They must be readily identifiable and available in the market place.

Concept of Fire Detection

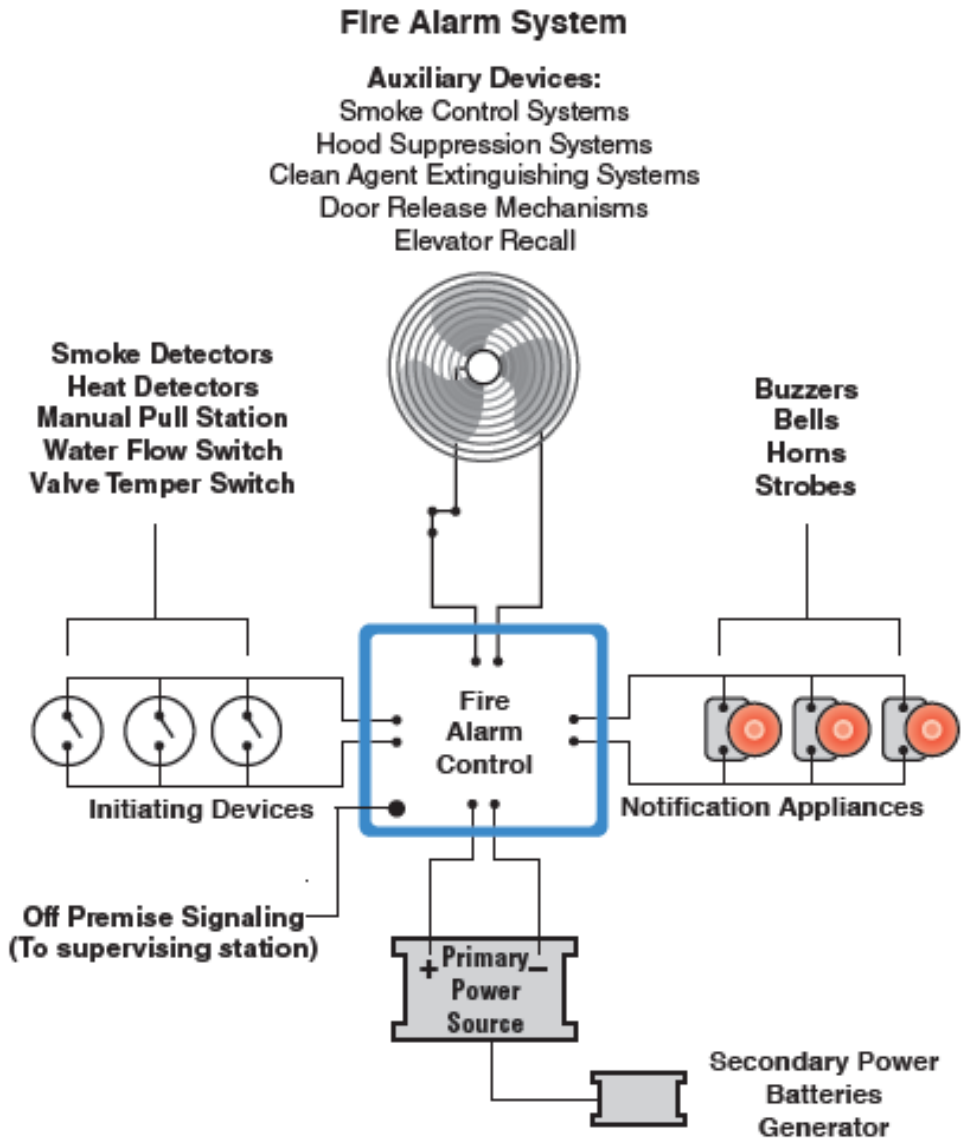


Components of Fire Alarm System

Detection → **Control** → **Notification**

FIRE ALARM CONTROL PANELS

Fire Alarm Control Panel (FACP)



Controls for the system are located in the FACU The FACU can also perform other functions, such as:

- Providing two-way firefighter communication
- Providing remote annunciator integration
- Controlling elevators, HVAC, fire doors, dampers, locks, or other fire protection features

Fire Alarm Control Unit

- One of the most important parts of any fire alarm system is the **fire alarm control unit**, or as it is more frequently called, the fire alarm control panel, which is often described as the "brain" of the system.
- Over the past 45 or so years, fire alarm control panel technology has evolved from simple, single zone, relay-type units that ring one or more bells to logic circuit-type multiple zone units that provide additional system information and capabilities to sophisticated microprocessor-based software-driven panels that interface and control other building and life safety systems

Earlier Generation FACPs

Used **Conventional Technology** to link to manual fire alarm boxes and bells to provide *coded or non-coded* alarm signals for evacuation

Used two-wire circuits to establish initiating device and notification appliance zones

Depending on the arrangement of the wiring and devices, a break in a wire could render any device beyond the break inoperative.

Later Generation FACP

Conventional technology panels featured modular equipment with smaller electronic components, logic or relay circuits, two- and four-wire circuits to support initiating devices and notification appliances, and expanded performance and system monitoring capabilities

The four-wire systems provided a higher level of reliability because the setup typically allowed for two wires to power the device and two to initiate the alarm, whereas in most other wiring configurations, a break in the wire or a device failure would disable other devices from operating.

Is replacement possible with new generation Panels ?

The good news is that when a conventional panel requires replacing, in some instances, many of the new-generation panels can be installed with existing two- and four wire systems that utilize interface modules and software to communicate with the field devices so entire systems do not have to be replaced.

Latest Generation FACP

Utilize state-of-the-art electronics, microprocessors, and intelligent software that provide specific information concerning device identification and alarm location and type.

It is commonly referred to as **addressable technology**, **intelligent technology**, or **multiplex technology**

Addressable/intelligent technology is very versatile, able to support all sizes of fire alarm systems, and extremely valuable to first responders, inspectors, building engineers, and service technicians because information concerning the specific initiating device—such as the exact location of the device and, in some instances, the associated problem—is immediately available

INITIATING DEVICES

Initiating Devices

- An **initiating device** interfaces with the fire alarm control panel to provide manual or automatic means of activating fire alarm and supervisory signals. Manual activation requires a person to operate the initiating device. Automatic activation occurs when the products of combustion or an event associated with a fire automatically activates the initiating device.
- There are a number of different operating principles for automatic activation, including thermal sensitivity, aspirating, detection of products of combustion or radiant energy, movement of water, changes in air pressure, and signals from automatic extinguishing systems.

Manual Initiating Devices

- The **manual fire alarm box** is the only type of manual alarm initiating device; it is known by a number of different names, including *manual box*, *manual pull box*, and *manual pull station*.
- It is critical that these devices are accessible, unobstructed, visible, and consistently located so building occupants and visitors are able to recognize and use them.

Manual Initiating Devices

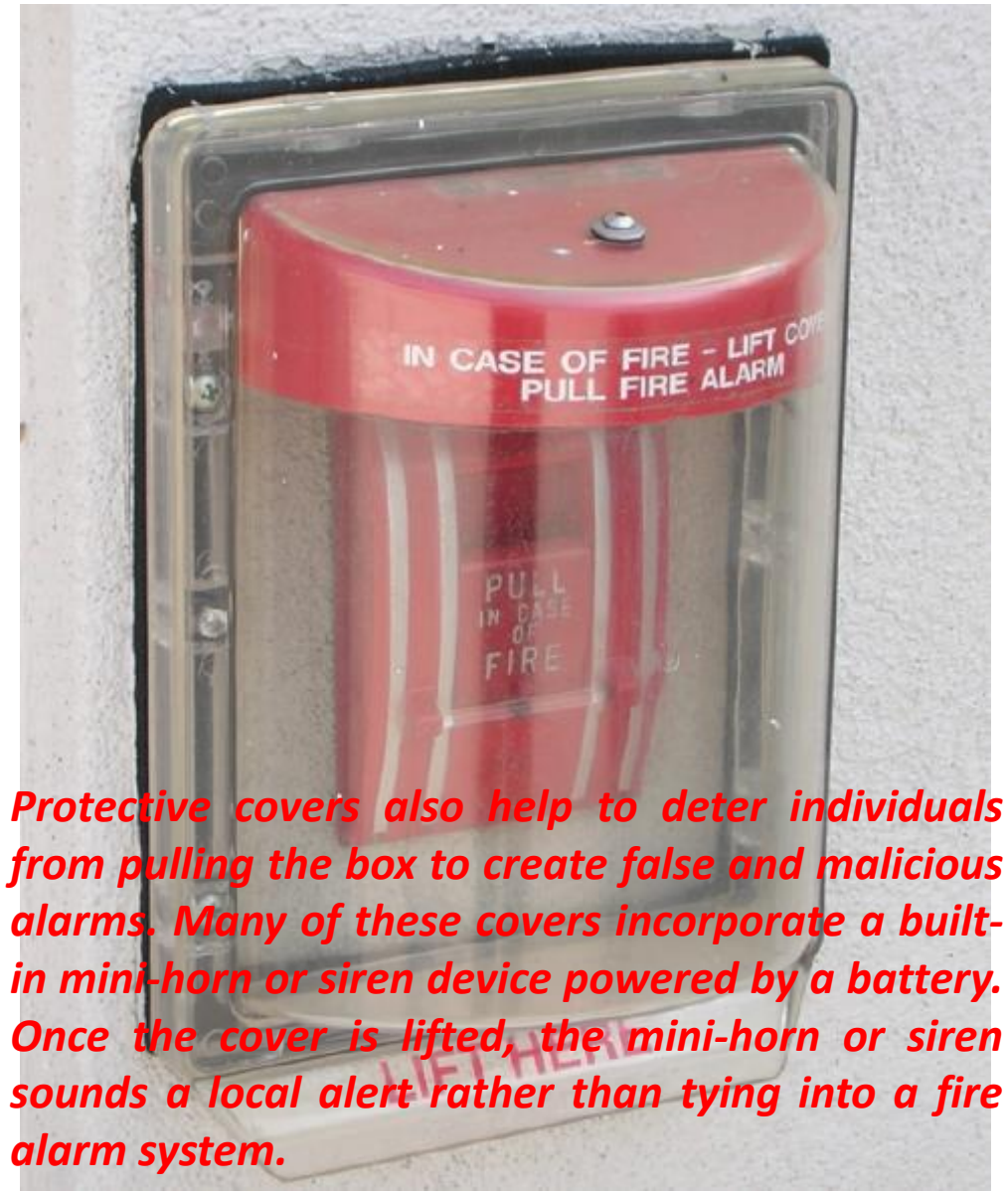
- The purpose is to provide a manual means of activating the fire alarm system at the first sign of a fire. Still, activation of a manual fire alarm box does not guarantee a fire department response, as the fire alarm systems in many older buildings are not monitored by an on- or offsite entity that would call the fire department.
- Therefore, in many buildings, there are cards, placards, or signs mounted above the manual fire alarm box providing instruction to notify the fire department after safely exiting the building.

Manual Initiating Devices – Installation requirements

- To provide for easy reach when exiting a building, NFPA 72® requires manual fire alarm boxes to be located within 5 ft of an exit, mounted between 42 and 48 in. above the floor, located on each side of an exit opening greater than 40 ft wide, and located within every 200 ft of travel distance measured horizontally on the same floor.
- If the travel distance exceeds 200 ft, additional boxes are required. In addition, manual fire alarm boxes should be colored red unless the environment precludes the use of the color

Manual Initiating Devices – Installation requirements

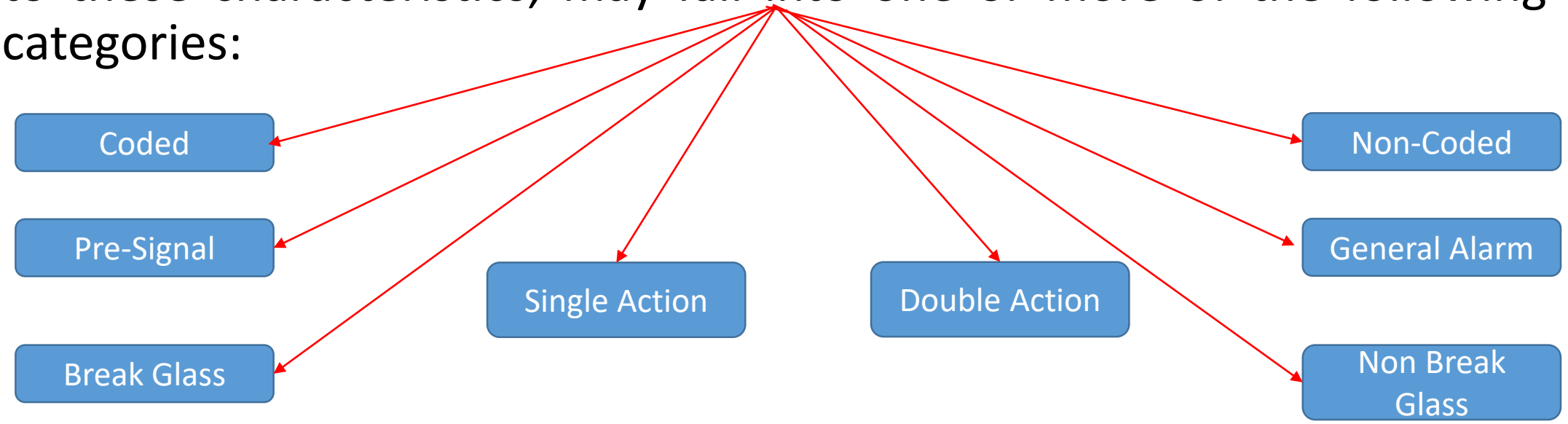
- In locations where manual fire alarm boxes are subjected to moist, damp, or wet environmental conditions, they must be listed or approved for the conditions as well as appropriately protected to avoid problems with corrosion, rust, electrical shorting, and grounding.
- For these reasons, it is common to see some type of protective cover over these devices



Protective covers also help to deter individuals from pulling the box to create false and malicious alarms. Many of these covers incorporate a built-in mini-horn or siren device powered by a battery. Once the cover is lifted, the mini-horn or siren sounds a local alert rather than tying into a fire alarm system.

How to Operate MCP ?

- All manual fire alarm boxes operate on the same basic principle: you must pull a lever on the box to initiate an alarm. However, some boxes may have additional operational characteristics and, according to these characteristics, may fall into one or more of the following categories:

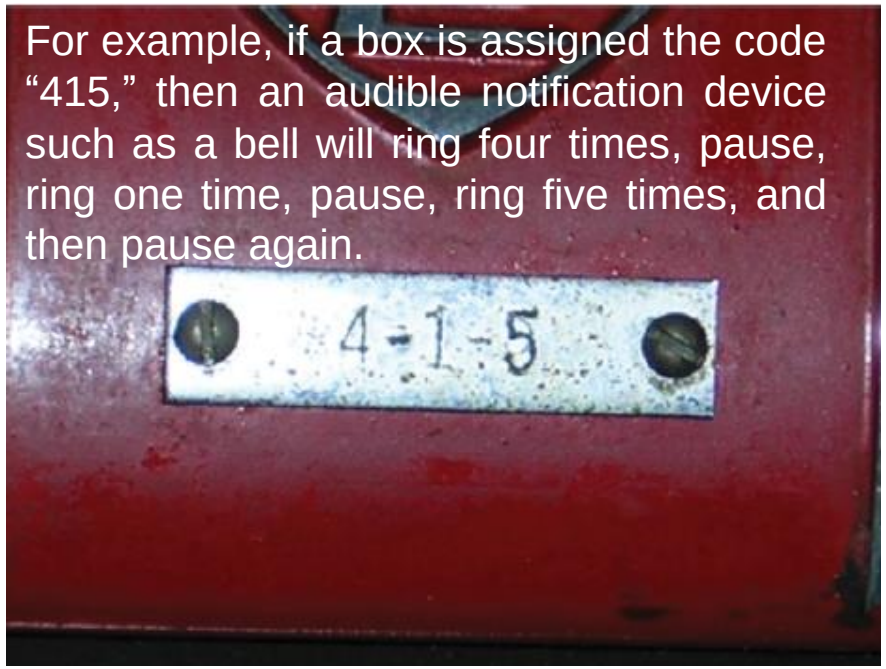


Non- Coded MCP

When activated, this type of box simply initiates an alarm until it is reset.

Coded MCP

This type of box is assigned a code that sounds from an audible notification device when a mechanical or electrical driven motor turns a wheel. A person can determine which box is operating by counting the code that is sounding.



Once the code is recognized, a person can look at the annunciator or compare the number to a code list to determine the location of the box. In addition, the system might record the event by punching the code onto a paper tape recorder, allowing responders or building personnel to verify the code or review the alarm information later

