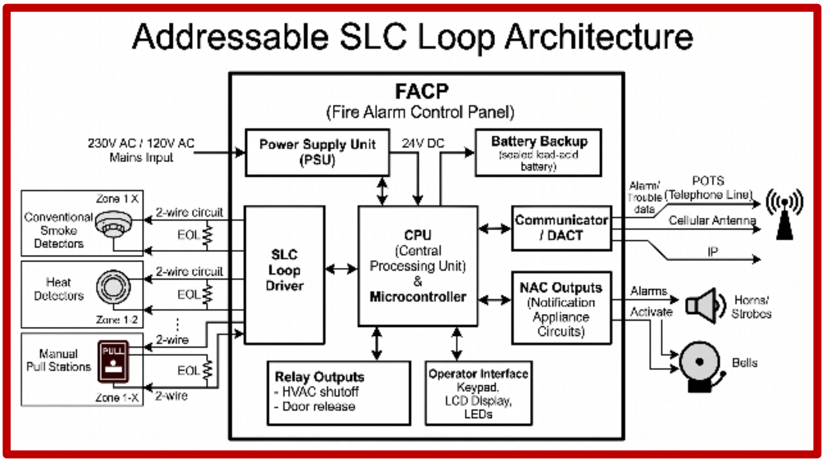
Fire Alarm Systems
A Comprehensive Training Guide

A Practical Reference for Design, Operation, and Code Compliance

Aligned with NFPA 72 (2022) • NFPA 70 / NEC Article 760 • IBC / IFC



This book is intended as a general educational reference. It is not a substitute for the official NFPA 72, NFPA 70, or local codebooks. Professionals must consult current editions of applicable codes and coordinate with the Authority Having Jurisdiction (AHJ) for compliance.

Printed in USA.

Technical Reviewer's Note

This second edition has been technically reviewed and updated. The intent of the review was to preserve the author's clear, training-oriented voice, refreshing references to the current edition of NFPA 72 (2022), and adding clarifications that practicing designers and inspectors frequently ask about. The principal updates are summarized below; each change is also flagged inline within the relevant chapter using a red-margin "Reviewer's Update" callout so readers can see what changed and why.

Summary of substantive changes

- • NFPA 72 chapter map. The original text labeled Chapter 7 as "Fundamentals" and Chapter 10 as "Power Supplies." The changed assignment in NFPA 72 (2016, 2019, and 2022 editions) is Chapter 7 — Documentation and Chapter 10 — Fundamentals (which includes power-supply requirements, signal performance, and supervisory requirements).
- • Audible notification appliance limits. The 120 dBA value was retained but reframed: per NFPA 72 §18.4.4, the maximum sound pressure permitted at the minimum hearing distance is 110 dBA, and 120 dBA is the absolute ceiling not to be exceeded anywhere occupants may be present. Public-mode minimums (75 dBA at 10 ft) and private-mode minimums (45 dBA) were added.
- • Secondary-power durations. The book stated the NAC alarm duration as 5 minutes after 24 hours of standby. That value is correct for a standard protected-premises fire alarm system, but Emergency Voice/Alarm Communication Systems (EVACS) and Emergency Communication Systems (ECS) require 15 minutes of alarm operation after 24 hours of standby. Both values are now distinguished clearly.
- • Circuit classifications. The original mentioned Class A, B, and C only. Class X (combined survivability) and Class N (Ethernet/network-based) were added; Class N was formally introduced in NFPA 72-2016 and remains in the 2022 edition.

- • Wire size for NACs. The book stated 14 AWG as the minimum. NEC §760.142 and §760.179 permit 26 AWG through 12 AWG fire-alarm conductors depending on listing and current; 14 AWG is a common practical minimum but is not a code-mandated minimum. The text now reflects this.
- • Smoke-detection technology. A short note was added explaining the UL 217 9th edition (effective 2022) requirements that effectively phase out ionization-only residential smoke alarms in favor of photoelectric or multi-criteria devices.
- • Carbon monoxide detection. A brief subsection was added in Chapter 5 reflecting the IBC §915, NFPA 72 Chapter 17, and the withdrawal of NFPA 720 in 2020, with CO detection requirements now consolidated into NFPA 72.
- • Inspection, Testing, and Maintenance (ITM). A new short reference section was added in Chapter 14/16 summarizing the periodic ITM frequencies from NFPA 72 Chapter 14 (Table 14.4.5).
- • Misc changes. "NEPA 101" → "NFPA 101", "NEPA 5000" → "NFPA 5000", "Tums on" → "Turns on", "exit dour" → "exit door", "tamper swith" → "tamper switch," and several other minor typos were corrected.
- • Emergency Communication Systems (ECS) terminology. The 2010 edition of NFPA 72 promoted EVACS to a subset of the broader ECS framework (Chapter 24). The text was updated to reflect ECS as the current umbrella term, with EVACS retained as the specific in-building voice evacuation use case.

Acknowledgments

I would like to thank the mentors, colleagues, and fire protection professionals who shared their experience, technical insight, and real-world perspectives with me during the development of this book.

Special appreciation goes to the code officials and instructors who helped clarify the application of fire alarm standards in practical scenarios, and to the licensed fire-alarm engineer who performed the technical review for this second edition.

Disclaimer

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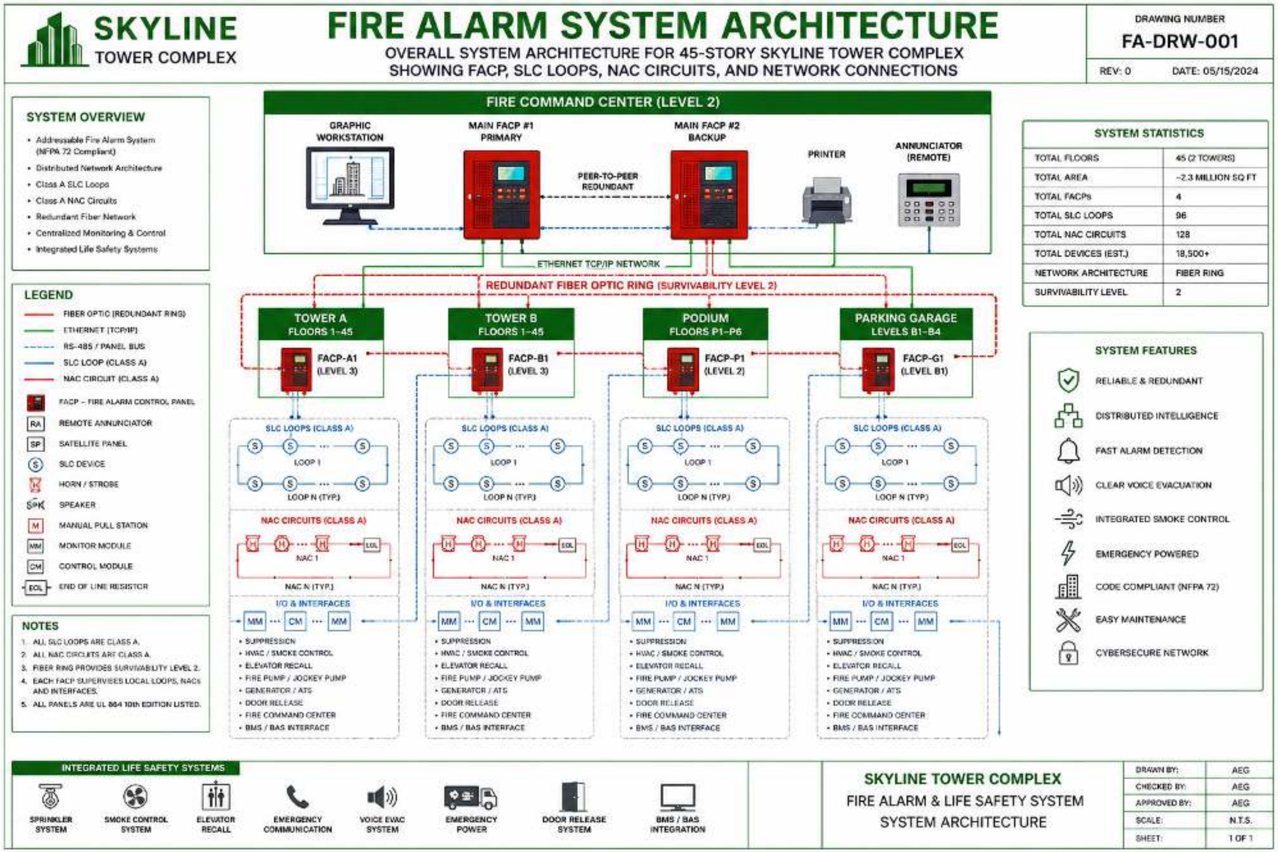
About This Book

This book was created to serve as a practical reference for engineers, technicians, inspectors, and building professionals who are involved in the design, implementation, or maintenance of fire alarm systems. It is designed to provide comprehensive knowledge on fire alarm systems, including code compliance, system design, component functions, and emergency response operations. It is intended for use by building professionals, safety inspectors, facility managers, and trainees preparing to work with fire alarm technologies.

While many resources cover the technical standards, this guide aims to explain fire alarm system concepts in a clear and accessible way — backed by real-world context and illustrations. Whether you are preparing for certification, coordinating with contractors, or verifying code compliance, this book is meant to bridge the gap between code requirements and practical understanding.

The content is based primarily on NFPA 72 (2022 edition) and NFPA 70 (2023 NEC), along with industry best practices and commonly referenced design approaches. It is intended to support continued learning and safe system implementation across various occupancies and jurisdictions.

— *Evan M. Calderon*


SKYLINE
TOWER COMPLEX
FIRE ALARM SYSTEM ARCHITECTURE
OVERALL SYSTEM ARCHITECTURE FOR 45-STORY SKYLINE TOWER COMPLEX
SHOWING FACP, SLC LOOPS, NAC CIRCUITS, AND NETWORK CONNECTIONS
DRAWING NUMBER
FA-DRW-001
REV: 0
DATE: 05/15/2024
SYSTEM OVERVIEW
• Addressable Fire Alarm System (NFPA 72 Compliant)
• Distributed Network Architecture
• Class A SLC Loops
• Class A NAC Circuits
• Redundant Fiber Network
• Centralized Monitoring & Control
• Integrated Life Safety Systems
LEGEND
FIBER OPTIC (REDUNDANT RING)
ETHERNET (TCP/IP)
RS-485 / PANEL BUS
SLC LOOP (CLASS A)
NAC CIRCUIT (CLASS A)
FACP – FIRE ALARM CONTROL PANEL
RA REMOTE ANNUNCIATOR
SP SATELLITE PANEL
S SLC DEVICE
HORN / STROBE
SPK SPEAKER
M MANUAL PULL STATION
MM MONITOR MODULE
CM CONTROL MODULE
EOL END OF LINE RESISTOR
NOTES
1. ALL SLC LOOPS ARE CLASS A.
2. ALL NAC CIRCUITS ARE CLASS A.
3. FIBER RING PROVIDES SURVIVABILITY LEVEL 2.
4. EACH FACP SUPERVISES LOCAL LOOPS, NACs AND INTERFACES.
5. ALL PANELS ARE UL 864 10th EDITION LISTED.
FIRE COMMAND CENTER (LEVEL 2)
GRAPHIC WORKSTATION
MAIN FACP #1 PRIMARY
PEER-TO-PEER REDUNDANT
MAIN FACP #2 BACKUP
PRINTER
ANNUNCIATOR (REMOTE)
ETHERNET TCP/IP NETWORK
REDUNDANT FIBER OPTIC RING (SURVIVABILITY LEVEL 2)
TOWER A FLOORS 1–45
FACP-A1 (LEVEL 3)
TOWER B FLOORS 1–45
FACP-B1 (LEVEL 3)
PODIUM FLOORS P1–P6
FACP-P1 (LEVEL 2)
PARKING GARAGE LEVELS B1–B4
FACP-G1 (LEVEL B1)
SLC LOOPS (CLASS A)
LOOP 1
LOOP N (TYP.)
NAC CIRCUITS (CLASS A)
NAC 1
NAC N (TYP.)
EOL
I/O & INTERFACES
MM CM MM
• SUPPRESSION
• HVAC / SMOKE CONTROL
• ELEVATOR RECALL
• FIRE PUMP / JOCKEY PUMP
• GENERATOR / ATS
• DOOR RELEASE
• FIRE COMMAND CENTER
• BMS / BAS INTERFACE
SYSTEM STATISTICS
TOTAL FLOORS 45 (2 TOWERS)
TOTAL AREA ~2.3 MILLION SQ FT
TOTAL FACPs 4
TOTAL SLC LOOPS 96
TOTAL NAC CIRCUITS 128
TOTAL DEVICES (EST.) 18,500+
NETWORK ARCHITECTURE FIBER RING
SURVIVABILITY LEVEL 2
SYSTEM FEATURES
RELIABLE & REDUNDANT
DISTRIBUTED INTELLIGENCE
FAST ALARM DETECTION
CLEAR VOICE EVACUATION
INTEGRATED SMOKE CONTROL
EMERGENCY POWERED
CODE COMPLIANT (NFPA 72)
EASY MAINTENANCE
CYBERSECURE NETWORK
INTEGRATED LIFE SAFETY SYSTEMS
SPRINKLER SYSTEM
SMOKE CONTROL SYSTEM
ELEVATOR RECALL
EMERGENCY COMMUNICATION
VOICE EVAC SYSTEM
EMERGENCY POWER
DOOR RELEASE SYSTEM
BMS / BAS INTEGRATION
SKYLINE TOWER COMPLEX
FIRE ALARM & LIFE SAFETY SYSTEM
SYSTEM ARCHITECTURE
DRAWN BY: AEG
CHECKED BY: AEG
APPROVED BY: AEG
SCALE: N.T.S.
SHEET: 1 OF 1

Abbreviations and Acronyms

Abbreviation	Full Term
AHJ	Authority Having Jurisdiction
FACP	Fire Alarm Control Panel (also FACU — Fire Alarm Control Unit)
NAC	Notification Appliance Circuit
IDC	Initiating Device Circuit
SLC	Signaling Line Circuit
NFPA	National Fire Protection Association
NEC	National Electrical Code (NFPA 70)
ADA	Americans with Disabilities Act
IBC	International Building Code
IFC	International Fire Code
EVACS	Emergency Voice/Alarm Communication System
ECS	Emergency Communications System (NFPA 72 Chapter 24)
ITM	Inspection, Testing, and Maintenance
DACT	Digital Alarm Communicator Transmitter
MNS	Mass Notification System
PLFA	Power-Limited Fire Alarm (NEC Article 760)
NPLFA	Non-Power-Limited Fire Alarm (NEC Article 760)
UL	Underwriters Laboratories
FM	FM Approvals (Factory Mutual)
STI	Speech Transmission Index

Chapter 1. Introduction to Fire Alarm Codes and Standards

Fire alarm systems are a critical component of building safety infrastructure. They are not only essential for life safety and property protection, but also highly regulated by a series of codes and standards to ensure uniformity, reliability, and legal compliance.

A. Why Codes and Standards Matter

Codes define when and where fire alarm systems are required, while standards describe how the systems should be designed, installed, tested, and maintained. These documents ensure that fire alarm systems function correctly in an emergency, minimizing injury, loss of life, and property damage.

B. Codes That Determine Applicability

These codes establish whether a fire alarm system is required for a given occupancy type or building:

- **International Building Code (IBC):** Defines the need for fire alarm systems based on occupancy classification, construction type, and height.
- **NFPA 101 — Life Safety Code:** Focuses on building egress, occupancy, and life-protection systems.
- **NFPA 5000 — Building Construction and Safety Code:** Includes requirements similar to the IBC but published by NFPA.
- **State and Local Building Codes:** May amend or expand national model codes to reflect regional risks or policy decisions.

C. Codes and Standards for System Implementation

Once a fire alarm system is required, these standards dictate how it must be installed and operated:

- **NFPA 72 — National Fire Alarm and Signaling Code:** The primary standard for the design, installation, testing, and maintenance of fire alarm systems.
- **NFPA 70 — National Electrical Code (NEC):** Governs electrical wiring and power-supply requirements for fire alarm systems, particularly in Article 760.
- **International Fire Code (IFC) and NFPA 1 (Fire Code):** Adopted by many jurisdictions; also incorporates portions of NFPA 72 by reference for ongoing fire-prevention enforcement.