Other Types of MCPs

Other Types of MCPs

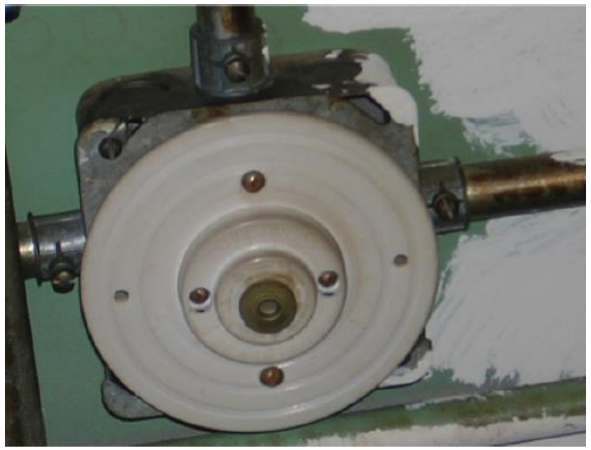
Automatic Initiating Devices

Heat Detectors

Fixed Temperature

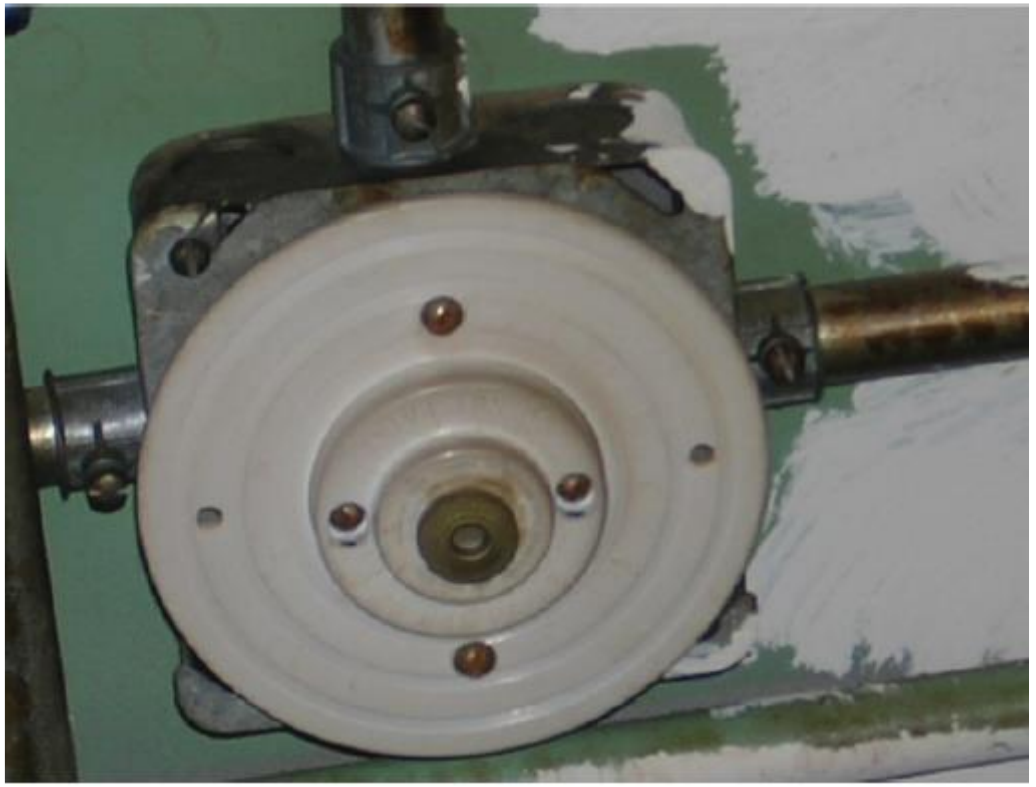
Rate of Rise

Rate compensation



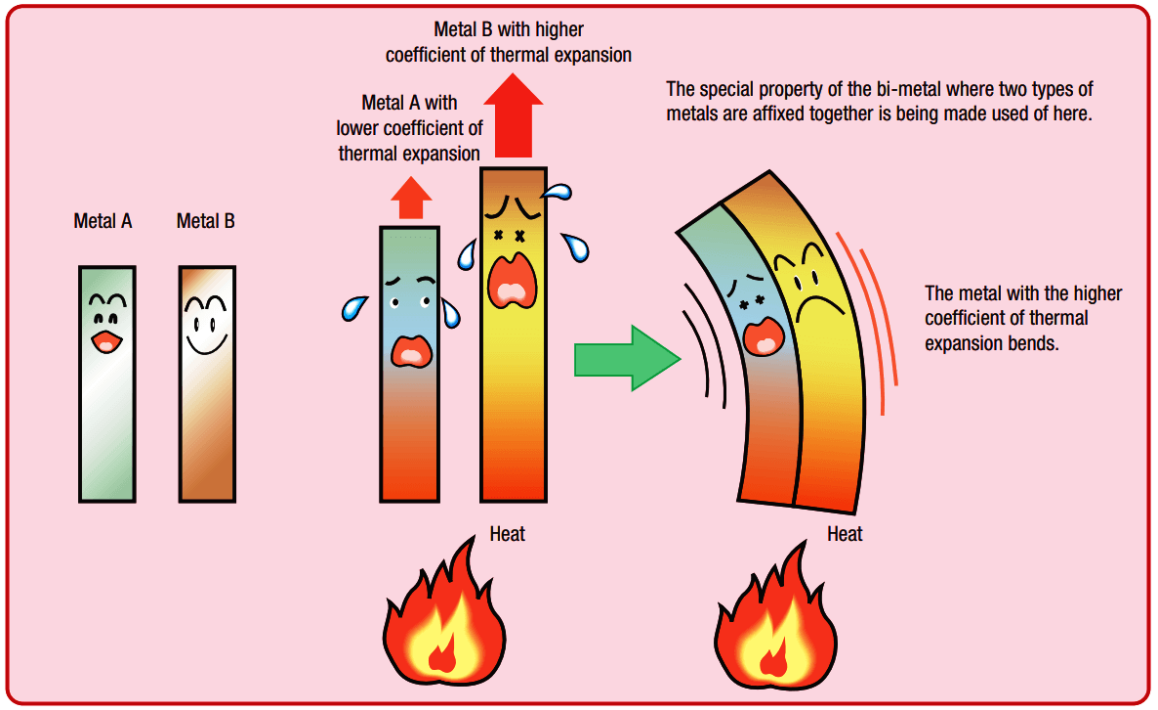
Fixed Temperature

- A **fixed-temperature heat detector** operates when a sensing element within the detector reaches a predetermined temperature. Some fixed-temperature heat detectors use a fusible link sensing element that melts when the predetermined temperature is met, therefore requiring the detector or the detection element to be replaced after activation.



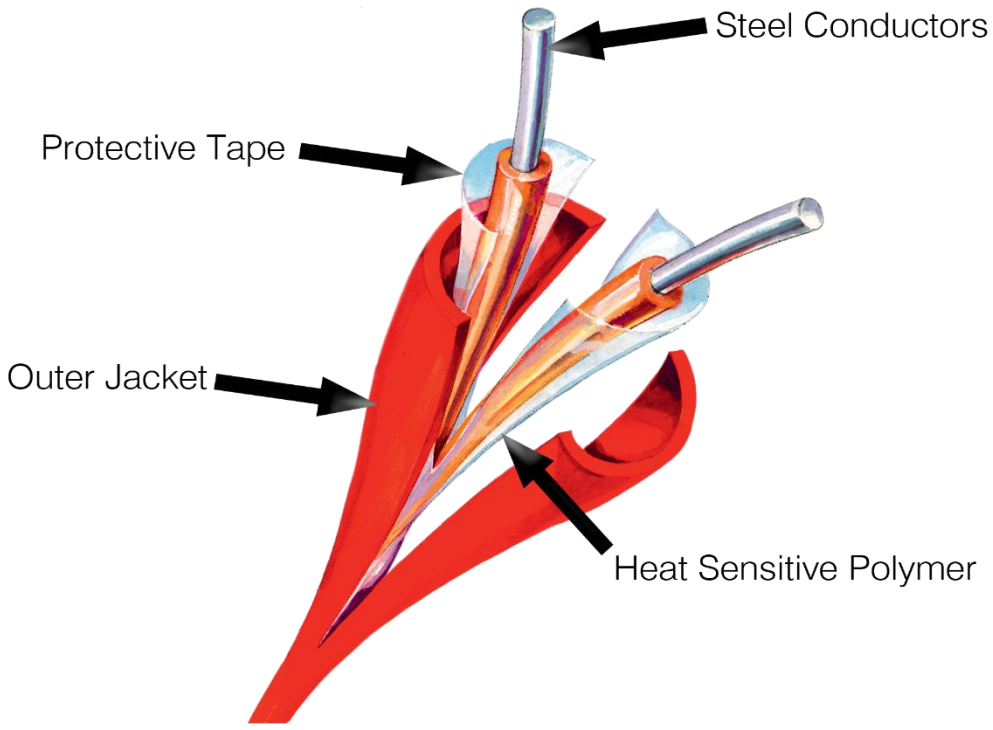
Fixed Temperature

- Other fixed-temperature heat detectors use bimetal sensing elements, which include different bonded metals that expand at different rates and, when exposed to increasing temperatures, cause the contacts to close, sending a signal to the fire alarm panel. Once the temperature returns to a normal level, the bimetal sensing element returns to its normal shape and, if not damaged by fire, is ready for future service.



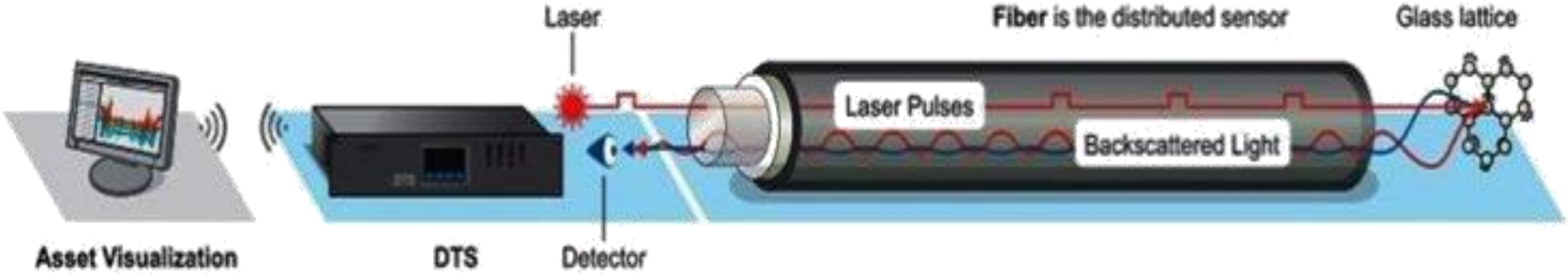
Line Type Heat detector(LTHD)

- Line type heat detectors are frequently installed in challenging locations and environments because the detector, in the form of a cable, can be laid to conform to the physical conditions. Some line-type detectors are restorable but others may need to be replaced or at least have the part exposed to the fire replaced.
- There are different kinds of line-type heat detectors, but they all basically consist of sensing elements (e.g., conductors in a special cable) surrounded by materials that change condition when exposed to heat, causing the elements to make contact or become conductive.



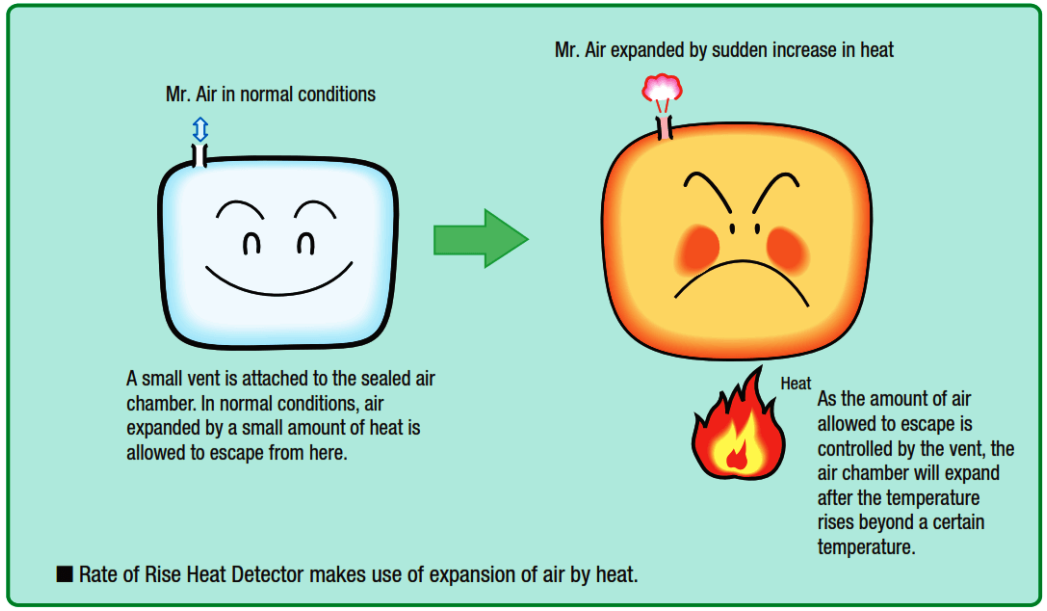
Line Type Heat detector(LTHD)

- Newer technology uses fiber-optic cable that sends a light source through the cable. When there are changes in the light source parameters due to the temperature change, the cable distorts, causing an alarm.



Rate of Rise

- A **rate-of-rise detector** is a heat detector that uses pneumatic or electronic methods to monitor how much temperature change takes place over a fixed amount of time.
- When the temperature rises at a rate exceeding the fixed amount either 5°F in 20 seconds or between 12°F and 15°F per minute, regardless of the starting temperature—a signal transmits to the fire alarm control panel.
- The pneumatic rate-of-rise detectors can be linear or spot-type detectors, both of which use rubber diaphragms to initiate an alarm. Changes in temperature are detected when heat expands the air in a tube that exerts pressure on the diaphragm (line type) or when the air in the diaphragm is heated (spot type)



Rate of Rise

- Once the diaphragm is heated, it enlarges to close electrical contacts connected to the fire alarm system. The electronic rate-of-rise detectors detect temperature change through the use of a semiconductor component (thermistor) that responds to increased temperature by increasing electrical resistance.
- Rate-of-rise detectors typically detect temperature changes more rapidly than fixed-temperature detectors and, therefore, may not be appropriate in locations where normal ambient conditions dictate rates of temperature change that could cause false alarms. In addition, although rate-of-rise detectors are usually restorable after a fire, they may need some time to cool down before they can be reset.

Rate Compensation

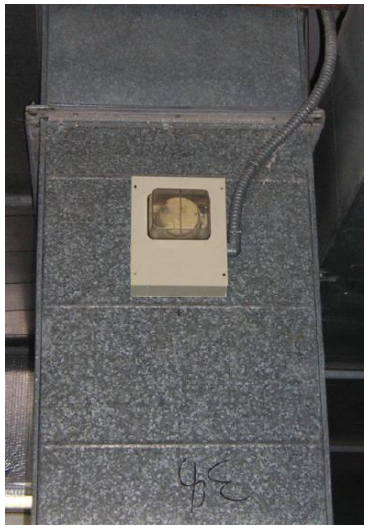
- **Rate-Compensation Heat Detectors.** The **rate compensation detector** is a type of heat detector that responds to predetermined air temperatures and is not dependent on rates of temperature change. Rate-compensation detectors are typically tubular and use a two-element sensing system.
- To compensate for slow or fast temperature changes, the sensing elements are manufactured with metals that are designed to expand at different rates. During a slow rate of temperature rise, there is more time needed to heat the inner sensing element, thus giving the entire detector, including the outer sensing element, time to reach the rated temperature before an alarm is sounded

Rate Compensation

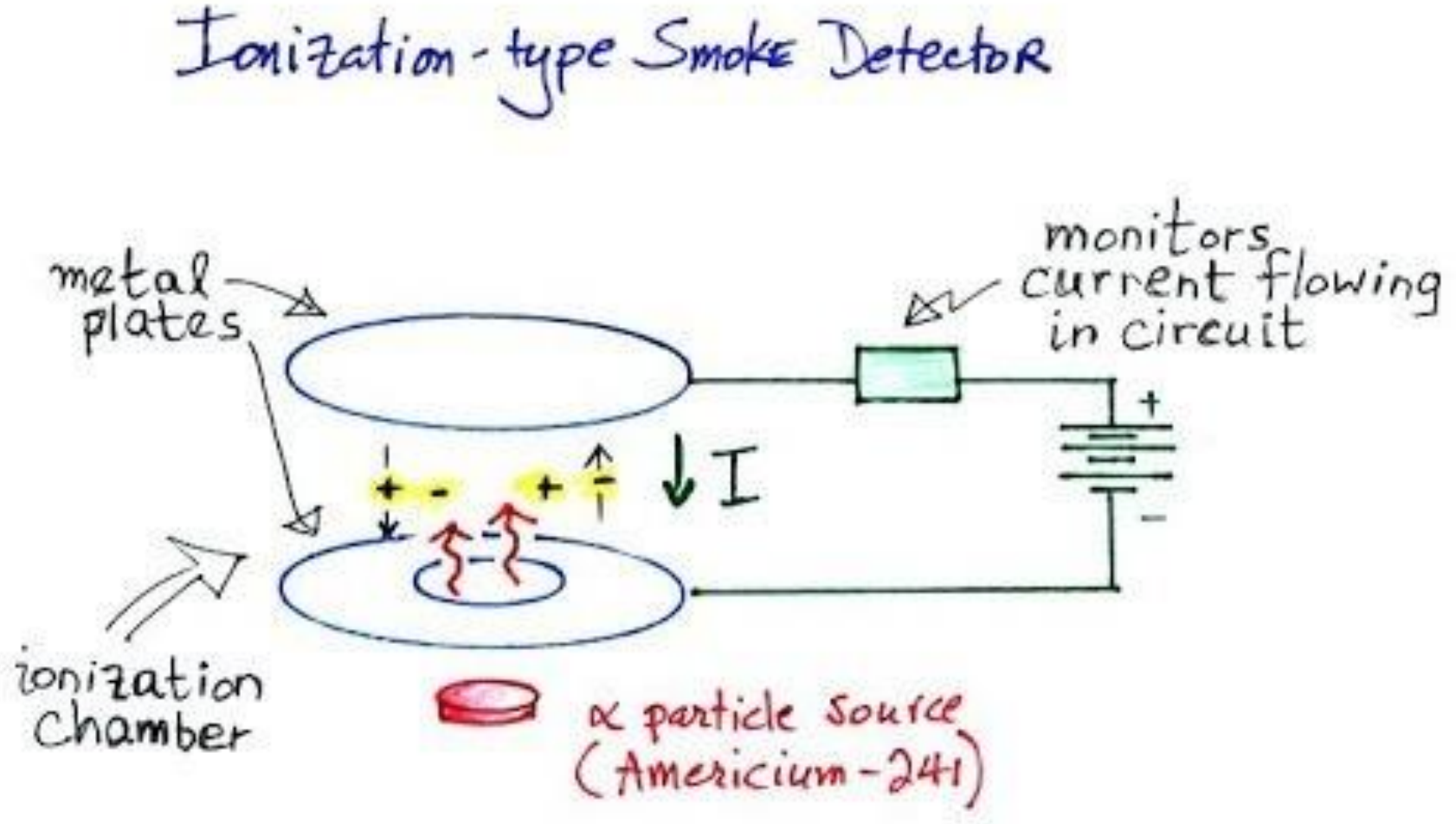
- During a fast rate of temperature rise, it takes much less time for the outer sensing element to heat than it does the inner sensing element, resulting in the entire device activating an alarm at a lower temperature.
- This method of operation compensates for thermal lag conditions associated with the fixed-temperature detectors. In addition, these types of detectors are restorable.

Automatic Initiating Devices

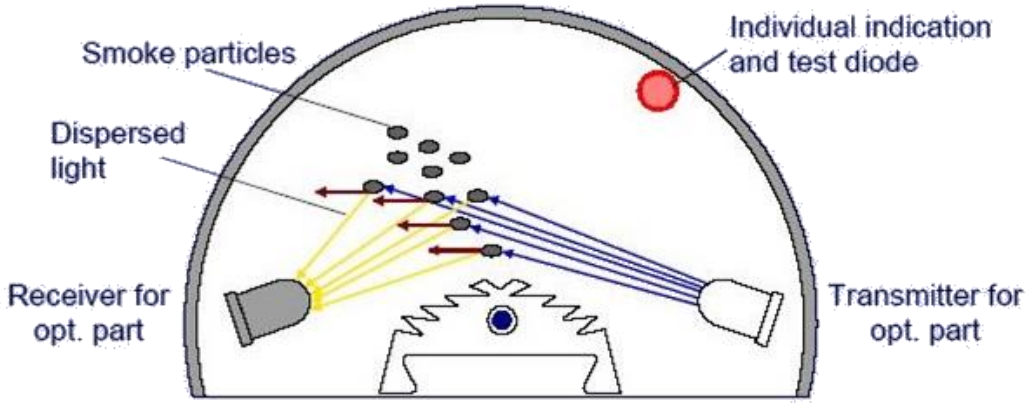
- Smoke Detectors
  - Ionization
  - Photoelectric
    - Light Scattering
    - Light Obscuration
  - Air Sampling
  - Duct
  - Video



Ionization


Ionization-type Smoke Detector
metal plates
monitors current flowing in circuit
+
-
I
ionization Chamber
α particle source (Americium-241)

Photoelectric – Light Obscuration



Cl. 17.7.3.7 – Projected Beam Detectors

HOW IT WORKS…?

Cl. 17.7.3.7 – Projected Beam Detectors

- Beam detectors work on the following principles:
  - Beam detector consists of sender and receiver
    - The sender and receiver be mounted firmly to avoid movement of the projected beam and possible unwanted alarms
    - The projected beam remain unobstructed by storage, ceiling-mounted equipment, or other objects that would result in a trouble condition on the FACU and prohibit the detectors from sensing smoke.

Cl. 17.7.3.7 – Projected Beam Detectors

- Smoke obscures the projected beam and reduces transmission of the infrared beam to the receiver
- Beam detectors are for indoor use, and are to be mounted to stable surfaces
- Mirrors can be used with projected beams, per manufacturer's instructions, provided that mirrors are mounted to stable surfaces

Cl. 17.7.3.7 – Projected Beam Detectors

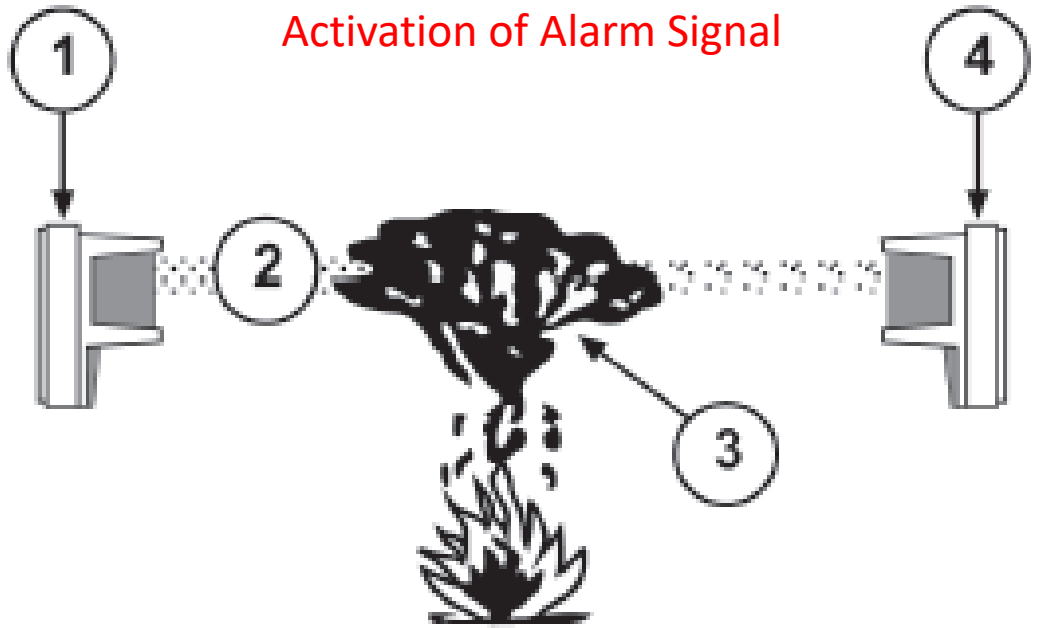


Figure 2.2: Beam Obscuration

1	Transmitter	3	Obscuring matter
2	Beam	4	Receiver

Cl. 17.7.3.7 – Projected Beam Detectors

- As smoke obscures the beam, the receiver senses a decrease in the signal strength and measures that decrease. The receiver compares the signal level with two preset thresholds:

– an alarm threshold that is set using the sensitivity switch and

– a trouble threshold that is preset at approximately 10%

- If the signal falls below the alarm threshold for the programmed alarm period, the receiver signals an alarm.

Cl. 17.7.3.7 – Projected Beam Detectors

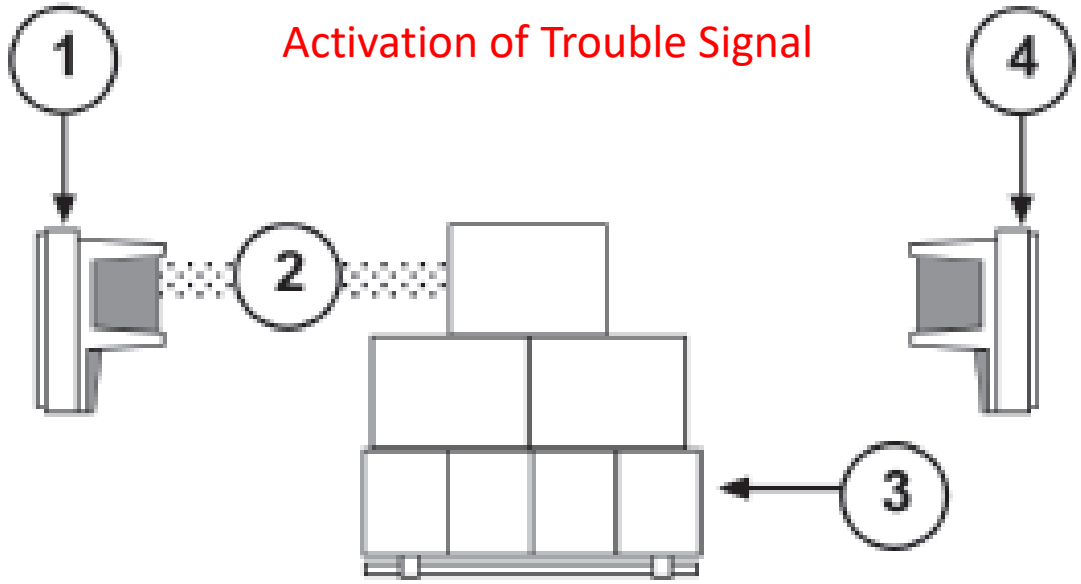


Figure 2.3: Beam Blockage

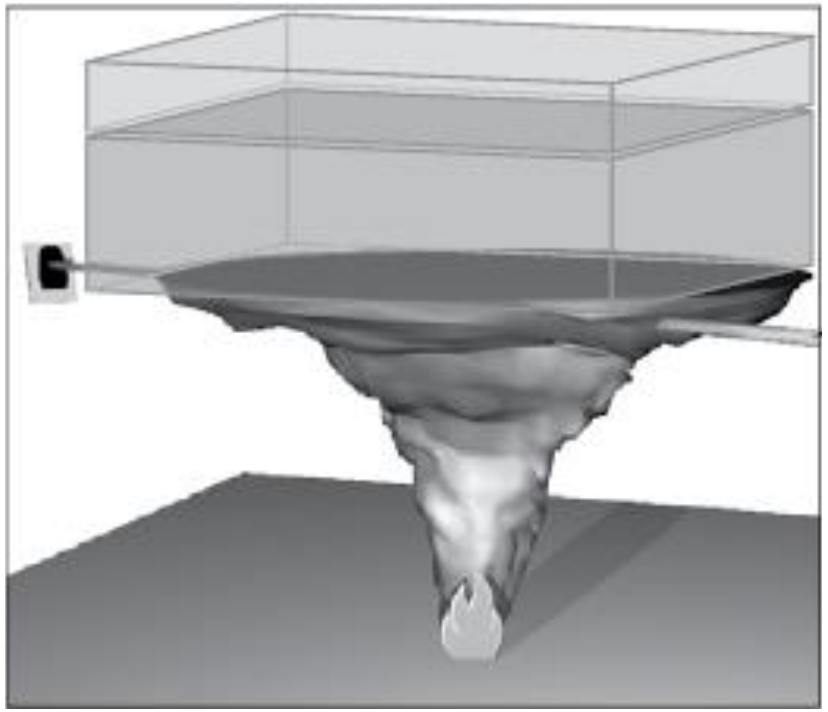
1	Transmitter	3	Blocking object
2	Beam	4	Receiver

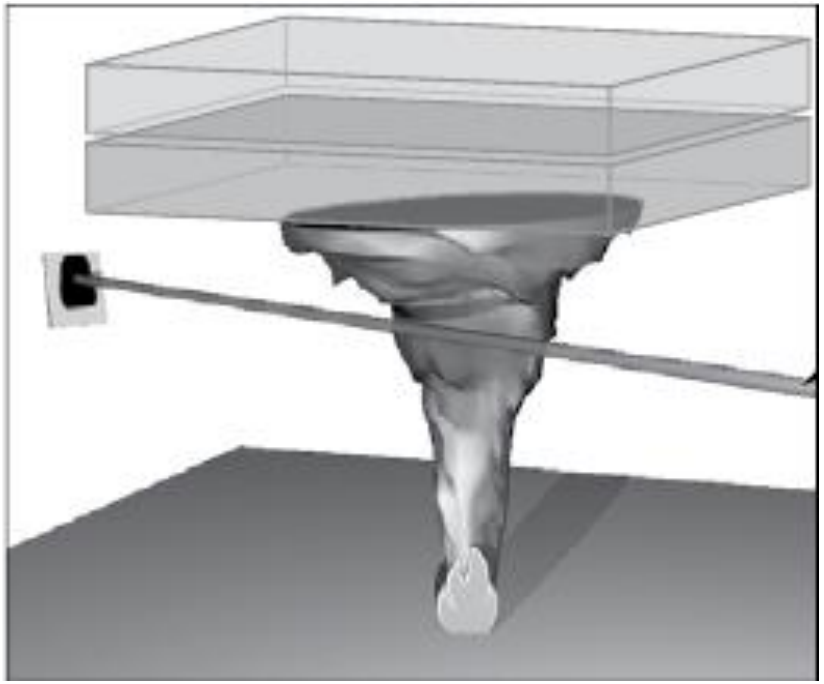
Cl. 17.7.3.7 – Projected Beam Detectors

- Where the light path of a projected beam–type detector is abruptly interrupted or obscured, the unit should not initiate an alarm. It should give a trouble signal after verification of blockage.
- *If an object blocks the beam, the signal falls below the trouble threshold. If this condition lasts for more than 20 seconds, the receiver signals a trouble condition.*

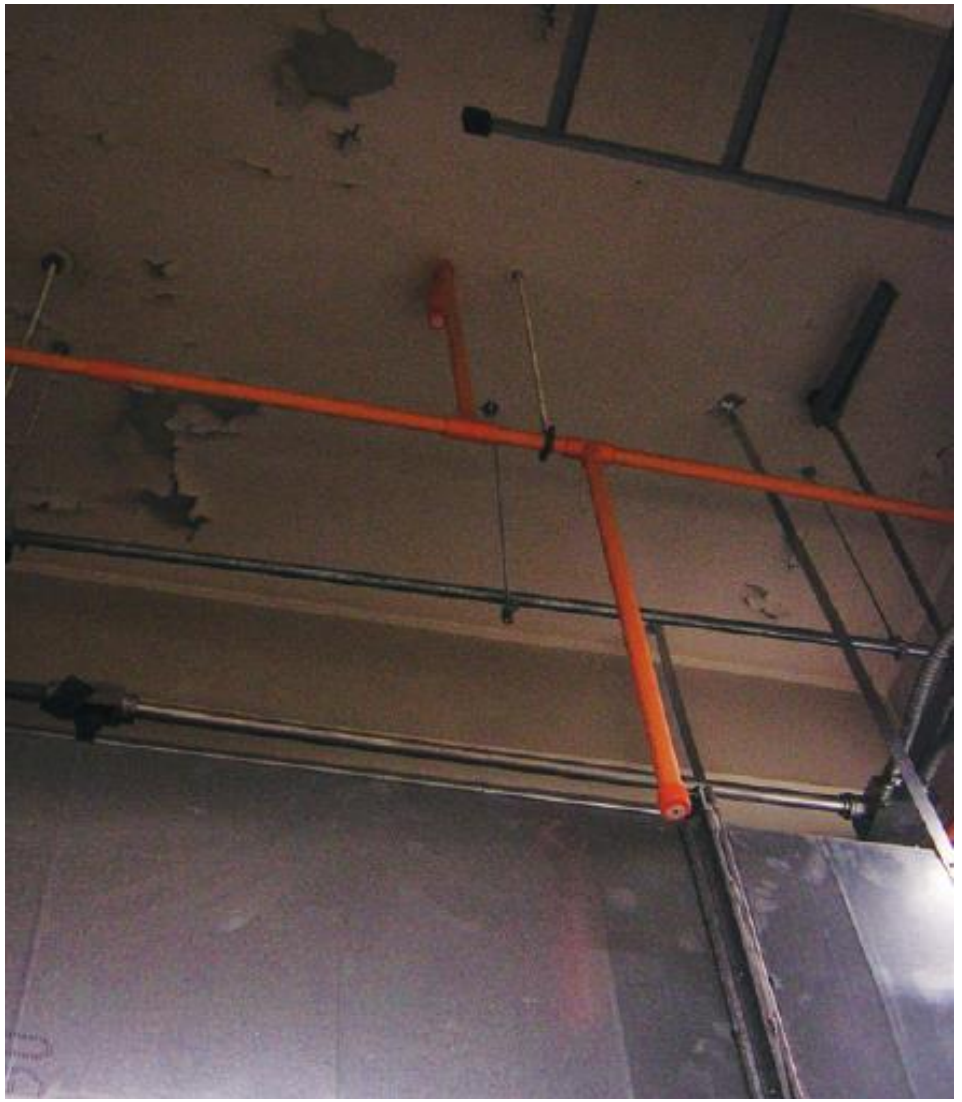
Installation of Beam Type Detectors SMOOTH CEILING

The effects of stratification shall be evaluated when locating the detectors.





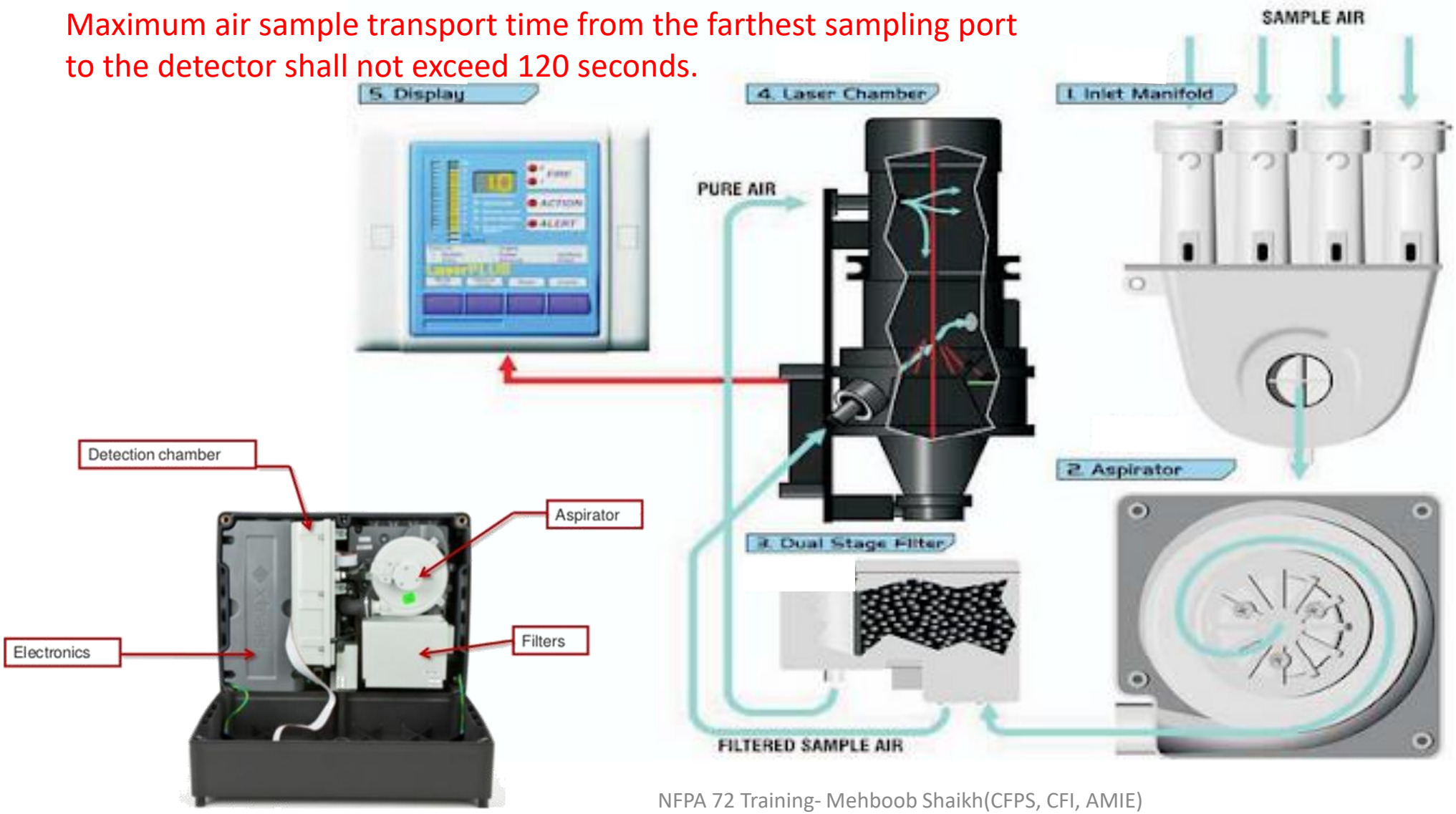
Air Sampling



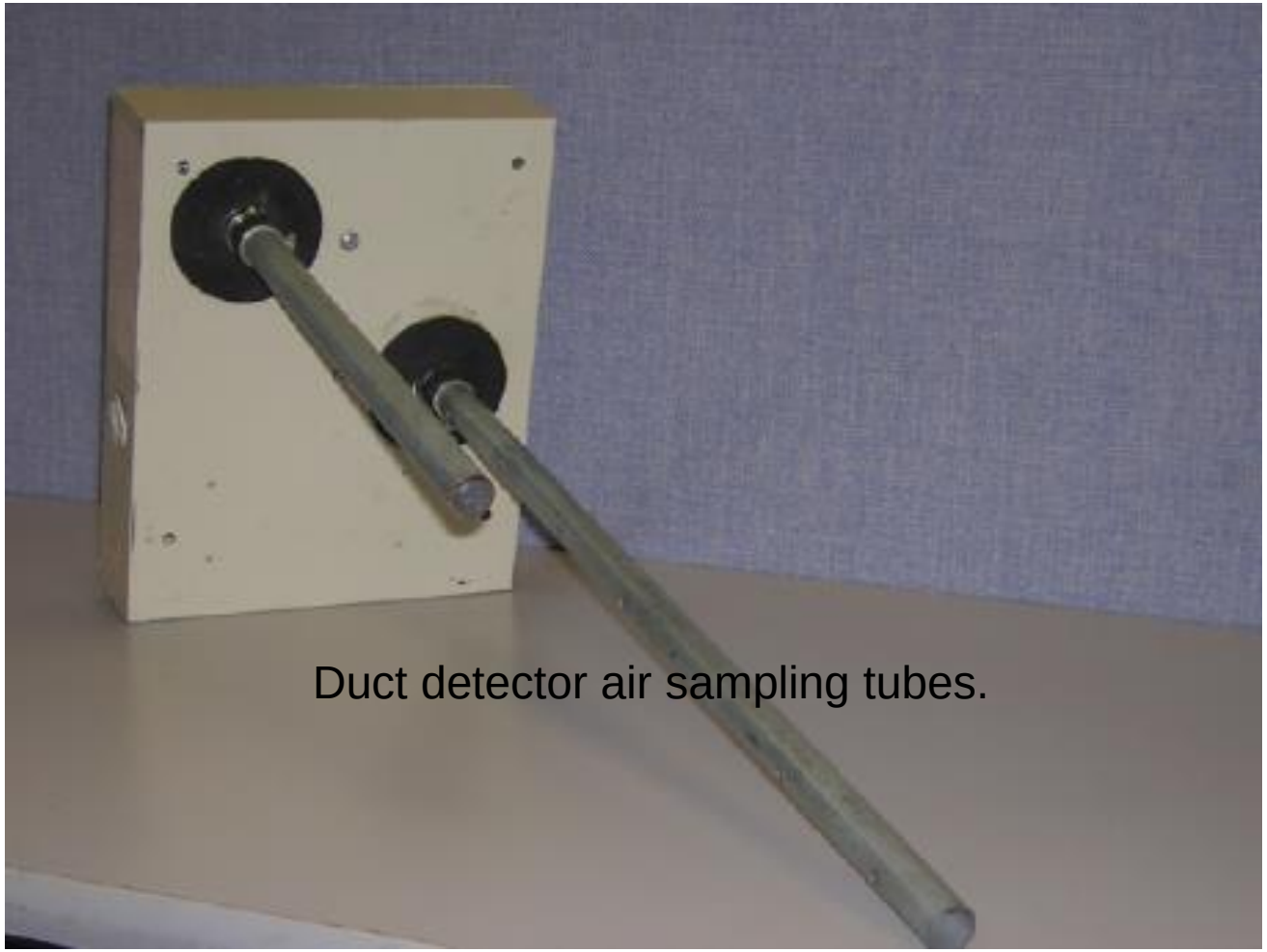
Cl. 17.7.3.6 – Air Sampling Type Smoke Detector - VESDA

Cl. 17.7.3.6 – Air Sampling Type Smoke Detector - VESDA

Maximum air sample transport time from the farthest sampling port to the detector shall not exceed 120 seconds.