D. Understanding Code Hierarchy

- **Model Codes (IBC, NFPA 101):** Determine the need based on occupancy.
- **System Codes (NFPA 72, NFPA 70):** Provide technical requirements once a system is deemed necessary.
- **Authority Having Jurisdiction (AHJ):** Enforces the codes and may interpret or modify requirements based on local needs.

In training and practice, it is critical to consult the most current edition of each code and to understand how they interrelate. Fire-protection professionals must stay up-to-date with code revisions, enforcement changes, and emerging technologies referenced in these standards.

E. Structure of NFPA 72

NFPA 72, the National Fire Alarm and Signaling Code, is a comprehensive standard that outlines the requirements for fire detection, signaling, and emergency communication systems. It is structured to guide professionals through every phase of a system's life cycle — from design to installation, testing, and maintenance.

Why understanding the structure matters

Navigating NFPA 72 effectively ensures code compliance and helps professionals locate the specific rules that apply to their system type or situation. Whether you are designing a new system, troubleshooting an existing one, or performing routine inspections, knowing how NFPA 72 is organized allows you to apply the right section of the code with confidence.

Chapter group breakdown (NFPA 72-2022)

NFPA 72 is divided into the following logical groups:

1. Guiding chapters — foundational context and definitions used throughout the document:

- **Chapter 1 — Administration:** Scope, purpose, and enforcement.
- **Chapter 2 — Referenced Publications:** List of related codes and standards.
- **Chapter 3 — Definitions:** Key terms and concepts used in the code.

2. Foundation chapters — general principles applicable to all fire alarm systems:

- **Chapter 7 — Documentation:** Owner-furnished records, design drawings, sequence of operations, and as-built documentation.
- **Chapter 10 — Fundamentals:** Core system functions, signal types, power supplies, and general system requirements. (In NFPA 72-2022 this is Chapter 10 — Fundamentals; power-supply requirements live inside it, not in a separate chapter.)
- **Chapter 12 — Circuits and Pathways:** Circuit classes, performance criteria, pathway designations, and wiring methods.
- **Chapter 14 — Inspection, Testing, and Maintenance (ITM):** Procedures and frequencies for inspection, testing, and maintenance.
- **Chapter 17 — Initiating Devices:** Requirements for detectors and manual stations.
- **Chapter 18 — Notification Appliances:** Audible, visual, tactile, and textual signaling devices.

3. System-specific chapters — specialized system configurations and functions:

- **Chapter 21 — Emergency Control Functions and Interfaces:** Interface with building systems (HVAC, elevators, smoke control, door release).

- **Chapter 23 — Protected Premises Fire Alarm and Signaling Systems:** Systems for individual buildings.
- **Chapter 24 — Emergency Communications Systems (ECS):** Mass notification, voice evacuation, in-building two-way emergency communication, and area-of-refuge stations.
- **Chapter 26 — Supervising Station Alarm Systems:** Monitoring service configurations.
- **Chapter 27 — Public Emergency Alarm Reporting Systems:** Municipal alarm infrastructure.
- **Chapter 29 — Single- and Multiple-Station Alarms and Household Signaling Systems:** Residential applications.

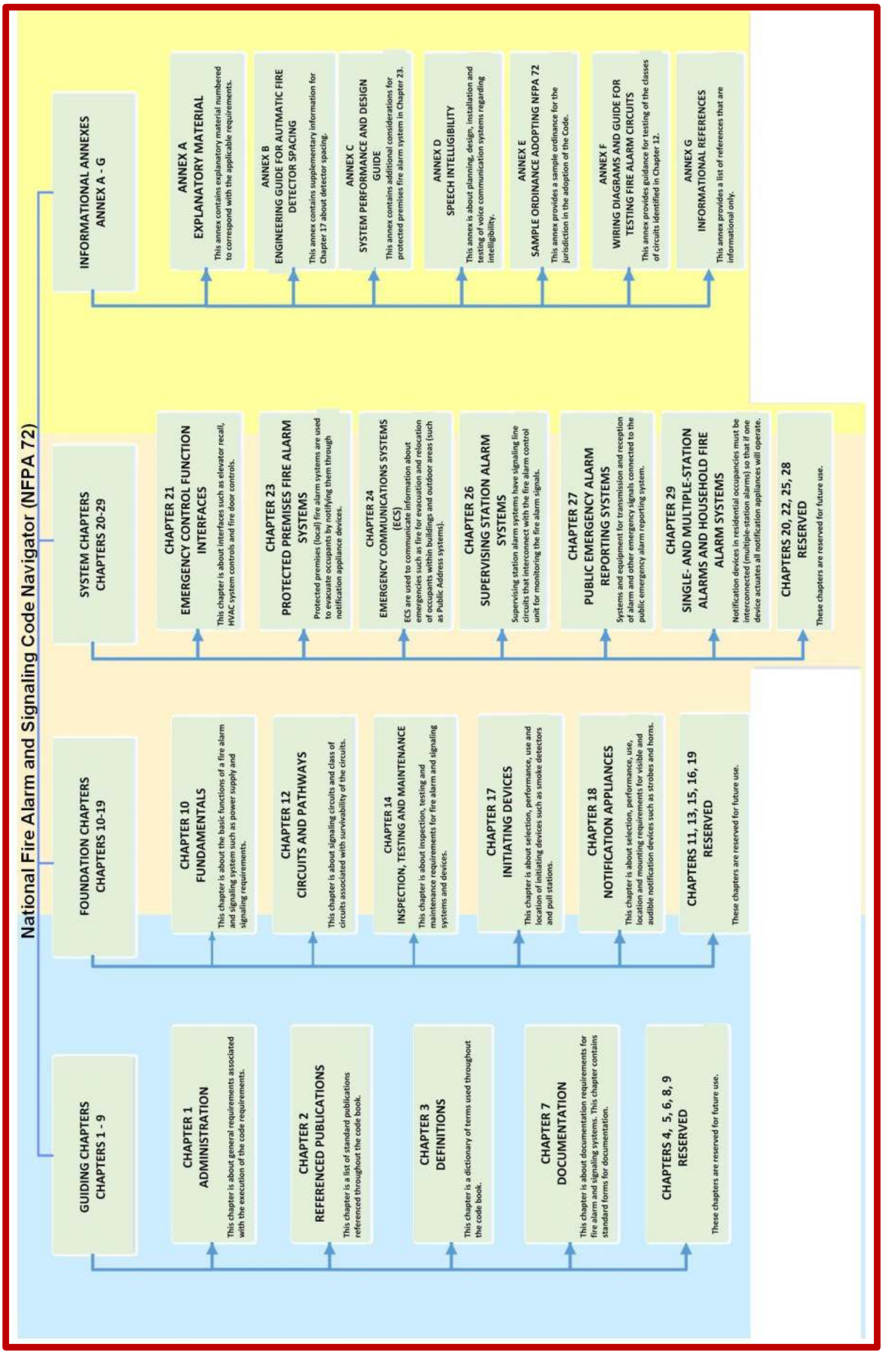


Figure 1. National Fire Alarm Code and Signaling (NFPA 72) Book Chapter Organization

4. Informational annexes — additional guidance, not mandatory unless specifically referenced:

- **Annex A:** Explanatory material — interpretations and examples.
- **Annex B:** Engineering guide for automatic fire detector spacing.
- **Annex C:** Performance-based design.
- **Annex D:** Speech intelligibility.
- **Annex E:** Sample ordinance language.
- **Annex F:** Wiring diagrams and examples.
- **Annex G:** Guidelines for emergency communication strategies.
- **Annex H:** Informational references.

Tips for using NFPA 72 effectively

- Use the table of contents and index in the codebook to locate specific topics.
- Reference Annex A for explanations of complex rules.
- Always check the latest edition adopted by your local jurisdiction.
- Consult the AHJ when in doubt.

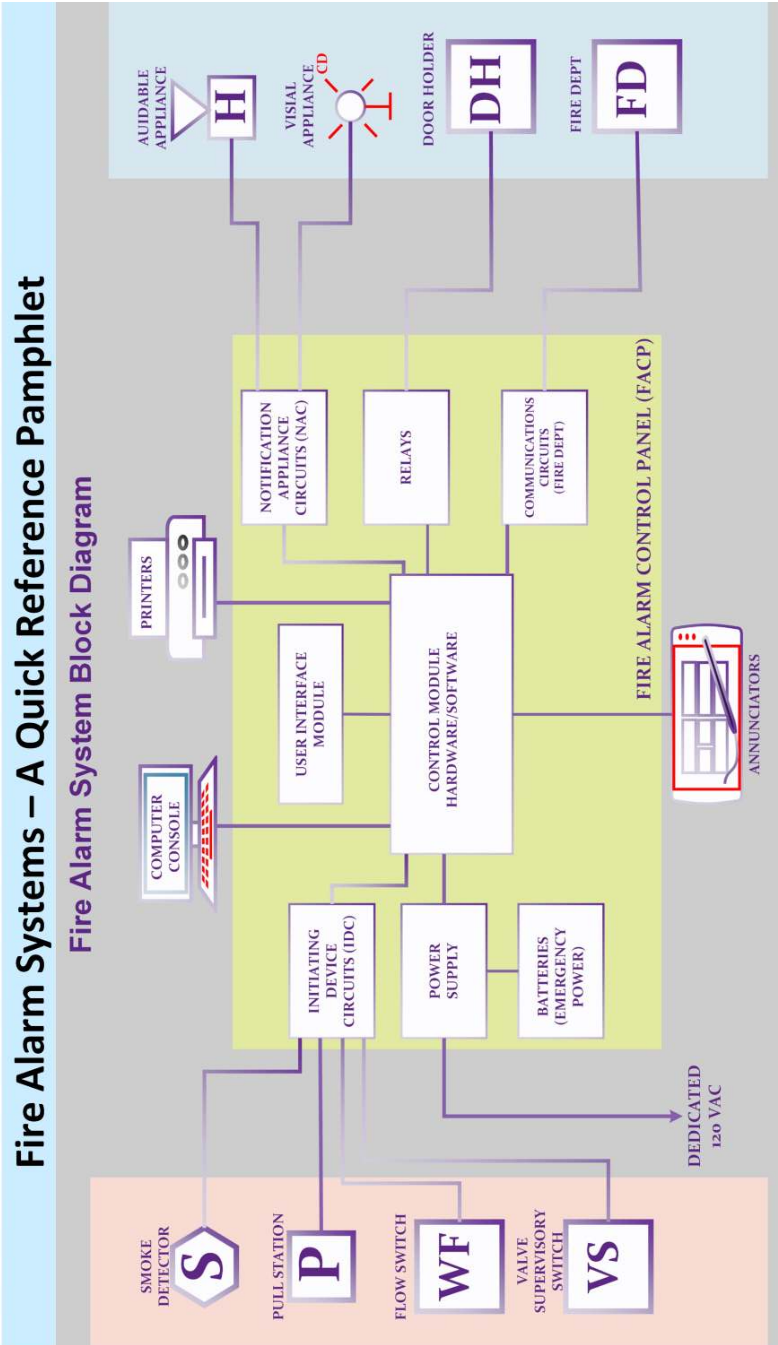


Figure 2. Fire Alarm Systems Block Diagram

Chapter 2. Purpose and Components of Fire Alarm Systems

Fire alarm systems are vital for protecting life, property, and business continuity. They serve as a proactive safety measure by detecting fire conditions early, notifying occupants and emergency responders, and controlling building systems to reduce the spread of fire and smoke.

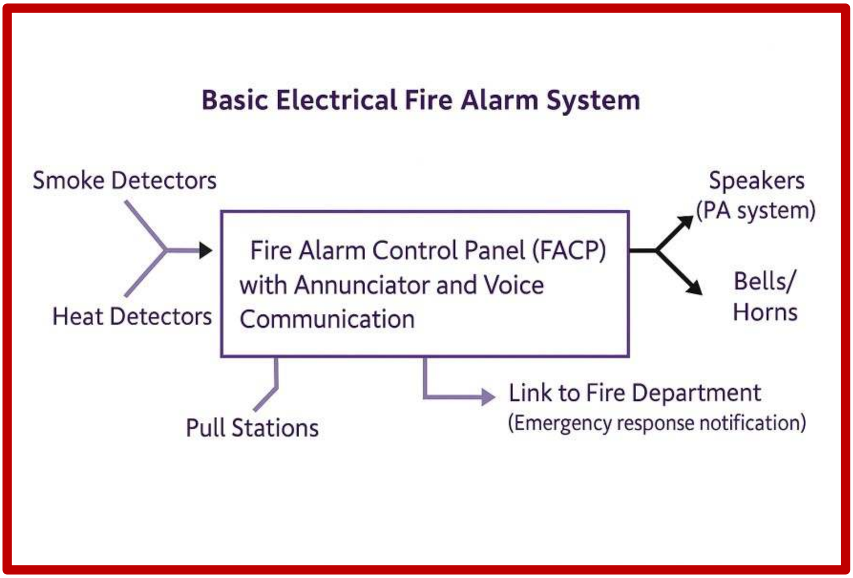


Figure 3. Basic electrical fire alarm system showing the flow of signals from input devices (detectors and pull stations) to the FACP and then to notification appliances and emergency responders.

A. Primary Purposes of Fire Alarm Systems

1. **Life Safety Protection.** The foremost objective is to alert occupants to evacuate safely in the event of fire or smoke. Audible and visual signals ensure timely notification, especially in large or multi-story buildings.
2. **Property Protection.** Early detection helps minimize structural damage by enabling a quicker response from fire departments or automatic suppression systems.

3. **Operational Protection.** By integrating with HVAC, elevator systems, and power systems, fire alarm systems limit operational disruptions and reduce equipment loss.
4. **Environmental Protection.** In sensitive facilities like laboratories or data centers, fire alarm systems help prevent the release of hazardous substances into the environment.
5. **Historical Preservation.** In heritage buildings, early fire detection systems help preserve irreplaceable architectural and cultural artifacts.

B. Core Components of a Fire Alarm System

A typical fire alarm system consists of the following:

- **Fire Alarm Control Panel (FACP / FACU):** The central hub of the system. It receives input signals from detectors and manual stations and sends output signals to notification and control devices.
- **Annunciators:** Remote display panels that provide system status and help first responders quickly locate the source of the alarm.
- **Manual Pull Stations:** Installed at exits and along evacuation routes, these allow occupants to manually initiate an alarm in case of fire.
- **Automatic Fire Detectors:** Includes smoke detectors (photoelectric, ionization, or multi-criteria), heat detectors (fixed-temperature or rate-of-rise), and gas detectors. These detect fire conditions without human intervention.
- **Notification Appliances:** Devices that alert occupants through audio (horns, bells, speakers) and visual (strobes, flashing lights) signals. They are distributed throughout a building to ensure full coverage.
- **Power Supplies:** Primary power typically comes from the building's electrical system, while secondary (backup) power is supplied by sealed lead-acid batteries or a UL-listed generator to ensure system operation during outages.
- **Interface (Relay / Control) Modules:** Allow the fire alarm system to connect with and control other building systems such as door locks, elevators, ventilation, and suppression systems.