Duct



Duct detector air sampling tubes.

Video

Analyzes the digital images and senses changes in pixels before there are enough smoke particles for visual detection, making detection many times faster than would be possible with a standard detector.

Radiant Energy Fire Detectors

Gas Sensing Detectors

Signal Processing/Alarm Verification

In an effort to reduce false alarms, most modern fire alarm systems and smoke detectors have the capability to implement a protocol that validates the smoke condition before a fire alarm signal sounds.

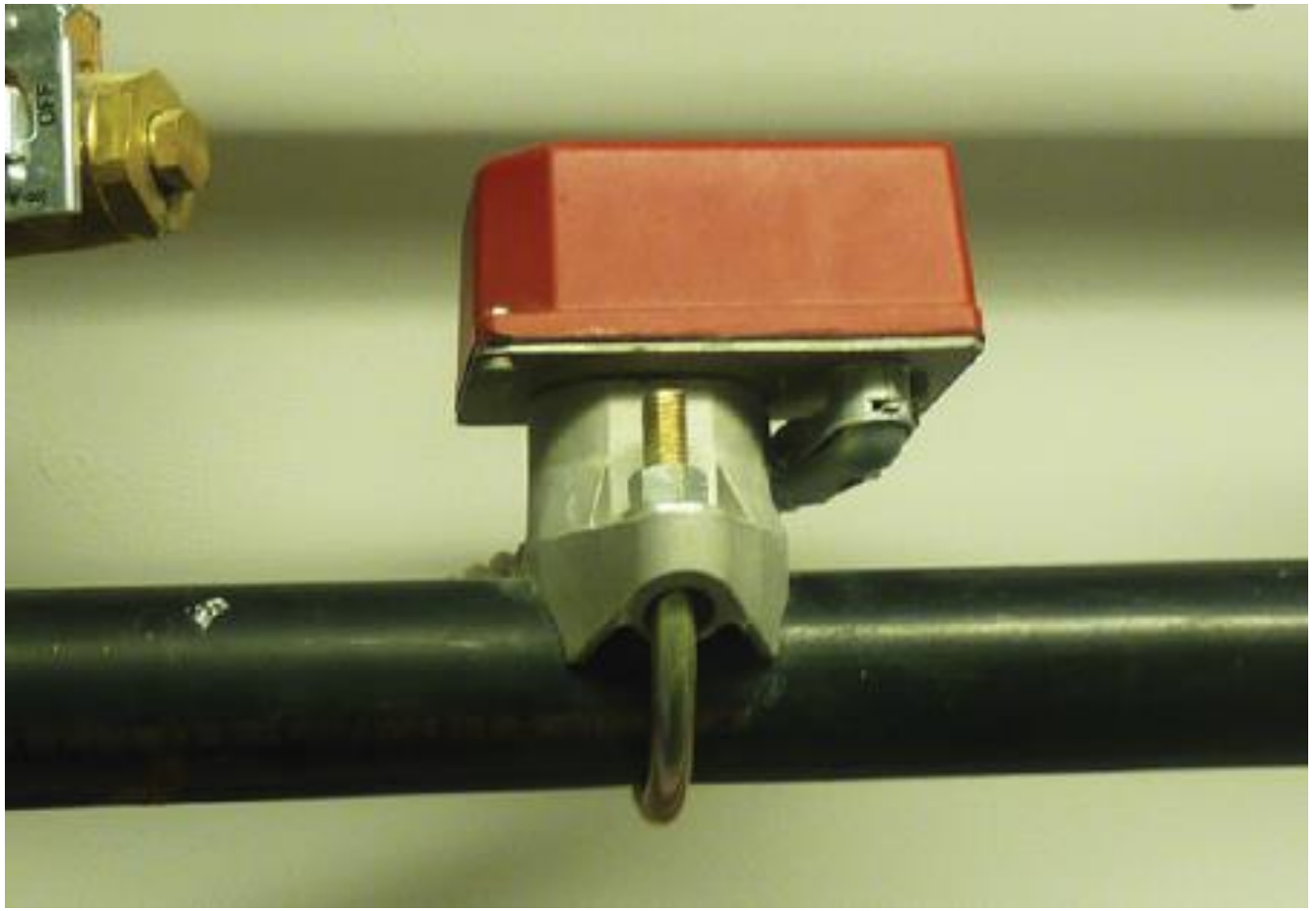
Signal Processing

Checks the smoke within the detector at specified intervals to ensure it continues to remain above a threshold amount. If the smoke remains above the threshold amount for the required time, alarm initiation takes place.

Alarm Verification

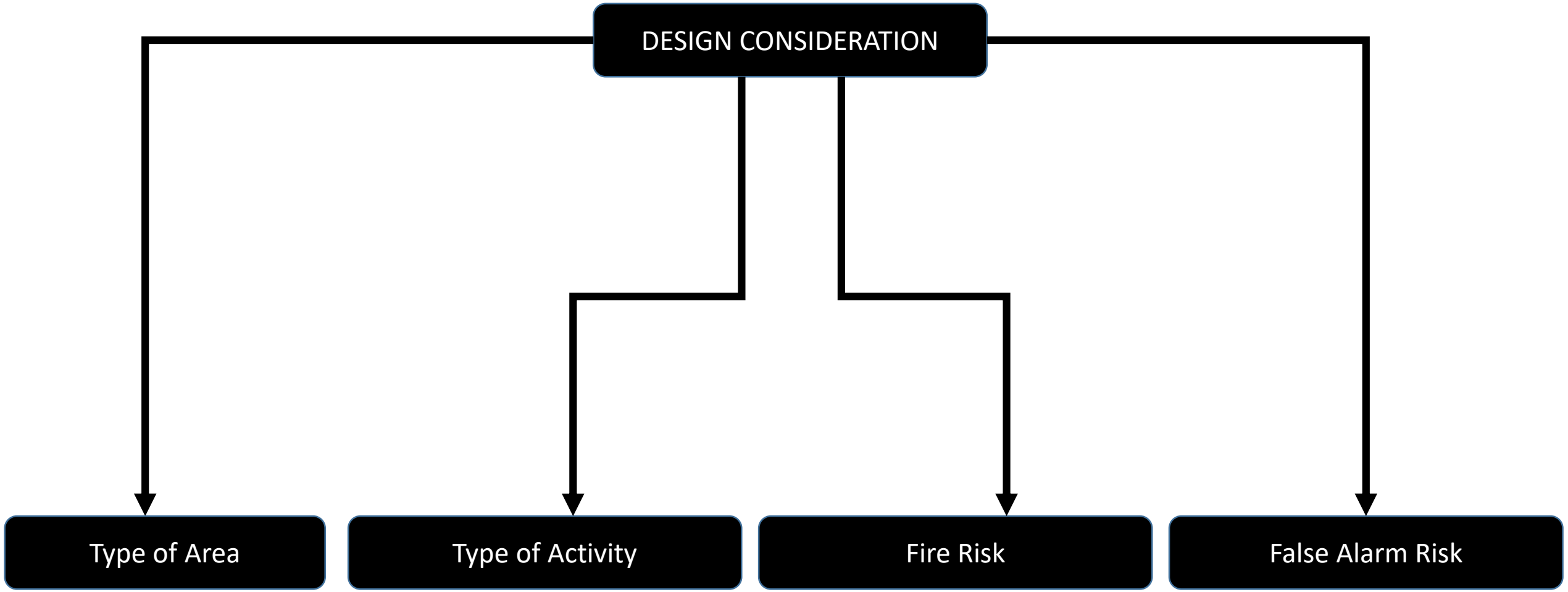
fire alarm panel receives a signal from the smoke detector and, in turn, either cuts the power to the detector or, in newer systems, ignores the alarm signal for no longer than 1 minute to allow the condition to clear. If after this verification period the smoke condition remains, the detector sends a signal back to the panel to alarm.

Water Flow initiating Devices



Alarm Pressure Switch Initiating Devices

Detectors Selection Criteria



Protected area/ type of area	Predominant use of area	Fire risk(s)	False alarm risk(s)	Detector type	Detector setting	Certified mode(s) chosen?	Fire strategy met?	Comments/ action
Choose from: Hotel bedroom en-suite Hotel bedroom non en-suite Hotel suite Bedroom dormitory style Office cellular Office open plan Kitchen (main) Kitchenette Restaurant/ Canteen Corridor Escape route Reception area Lobby Workshop (clean) Workshop (moderate) Workshop (dirty) Warehouse/ storage Other: please specify	**Choose from:** Sleeping Cooking Unoccupied Storage nonflammable Storage flammable General office work Meetings Circulation route Escape route Manufacturing Manufacturing (hot works) Assembly Other: please specify	**Choose from:** Smoldering white smoke Smoldering dark smoke Smoldering changing to flaming Flaming (clean burn) Flaming (dirty) Other: please Specify	**Choose from:** None Steam Toaster Oven usage Cooking Dust Smoking Aerosol spray Hot works Other: please specify	**Choose from:** Optical Heat (static) Heat (RoR) Ionisation Multisensor: Optical/heat Heat/CO Optical/CO Optical/heat/ CO Other: please specify Optical beam Linear heat ASD Class C ASD Class B ASD Class A Flame Video CO Other: please specify	Specify	Specify	Specify	Details as appropriate

NOTIFICATION APPLIANCES

Operating Modes

There are two operating modes for alarm notification appliances:

(1) public operating mode and

(2) private operating mode

TABLE A.18.4.1.2
Permissible Noise Exposures

Duration (hr)	L_A *(dBA)*
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25	115
0.125 (7.5 minutes)	120

Source: OSHA, 29 CFR 1910.5, Table G-16, Occupational Noise Exposure.

Fire Alarm Audibility Design Goals

Occupancy Description	Minimum Sound Level
Public Mode – Audible or visible signaling is provided as evacuation notification to occupants or inhabitants of the area protected by the fire alarm system. *Examples: Business, educational, residential, sleeping areas, industrial and storage occupancies.*	At least **15 dB above** the average ambient or normal sound level or **5 dB above** the maximum sound level that lasts at least 1 minute.
Private Mode – Trained individuals are present 24 hours a day to take additional action when there is an emergency. *Examples: Hospital patient care areas, operating rooms or critical care areas. In situations like these, sound levels must adequately notify the occupants to evacuate, but not too loud as to startle them.* *Note; Energency signaling may not be required to meet ADA requirements or UL 1638*	At least **10 dB above** the average ambient or normal sound level or **5 db above** the maximum sound level that lasts at least 1 minute. *In either cases, if the area is used for sleeping, the minimum SPL required is 75 dBA*

What is Average Ambient sound Level ?

It is over

“Time that any person is present, or a 24-hour period, whichever time period is the lesser.”

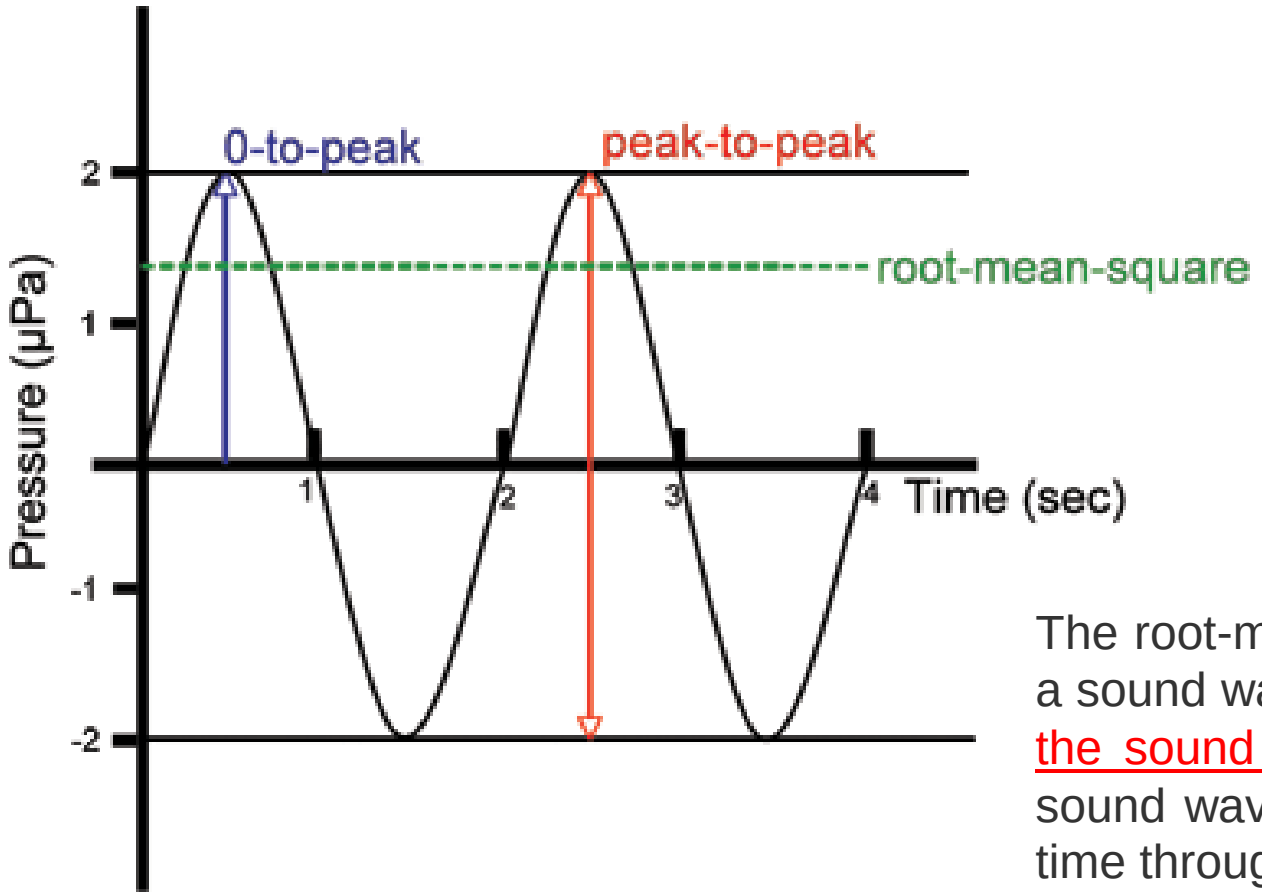
What is Max sound Level ?

Is it peak sound level …..?

NO !!

In acoustics, It is the maximum RMS value that lasts at least 60 seconds

Why RMS value and Not Peak ?

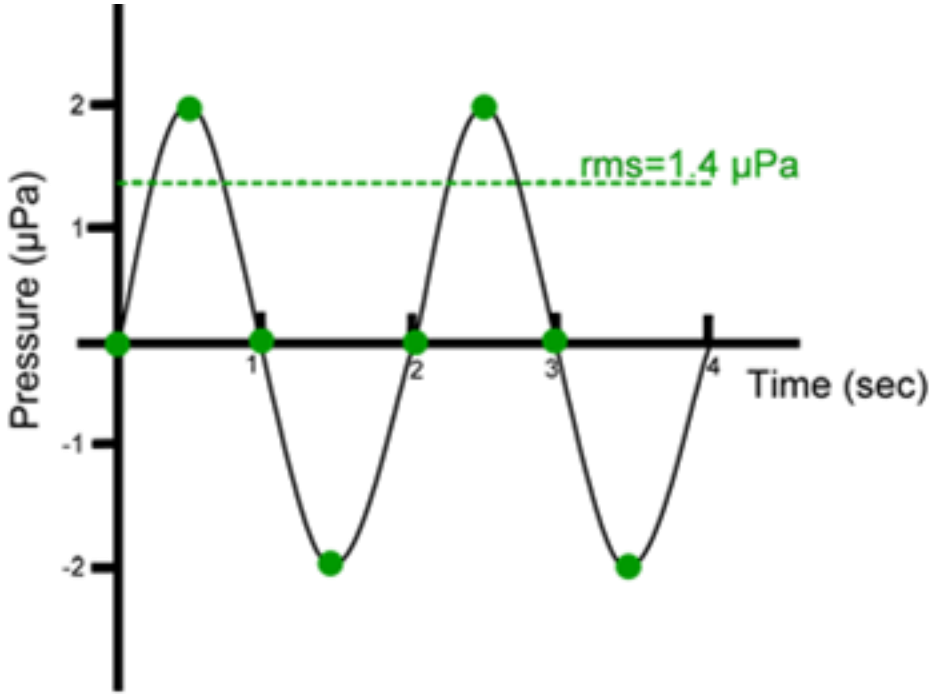


$$I = \left(\frac{p^2}{\rho c}\right)_{average}$$

$$mean\ square\ pressure = (p^2)_{average}$$

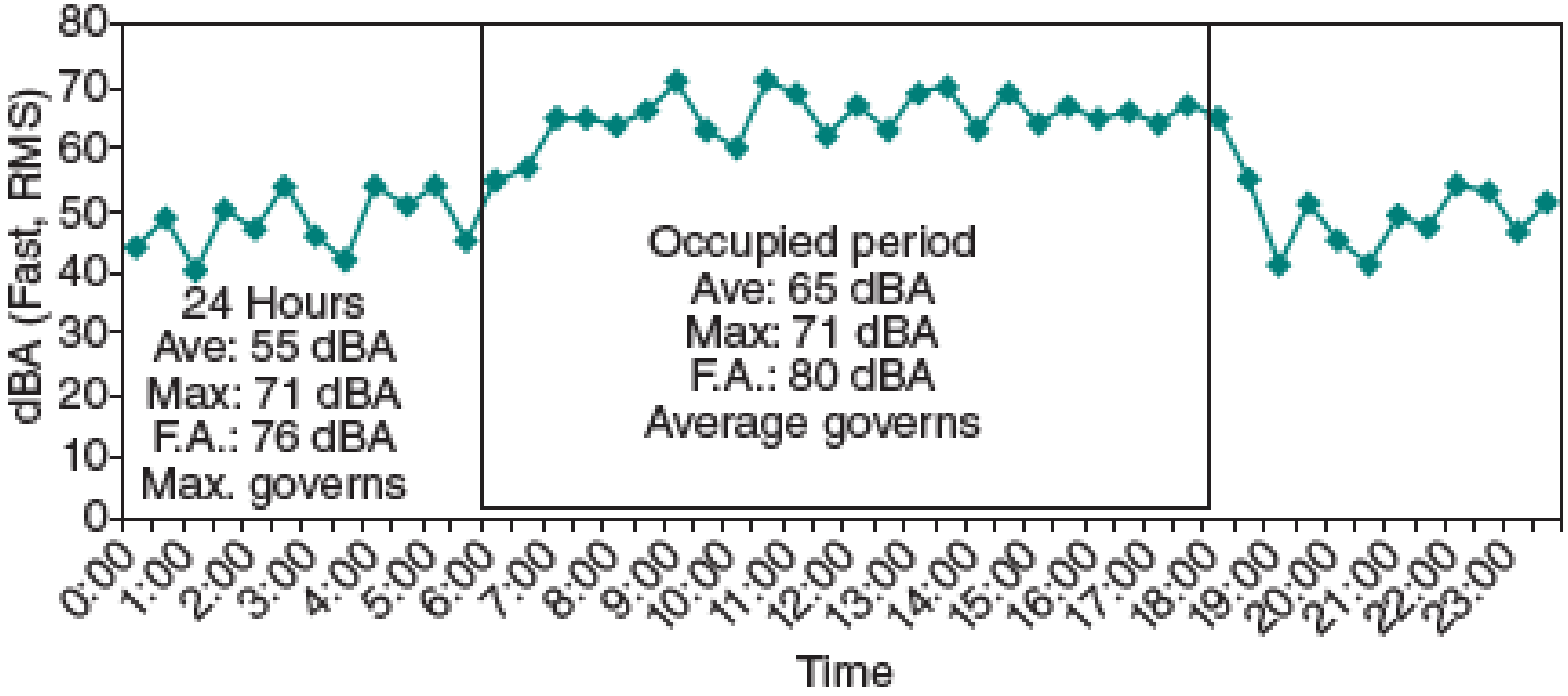
The root-mean-square pressure is most often used to characterize a sound wave because it is directly related to the energy carried by the sound wave, which is called the intensity. The intensity of a sound wave is the average amount of energy transmitted per unit time through a unit area in a specified direction

Measurement of RMS Value



Steps for calculating rms pressure	Sample calculation
1. Measure the pressure at points along the sound signal.	0, 2, 0, -2, 0, 2, 0, -2
2. Square the measured pressures.	0, 4, 0, 4, 0, 4, 0, 4
3. Average the squared pressures	(0+4+0+4+0+4+0+4)/8 = 2
4. Take the square root of the average of the squared pressures	√2 = 1.4

EXAMPLE


dBA (Fast, RMS)
80
70
60
50
40
30
20
10
0
24 Hours
Ave: 55 dBA
Max: 71 dBA
F.A.: 76 dBA
Max. governs
Occupied period
Ave: 65 dBA
Max: 71 dBA
F.A.: 80 dBA
Average governs
0:00
1:00
2:00
3:00
4:00
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21:00
22:00
23:00
Time

Annunciator Panels

When fire fighters arrive on a fire scene, the first arriving units typically respond to the main entrance or address side of the building to investigate and initiate operational activities. Upon entry into the building, fire fighters are likely to immediately look for a piece of fire alarm system equipment known as the **annunciator** panel.