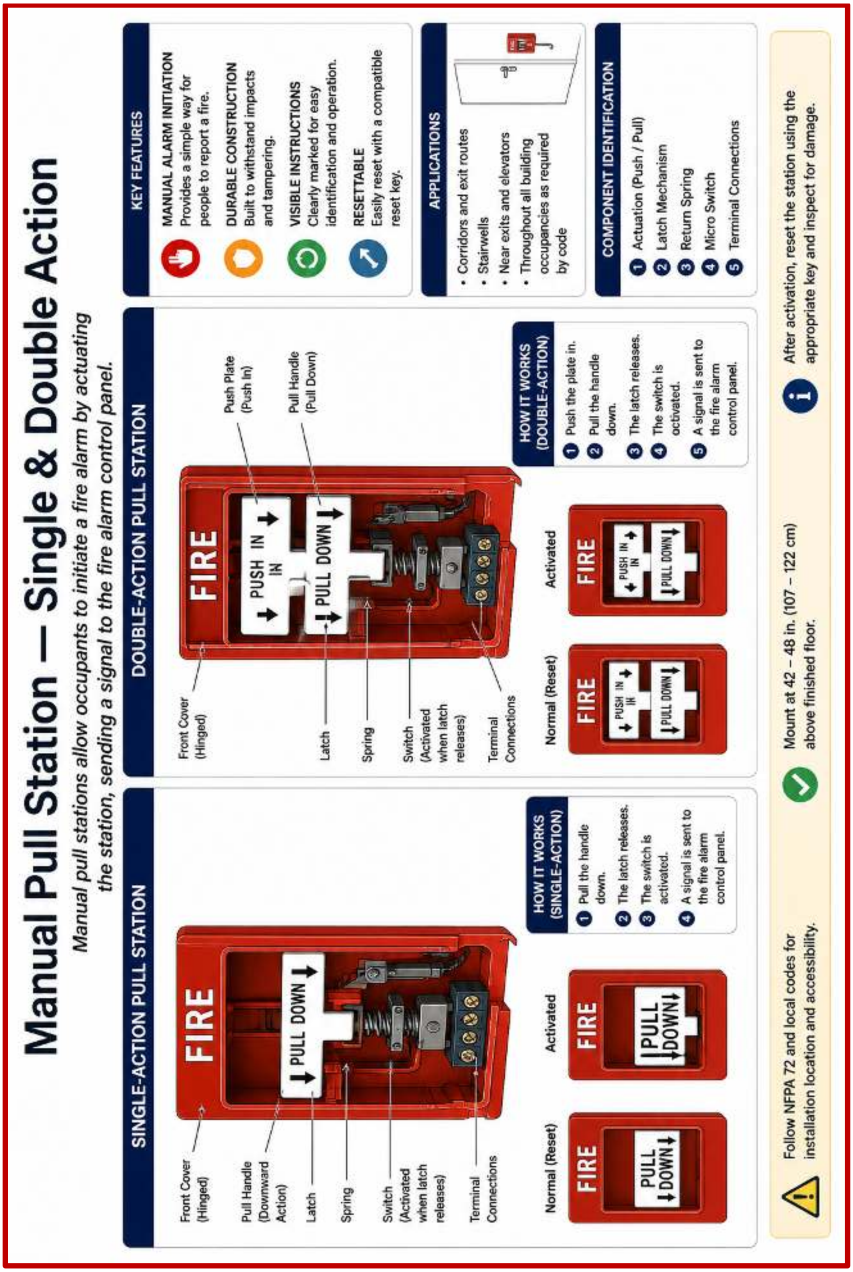


Figure 4. Manual Pull Station – Single and Double Action

This layered combination of detection, notification, and control ensures comprehensive protection and aligns with national codes and standards.

Chapter 3. Fire Alarm System Types and Communication Methods

Fire alarm systems can be configured in various ways depending on the building size, occupancy type, monitoring requirements, and emergency-response integration. Understanding these system types is essential for selecting the right solution for any facility.

A. Local Fire Alarm Systems

- Provide notification only within the premises.
- Not connected to emergency responders or external monitoring stations.
- Typically include manual pull stations, smoke/heat detectors, and local notification appliances (horns, strobes).
- Ideal for small facilities where internal evacuation is the primary goal.

B. Auxiliary Fire Alarm Systems

- Similar to local systems but with the added capability to signal a municipal alarm center.
- Automatically alerts the fire department when activated.
- Uses shared infrastructure with the municipality but is independently operated.

C. Remote Station Fire Alarm Systems

- Signals are sent to a remote, continuously staffed station via phone line, radio, or IP connection.
- Often monitored by a fire department or third-party monitoring company.
- Supervision and reliability are critical; uses approved transmission methods such as cellular communicators, IP communicators, or radio links. (The traditional digital alarm communicator transmitter (DACT)

using two POTS lines remains in service but is increasingly replaced by sole-path cellular and IP communicators that are listed for this purpose.)

D. Proprietary Fire Alarm Systems

- Used by large organizations with multiple buildings on a single site.
- Operated by a 24/7 in-house supervising station that handles system monitoring and internal response.
- Designed for corporate campuses, universities, or industrial facilities.

E. Central Station Fire Alarm Systems

- Monitored by a third-party company offering alarm services for a fee.
- Includes system maintenance, supervision, and immediate communication with emergency services.
- Must comply with NFPA 72 and the central station's UL 827/UL 864 listings for staffing, equipment, and response time.

F. Emergency Voice/Alarm Communication Systems (EVACS) and ECS

- EVACS is a subsystem designed to provide voice instructions to building occupants.
- Can be standalone or integrated with the fire alarm system.
- Must support 24 hours of standby operation and 15 minutes of alarm operation on secondary power (NFPA 72 §24.3.3 and §10.6).
- Useful for high-occupancy or complex buildings where voice guidance improves evacuation efficiency.

> **Reviewer's Update —** *Since the 2010 edition, NFPA 72 has used the broader term Emergency Communications Systems (ECS, Chapter 24) to encompass in-building fire EVACS, mass notification systems (MNS), area-of-refuge two-way communication, and similar systems. EVACS is one application within the ECS umbrella. Many AHJs and consulting engineers still use EVACS interchangeably, but specifications should reference the ECS chapter when applicable.*

G. Communication Methods Across Systems

- **PSTN (Public Switched Telephone Network):** Used in remote and central station systems, often via DACT. Increasingly being phased out by AT&T and Verizon as POTS lines are retired; many AHJs now require redundant cellular + IP in lieu of two POTS lines.
- **Radio Frequency (RF) Transmission:** Often used where phone lines are unreliable; must use a listed radio transmitter or cellular communicator.
- **IP-Based Communication:** Increasingly common in modern systems for fast, redundant data transmission. Sole-path IP communicators must comply with the supervision requirements of NFPA 72 §26.6.
- **Cellular Communicators:** Listed cellular communicators provide reliable transmission and are commonly used as the primary path or as a redundant backup to an IP path.

Chapter 4. Fire Alarm Signal Types

Fire alarm systems use various signal types to indicate different kinds of events or conditions. Recognizing these signals helps building staff, emergency responders, and technicians understand what action is required — whether immediate evacuation, investigation, or maintenance.

A. Alarm Signals

- **Definition:** Indicate the presence of a fire or life-threatening condition.
- **Purpose:** Notify building occupants of the need to evacuate and alert emergency personnel.
- **Trigger Sources:** Smoke detectors, heat detectors, manual pull stations, sprinkler waterflow switches.
- **Action Required:** Immediate evacuation and emergency-response activation.

B. Supervisory Signals

- **Definition:** Indicate that a component of a fire-protection system is in an off-normal condition, but not a fire.
- **Examples:** A closed sprinkler control valve, fire pump in 'Off' mode, low air pressure on a dry-pipe system, or a tamper switch activated.
- **Purpose:** Alert personnel to check systems that are expected to be in a normal, ready state.
- **Action Required:** Investigation by qualified personnel to restore proper system status.

C. Trouble Signals

- **Definition:** Indicate a fault or abnormality in the fire-alarm system that could compromise its function.
- **Common Causes:** Low battery voltage, loss of AC power, open or shorted wiring, ground fault, disconnected device, or communications failure.

- **Purpose:** Ensure that fire-alarm systems remain fully operational and alert personnel when a portion of the system is impaired.
- **Action Required:** Prompt service or maintenance by a qualified technician.

D. Visual and Audible Distinction

- Alarm, supervisory, and trouble signals must each have distinct indicator lights, audible tones, and annunciator messages.
- NFPA 72 requires that signal types be clearly distinguishable to avoid confusion.
- Per NFPA 72 §10.10, the alarm signal must take precedence over supervisory, which takes precedence over trouble.

E. Why Signal Differentiation Matters

- Enables appropriate responses — evacuation versus inspection versus service call.
- Reduces unnecessary panic and so-called nuisance evacuations triggered by mis-interpreted trouble conditions.
- Helps facility managers maintain code compliance and system health.

Chapter 5. Alarm Initiating Devices

Alarm initiating devices are the first line of detection in a fire alarm system. These components either sense a fire condition automatically or allow building occupants to manually report a fire. Once activated, they send a signal to the FACP, which then initiates alarms and other emergency responses.

A. Categories of Initiating Devices

1. Manual initiating devices

- **Manual Pull Stations:** Installed at exits and in corridors, these devices allow occupants to manually trigger an alarm. They are essential for human detection in areas not covered by automatic devices.
- **Operation:** Requires the user to pull or press to activate; resets with a key or tool. Single-action stations are most common; double-action stations (lift cover, then pull) are used where unintentional activation is a concern.

2. Automatic initiating devices

These detect fire-related phenomena such as smoke, heat, flame, or gas and activate the alarm system without human involvement.

Smoke Detectors:

- **Photoelectric:** Detect smoke using a light source and photo sensor; best for smoldering fires. Recommended for most residential and commercial applications.
- **Ionization:** Detect smoke particles by their effect on ionized air from a small Americium-241 source; faster on fast-flaming fires. Photoelectric is generally preferred in residential occupancies (see Reviewer's Update below).
- **Duct Smoke Detectors:** Sample air drawn from an HVAC duct to detect smoke being transported through the air-handling system;

required to be supervised separately and to initiate appropriate HVAC shutdown (NFPA 90A and NFPA 72 §17.7).

- **Multi-Criteria / Dual-Sensor:** Combine two or more sensing technologies (e.g., photoelectric + heat + CO) for fewer nuisance alarms and faster detection. Increasingly common for residential and high-value commercial installations.

> **Reviewer's Update —** *UL 217 9th Edition (effective June 2022 for new listings) requires smoke alarms to meet revised performance criteria including a polyurethane-foam (flaming) and a smoldering-fire test, while also rejecting cooking nuisance sources. The practical effect is that ionization-only residential smoke alarms can no longer meet the standard; new residential alarms are photoelectric or multi-criteria. NFPA 72 (2022) §29.7 and §29.8 reflect these requirements.*

Heat Detectors:

- **Fixed Temperature:** Activate when the ambient temperature exceeds a set point (e.g., 135 °F / 57 °C ordinary, 200 °F / 93 °C intermediate, 325 °F / 163 °C high temperature).
- **Rate-of-Rise:** Activate when temperature increases rapidly (typically 15 °F per minute), even if a fixed threshold has not been reached.
- **Linear Heat Detection (Wire):** A continuous wire-type sensor that detects heat at any point along its length; used in tunnels, cable trays, and warehouse racks.

Flame Detectors: detect infrared (IR), ultraviolet (UV), or combined IR/UV radiation from flames; used in high-risk or industrial environments such as petrochemical plants and aircraft hangars.

Gas Detectors: detect combustible (LEL) or toxic gases that may be fire precursors. Carbon monoxide alarms are addressed in the box below.

Waterflow Switches: installed in sprinkler risers and on individual floor control assemblies to detect water movement (indicative of sprinkler activation). Typically include a 30–90 second pneumatic or electronic retard timer to filter out surges and water-pressure transients.

Carbon monoxide detection (new in this edition)

Although carbon monoxide alarms are not strictly a fire-detection function, modern codes consolidate CO detection within the fire-alarm framework:

- NFPA 720 was withdrawn in 2020 and its content was integrated into NFPA 72.
- IBC §915 requires CO alarms or detection in new and renovated Group R occupancies and in classrooms when there is a fuel-burning appliance, attached garage, or shared mechanical space.
- Listed CO detectors that connect to the FACP must provide a distinctive temporal 4 pattern audible signal — four pulses, pause, four pulses — that is different from the temporal 3 fire pattern.
- CO sensors are typically replaced on a 5- to 10-year cycle depending on the listing; the manufacturer's date code is the controlling reference.

B. Location and Spacing

Placement of initiating devices must comply with NFPA 72 §17, which specifies minimum and maximum distances for each device type. Common reference values (always verify against the listing and the AHJ):

- Spot-type smoke detectors: typical maximum 30 ft × 30 ft (≈ 900 ft^2) on smooth, level ceilings 10 ft or less high, with reductions for higher ceilings, beams, joists, and high-velocity airflow.
- Spot-type heat detectors: typical maximum 50 ft × 50 ft listing spacing, again with adjustment for ceiling height and obstructions.
- Detectors should be placed in every room, hallway, storage area, mechanical space, attic, and concealed ceiling void where applicable, unless excluded by NFPA 72 §17.7.
- Detectors must be kept at least 36 in. (914 mm) away from supply air diffusers per NFPA 72 §17.7.3.2.3.4.

C. Supervision and Testing

- Initiating devices must be electrically supervised to detect wiring faults (open, short, and ground).

- Routine functional testing is required: NFPA 72 Table 14.4.5 specifies monthly, quarterly, semi-annual, annual, and (for some devices) longer intervals.
- Sensitivity testing of smoke detectors is required at 1 year after installation and at intervals not exceeding alternate years thereafter, unless laser-based analysis or self-test functions are listed equivalents.

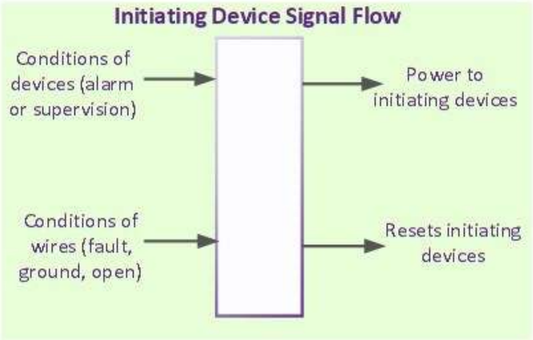


Figure 5. Initiating Device Signal Flow — diagram showing the electrical signal path and communication functions of initiating devices, including power delivery, fault detection, device status signaling, and reset capability.

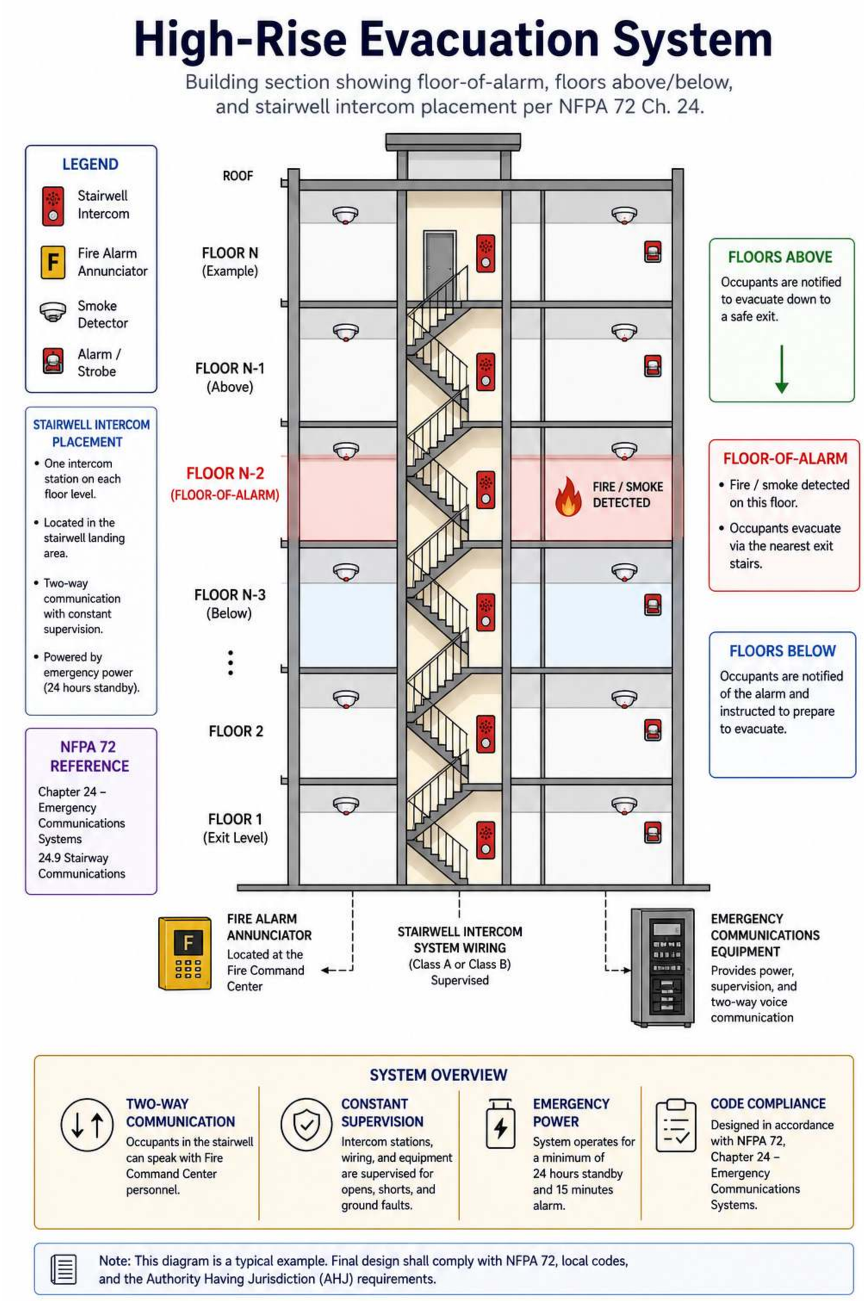


Figure 6 High-Rise Evacuation System

Chapter 6. Supervisory Initiating Devices

Supervisory initiating devices are designed to monitor the readiness and operational status of fire-suppression systems and other critical fire-protection infrastructure. These devices do not detect fire directly but indicate that a system essential to fire safety is in an off-normal condition — a state that could impair system performance in a fire event.