The annunciator panel is a type of notification or indicating device that provides valuable information concerning the initiating device, system involved, and area of the building where the fire is located.

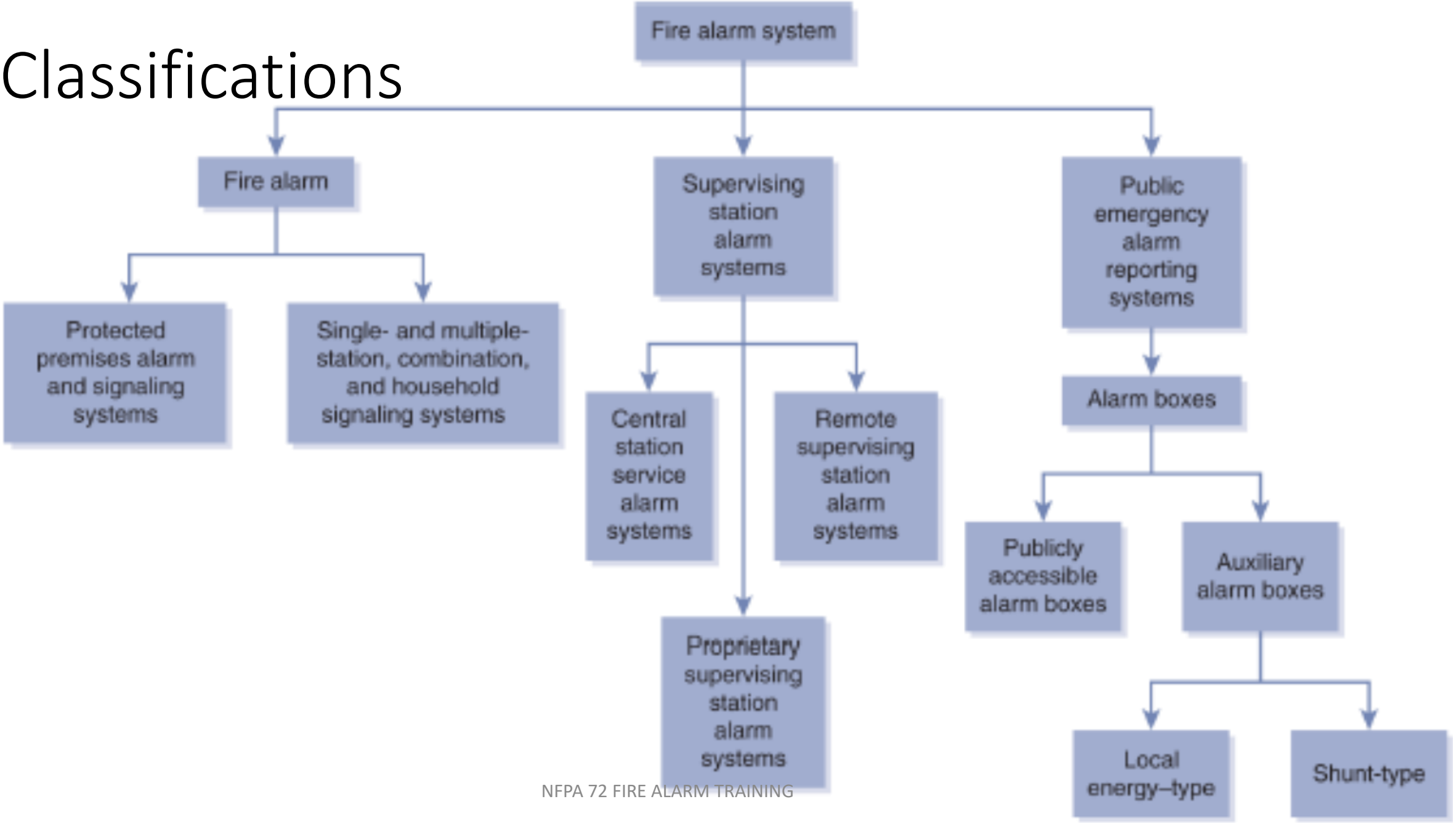
Power Expander Panels

- When building renovation leads to fire alarm system changes, fire system designers often discover existing fire alarm control panels do not have the power capacity to support all of the additional required audible and visual notification devices. Modern-day notification appliances use considerable electrical current to operate, so it is not always practical or cost-effective to place all of the power and circuits in the fire alarm control panel.

- In addition, if the original fire alarm system remains, additional power to support expansion or power distribution to devices may become a design issue owing to the requirements to comply with or improve accessibility features, or the need to pursue an alternative design approach because of space, location, and access limitations or considerations. These issues can be resolved with the installation of a power expander panel that provides supplemental power to support the devices. These panels are also called notification appliance circuit panels, NAC panels, or NAC power supplies.

FIRE ALARM SYSTMS

Classifications

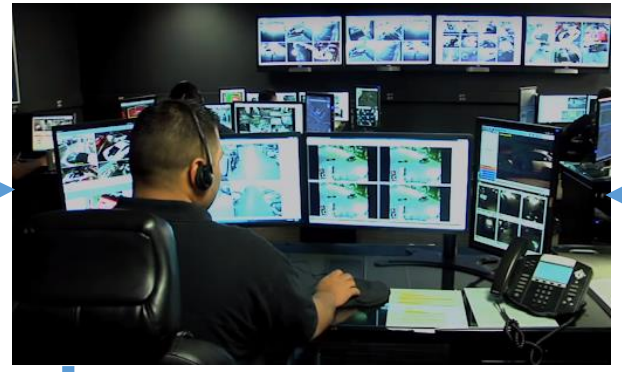


Single- and Multiple-Station, Combination, and Household Signaling Systems

Central Station Service Alarm Systems

Communication with Central Monitoring System(CMS) in Fire Alarm

NFPA 72 2013,26.6.3.2



IP Communications

Radio System

From Telephone Company

Digital Alarm Communicator Transmitter (DACT)

(located at Fire Alarm System site)

DACT

Transmitter

Communication Pathways

Must be PSTN

Primary

Secondary

The "off-hook" back to "on-hook" time cannot exceed 90 seconds per attempt!

Receiver

DACR

Gets a dial tone

1

2

3

Dials DACR phone number

Releases phone line

Ring Signal

Tip Signal

In non Alarm Condition

In Alarm Condition

4 5 3 6 2 7 1 8

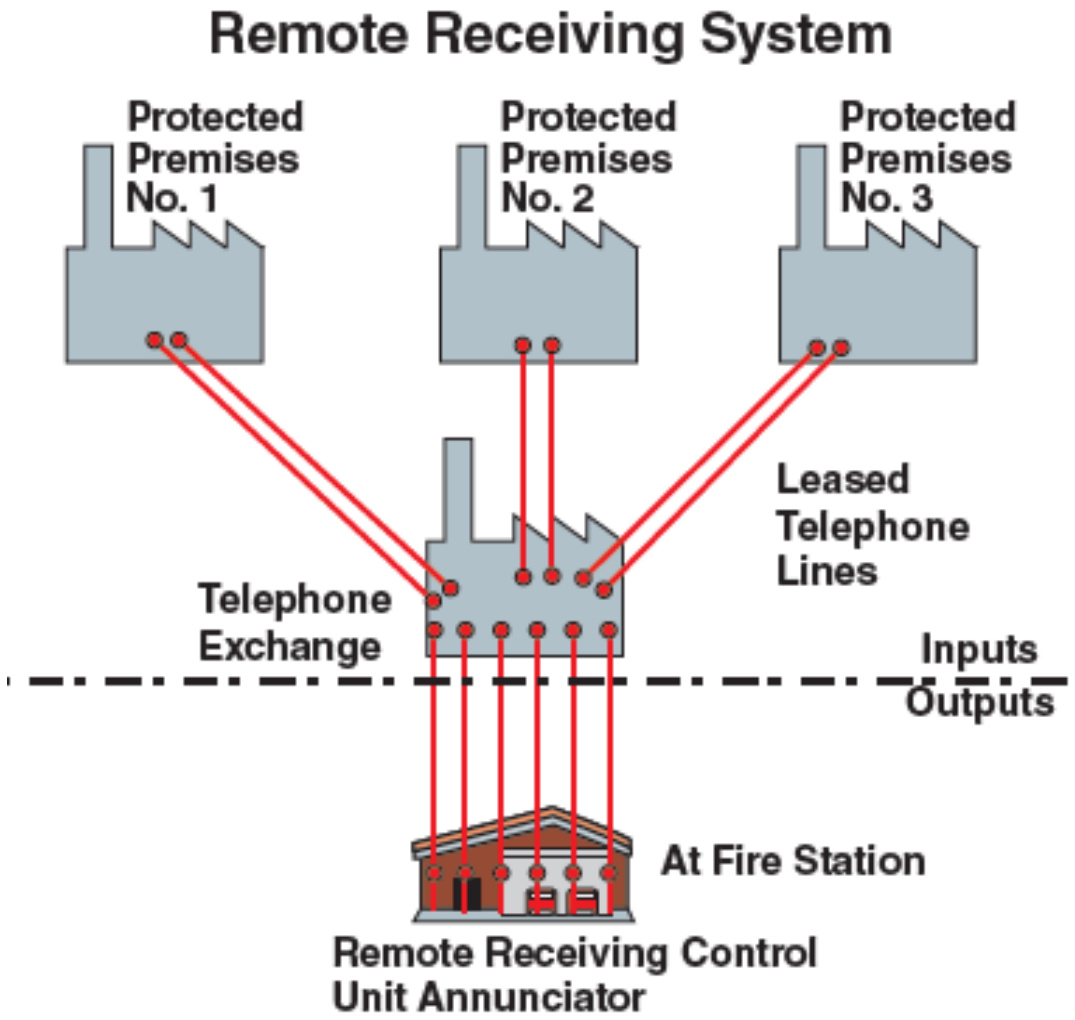
RJ-31X 8 pin modular connector

Premises phones

"off-hook"

DACT seizes a phone line

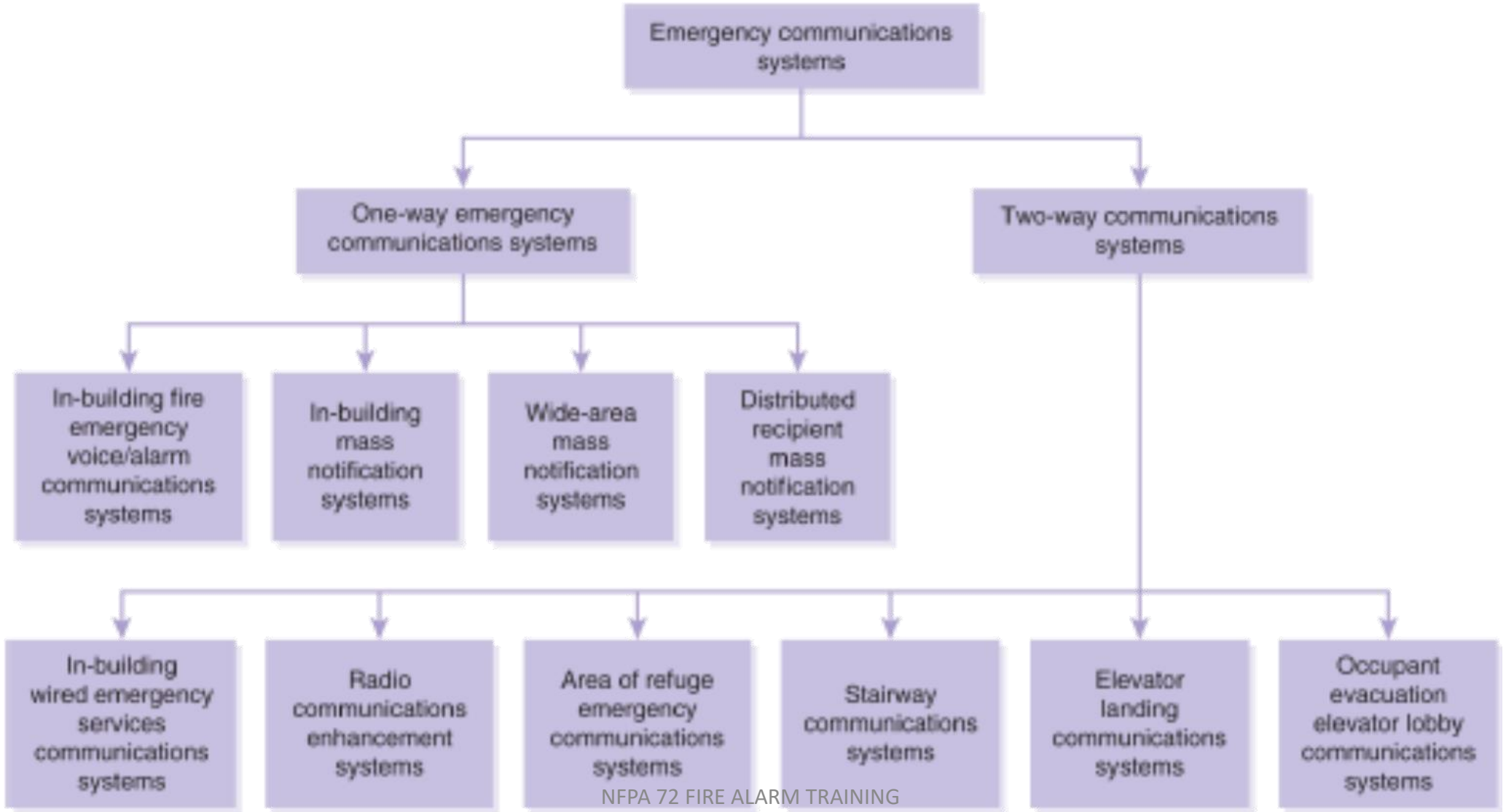
Remote Supervising Station Alarm Systems



Proprietary Supervising Station Alarm Systems

Public Emergency Alarm Reporting Systems

Emergency Communications Systems



Emergency Communications Systems

Emergency Communications Systems

Interface with Other Systems

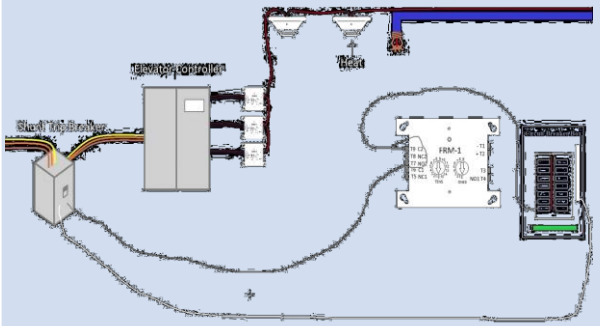
- Unlock Exit Door
- Close Doors
- Recall and Shutdown elevators
- Turn ON or shut down AHU
- Start up smoke Control and management equipment's
- Close Fire Dampers
- Monitor and Activate Fire suppression Systems

Interface with Other Systems

Elevator Nomenclature

Name	Description	Photo
Elevator Hoistway	An opening through a building or structure for the travel of elevators extending from the pit floor to the roof or floor above.	
Elevator Pit	The portion of the hoistway extending from the sill level of the lowest landing to the floor at the bottom of the hoistway.	

Elevator Nomenclature

Name	Description	Photo
Shunt-Trip	Shutdown of electric power to the elevator resulting from heat detector activation in the hoistway or elevator machine room prior to sprinkler operation.	
Firefighter Service	Function that allows firefighters to take control of elevators through key access to use them as needed for firefighting and rescue operations.	

Elevator Construction

According to the,

- *International Building Code* (IBC)
- NFPA 101, the *Life Safety Code*
- ASME 17.1, *Safety Code for Elevators and Escalators*,
- Elevator hoistways, or shafts as they are sometimes called, are required to be constructed of materials that provide a two-hour fire resistance rating.

Elevator Construction- Hoistway

Three stories or higher are required to have **smoke venting** of the hoistway for the removal of smoke and hot gases during a fire condition

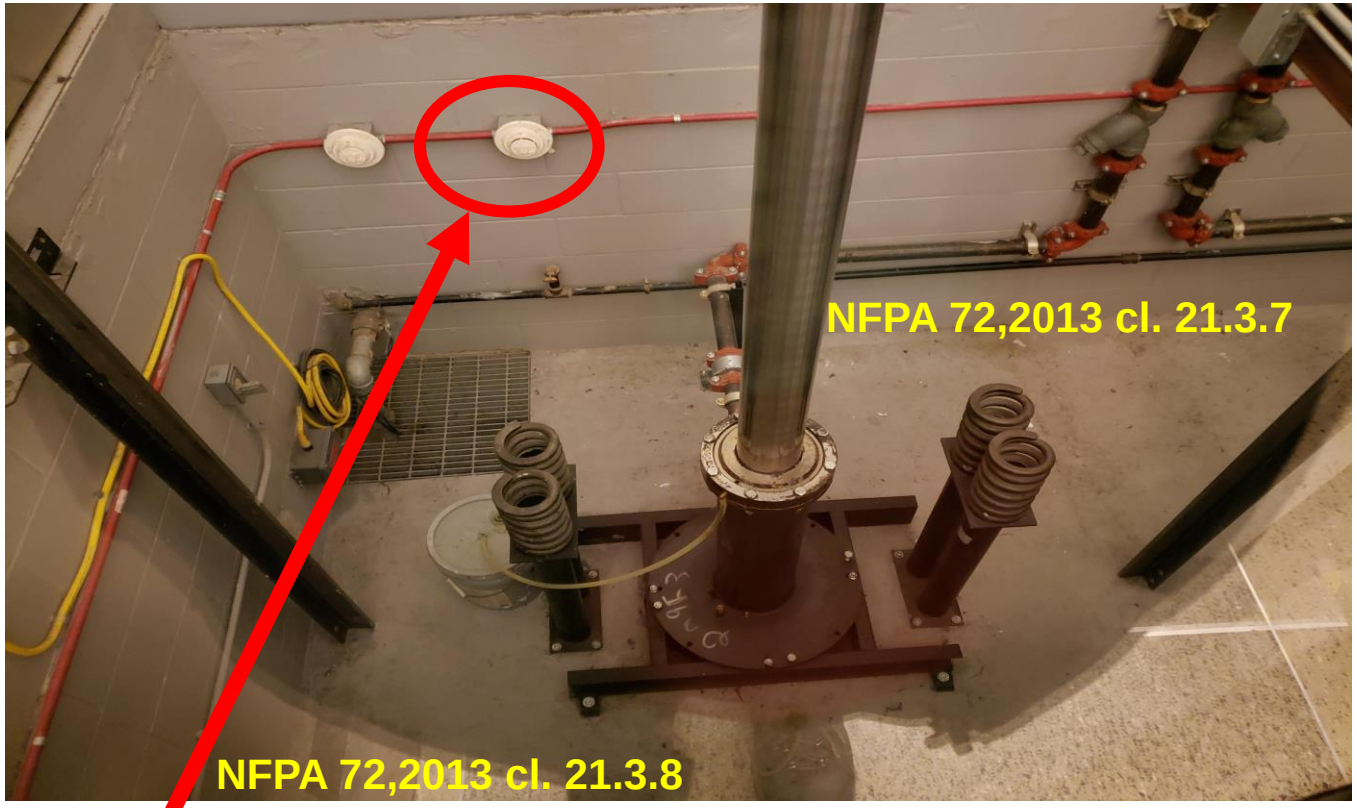
Installation of SD shall as per the below clause

NFPA 72,2013 cl. 21.3.6

When sprinklers are installed in hoistways, **heat detectors** have to be installed to activate prior to the sprinkler heads and activate the **shunt-trip** function of the elevator controls

IBC, Section 3006,Cl. 3006.2

Elevator Construction- Pit



Smoke detector in pit shall not be used for recall purpose unless listed for environment

- *Sprinkler coverage is required in elevator pits for hydraulic elevators that use flammable hydraulic fluid*

- *If the elevator is not hydraulic or nonflammable fluid is used, then no sprinkler heads and no detection devices are required in the pit*

Elevator Construction- Machine Room

- *Machine rooms must be constructed to the same or greater rating as the elevator hoistway.*
- *Plumbing systems other than sprinkler piping cannot be located in elevator machine rooms because of all of the electrical equipment located there*
- *ASME A17.1 requires that an ABC-rated portable fire extinguisher be located in all elevator machine rooms.*
- *NFPA 101,2015,Cl.9.4.5 the Life Safety Code, requires elevator machine rooms with a travel distance exceeding fifty feet (15 m) above the level of exit discharge or thirty feet (9.1 m) below the level of exit discharge be provided with independent ventilation or air conditioning systems to maintain temperatures during firefighter emergency operations*

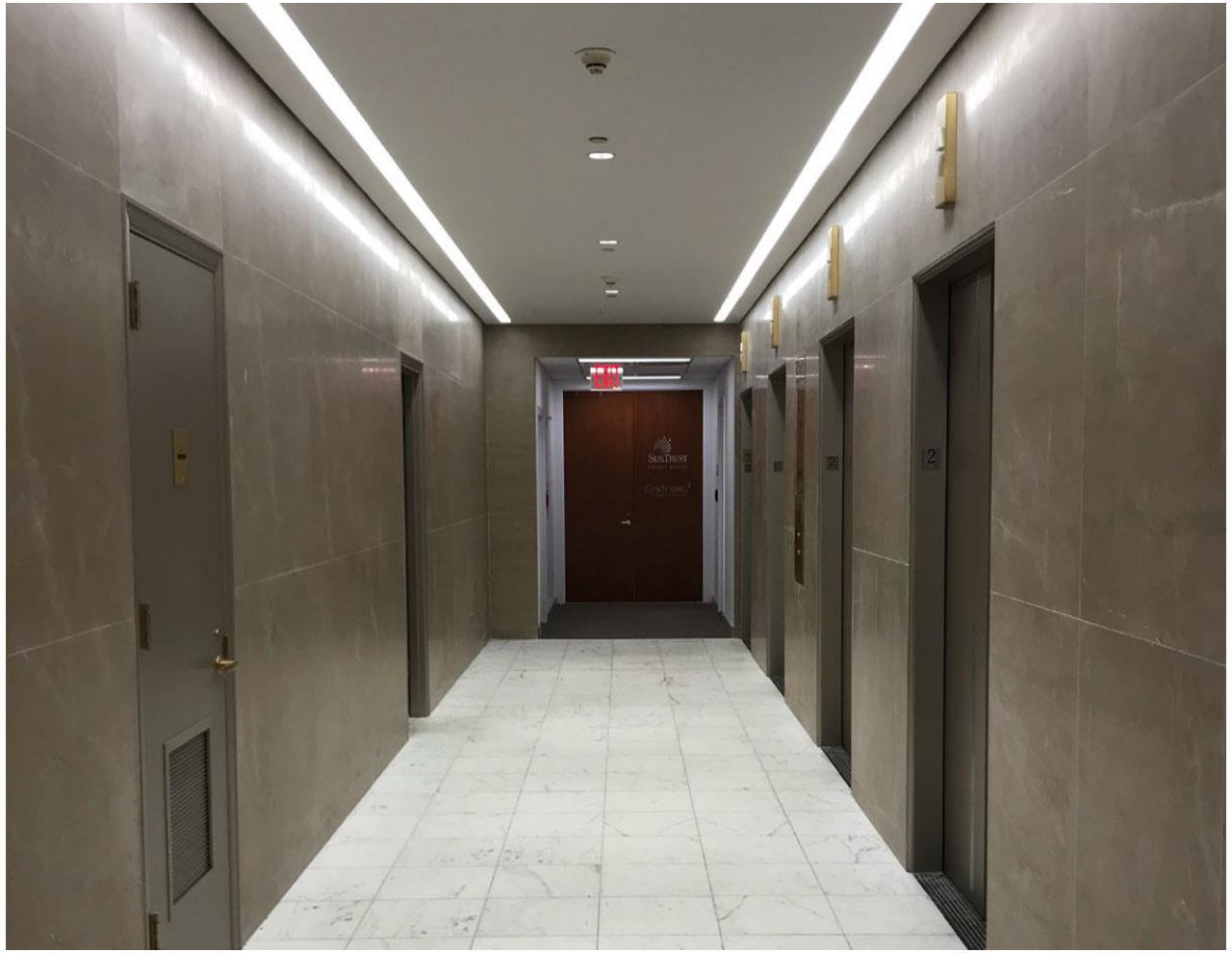
Elevator Construction- Machine Room

- *Elevator machine rooms are usually sprinkled (UAE FLSC, Table 9.30)*
- *Because of the electrical equipment in the room, having water discharge from the sprinkler system can be damaging to the equipment.*
- *When installing sprinklers in the machine room, it is a good idea to have a shutoff valve in the sprinkler piping just outside the machine room so that the water can be shutoff as soon as the fire is extinguished.*

Elevator Recall for Fighters Services

NFPA 72, 2013,Cl. 21.3

WHY….?



- *Building occupants should not use elevators during a fire or when the building fire alarm is sounding.*
- Elevators can be programmed to be recalled automatically to designated floor or alternate floor
- when the fire alarm system in the building is activated, which will keep building occupants from using elevators during a fire.
- Elevators are generally not safe for civilians to use under fire conditions. Firefighters, however, may be able to use.
- elevators to transport personnel and equipment if it is determined that it can be done safely.

Elevator Recall for Fighters Services

NFPA 72, 2013,Cl. 21.3

Initiation…?

Fire alarm initiating devices (smoke or heat detectors) are installed at each elevator floor.

OR

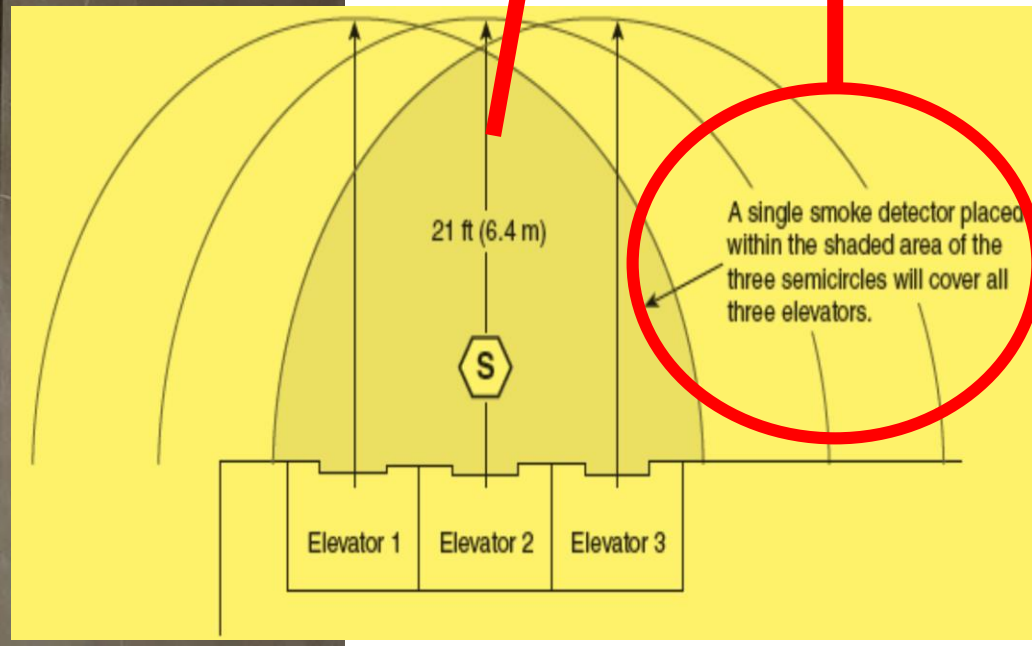
Smoke detectors, heat detectors, and sprinkler flow switches in or associated with elevator hoistways and elevator machine rooms will also activate elevator recall

NFPA 72, 2013,Cl. 21.3.14.1 & 21.3.14.2

Centerline of Elevator

Should be within 21 ft. (Cl. 21.3.5)

A single Detector can cover Three Elevators placed within the shaded area….



ELEVATOR FIRE SERVICE FUNCTION

- Phase-1 Fire Fighter Service
- Phase-2 Fire Fighter Service

ELEVATOR FIRE SERVICE FUNCTION

❑Phase-1 Fire Fighter Service

A Three-position key

This switch or FA devices are allowed to initiate elevator recall phase-1 operation

In the "Bypass" position, normal elevator operations are restored regardless of the status of elevator lobby detectors.

In the "On" position, all elevator cars controlled by the switch (usually only those in the elevator bank) will return to the designated level non-stop and doors will open and remain open

In the "Off" position, elevators will operate normally and be controlled by the smoke or heat detectors in the lobbies.

ELEVATOR FIRE SERVICE FUNCTION

❑Phase-2 Fire Fighter Service

- *Phase II firefighter service permits firefighters to manually take control of the elevators with an override key Elevators with Phase II operation also have Phase I elevator recall as well. Phase II overrides all automatic controls, including the Phase I recall.*

Phase II key switches are required to rotate clockwise from "Off" to "Hold" to "On."

ELEVATOR FIRE SERVICE FUNCTION-Phase II operational instructions

Item	Description
	When flashing, exit elevator
To operate car	Insert fire key and turn to “ON” Press desired floor button
To cancel Floor selection	Press “CALL CANCEL” button
To open power operated Door	Press and hold “DOOR CLOSE” button
To close power operated door	Press and hold “DOOR OPEN” button
To hold car at floor	With doors open, turn key to “HOLD”
To automatically send car to recall floor	With doors open, turn key to “OFF”

DESIGN AND INSTALLATION

Personnel Qualification

1. Personnel who are registered, licensed, or certified by a state or local authority
2. Personnel who are certified by a nationally recognized certification organization acceptable to the authority having jurisdiction
3. Personnel who are factory trained and certified for fire alarm system design and/or emergency communication system design of the specific type and brand of system and who are acceptable to the authority having jurisdiction.

OCCUPANCY BASED REQUIREMENTS

International Building Code (2018 Edition) Occupancy- Based Requirements

Occupancy	Manual Fire Alarms	Automatic Fire Detection or Smoke Alarms
Assembly	X	
Business	X	
Educational	X	
Factory/Industrial	X	
Hazardous	X	X
Institutional	X	X
Mercantile	X	
Residential	X	X
Storage		

OCCUPANCY BASED REQUIREMENTS

NFPA 1, NFPA 101 & NFPA 5000 (2018 Edition) Occupancy- Based Requirements

	NFPA 1		NFPA 101		NFPA 5000	
	Manual Alarm	Automatic Alarm	Manual Alarm	Automatic Alarm	Manual Alarm	Automatic Alarm
Assembly	X		X	X	X	X
Business	X		X		X	
Day Care	X	X	X	X	X	X
Detention	X	X	X	X	X	X
Educational	X		X		X	
Health Care	X	X	X	X	X	X
Health Care-Ambulatory	X		X		X	
Industrial	X		X		X	
Mercantile	X		X		X	
Residential Apartments	X	X	X	X	X	X

OCCUPANCY BASED REQUIREMENTS

NFPA 1, NFPA 101 & NFPA 5000 (2018 Edition) Occupancy- Based Requirements

	NFPA 1		NFPA 101		NFPA 5000	
	Manual Alarm	Automatic Alarm	Manual Alarm	Automatic Alarm	Manual Alarm	Automatic Alarm
Residential – Board and Care	X	X	X	X	X	X
Residential – hotel and Dormitory	X	X	X	X	X	X
Residential – lodging and Rooming	X	X	X	X	X	X
Residential – One and Two family dwelling		X		X		X
Storage	X		X		X	

Installation & Design

- In order for a fire alarm system to work, there has to be some method tying together the initiating devices, notification appliances, fire alarm control panel, and other internal and external components and systems.
- Approved methods include fiber-optic cable and bidirectional wireless communication, but most system installations still use wire as the primary connection method.

Role of NEC

The Fire Protective Signaling Systems portion of the code **(NEC Article 760)**details the specific requirements for wiring and equipment installation for fire protection signaling systems. Specifications include installation methods, connection types, circuit identification, and wire types (including gauges and insulation).

The *NEC*®places restrictions on the number and types of circuit combinations that can be installed in the same enclosure.

Scope of NEC 760

This article covers the installation of wiring and equipment of fire alarm systems including all circuits controlled and powered by the fire alarm system.

Power-Limited and Nonpower-Limited Circuits

Power-Limited Fire Alarm (PLFA) Circuits. A power-limited fire alarm circuit is one that is inherently unable to exceed maximum voltages, or is equipped with a power-limiting source (transformer or battery) and a circuit breaker. Generally, these operate in the 24-volt direct current range, although they may employ higher voltages

Power-Limited and Nonpower-Limited Circuits

Nonpower-Limited Fire Alarm (NPLFA) Circuits. Nonpower-limited fire alarm circuits cannot operate at more than 600 volts, and there is no other power or current limitation for these systems. Usually these are used in 120-volt alternating current (AC) systems which have been rendered generally obsolete by the advent of low-voltage, direct current (DC) systems.

Types of Cable

- **Power-limited fire alarm (FPL) cable :** *Power-limited non-plenum-rated fire alarm cable is a general purpose cable that is not rated for plenum spaces.*
- **Power-limited fire alarm riser (FPLR) cable :** *Power-limited riser-rated fire alarm cable is installed where vertical cable runs are required. This cable must have low flammability, but smoke generation characteristics can be higher than those for a plenum-rated cable.*
- **Power-limited fire alarm plenum (FPLP) cable :** *Power-limited plenum-rated fire alarm cable can be installed in plenums or other similar spaces. This cable must meet strict flammability requirements and must have low smoke generation characteristics*

Types of Cable

- **Nonpower-limited fire alarm (NPLF) circuit cable :** *Non-power-limited fire alarm cable is for general use but not for plenum, riser, ducts, or spaces where there is environmental air.*
- **Nonpower-limited fire alarm plenum (NPLFP) circuit cable :** *Non-power-limited fire alarm plenum cable can be installed in plenums, ducts, and other similar spaces that must be fire resistant and must have low smoke generation characteristics.*

Other NEC articles

- NEC Sections 110.11 and 300.6(A),(B), and (C), Corrosive, Damp, or Wet Locations
- NEC Section 300.21, Spread of Fire or Products of Combustion
- NEC Section 300.22, Ducts, Plenums, and Other Air Handling Spaces
- NEC Articles 500 through 516 and 517, Part IV, Locations Classified as Hazardous
- NEC Article 695, Fire Pumps
- NEC Article 725, Remote-Control and Signaling Circuits (Building Control Circuits)
- NEC Article 770, Fiber Optics
- NEC Article 800, Communications Circuits
- NEC Article 810, Radio and Television Equipment

Circuits and Wiring

- NFPA 72® discusses circuit classification and the types of circuits installed as related to the systems and devices. Three different types of circuits are used with conventional and addressable technology based systems:

- **Initiating device circuit (IDC)**
- **Signal line circuit (SLC)**
- **Notification appliance circuit (NAC)**

Circuits and Wiring

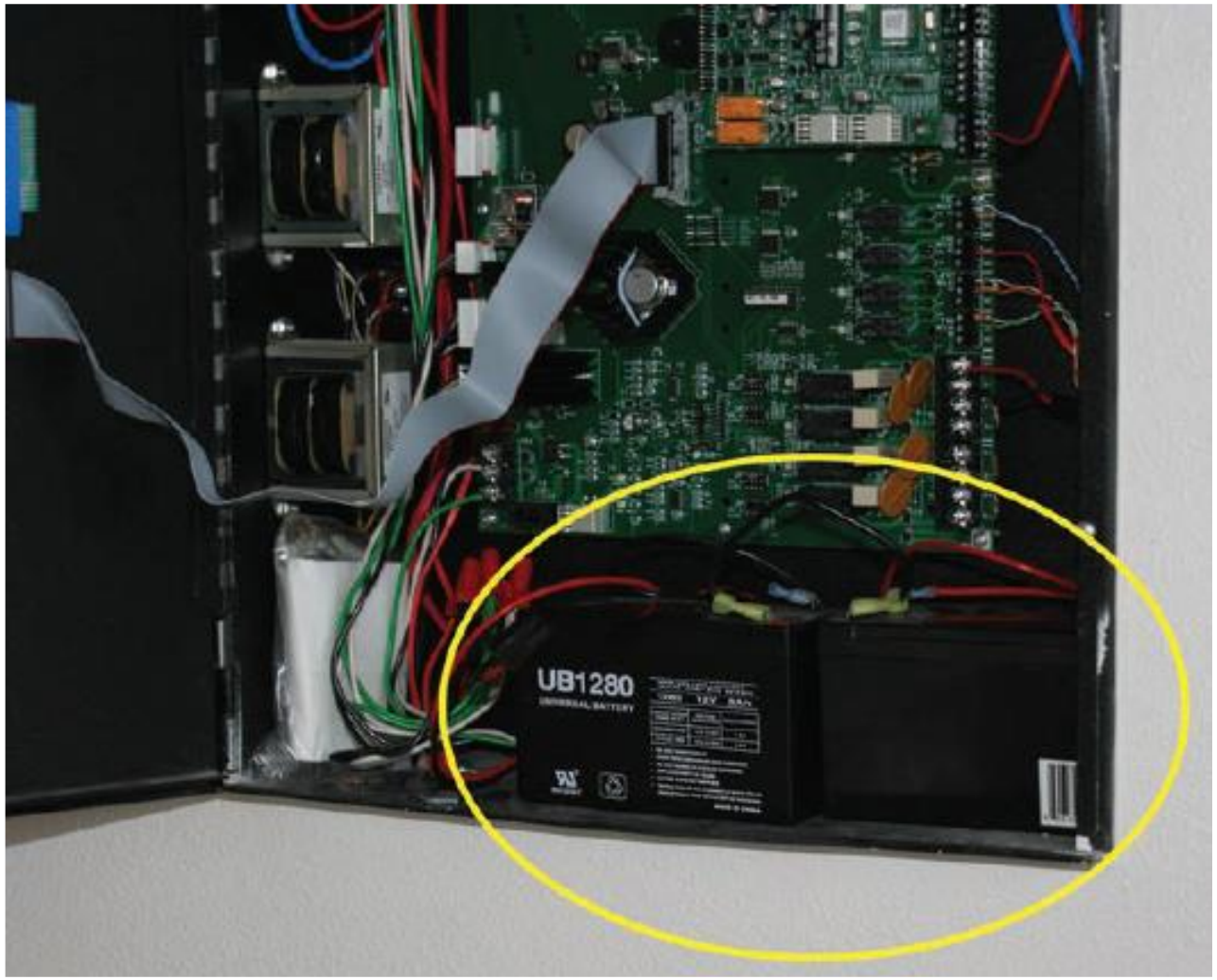
Initiating device circuits are installed with conventional technology systems, signal line circuits are installed with addressable technology systems, and notification appliance circuits are installed with both.