Their role is to provide early warning when a suppression system may not function as intended, allowing time for correction before an emergency arises.

A. What Supervisory Devices Monitor

6. **Control Valves (Sprinkler Systems).** Supervisory switches on control valves detect if the valve is closed or partially closed when it should be open. If a valve is left closed, water will not reach the sprinklers during a fire, rendering the system ineffective.
7. **Fire Pump Status.** Monitors whether the pump is in the correct mode (usually 'Auto'), detects loss of power, pump-on-running, and phase reversal per NFPA 20.
8. **Tank Water Levels.** Float switches or level sensors ensure water storage tanks maintain required levels. Low or high levels may impair system pressure or operation.
9. **Air or Water Pressure.** In dry-pipe or pre-action sprinkler systems, supervisory pressure switches ensure air or nitrogen pressure remains within limits. For wet systems, pressure monitoring helps maintain readiness.
10. **Room Temperature Monitoring.** Ensures rooms containing wet sprinkler pipes (attics, mechanical spaces) are not at risk of freezing. Low-temperature alarms are typically set for 40 °F (4 °C).
11. **Valve Tamper Switches.** Indicate if someone has tampered with or unintentionally altered a valve's position. Helps prevent sabotage or accidental deactivation.

B. Types of Systems Using Supervisory Devices

- Wet-pipe sprinkler systems
- Dry-pipe sprinkler systems
- Pre-action sprinkler systems
- Deluge systems
- Water-mist systems
- Gaseous fire-suppression systems (CO_2, FM-200/HFC-227ea, FK-5-1-12/Novec, IG-541/Inergen)
- Foam systems
- Kitchen and industrial chemical-suppression systems (UL 300 hood systems)

C. Signal Handling

- Supervisory signals are non-alarm signals but still require investigation.
- When triggered, they notify personnel via annunciators, FACP indicators, or remote monitoring centers.
- They are usually time-sensitive; failure to correct the condition may result in system failure during a fire.
- Supervisory signals must be transmitted to a constantly attended location or supervising station (NFPA 72 §23.8.4.1) within 90 seconds.

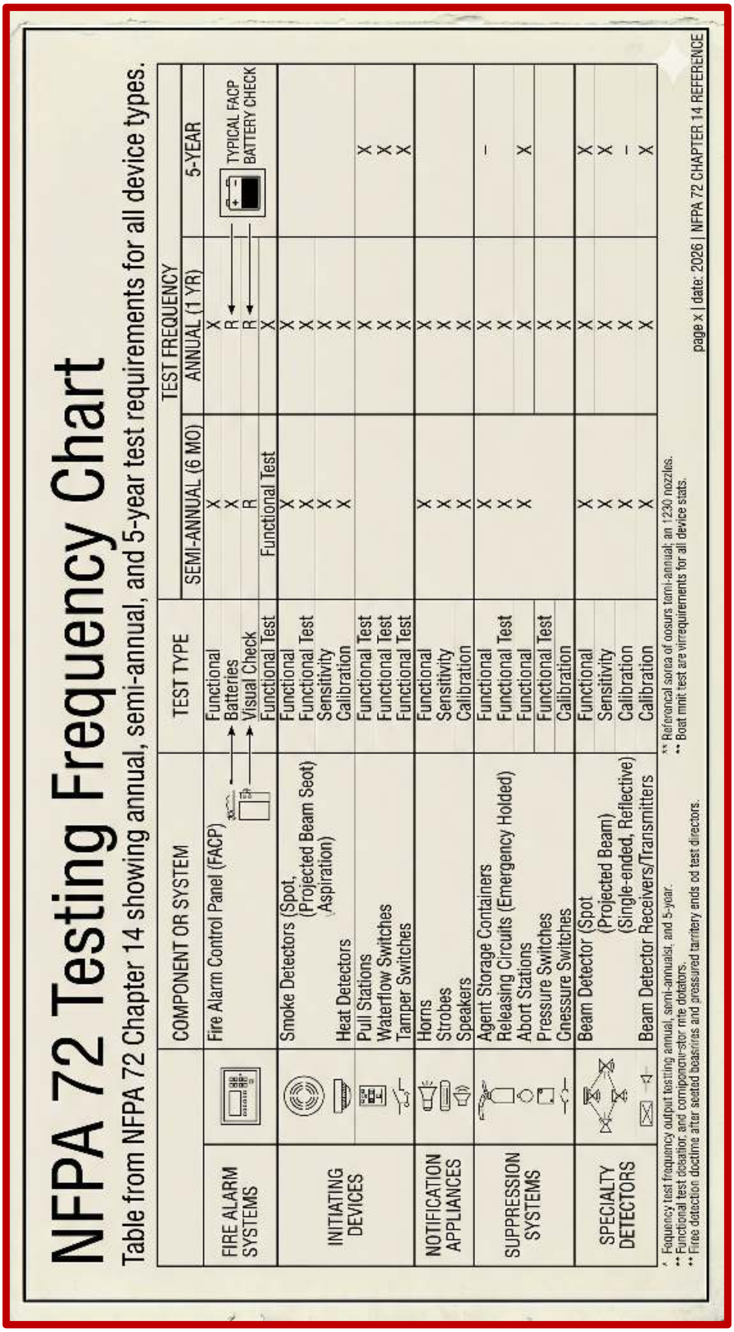

NFPA 72 Testing Frequency Chart

Table from NFPA 72 Chapter 14 showing annual, semi-annual, and 5-year test requirements for all device types.

	COMPONENT OR SYSTEM	TEST TYPE	TEST FREQUENCY: SEMI-ANNUAL (6 MO)	ANNUAL (1 YR)	5-YEAR
FIRE ALARM SYSTEMS	Fire Alarm Control Panel (FACP)	Functional	X	X	TYPICAL FACP BATTERY CHECK
		Batteries	X	R	
		Visual Check	R	R	
		Functional Test	Functional Test	X	
INITIATING DEVICES	Smoke Detectors (Spot,	Functional	X	X	
	(Projected Beam Seot)	Functional Test	X	X	
	(Aspiration)	Sensitivity	X	X	
	Heat Detectors	Calibration	X	X	
	Pull Stations	Functional Test		X	X
	Waterflow Switches	Functional Test		X	X
	Tamper Switches	Functional Test		X	X
NOTIFICATION APPLIANCES	Horns	Functional	X	X	
	Strobes	Sensitivity	X	X	
	Speakers	Calibration	X	X	
SUPPRESSION SYSTEMS	Agent Storage Containers	Functional	X	X	–
	Releasing Circuits (Emergency Holded)	Functional Test	X	X	
	Abort Stations	Functional	X	X	X
	Pressure Switches	Functional Test		X	
	Cnessure Switches	Calibration		X	
SPECIALTY DETECTORS	Beam Detector (Spot	Functional	X	X	X
	(Projected Beam)	Sensitivity	X	X	X
	(Single-ended, Reflective)	Calibration	X	X	–
	Beam Detector Receivers/Transmitters	Calibration	X	X	X

* Fequency test frequency output testing annual, semi-annualst, and 5-year.
** Functional test doeatior, and corriponcnr-stor rite dotators.
** Firee detection doctime after seeted beasiiras and pressured tarritery ends od test directors.
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Figure 7. NFPA 72 Testing Frequency Chart

Chapter 7. Notification Appliances

Notification appliances are the components of a fire-alarm system that alert building occupants to a fire or other emergency. They use audible, visual, or voice communication to ensure that people in the building are aware of the need to evacuate or take other protective action.

These devices must be properly located, powered, and maintained to meet the requirements of NFPA 72 and ensure that signals are perceived clearly by all occupants, including those with disabilities.

A. Types of Notification Appliances

1. Audible appliances

- **Horns, Bells, and Sirens:** Produce a loud tone or sound pattern to indicate alarm. The standard fire-alarm pattern is temporal-three (three half-second on, half-second off pulses, repeating).
- **Speakers (Voice Notification):** Used to deliver pre-recorded or live voice-evacuation instructions, often replacing horns in larger or higher-risk occupancies.

Performance requirements (NFPA 72 §18.4):

- Sound must be at least 15 dBA above the average ambient sound level, or 5 dBA above the maximum sound level lasting 60 seconds (whichever is greater), measured 5 ft above the floor.
- Minimum public-mode sound pressure: 75 dBA at 10 ft.
- Minimum private-mode sound pressure: 45 dBA at 10 ft.
- Maximum sound pressure at the minimum hearing distance: 110 dBA.
- No location occupants can normally access may exceed 120 dBA.
- In sleeping areas, the signal at the pillow must be at least 75 dBA, and a 520-Hz low-frequency square-wave signal is required for new installations in sleeping rooms (NFPA 72 §18.4.5.3 and §29.3.8 for households).

2. Visual appliances

- Strobes and flashing lights emit high-intensity light pulses to alert individuals who are deaf or hard of hearing.
- Strobes must flash at 1 Hz minimum, 2 Hz maximum.
- Strobes within the same field of view must be synchronized — NFPA 72 §18.5.5.6.1 requires synchronization when more than two appliances are in a field of view, to prevent the risk of photosensitive seizures.
- Candela rating, mounting height, and spacing are determined by room size per the wall- and ceiling-mounted tables in NFPA 72 §18.5.5.4 (typical wall-mount values: 15 cd for 20 × 20 ft rooms up to 185 cd for 70 × 70 ft rooms).
- Strobes are required in restrooms, lobbies, corridors, meeting rooms, and other common-use areas where ADA accessibility applies.

3. Voice evacuation systems (EVACS)

- Provide detailed spoken instructions, especially useful in high-rise buildings, schools, hospitals, and assembly occupancies.
- Can direct occupants to specific exits or shelter-in-place zones.
- Integrated with the fire-alarm system and often shared with the building public-address system.
- Speech intelligibility must be verified per NFPA 72 §18.4.10 and Annex D, with a minimum Common Intelligibility Scale (CIS) score of 0.70 or a Speech Transmission Index (STI) of 0.45 in each acoustically distinguishable space (ADS).

B. Special Considerations for Accessibility

- Appliances must comply with the ADA Standards for Accessible Design and ICC A117.1.
- Combined audible/visual devices are required in many occupancies to accommodate all individuals.
- Placement in restrooms, sleeping rooms, and areas of refuge is particularly important.

C. Power and Circuit Requirements

- Notification Appliance Circuits (NACs) must be designed per NFPA 70 Article 760 and NFPA 72 §10.6, §12.3.
- Conductor size is determined by voltage-drop and current-carrying calculations. Listed power-limited fire-alarm cable (FPL/FPLR/FPLP) is permitted in 12, 14, 16, and 18 AWG sizes; 14 AWG is a common practical minimum for NAC trunks, but 18 AWG is often sufficient for short branch runs to individual appliances.
- Appliances must function on secondary (battery) power for at least 5 minutes in alarm condition after 24 hours of standby operation for standard fire-alarm systems; EVACS and other ECS require 15 minutes of alarm operation after 24 hours of standby (NFPA 72 §10.6.7).

Chapter 8. Fire Alarm Control Panel (FACP)

The Fire Alarm Control Panel (FACP) — also referred to as the Fire Alarm Control Unit (FACU) — is the central brain of a fire-alarm system. It receives input from initiating devices, processes those signals, and then activates outputs such as notification appliances, emergency control functions, and communication with external monitoring services.

It serves as the primary user interface for monitoring system status, acknowledging events, and troubleshooting.

A. Key Functions of the FACP

12. **Input Monitoring.** Monitors all initiating devices (smoke detectors, pull stations, water-flow switches) for alarms, troubles, and supervisory conditions. Performs continuous electrical supervision to detect open circuits, shorts, or ground faults.
13. **Output Control.** Activates notification appliances (horns, strobes, speakers). Controls auxiliary functions such as elevator recall, HVAC shutdown, or fire-door release.
14. **Status Display and Logging.** Displays system conditions on LED/LCD screens or touch panels. Stores event-history logs that can be retrieved for troubleshooting or compliance audits. NFPA 72 requires a minimum 400-event history log.
15. **Communication.** Sends signals to remote monitoring centers (central, proprietary, or remote stations). Interfaces with EVACS/ECS, building automation systems, and mass-notification systems.
16. **Power Supervision.** Monitors and controls both primary (AC) and secondary (battery) power supplies. Automatically switches to backup power on a primary-power failure, with a maximum 10-second transfer time per NFPA 72.

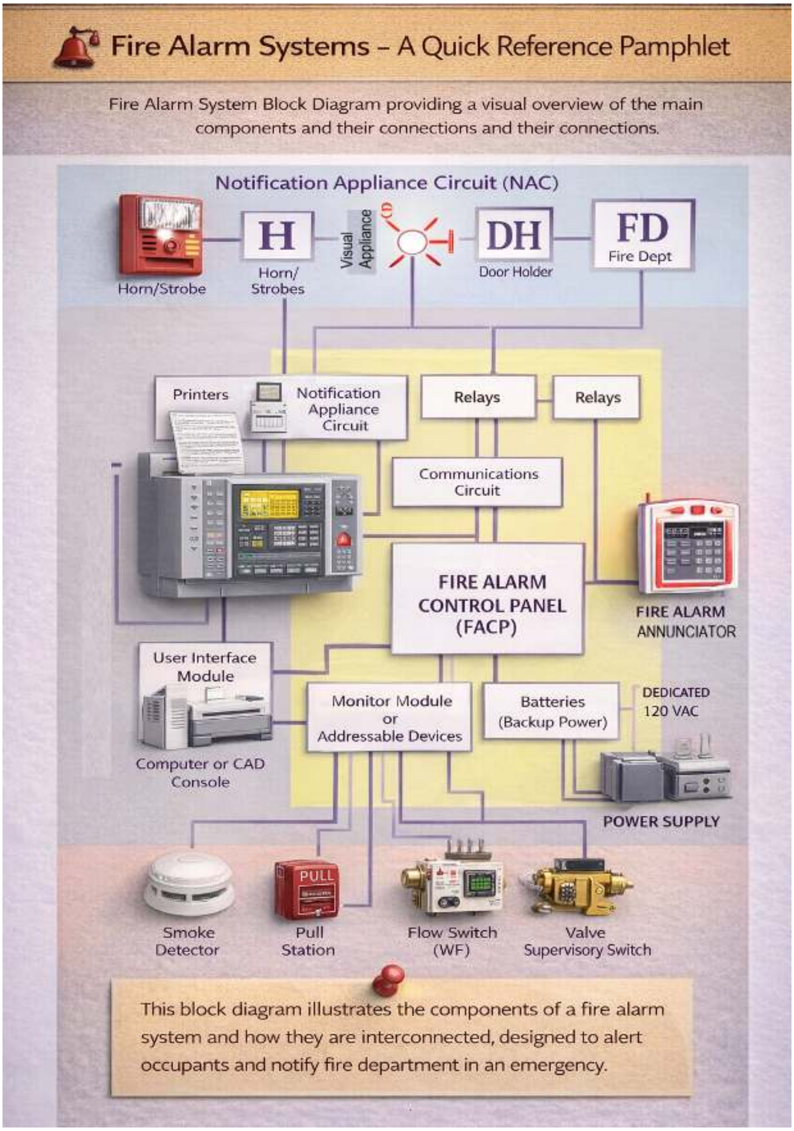

Figure 8. Conventional Fire Alarm System Riser Diagram — typical conventional fire alarm panel connected to multiple zones of initiating devices, notification appliances, power sources, and control interfaces such as relays, mimic panel, and access control systems.