Power Supply

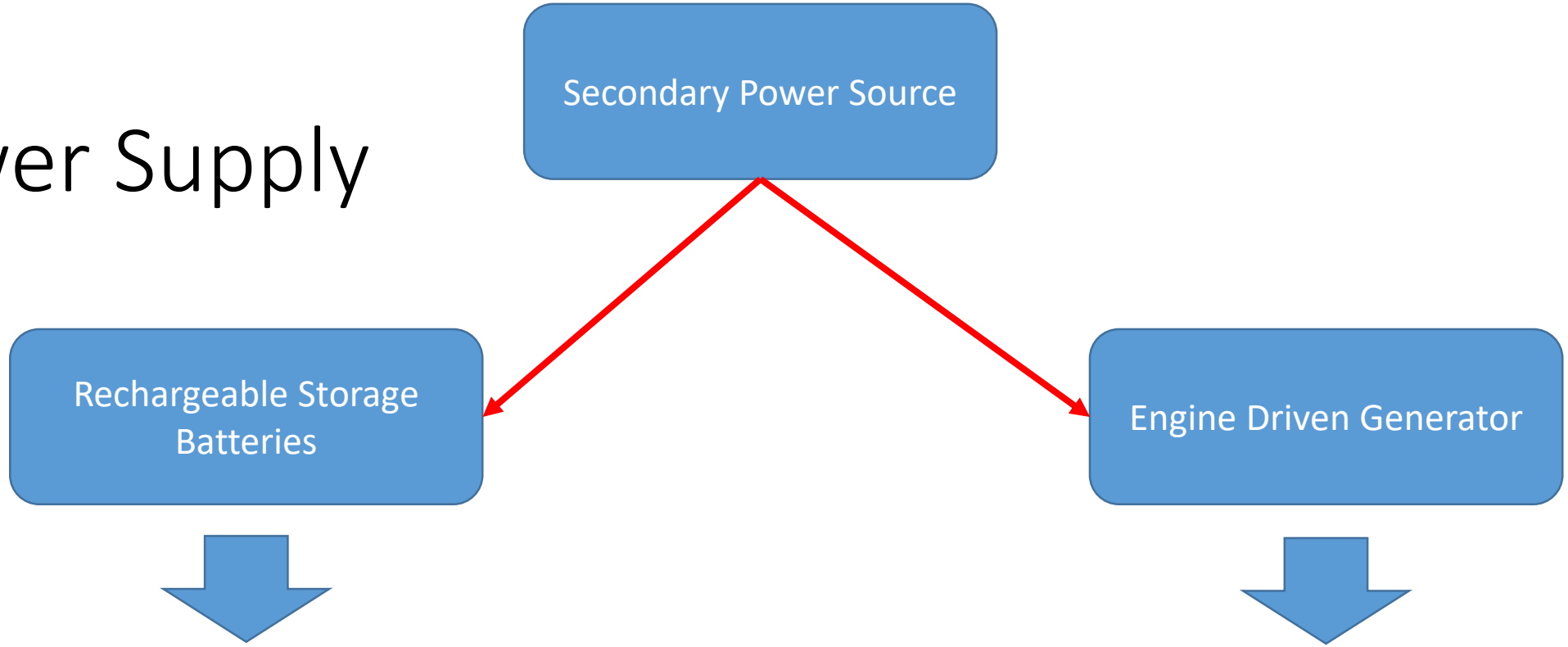
Two independent and reliable sources of power are required to supply a fire alarm system. Typically, the main or primary source of power is supplied by a power utility.

Primary power could be supplied by an engine-driven generator or equivalent that is under the constant attention of a trained operator.

Once the primary power enters the facility, it must be protected from physical damage; it must be on a dedicated circuit supplying the fire alarm control panel; access to the circuit must be controlled; and the circuit must be identified



Power Supply



If storage batteries are used, they must have the capacity to sustain power for 24 hours in normal ready mode and 5 minutes in full alarm mode at the end of the 24-hour loss-of-power period.

These requirements differ for emergency voice alarm communications systems and mass notification systems, for which 15 minutes of power in full alarm mode is required at the end of the 24-hour loss-of-power period

When a generator is used to provide the power, the generator must have 4 hours of battery capacity

No matter the secondary source, power transfer must be automatic and seamless; not allow for loss of system function, delay or interrupt signals; and take place within 10 seconds

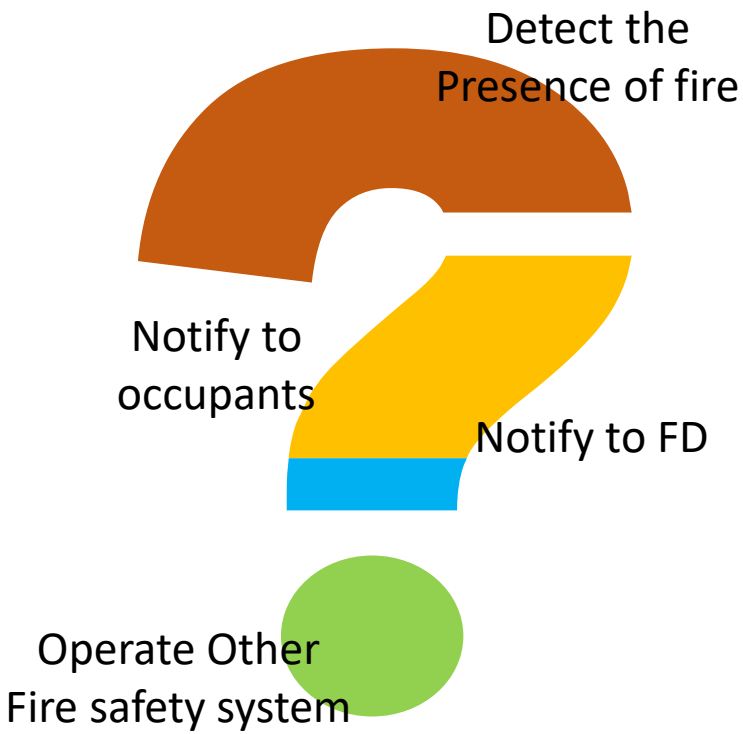
Types of Fire Alarm Signals

Fire alarm systems may provide three types of signals:

(1) Alarm,

(2) Supervisory

(3) Trouble



Alarm Signal

- When an **alarm signal** sounds in a building, it is alerting occupants there is a fire emergency. The alarm signal should spur the occupants to immediately leave the building, call the fire department, or take other appropriate action to ensure life safety.
- Alarm signals must sound within 10 seconds of a manual or automatic initiation device activation such as a manual fire alarm box, a fire detector, or a water flow or pressure switch.
- Depending on the fire alarm system, this signal either will automatically be transmitted offsite so the appropriate action can be undertaken by the receiving party or might require that a person make contact with the fire department to respond.

Supervisory Signals

- The **supervisory signal** sounds when there is a change in the normal ready status of other fire protection systems or devices that are connected to or integrated with the fire alarm control panel.
- The typical supervisory signal sounds a constant tone, beep, or buzz usually accompanied by a visible indication (lamp, LED, or text information) on the fire alarm control panel and, if installed, the annunciator.
- In many buildings, the fire alarm control panel electrically monitors sprinkler system control valves; dry pipe sprinkler system air pressure; fire pump status; air temperature of a sprinkler system valve room; water temperature, level, and pressure in a water storage tank; and, in some configurations, duct smoke detector operation.

Supervisory Signals

For example,

- A change in the normal status of a sprinkler system control valve could indicate someone closed a valve, thus cutting off the water supply to the sprinkler system. This act may have been accidental, malicious, or necessary for service or maintenance activities.
- By electronically supervising the valve, those responsible can initiate an immediate response and investigation to determine the nature of the incident.

Trouble Signals

- It sounds when there is a problem with the system's integrity, such as a power or component failure, device removal, communication fault or failure, ground fault, or break in the system wiring.
- It is common for the trouble signal to use the same audible signal and visible indicator as the supervisory signal to notify that there is a condition requiring attention.
- System problems that generate a trouble signal should be investigated and resolved as soon as practical by building maintenance or engineering personnel because trouble conditions may prevent initiation or reception of alarm signals.

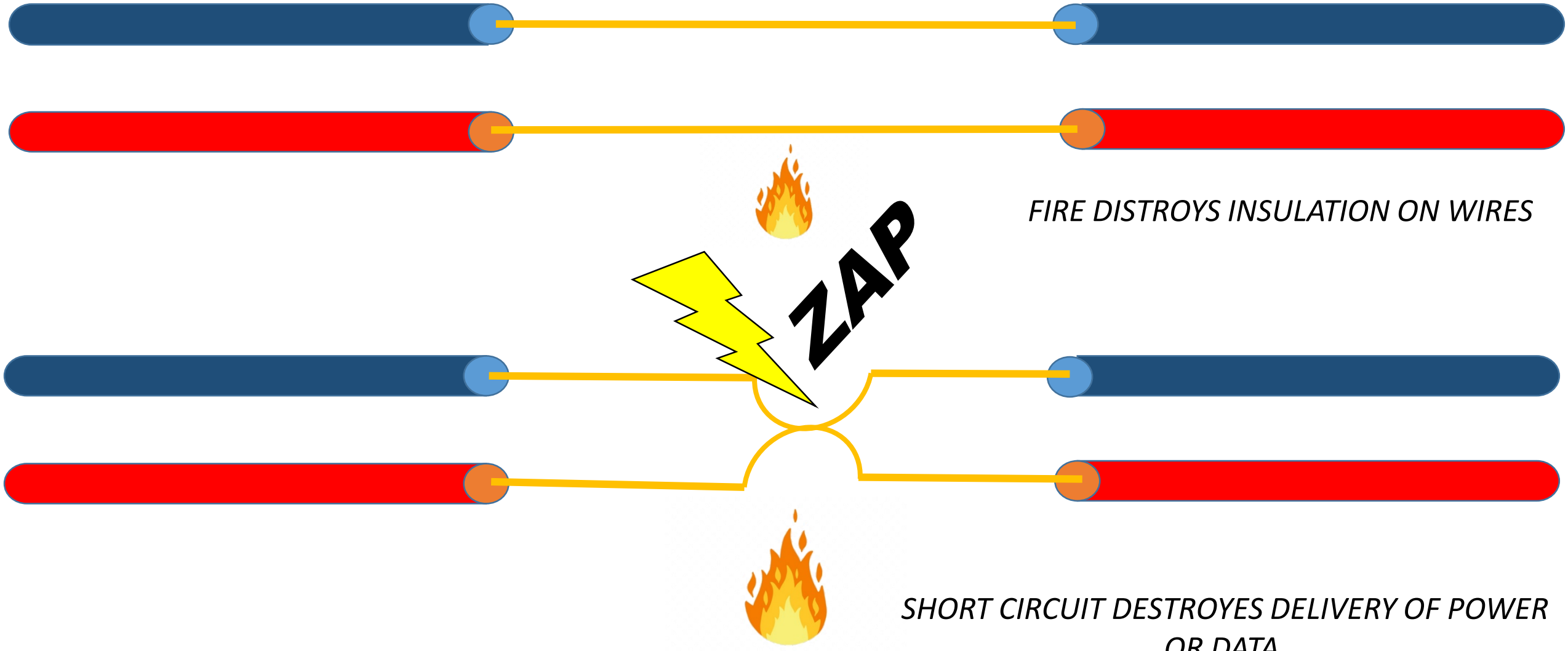
Trouble Signals

- ***Many times, a trouble signal is acknowledged and forgotten, but newer fire alarm systems must sound the trouble signal every 24 hours until the problem is resolved.***

Types of Fire Alarm Signals

Signal Type	Possible Conditions	Action Required
Alarm	The following conditions may exist: • Automatic water flow device (*i.e., flow switch*) • Manual fire alarm station (*i.e., pull station*) • Automatic fire detectors (*i.e., smoke or heat detectors*)	Indicates an **emergency** that requires **immediate action**, such as a signal characteristic of a fire.
Supervisory	The following conditions may exist: • Control valve switch • High/low air pressure switch • Water tank level and temperature switches • Low water pressure for public water supplies • Low building temperature switch • Alarm line valve position	Indicates that action must be taken by an on-site supervising guard to inspect the fire suppression systems or equipment, or the maintenance of related systems
Trouble	The following conditions may exist: • Loss of primary power (120VAC) • Loss of secondary power (backup battery) • A break in the wiring to an initiating device, or an open or shorted condition on a notification appliance (NAC) or release circuit.	Indicates a problem with the fire control panel or associated wiring, which may cause faulty system operation.

Need of Fault Isolation in Fire Alarm System



FIRE DISTROYS INSULATION ON WIRES

SHORT CIRCUIT DESTROYES DELIVERY OF POWER OR DATA

NFPA 72, CHAPTER 23, 23.6.1

23.6.1 : SLC Zones : A single fault on a pathway connected to the addressable devices shall not cause the loss of the devices in more than one zone.

23.6.1.1 -Each floor of the building shall be considered a separate zone.

23.6.1.2 - If a floor of the building is subdivided into multiple zones by fire or smoke barriers and the fire plan for the protected premises allows relocation of occupants from the zone of origin to another zone on the same floor, each zone on the floor shall be considered a separate zone.

A single zone could be designated in the following ways:

(1) By floor where an SLC would not span multiple floors
(2) By floor area, where a large floor would be split into multiple zones based on a maximum floor area size (e.g., 22,500 ft2)
(3) By re barrier or smoke barrier compartment boundaries, which an SLC would not cross
(4) By maximum length or circuit, where an SLC would not be longer than a predetermined length (e.g., 300 ft)

Need of Fault Isolation in Fire Alarm

Zone-1

Zone-2

Zone-3

ISOLATOR

Short Circuit

ISOLATOR

Concept of Reliability Prediction Techniques for Fire Alarm Systems

Lusser Product Law

- According to the Lusser product law, as the number of components increases, the reliability of each individual component has to be improved commensurately to maintain the reliability of the overall system.

$$PT = P1 \times P2 \times P3 \times \cdots \times P$$

PT = Probability of successful operation for the system, or reliability

Pn = Probability of successful operation of the *n*th component

n = The number of constituent components

Lusser Product Law

- The probability of successful operation of a system is not directly computable. It is computed from failure rate data for each of the constituent components of that system. Failure rate, that is, the probability of failure, is related to the probability of successful operation by :

$$\Lambda T = 1 - PT$$

where

ΛT = Failure rate of the total system

PT = Probability of successful operation for the system, or reliability

Failure Rate

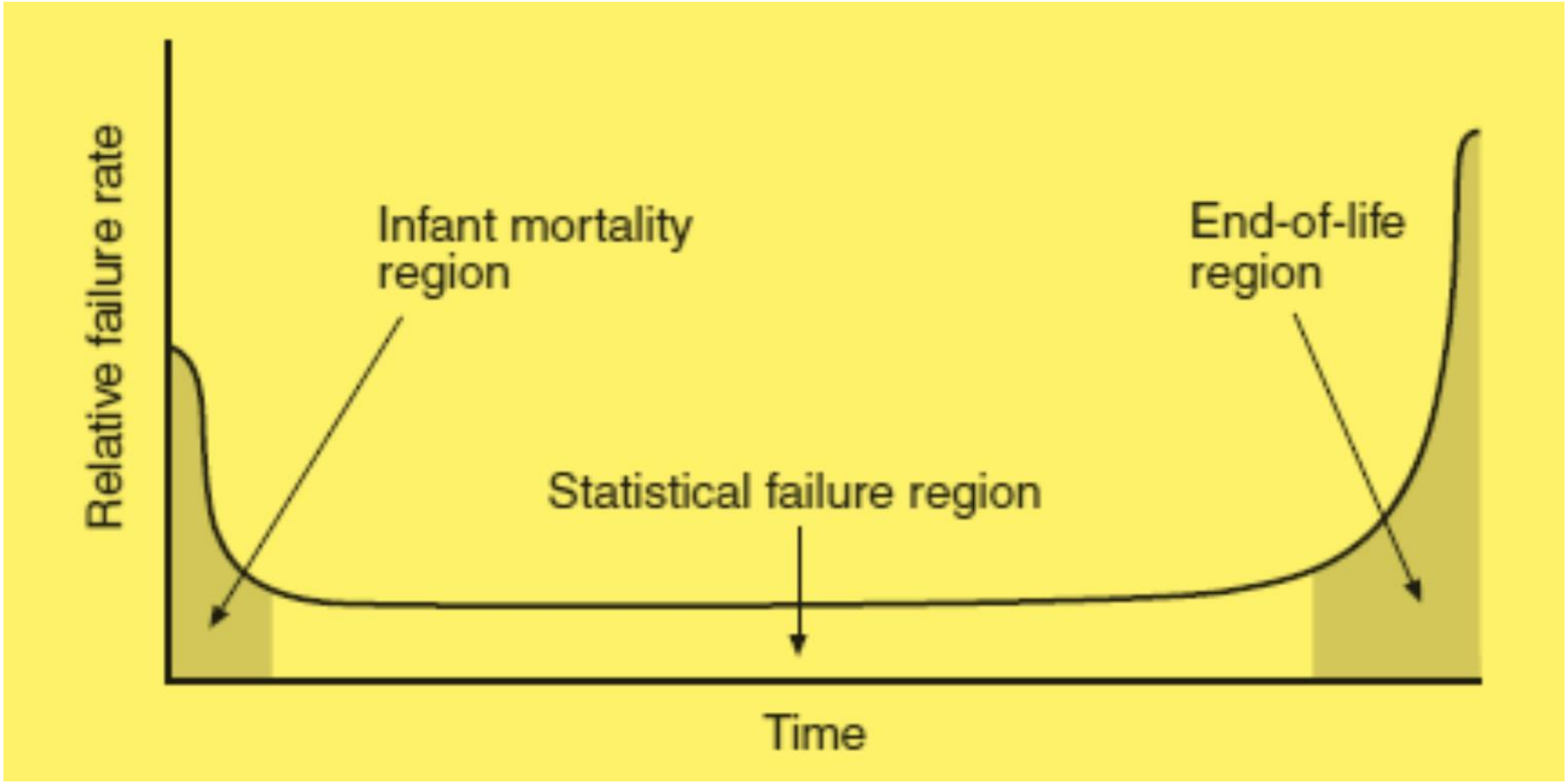
Defined As :

- Rate of Occurrence of failure
- Number of failure specified time period

Units :

- Failure per million hours (f/moh)
- Failure per billion hours (f/boh)