B. Types of Fire Alarm Panels

17. **Conventional Panels.** Use separate wire runs for each initiating device or zone. Indicate alarm by zone but cannot identify the specific device

without manual inspection. Typically used in smaller facilities or retrofits.

18. **Addressable Panels.** Use a Signaling Line Circuit (SLC) that supports up to 99–318 addressable devices on a single pair of wires depending on the manufacturer. Provide specific location information for alarms, troubles, and supervisory signals. Allow advanced features like detector sensitivity adjustment, drift compensation, and group programming.
19. **Hybrid Panels.** Combine both conventional and addressable circuits in one panel. Ideal for buildings with a mix of existing and new infrastructure.
20. **Networked / Voice-Integrated Panels.** Cabinet-based platforms that incorporate the FACP, voice amplifiers, and emergency-communication controls in a coordinated chassis for high-rise, transportation, healthcare, and large-campus applications.

C. User Interface Components

- **Keypad or Touchscreen:** For acknowledging alarms and navigating menus.
- **Indicator LEDs:** For system status — Power (typically green), Alarm (red), Trouble (amber), Supervisory (amber, distinct cadence).
- **Annunciator Panels (Remote):** Provide status information and control at secondary locations, such as building lobbies or fire-command centers. The fire-command-center location is determined by the AHJ and is required in many high-rise buildings.

Chapter 9. Emergency Control Functions

In addition to detecting fires and alerting occupants, modern fire-alarm systems often include emergency control functions. These are automatic responses the system performs to make the building safer during a fire, primarily by managing smoke, maintaining escape routes, and supporting firefighting operations.

These features are required or recommended by NFPA 72 (Chapter 21) and local codes in many occupancy types, especially in larger or more complex buildings such as hospitals, high-rises, schools, and transit facilities.

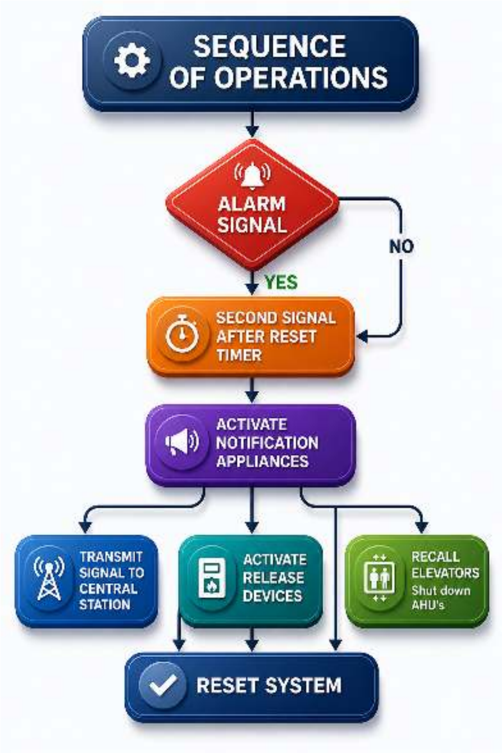

Figure 9. Sequence of operations workflow showing how various alarm and supervisory inputs trigger control unit functions, emergency response actions, and auxiliary system activations.

A. Common Emergency Control Functions

1. Elevator recall and shutdown

- **Phase I Recall:** Automatically sends elevators to a designated floor (usually the lobby) and disables user controls to prevent use during a fire. Alternative-recall to a different floor is initiated when smoke is detected in the primary recall lobby (ASME A17.1 / NFPA 72 §21.3).
- **Shunt Trip:** Disconnects power to the elevator before sprinklers in the shaft or machine room operate, preventing brake-energized cabs from being released onto wet rails. Required in elevator equipment rooms protected by sprinklers per NFPA 72 §21.4 and ASME A17.1.
- **Phase II Firefighter Service:** Allows responding firefighters to assume manual control of the cab after Phase I recall is complete.

2. HVAC shutdown

- Stops air-handling units to prevent the spread of smoke through ducts. Typically triggered by duct detectors or by general smoke detection in the equipment room. Required by NFPA 90A in air-handling units serving more than 2,000 CFM.

3. Smoke control systems

- Includes fans, dampers, and barriers that direct or restrict smoke movement. Often part of a zoned smoke-control strategy in large buildings; designed and balanced per NFPA 92.

4. Door release / door holders

- Automatically releases magnetically held fire doors to allow them to close and contain fire or smoke. Common in corridors and at fire-rated partitions.

5. Stairwell pressurization

- Activates fans to increase air pressure in stairwells, preventing smoke from entering. Pressure differentials are designed per NFPA 92 (typically 0.05 to 0.35 in. w.c.) so that occupants can still open the doors.

6. Unlocking egress doors

- Fire-alarm signal can unlock controlled egress doors or access-control systems to allow evacuation, per IBC §1010 and NFPA 101 §7.2.1.6.

7. Suppression-system activation interface

- Coordinates activation of pre-action, deluge, or gas-based suppression systems in tandem with detection, including cross-zoned interlocks for pre-action systems.

8. Gas shutoff

- Closes solenoid valves or shunt-trips utility-supplied gas during a confirmed fire alarm in occupancies such as commercial kitchens, laboratories, and industrial facilities.

Sequence of Operations

Sequence	Control Untt Annnunicïatt	Annnunciate Cennon Trouble	Annnunctate Common to Supervlsory	Activate Alem te Annuclator	ActivarActtvate Troddo Trouble	Recalt Elevator	Activate Evacuatlon	Activate inlcate Evacuatton	Untooe Supprescion Svctein
Manual Pull Station – 1st Floor	X	X	X	X	X	X	X	X	X
Manual Pull Station – 2nd Floor	X	X	X	X	X	X	X	X	X
Smoke Detector – 1st Floor	X	X	X	X	X	X	X	X	X
Smoke Detector – 2nd Floor	X	X	X	X	X	X	X	X	X
Heat Detector – Electric Room	X		X	X		X	X	X	X
Tamper Switch					X	X	X	X	X
Water Flow Switch			X	X		X	X	X	X
AC Power Failure				X	X	X	X	X	X
Low Battery					X	X	X	X	X
Short Circuit				X	X	X	X	X	X
Ground Fault				X	X	X	X	X	X

Figure 10. Sequence of operations matrix (cont.) — companion view showing how various alarm and supervisory inputs trigger control unit functions, emergency response actions, and auxiliary system activations.

B. Integration and Programming

- Each function must be programmed into the FACP via a documented cause-and-effect (sequence of operations) matrix.
- Each control output must be supervised, and its operation must be verified during commissioning and during periodic ITM.
- Some functions may require manual override controls for emergency personnel (e.g., the fire-service smoke-control panel required by IBC §909.16 and NFPA 92 §7.3).

Chapter 10. Emergency Response Notification

Emergency-response notification is the process by which a fire-alarm system communicates alarm conditions to entities outside the protected premises — most commonly to a fire department or monitoring service. This function ensures that a fire event receives rapid attention, even if no one in the building makes a manual emergency call.

This capability is particularly important in buildings that are unoccupied during certain hours or contain sleeping occupants, such as residential buildings, schools, and hospitals.

A. How Notification Works

When an initiating device detects a fire condition, or a manual pull station is activated, the FACP:

- Sends a signal to on-site notification appliances (strobes, horns, speakers).
- Triggers automatic control functions if programmed.
- Transmits an alarm signal to a remote receiving station — usually via cellular, IP network, radio, or, where still permitted, two POTS lines.

B. Monitoring Systems

1. Central station service

- A UL-listed, third-party facility continuously staffed 24/7 (listed to UL 827 and UL 864).
- Receives alarm, trouble, and supervisory signals.
- Relays alarm information directly to the local fire department, typically within 90 seconds of receipt.
- Often includes periodic testing and maintenance as part of the service.

2. Remote-station monitoring

- Similar to central station, but typically operated by or in cooperation with local authorities (e.g., fire departments).
- Signals are sent over telephone or radio links, or via supervised IP.
- May offer fewer ancillary services compared with full central stations.

3. Proprietary supervising stations

- Located at the protected premises and operated by the building owner (university campus, industrial plant, healthcare network).
- Staffed 24/7 and responsible for contacting emergency services.

C. Common Communication Technologies

- **PSTN (Plain Old Telephone Service):** Traditional, often used with a Digital Alarm Communicator Transmitter (DACT). Increasingly being phased out as carriers retire POTS infrastructure.
- **Cellular:** Ensures connectivity if a landline is compromised, and is now commonly the primary path on new installations.
- **IP-Based Transmission:** Used in modern systems for fast and secure communication. Sole-path IP communicators must include supervision intervals that meet NFPA 72 §26.6.
- **Radio Transmitters:** Used where landlines or internet are unreliable; municipal radio systems remain common in some jurisdictions.

D. Supervision and Redundancy

- Transmission paths must be supervised for faults.
- NFPA 72 §26.6 requires either redundant communication paths or a single-path technology specifically listed for sole-path use (e.g., a UL 864 Listed cellular communicator with the appropriate supervision interval).
- Signals must be acknowledged within specific timeframes (typically 90 seconds) to meet code.

FIRE ALARM INSPECTION FORM

INSPECTION INFORMATION

Date of inspection ________________ Type of inspection: ________________

Building name ________________ Address ________________

Address ________________________________

INSPECTION ENTITY INFORMATION

Inspecting company ________________ Inspector name ________________

License number ________________ Phone ________________

SYSTEM INFORMATION

Yes. System monitorring/ I by a supervising station?	YES ☐Y	NO	Yes	☐ NO
Yes. Present pσ remate annu'oncisators?	YES ☐Y	NO	Yes	☐ NO
Yes. Compauble with fire safety control funtions?	YES ☐Y	NO	Yes	☐ NO

Yes. Required signage, for system styles generaded during testing ________________

DEVICES AND COMPONENTS	PASS	FAIL
Control unit		
Transponders		
Smoke detectors		
Hext detectors		
Duct detectors		
Manual pull stations		
Audible notification apppliances		
Visible notification appliances		

SYSTEM INTERFACE FUNCTIONS	PASS	FAIL
Door unlocking		
Fan shutdown		
Elevator recall		
Kitchen suppression systems		
Other ________________		

☐ I certity that this fire alarm system has been tested and inspected in accordance with applicable NFPA requirements.

Inspector signature ________________________ Date ____________

Figure 11. Comprehensive Fire Alarm System Inspection and Testing Form for Periodic Compliance Verification. Aligns with NFPA 72 Chapter 14 requirements for routine inspections and maintenance.

Chapter 11. Manual vs. Automatic Operation

Fire-alarm systems are designed to detect, signal, and respond to fire conditions through both manual activation by occupants and automatic detection using specialized devices. Understanding the difference between these two operational modes is essential for both system design and emergency planning.

A. Manual Operation

Manual fire-alarm activation relies on building occupants who discover a fire to initiate an alarm signal.

Key device:

- **Manual Pull Stations:** Installed along egress routes, near exits, and at strategic points throughout the building. Activated by pulling a handle or pressing a button.

Advantages:

- Allows occupants to trigger an alarm even before automatic detectors activate.
- Ensures human oversight, especially in areas not fully covered by automatic detection.

Design requirements (NFPA 72 §17.14):

- The operable part of each manual fire alarm box must be mounted between 42 in. (1.07 m) and 48 in. (1.22 m) above the floor — a range that also satisfies ADA Standards §308.2.1 (48 in. max forward reach) and §308.3.1 (48 in. max side reach).
- Must be unobstructed, conspicuous, and accessible.
- Must be located within 5 ft (1.5 m) of each exit doorway on each floor, and additional stations are required so that the travel distance to the nearest station does not exceed 200 ft (61 m).

- Required in most commercial occupancies per IBC §907 and NFPA 72.
- Where unwanted activations are a concern, double-action or covered stations are acceptable, but they must remain accessible without keys or tools.

B. Automatic Operation

Automatic fire detection uses sensors that continuously monitor for signs of fire — smoke, heat, flame, or gas — and activate the fire-alarm system without human intervention.

Common devices:

- **Smoke Detectors:** Detect visible or invisible particles produced by combustion.
- **Heat Detectors:** Triggered by high temperature or rapid temperature rise.
- **Gas Detectors:** Monitor for combustible (LEL) or toxic gases.
- **Waterflow Switches:** Detect activation of a sprinkler system.
- **Flame Detectors:** Detect IR, UV, or combined radiation from flames.

Advantages:

- Enables early detection, even when buildings are unoccupied.
- Reduces response time by automatically initiating alarms and emergency-control functions.
- Can interface with suppression systems to begin extinguishing actions automatically.

C. Combined System Functions

Most modern systems incorporate both manual and automatic operation for redundancy and effectiveness.

Part #	Qty	Standby Current, Amps Unit	 Sub-Total	Alarm Current, Amps Unit	 Sub-Total
Panel Equipment					
Module A	3	0.1000	0.3000	0.1700	0.5100
Module B	3	0.0261	0.0783	0.0267	0.0801
Main Board	1	0.1370	0.1370	0.3200	0.3200
Power Supply	2	0.1000	0.2000	0.1000	0.2000
Initiating Devices					
Smoke Detectors	52	0.0003	0.0156	0.0003	0.0156
PB Smoke Det.	2	0.0450	0.0900	0.0600	0.1200
Notification Appliances					
Horns	10		0.000	0.0180	0.1800
15 cd strobes	15		0.000	0.0590	0.8850
110 cd strobes	4		0.000	0.1450	0.5800
Horn/15 cd strobe	10		0.000	0.0830	0.8300
Horn/110 cd strobe	5		0.000	0.1930	0.9650
Other					
Relays	4	0.0300	0.1200	0.0000	0.0000
Net Standby Load, Amps:			**0.9409**		
				Net Alarm Load, Amps:	**4.6857**
Enter Required Standby Duration:		24	Hours		
Enter Required Alarm Duration:		5	Mins	0.083	Hours
Total Standby, Amp-Hours:				22.5816	Amp-hours
Total Alarm, Amp-Hours:				0.3905	Amp-hours
Total Calculated Battery Capacity:				23.0	Amp-hours
Required Factor of Safety:				20%	
Code Required Battery Size/Capacity:				**28**	Amp-hours
Supplied Battery Size/Capacity:				**36**	Amp-hours
Actual Factor of Safety:				**57%**	

Table 1. Simplified Secondary Power Calculation Example

Figure 12. Fire Alarm Systems Backup Power Calculations Sample

Examples of combined responses:

- A smoke detector triggers an alarm and HVAC shutdown.
- A manual pull station activates alarms and releases fire doors.
- A sprinkler waterflow switch triggers alarm signals and notifies remote monitoring centers.

Chapter 12. Emergency Voice/Alarm Communication Systems (EVACS)

Emergency Voice/Alarm Communication Systems (EVACS) are specialized subsystems integrated with fire-alarm systems that provide clear verbal instructions to building occupants during an emergency. While traditional fire-alarm systems rely on horns and strobes to alert people, EVACS systems go further by delivering detailed information to guide safe evacuation or other actions.

These systems are especially critical in large, multi-story, or complex buildings where:

- Audible tones may not be sufficient.
- People may not know the best evacuation routes.
- Different instructions need to be delivered to different areas (phased or relocation evacuation).

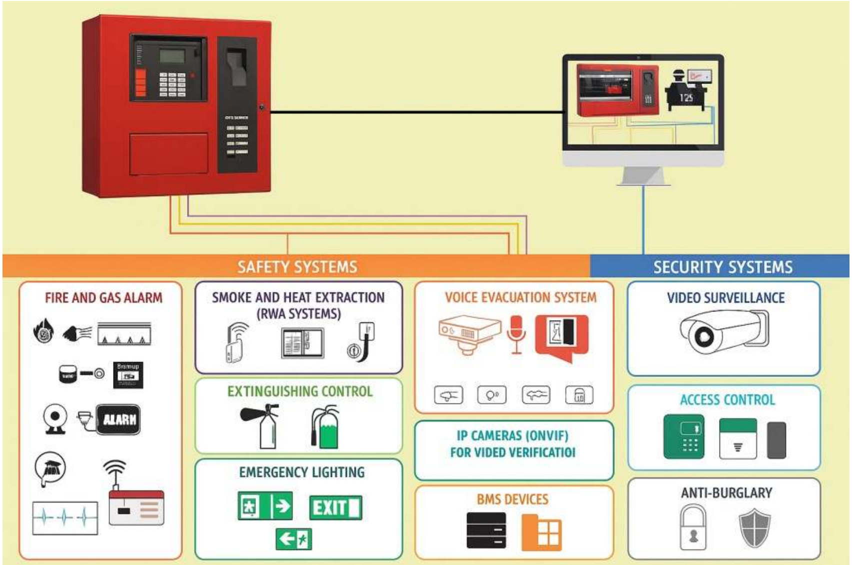

Figure 13. Integrated Emergency Alarm and Voice Communication System with Safety and Security Controls — illustrates the integration of fire detection, gas alarms, emergency lighting, and voice evacuation systems (EVACS) with security technologies such as video surveillance and access control.

A. Types of EVACS

1. Standalone manually controlled systems

- Operated by personnel from a fire command center.
- Messages are selected or broadcast live to direct building occupants.
- May be used in high-security environments or facilities with on-site emergency-response staff.

2. Integrated EVACS systems

- Automatically activated by the FACP.
- Capable of distributing pre-recorded or live voice messages throughout the building.
- Often synchronized with other fire-alarm components such as strobes and horns/speakers.

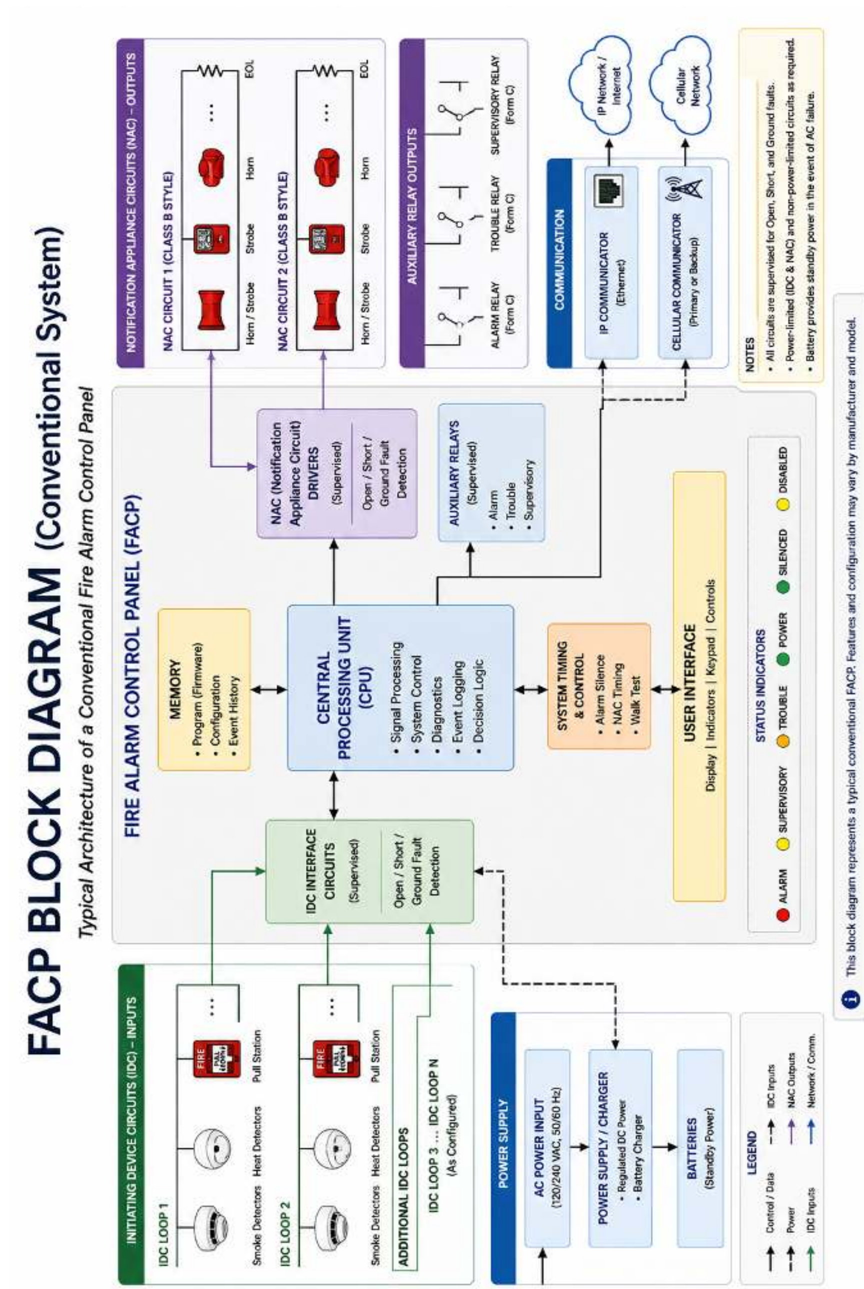

Figure 14. FACP Block Diagram (Conventional Systems)

B. Components of an EVACS System

- **Microphones and Control Consoles:** Allow manual announcements or message selection.
- **Amplifiers:** Boost signal strength to reach all required areas. Sized per worst-case zone-load calculations with 20 % spare capacity recommended.
- **Speakers:** Strategically installed for optimal voice intelligibility; 25 V or 70.7 V constant-voltage distribution is typical.
- **Message Storage:** Holds pre-recorded emergency messages on non-volatile media; messages are re-tested as part of ITM.
- **Priority Override Function:** Emergency messages take precedence over normal public-address system use.

C. Design and Installation Considerations

- **Voice Intelligibility:** Messages must be clearly understood. Performance is measured by STI (≥ 0.45) or CIS (≥ 0.70) in each acoustically distinguishable space (ADS) per NFPA 72 Annex D.
- **Zoning Capabilities:** Different floors or areas may receive customized messages based on location or fire zone.
- **Power Requirements:** Must operate for 24 hours on standby power and 15 minutes in alarm condition, per NFPA 72 §24.3.3 and §10.6.
- **Ambient Noise Compensation:** Systems must be audible above the typical background noise level by at least 15 dBA, or 5 dBA above the maximum sound level lasting 60 seconds.

D. Common Applications

- High-rise office and residential buildings
- Schools and universities
- Hospitals and healthcare facilities
- Transportation hubs (airports, transit, rail)
- Shopping malls and large assembly venues

Chapter 13. Fire Alarm Circuit Types and Classification

Fire-alarm circuits form the electrical infrastructure that connects initiating devices, control panels, notification appliances, and auxiliary controls. These circuits are classified both by function (what they do) and by class (how reliable or fault-tolerant they are).

Understanding the various types and classifications of circuits is essential for designing compliant, safe, and responsive systems.

A. Fire Alarm Circuit Types (Function)

21. **Initiating Device Circuits (IDC).** Connect conventional detectors (smoke, heat) and manual pull stations to the FACP. Typically used in conventional systems. An alarm condition is detected by monitoring changes in circuit resistance (open/short).
22. **Signaling Line Circuits (SLC).** Used in addressable systems where each device has a unique address. Carry bidirectional communication and power on a single pair of wires. Devices report alarms, trouble conditions, and supervisory status to the control panel. Enable advanced diagnostics and programmable logic.
23. **Notification Appliance Circuits (NAC).** Carry output signals from the control panel to strobes, horns, bells, and speakers. Can be synchronized for proper strobe flash and temporal-tone compliance. Must be supervised to detect faults like open or short circuits.

Fire Alarm System Backup Power Capacity Calculation Example

Component	Quantity	Standby Current (A)	Total Standby Current (A)	Alarm Current (A)	Total Alarm Current (A)
		(Amps)		Alarm Current	
Control Unit	1	0.615	0.615	1.325	1.325
Pull Stations	25	0.007	0.175	0.015	0.375
Smoke Detectors	60	0.005	0.300	0.015	0.900
Heat Detectors	10	0.085	0.850	0.020	0.200
Horns	35	0.000	0.000	0.175	6.125
Strobes	35	0.000	0.000	0.185	6.475
Control Modules	5	0.015	0.075	0.025	0.125
Relays	24	0.025	0.600	0.000	0.000
		Total Standby Load	2.615		
				Total Alarm Load	15.525
				Standby Duration	24 hours
				Alarm Duration	5 minutes (0.083 hours)
				Total Standby Capacity	24x2.615=62.76AH
				Total Alarm Capacity	0.083x15.525=1.288AH
				Total Capacity	62.76+1.288=64.05AH
				Stafety Factor	20%
				Total Battery Size (Capacity)	1.2x64.05=76.86AH
Actual Battery Capacity: Next higher standard size battery is selected					

Figure 15. Fire Alarm System Backup Battery Capacity Calculation Example — sample battery capacity calculation based on total standby and alarm loads, system current draw, and NFPA 72-required durations.

B. Fire Alarm Circuit Classes (NFPA 72 Chapter 12)

Fire-alarm circuits are further classified by their pathway performance — how they behave when a problem (wire break, short, or earth fault) occurs.

1. Class A

- Designed with redundant loops. If a wire breaks, communication continues from the other side.
- Devices beyond the break remain functional.
- Ideal for high-risk occupancies (hospitals, airports, high-rises, detention facilities).
- Fault detection triggers a trouble signal but does not disable the system.

2. Class B

- Single-path wiring. If an open fault occurs, devices beyond the break stop functioning.
- Less reliable but simpler and more economical. Used in low-risk occupancies or small buildings.
- All circuits must still be supervised; an End-of-Line (EOL) resistor (commonly 4.7 kΩ or 10 kΩ depending on the panel) is used at the far end of the circuit to provide supervision.

3. Class C

- Applies to digital pathways such as LANs, WANs, and PSTN that have end-to-end (rather than wire-level) supervision.
- Used in newer systems with network-based architectures or IP communication.
- Reliability is determined by the supervision protocol and network design rather than physical wiring redundancy.

4. Class N (new in this edition's coverage)

- Introduced in NFPA 72-2016 (Chapter 12) for Ethernet-based pathways.

- Provides redundant paths between two or more network nodes; a single fault does not impair communication between any two operational nodes.
- Typical in modern voice/MNS networked panels.

5. Class X (new in this edition's coverage)

- Combines features of Class A (open-fault tolerance) with short-circuit isolation: a short on the loop is isolated and the remainder of the loop continues to operate.
- Common on addressable SLCs that use built-in short-circuit isolators between devices.
- Required for some specialized high-survivability applications.

6. Class D and Class E

- Class D — circuits that perform their intended function only on an alarm condition (e.g., fail-safe interfaces).
- Class E — circuits that are not required to be monitored for integrity (sometimes used for control outputs that do not require supervision).

> **Reviewer's Update —** *The first edition mentioned only Class A, B, and C. NFPA 72-2016 added Class N (Ethernet) and continued Class X as a separate pathway class; specifications written today for hospitals, transit, and large campuses commonly call for Class X for SLCs and Class N for the network backbone.*

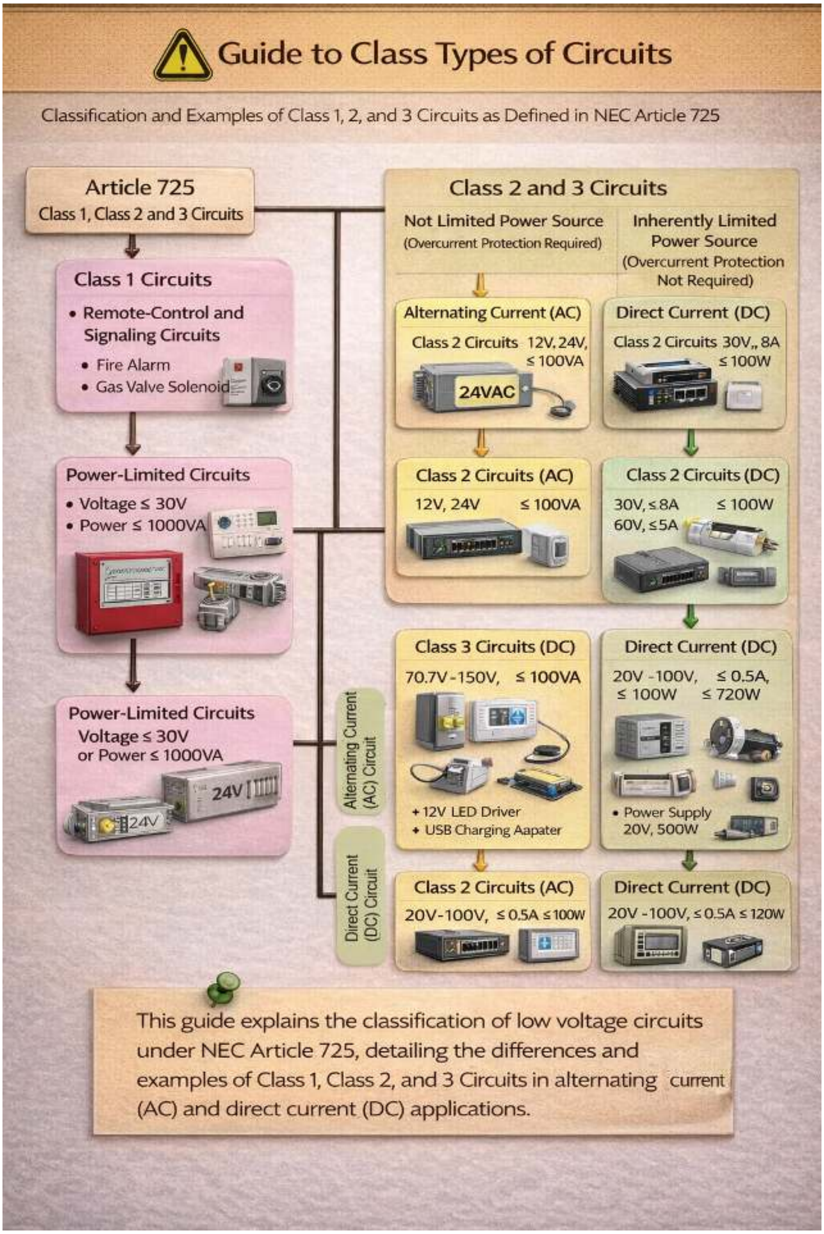

Figure 16. Classification of Class 1, Class 2, and Class 3 circuits as defined in NEC Article 725, including power limits, voltage thresholds, and current restrictions for both DC and AC applications.