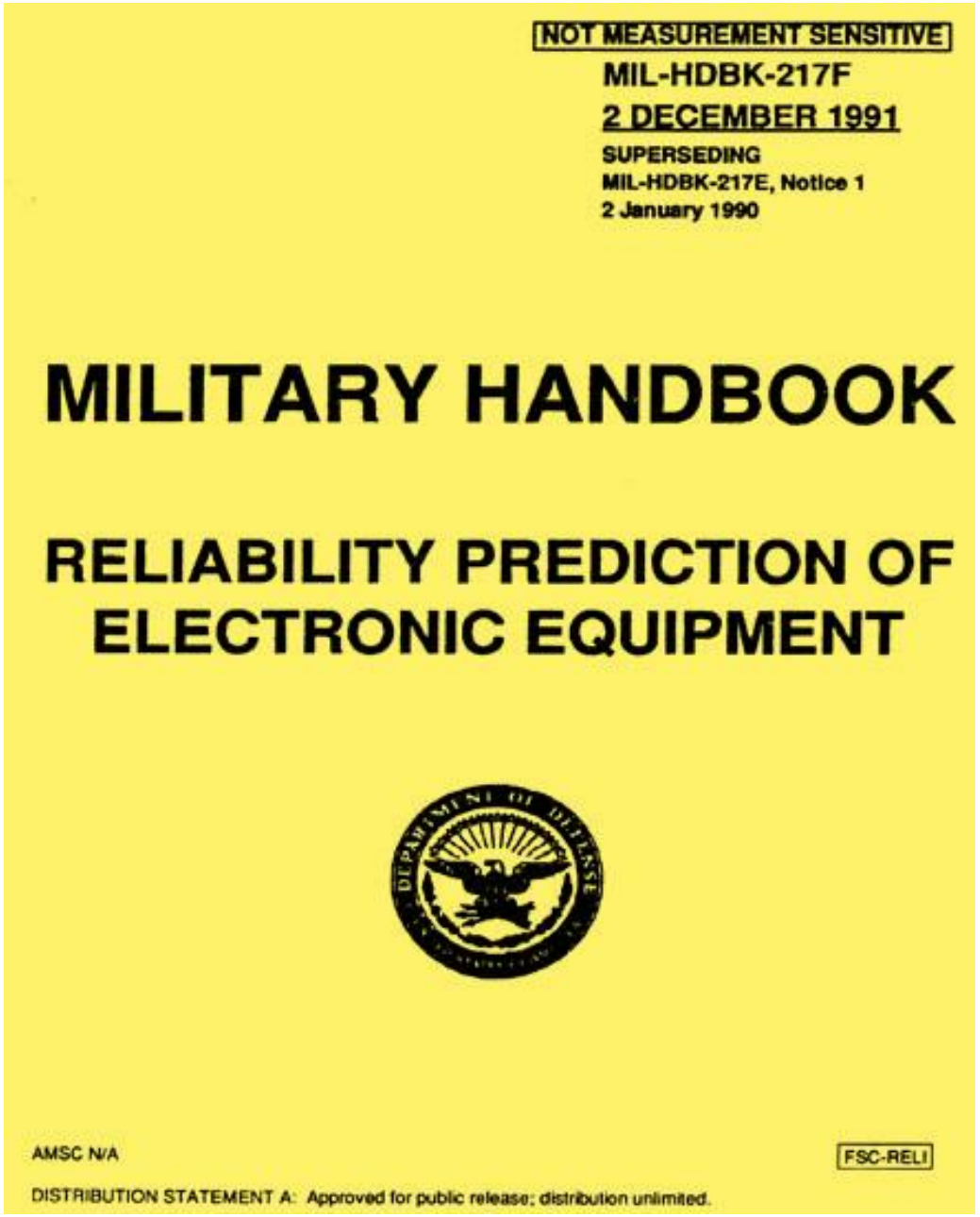
Failure Rate



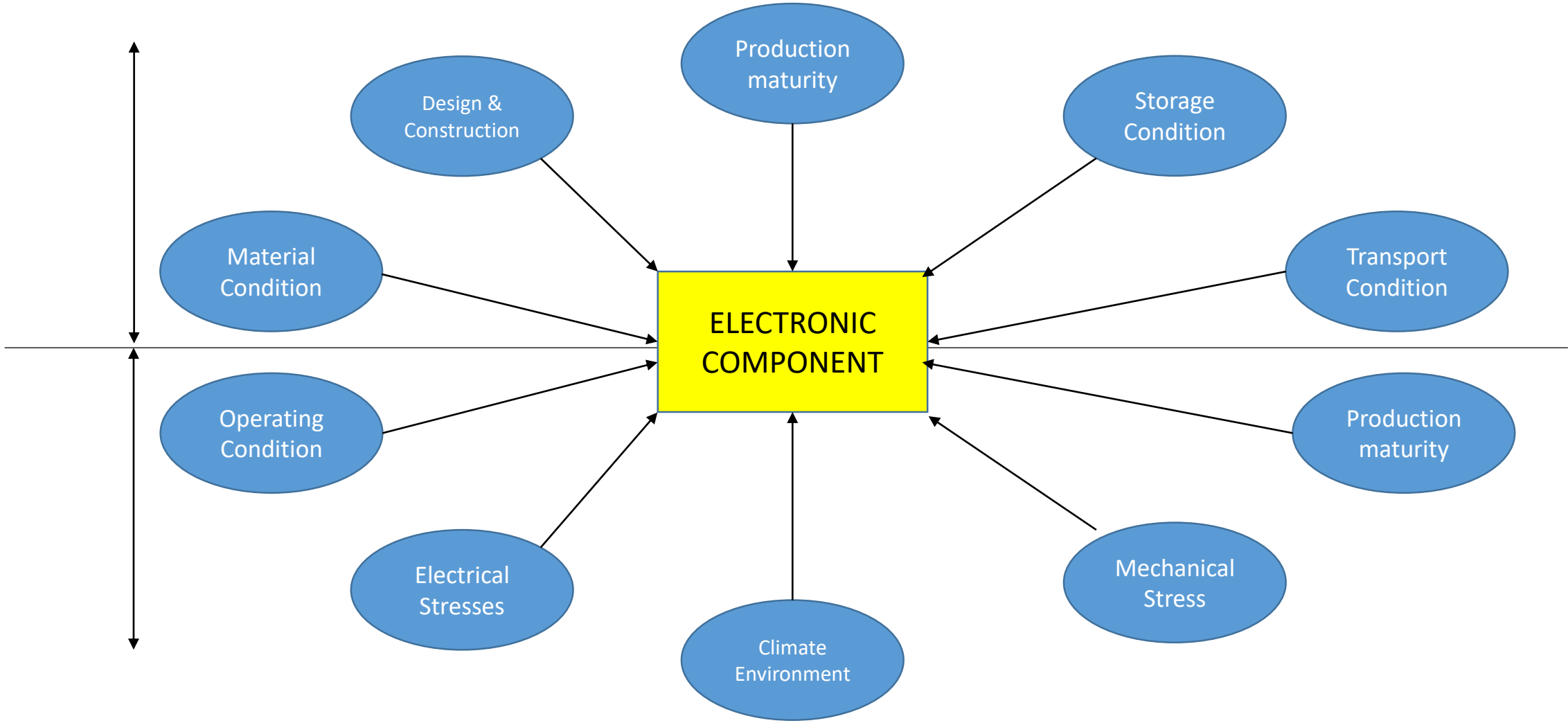
Failure Rate – MIL- HDBK-217

Since the *failure rate is essentially constant over the statistical failure rate region* of the bathtub curve, the failure rate of any electronic component and, hence, any electronic system assembled from electronic components can be derived from the failure rate data established in Military Handbook:

Reliability Prediction of Electronic Equipment.



Influences to Reliability



RELIABILITY CALCULATIONS

- Once the inherent failure rate has been computed, the reliability of the system can be calculated:

$$R = e^{\wedge} (-\Lambda t)$$

where

R = Reliability of the system

e = Napierian logarithm base, 2.71828

Λ = Inherent failure rate of the system

t = Time period for which reliability has been computed

RELIABILITY CALCULATIONS

- Assuming maintenance restores the entire system to complete operability, the required maintenance interval is computed from

$$tR = \ln RR / (-\Lambda)$$

where

ln *RR* = Napierian log of the required reliability, *RR*

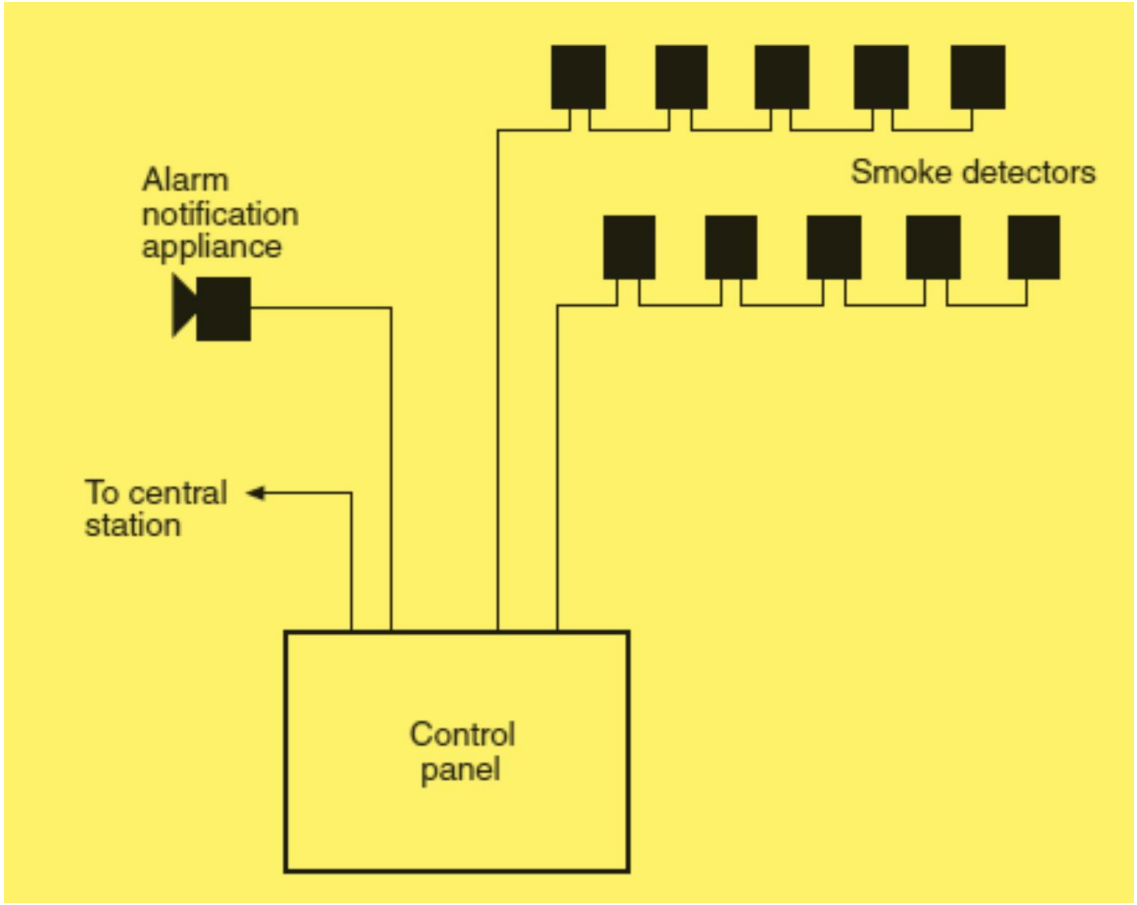
Λ = Inherent failure rate of the system

tR = Required maintenance interval to achieve the required reliability

The mathematical relations shown give the engineer the ability to calculate a recommended maintenance interval on a totally new product

EXAMPLE

DESIGN OBJECTIVE : *To alert the occupants of a fire, enabling them to make safe egress from the facility, with a reliability of 90 percent (0.9).*



EXAMPLE

System Components	Quantity*(q)*	Failure Rate *(λ) (f/mdoh)*	Total Failure rate *(qxλx) (f/moh)*
Smoke detectors	10	1	10
Horn/strobe	1	2.5	2.5
Control panel	1	25	25
Screw terminals	49	0.10	4.9
Wire segments	25	0.05	1.25
Inherent failure rate, Λ			**43.65**

EXAMPLE

- Lets Convert Inherent failure rate from failure per million operating hours to failure per year.
- 43.65 f/moh = 0.00004365 failures per hour (f/h)
- Λ = 0.3824 failures per year

Using the required interval equation.

$$tR = \ln RR / (-\Lambda)$$

where

$\ln RR = \ln 0.90 = -0.11$

$\Lambda = 0.3824$

$tR = -0.11/-0.3824$

$tR = 0.288$ yr

EXAMPLE - CONCLUSION

This indicates that this system, with the component failure rates used, will require a complete inspection, test, and maintenance routine every 0.288 years in order to maintain at least a 90 percent reliability in achieving its design objectives.

INSPECTION, TESTING & MAINTENANCE

Fire Alarm System- Inspection

14.3 – Inspections

- Inspection = A “visual” check of the system
- Frequencies are as stated in Table 14.3.1

Fire Alarm System- Inspection

14.3 – Inspections

- Inspections are permitted to be scheduled around scheduled shut downs if approved by the AHJ
- Intervals may be extended up to 18 months

Fire Alarm System- Inspection

14.3 – Inspections

Table 14.3.1 – Visual Inspection Frequencies

Fire Alarm System- Testing

14.4 – Testing

- Testing = A “functional” check of the system

Fire Alarm System- Testing

14.4 – Testing

- Frequencies as stated in Table 14.4.3.2

Fire Alarm System- Testing

14.4 – Testing

- 14.4.3.2 – Initial Acceptance Testing
- New systems shall be inspected and tested
- The AHJ shall be notified prior to initial acceptance testing

Fire Alarm System- Testing

14.4 – Testing

- 14.4.3.2 – Re-acceptance Testing
- 14.4.1.2 – Reacceptance Testing
- When an initiating device, notification appliance or control relay is added – functional test required
- When an initiating device, notification appliance or control relay is removed – functional test required on another device, appliance or relay on the circuit

Fire Alarm System- Testing

- 14.4.4.3 - Smoke detector sensitivity testing
- Within 1 year after installation
- Then check every other year; except…
- After the second test if the detector is within its listed sensitivity range the frequency can be extended to 5 years

Fire Alarm System- Testing

- 14.4.4.3 - Smoke detector sensitivity testing

Smoke detector sensitivity testing methods

✓Calibrated test method

✓Manufacturer's calibrated sensitivity test equipment

✓Listed control equipment that can perform sensitivity testing

✓Listed control equipment that warn of a detector outside of its listed range

Fire Alarm System- Testing

- 14.4.4.3 - Smoke detector sensitivity testing

14.4.5. - *Restorable* fixed-temp heat detectors

- 2 or more detectors shall be tested per initiating circuit
- Different detectors shall be tested each year (records must be kept)
- All detectors need to be tested within 5 years

Fire Alarm System- Testing

- 14.4.4.3 - Smoke detector sensitivity testing

Non-restorable fixed-temp heat detectors

- First test occurs at 15 years
- Test 2 detectors per 100 at lab
- Replace those detectors with new detectors
- If the test detectors pass, repeat the process in 5 years
- If the test detectors fail, test additional detectors
- Test circuit mechanically and electrically

Fire Alarm System- Testing

14.4.11 – Voice Intelligibility testing

1) Subject Based- Use of human subjects to assess how speech will be understood and simulate what it may sound like during a real event.

2) Quantitative- Use of an instrument or tool that will provide speech intelligibility score

Fire Alarm System- Testing

14.4.11 – Voice Intelligibility testing

1) Subject Based- Subject-based test methods can gauge how much of the spoken information is correctly understood by a person or a group of individuals. Results of speech intelligibility are usually described as predictions but documented as measurements

Fire Alarm System- Testing

14.4.11 – Voice Intelligibility testing

- 2) Quantitative Method : Speech Transmission Index (STI) and Speech Transmission Index for Public Address (STIPA), which is a modified version of STI, is special audio signal played over the emergency communications systems being tested and is the most commonly used.
- Instruments used to measure STI or STIPA use a special protocol consisting of signals in seven octave bands.

Fire Alarm System- Testing

Testing Method : When and Where

Intelligibility is important everywhere but is not always achievable in every location.

It is important to assess every area and discuss with your AHJ which areas will or will not be required to meet intelligibility.

Fire Alarm System- Testing

Testing Method : How

- Using Microphone with a live messages
- Using Prerecorded message

Fire Alarm System- Testing

Testing Method : How

The recommended method is using a pre-recorded message played through the speaker system via the panel or amplifier.

- The intelligibility measurements should be taken where a person would typically be, and the measurement should be taken where they do their normal activities. For example, in an office environment the measurement should be taken by the desk area. If it is a sleeping room, then the test measurement should be taken near the pillow.
- *Measurements should not be made near the floor, ceiling, or corners of a room because it's unlikely a person would position themselves there.*

Fire Alarm System- Testing

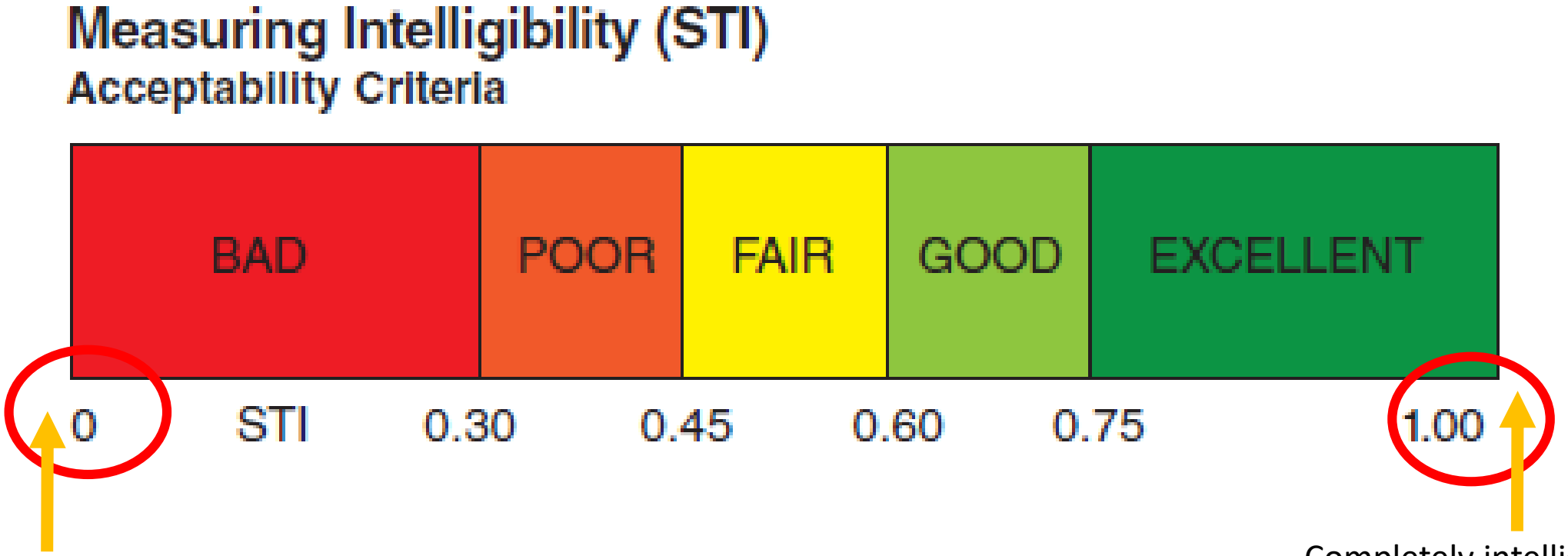
Testing Method : How

Calibrating Signal Source.

This will require the use of the STI or STIPA test signals played into the microphone using the talk box. The talk box should be calibrated per manufacturer's instructions before calibrating the signal source and be set up per the manufacturers' recommendation.

Fire Alarm System- Testing

Acceptable Criteria



THANK YOU