C. Circuit Selection Considerations

- **Occupancy Type:** Hospitals, dormitories, and detention occupancies frequently require Class A or X. Small offices may use Class B.
- **System Complexity:** Addressable systems use SLCs; conventional systems use IDCs and NACs.
- **Code Compliance:** Circuits must be designed to meet NFPA 70 Article 760 and NFPA 72 §12 performance standards.
- **Distance and Load:** Voltage drop and total current must be calculated to ensure devices work properly at the worst-case end-of-line device.

```
Ex. 15-2: Calculation of Voltage Drop

A notification appliance circuit is wired to a 24 VDC FACP and features:

  - Three horns rated at 0.083 A @ 24 VDC
  - Two horn/strobes rated at 0.105 A @ 24 VDC
  - One strobe rated at 0.070 A @ 24 VDC

Total Current = (3 × 0.083) + (2 × 0.105) + (1 × 0.070)
              = 0.249 + 0.210 + 0.070
              = 0.529 A

Assume:
  - Wire Gauge: 14 AWG
  - Wire Length (one-way): 100 feet
  - Resistance per 1000 ft (14 AWG): 2.525 ohms

Total Wire Length (two-way): 200 feet
Total Resistance = (200 / 1000) × 2.525 = 0.505 ohms

Voltage Drop = Current × Resistance
             = 0.529 A × 0.505 ohms
             = 0.267 V

Voltage at farthest device = 24 V - 0.267 V = 23.733 V

Conclusion: Voltage drop is within acceptable limits per NFPA 72 and UL.
```

Figure 17. Voltage drop example for a notification appliance circuit using a 24 VDC FACP. Highlights current loads from multiple devices and introduces key design considerations from NFPA 70, NFPA 72, and UL standards.

Chapter 14. Fire Alarm Circuit Classes, Wiring, and Operation

Fire-alarm systems rely on robust and well-designed wiring to interconnect components, deliver power, and ensure reliable communication during emergency situations. This chapter combines foundational wiring concepts, circuit classification, code-compliant practices, and their impact on system operation.

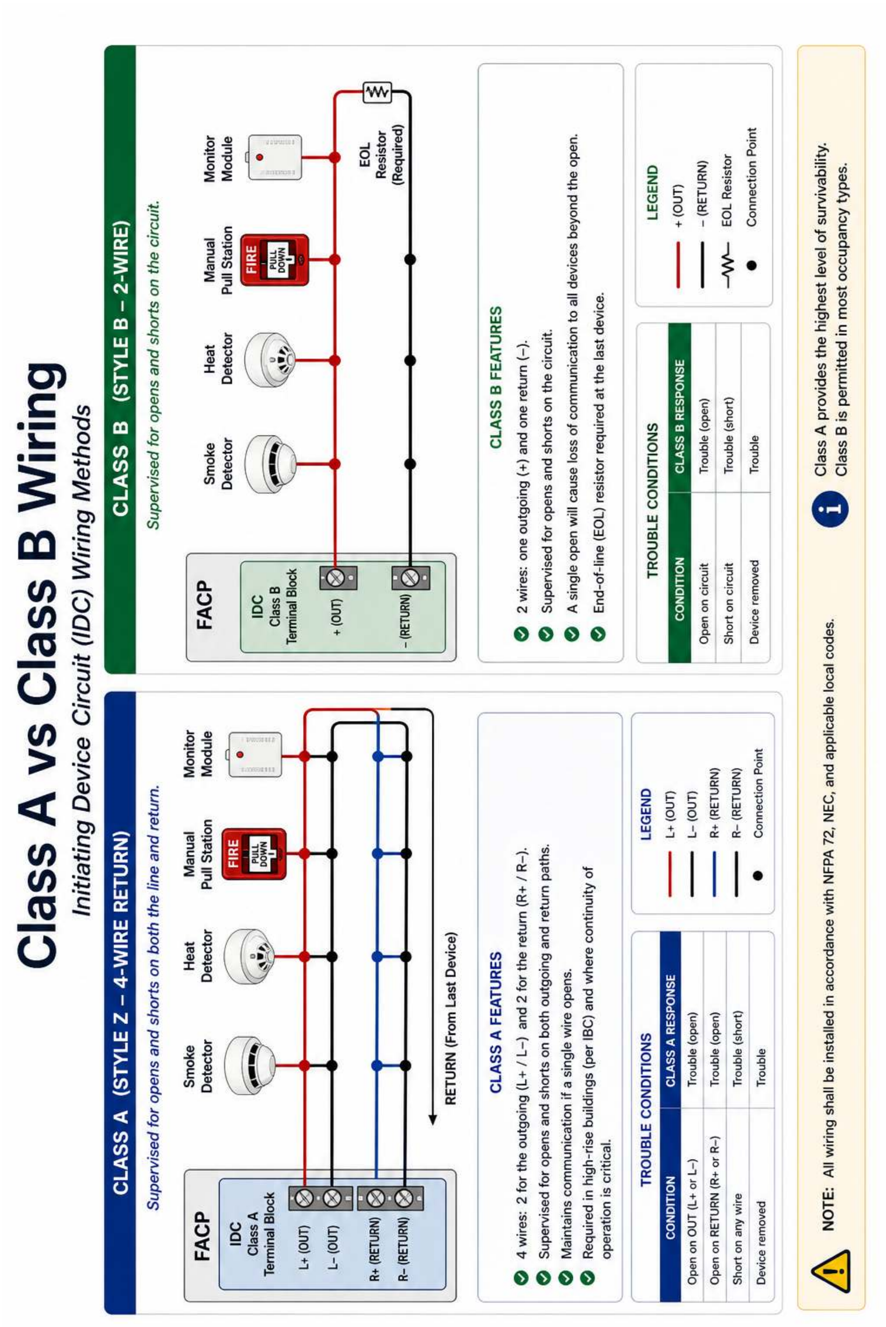

Figure 18. Class A vs Class B Wiring

A. Overview of Circuit Types and Interconnection

Fire-alarm systems use several types of circuits to link components:

- **IDC:** Connect initiating devices (smoke detectors, pull stations) to the FACP.
- **NAC:** Distribute power and synchronized signals to horns, strobes, and speakers.
- **SLC:** Facilitate bidirectional communication in addressable systems.
- **Control Interfaces:** Connect to auxiliary systems such as elevator recall, HVAC shutdown, and door release. Typically use supervised relay modules.

Wiring paths must be clearly identified, routed to minimize damage, and comply with NEC Article 760 and NFPA 72.

B. Code-Compliant Wiring Practices

Wire types and ratings

- Fire-alarm wiring is classified under NEC Article 760 as either Power-Limited (PLFA) or Non-Power-Limited (NPLFA).
- PLFA circuits use listed low-voltage cables such as FPL, FPLR (riser), and FPLP (plenum).
- NPLFA circuits can carry higher voltages (up to 600 V) and require enhanced insulation and conduit.
- Survivable circuits (used in some EVACS/ECS applications) require 2-hour rated cable, electrical circuit protective system, or routed through 2-hour rated construction per NFPA 72 §12.4.

Segregation from other systems

- Fire-alarm wiring must be separated from power and communication circuits unless protected by listed cables or physical barriers, per NEC §760.136 and §760.139.

Conduit use and sizing

- Conduits should be sized for proper cable fill (NEC Chapter 9, Table 1), heat dissipation, and future expansion (typical practice: 40 % fill maximum).
- Metallic conduits offer additional grounding and physical protection.

Labeling and identification

- All wiring and junction-box covers must be clearly marked as 'FIRE ALARM' or 'FACP' and preferably color-coded red (NEC §760.30 requires identification).

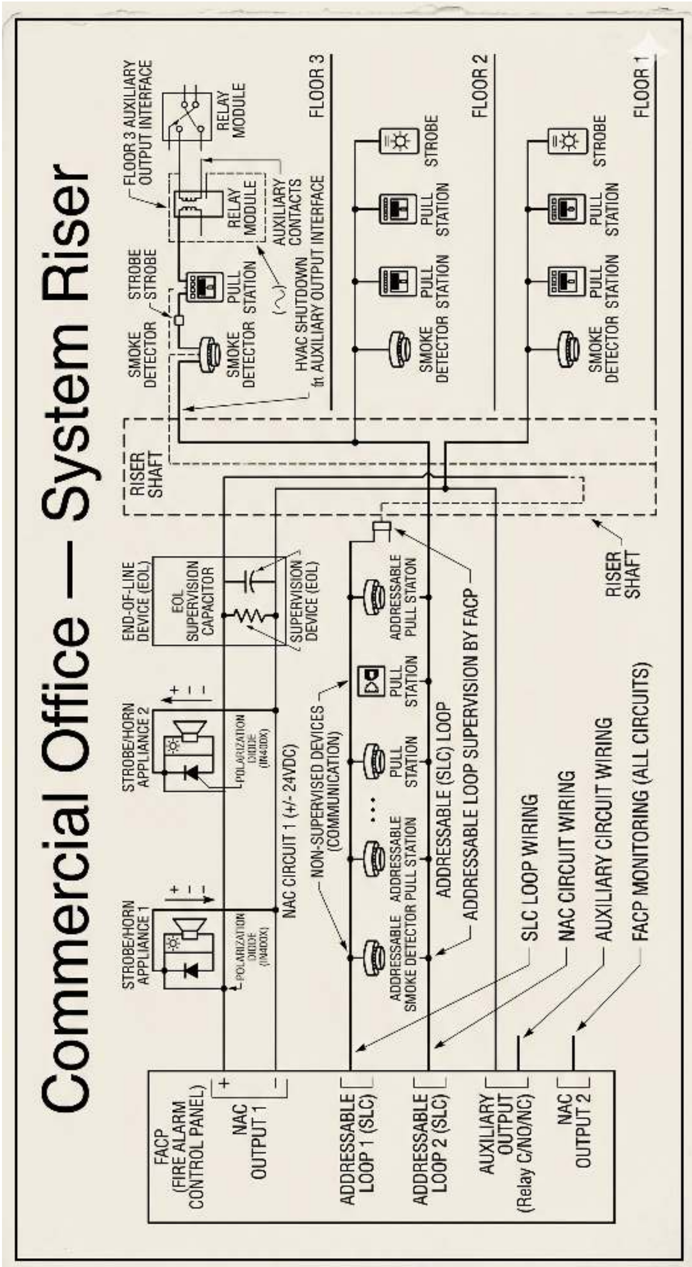

Figure 19. Commercial. Office – Fire Alarm System Riser Diagram (Sample).

C. Circuit Classifications (NFPA 72)

NFPA 72 defines fire-alarm circuits by their ability to tolerate faults:

- **Class A:** Redundant path maintains communication even if one wire is damaged.
- **Class B:** Single-path circuits lose communication beyond a fault.
- **Class C:** Used for digital/IP pathways with end-to-end supervision.
- **Class X:** Short-circuit and open-circuit fault tolerant via isolators.
- **Class N:** Network-based pathway with redundancy between nodes.

Choose circuit classes based on required survivability and building risk profile.

D. Supervision and Circuit Integrity

All fire-alarm system wiring must be supervised to detect:

- Open circuits (e.g., a severed wire).
- Short circuits (e.g., wires touching).
- Ground faults (e.g., contact with metal or earth).

The FACP issues a trouble signal for any detected fault, ensuring timely correction without system-wide failure.

Circuit integrity is enhanced by:

- Using conduit or armored cable in vulnerable areas.
- Avoiding shared conduit with non-fire-alarm systems.
- Segmenting systems into zones to isolate alarms and streamline response.
- Installing isolator modules at intervals along an SLC (Class X) so that a single short does not disable the entire loop.

E. Integration with System Operation

Wiring directly impacts fire-alarm operational logic:

- **Zoning and Addressing:** Align wiring with logical zones for better response.
- **Signal Prioritization:** Group NACs by signal type, area, or function.

- **Cause-and-Effect Programming:** Define logical responses, such as activating HVAC shutdown when a smoke detector is triggered, in the cause-and-effect matrix.

System behavior is programmed using vendor-specific tools or onboard interfaces during commissioning, and the programming must be backed up off-site (NFPA 72 §10.6.6).

F. Testing and Maintenance Access

Reliable operation requires accessible and well-maintained wiring:

- Install access panels and pull boxes for easy testing and troubleshooting.
- Perform regular tests for continuity, insulation resistance, and voltage drop.
- Ensure connections are secure, labeled, and free of corrosion or tampering.

G. Inspection, Testing, and Maintenance (ITM) frequency summary

Per NFPA 72 Table 14.4.5, common ITM intervals include:

- FACP and all initiating-device circuit components — visual inspection: semi-annually. Functional test: annually.
- Batteries (sealed lead-acid) — visual: monthly. Charger test: annually. Load test: annually. Replacement typically every 3 to 5 years.
- Notification appliances — annually (audible level and strobe flash verified).
- Smoke detectors — annually for functional, and sensitivity test at 1 year after installation, then at intervals not exceeding 2 years.
- Waterflow switches and tamper switches — semi-annually for waterflow; annually for tamper switches.
- Emergency control function interfaces — annually (recall, HVAC, door release, smoke control).

- Off-premises monitoring transmission — quarterly.

H. Summary

Proper wiring and circuit classification form the backbone of a reliable fire-alarm system. Compliance with NFPA 72 and NEC Article 760, thoughtful layout, and supervised operation ensure the system functions correctly when lives depend on it. Regular testing and clear documentation support long-term performance and code compliance.

Chapter 15. Grounding in Fire Alarm Systems

Grounding in fire-alarm systems is essential for safety, reliability, and proper electrical performance. It provides a path for fault currents, helps prevent electrical shock, and ensures that transient voltages do not damage system components.

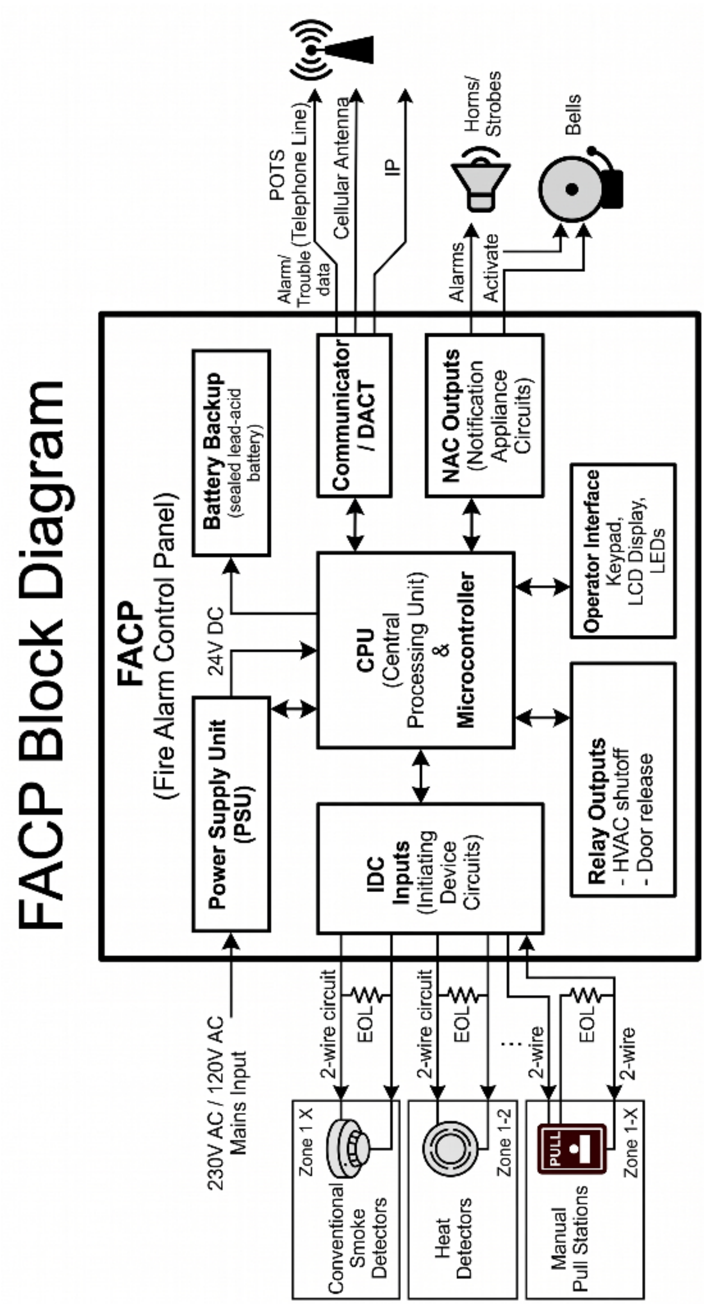

Figure 20 FACP Block Diagram.

A. Types of Grounding

24. **System Grounding (Earthing).** Establishes a reference point for the electrical system at the power source. Typically connected to a grounding electrode system (ground rods, building steel, concrete-encased electrode). Helps maintain voltage stability and provides a path for fault currents. Sized per NEC §250.66.
25. **Equipment Grounding.** Connects non-current-carrying metal parts of electrical equipment to the system ground. Ensures that exposed metal parts do not become energized during a fault. Provides a low-impedance path back to the source for fault clearing. Sized per NEC §250.122 (typically 12 AWG for 20 A circuits).
26. **Bonding of Fire-Alarm Equipment.** The dedicated bonding of all metallic parts of the fire-alarm system (cabinets, raceways, metallic shields of cables) to the equipment grounding system per NFPA 70 §250.110 and NFPA 72 §10.6.10.

B. Why Grounding Matters

- Prevents electrical-shock hazards.
- Reduces the risk of equipment damage from lightning or power surges.
- Helps fire-alarm systems function correctly by stabilizing voltage levels and providing a reference for ground-fault supervision.
- Enables protective devices (breakers and fuses) to operate properly during faults.

C. Installation Considerations

- Grounding conductors should be sized according to NEC §250.66 (system) and §250.122 (equipment).
- Bonding connections must be secure (listed lugs, exothermic welds, irreversible compression) and resistant to corrosion.
- Grounding should be verified through testing (ground-electrode resistance ≤ 25 Ω is a common NEC reference, with 5 Ω often required for sensitive equipment) and visual inspection during commissioning.

- Many FACPs include a built-in ground-fault detection circuit. This is a supervision feature, not a substitute for proper grounding of the equipment chassis.

Proper grounding is not optional — it is a code requirement and a vital part of a safe, reliable fire-alarm system.

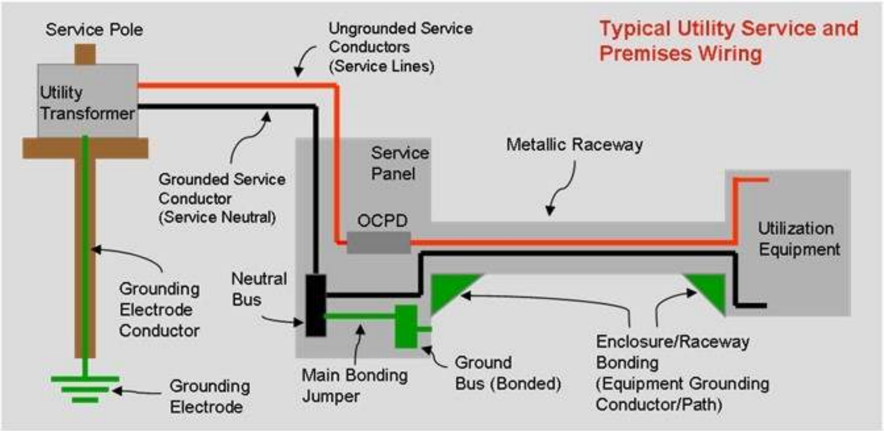

Figure 21. Typical grounding and bonding arrangement from utility transformer to premises wiring, demonstrating proper connections for safety, fault current return paths, and code compliance.

Chapter 16. Design Process and Documentation

Designing a fire-alarm system is both a technical and regulatory process. It begins with assessing building-specific risks and occupancy types and ends with comprehensive documentation that guides installation, inspection, testing, and maintenance. A well-documented design ensures that the system meets code, functions correctly, and remains maintainable over its life cycle.

Bill of Material

Qty.	Description	Manufacturer	Model	Part No.
1	Panel: P-7			
1	9 AMP NAC POWER SUPPLY W/SYNCH	SILENT KNIGHT	5499	5499
1	5499 DISTRIBUTED POWER MODULE BOARD	SILENT KNIGHT	5499	5499 B
1	Panel: P-2			
1	5808 INTELLIKNIGHT MAIN BOARD	SILENT KNIGHT	5808	5808 B
1	INTELLIKNIGHT, FACP, 4 PROGRAMMABLE OUTPUTS	SILENT KNIGHT	5808	5808 XL
1	Panel: P-1			
1	9 AMP NAC POWER SUPPLY W/SYNCH	SILENT KNIGHT	5499	5499
1	5499 DISTRIBUTED POWER MODULE BOARD	SILENT KNIGHT	5499	5499 B
1	Panel: P-9			
1	9 AMP NAC POWER SUPPLY W/SYNCH	SILENT KNIGHT	5499	5499
1	5499 DISTRIBUTED POWER MODULE BOARD	SILENT KNIGHT	5499	5499 B
1	Panel: P-5			
1	INTELLIGENT PWR EXPANDER, 6-AMP, 4-NAC	SILENT KNIGHT	5496	5496
1	INTELLIGENT POWER MODULE MAIN BOARD	SILENT KNIGHT	5496	5496 MB
1	Panel: P-8			
1	9 AMP NAC POWER SUPPLY W/SYNCH	SILENT KNIGHT	5499	5499
1	5499 DISTRIBUTED POWER MODULE BOARD	SILENT KNIGHT	5499	5499 B
1	Panel: P-4			
1	INTELLIGENT PWR EXPANDER, 6-AMP, 4-NAC	SILENT KNIGHT	5496	5496
1	INTELLIGENT POWER MODULE MAIN BOARD	SILENT KNIGHT	5496	5496 MB
1	Panel: P-6			
1	INTELLIGENT PWR EXPANDER, 6-AMP, 4-NAC	SILENT KNIGHT	5496	5496
1	INTELLIGENT POWER MODULE MAIN BOARD	SILENT KNIGHT	5496	5496 MB
7	L-SERIES STROBE, RED, WALL	SYSTEM SENSOR	SRL	SRL
1657'-0	18/2 SOL JKT FPLR 1M RL RED	GENESIS (HONEYWELL CABLE)	43061004	43061004
52'-0	16/2 SOL JKT FPLR 1M RL RED	GENESIS (HONEYWELL CABLE)	43111004	43111004
10889'-0	14/2 SOL JKT FPLR 1M RL RED	GENESIS (HONEYWELL CABLE)	43131004	43131004
8	GATE VALVE OSYSU-1	POTTER ELECTRIC SIGNAL	OSYSU-1	OSYSU-1
4	2 IN WATERFLOW SW, VANE TYPE W/RETARD	POTTER ELECTRIC SIGNAL	VSR-2	VSR-2
4	DUAL MONITOR MODULE	SILENT KNIGHT	MONITOR-2	SK-MONITOR 2
22	SMOKE, PHOTOELECTRIC, ADDRESSABLE	SILENT KNIGHT	PHOTO	SK-PHOTO
22	6 STANDARD BASE, ADDRESSABLE (SK)	SILENT KNIGHT	B210LP	B210LP
4	PULL STATION, DOUBLE ACTION, ADDRESSABLE	SILENT KNIGHT	PULL-DA	SK-PULL-DA
998'-0	16/4 STRANDED, SHIELDED, TYPE CMR	ANIXTER	B5202FE	AL-1604C-2-1S-09
11	HORN/STROBE, 2-WIRE, M-C HIGH, LOW FREQ, RED	SYSTEM SENSOR	P2RH-LF	P2RH-LF
123	LOW FREQUENCY SOUNDER, RED	SYSTEM SENSOR	HR-LF	HR-LF
16	L-SERIES 2-WIRE, HORN STROBE, RED, CEILING	SYSTEM SENSOR	PC2RL	PC2RL
4	HORN/STROBE, 2 WIRE, M-C HIGH, RED, OUTDOOR	SYSTEM SENSOR	P2RHK	P2RHK

Figure 22. Fire Alarm System Bill of Material Sample

A. Steps in the Design Process

27. **Risk Assessment and Code Review.** Identify fire hazards, building layout, and occupancy classification. Determine fire-alarm requirements using IBC, NFPA 101, NFPA 1, local codes, and insurance guidelines.
28. **Stakeholder Consultation.** Coordinate with architects, engineers, owners, and the AHJ. Determine system-performance expectations, evacuation strategy, and integration needs (e.g., HVAC, access control, elevator).
29. **System Type Selection.** Choose between conventional, addressable, or hybrid systems based on building complexity. Determine if mass notification or voice evacuation is required.

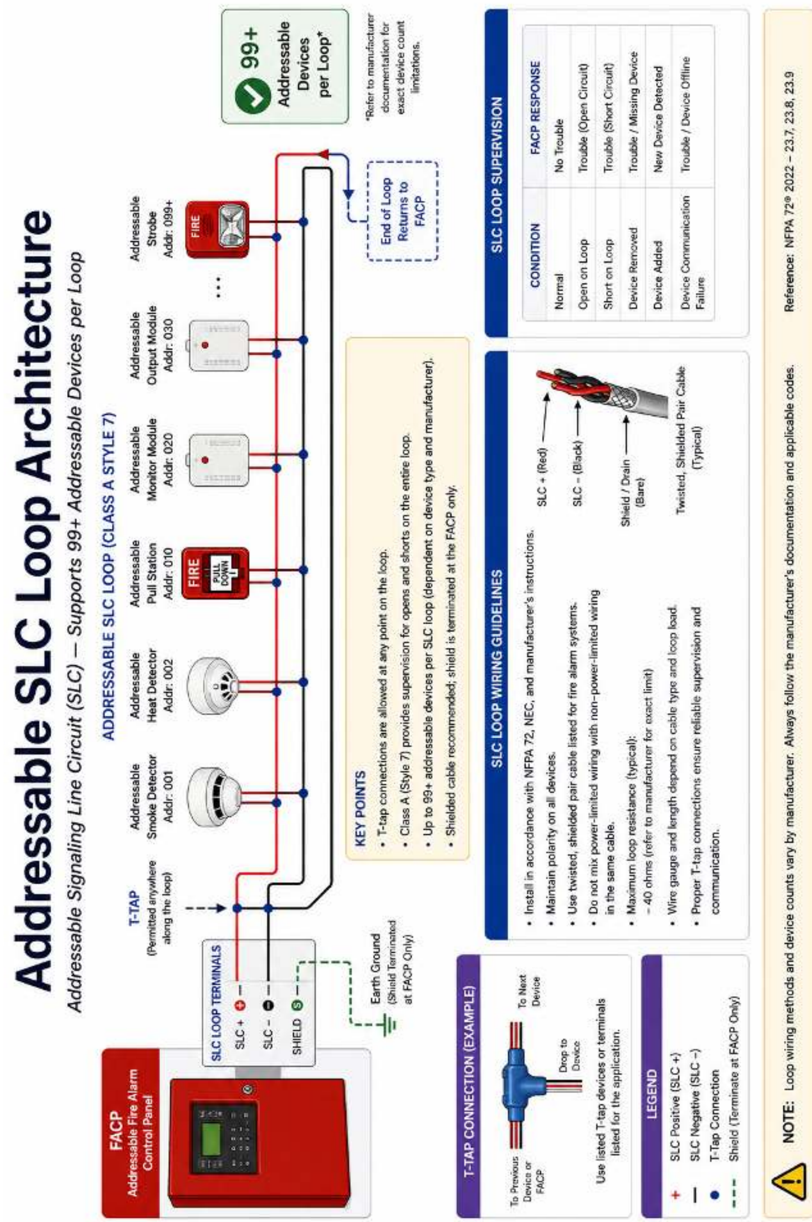

Figure 23. Addressable SLC Loop Architecture.

30. **Device Layout and Zone Design.** Identify fire-alarm zones and detection zones. Select appropriate detectors, pull stations, strobes, and speakers. Plan device placement for coverage per NFPA 72.

31. **Circuit and Power Planning.** Design NAC, IDC, and SLC loops. Calculate voltage drop and battery-backup capacity for code compliance. Apply Class X/N where survivability is required.
32. **Permit, Commissioning, and Acceptance.** Develop the sequence-of-operations matrix and submit the package to the AHJ for permit. Coordinate with the integrator and the owner for testing dates and acceptance.

B. Required Documentation

Proper documentation is essential for permitting, installation, inspection, and future maintenance. It also supports legal compliance and project accountability.

Core documents:

- **System Description:** Overview of the system type, purpose, and operating principles.
- **Riser Diagram:** Schematic showing vertical system connections across floors.
- **Floor Plans:** Device locations, wiring paths, and zoning.
- **Sequence of Operations:** Detailed logic for how the system behaves under specific conditions (e.g., smoke detected on 3rd floor triggers alarms and elevator recall).
- **Battery Calculations:** Verifies that backup power can support the system for 24 hours of standby plus 5 minutes of alarm (standard fire alarm) or 15 minutes of alarm (EVACS/ECS).
- **Voltage Drop Calculations:** Ensures all devices receive sufficient voltage at end-of-line (typically not less than 16.0 V on a nominal 24 VDC NAC, but always confirm per the appliance listing).
- **Loop Resistance Calculations:** Verifies that the total resistance of each SLC, IDC, and NAC is within the manufacturer's published limits.
- **Symbols and Bill of Materials:** Fire-alarm device legend, structured device list with model numbers and quantities (see Bill of Materials, below).

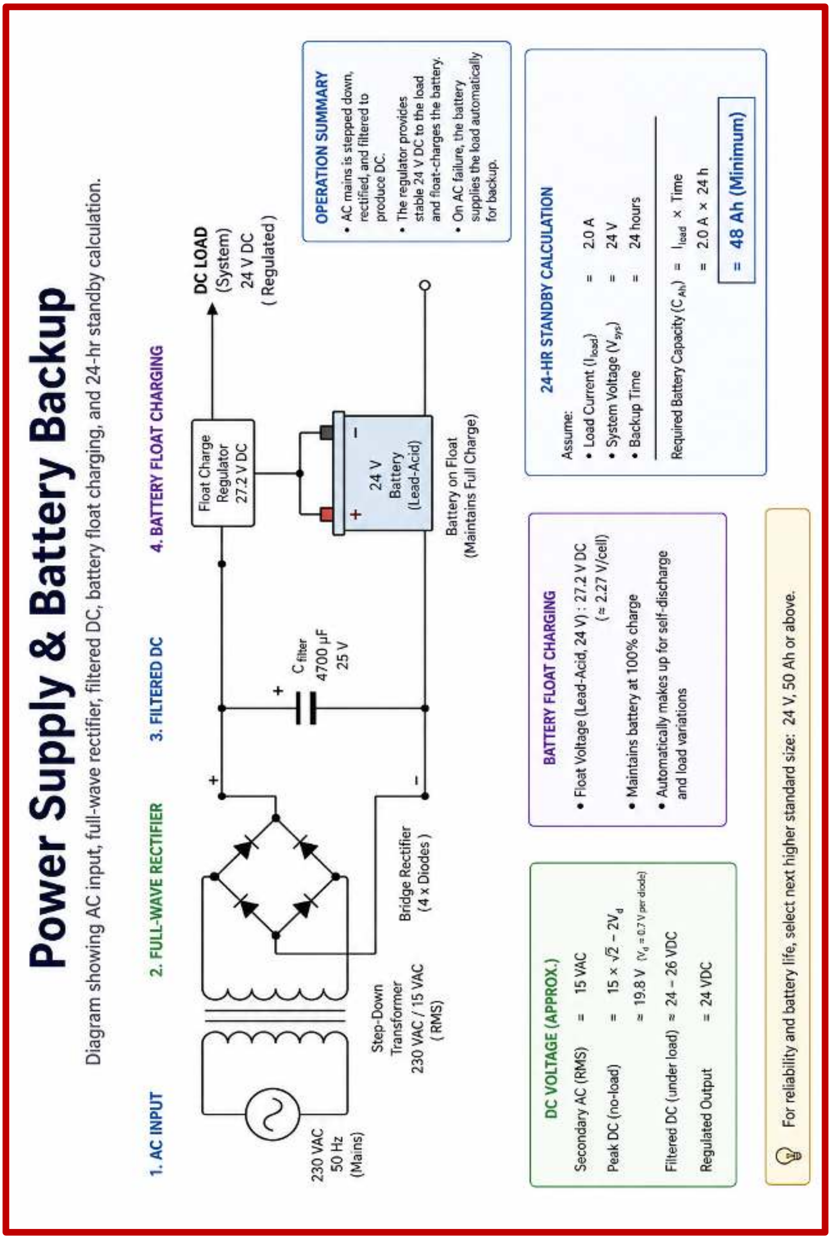

Figure 24. Fire Alarm Systems – Power Supply and Battery Backup

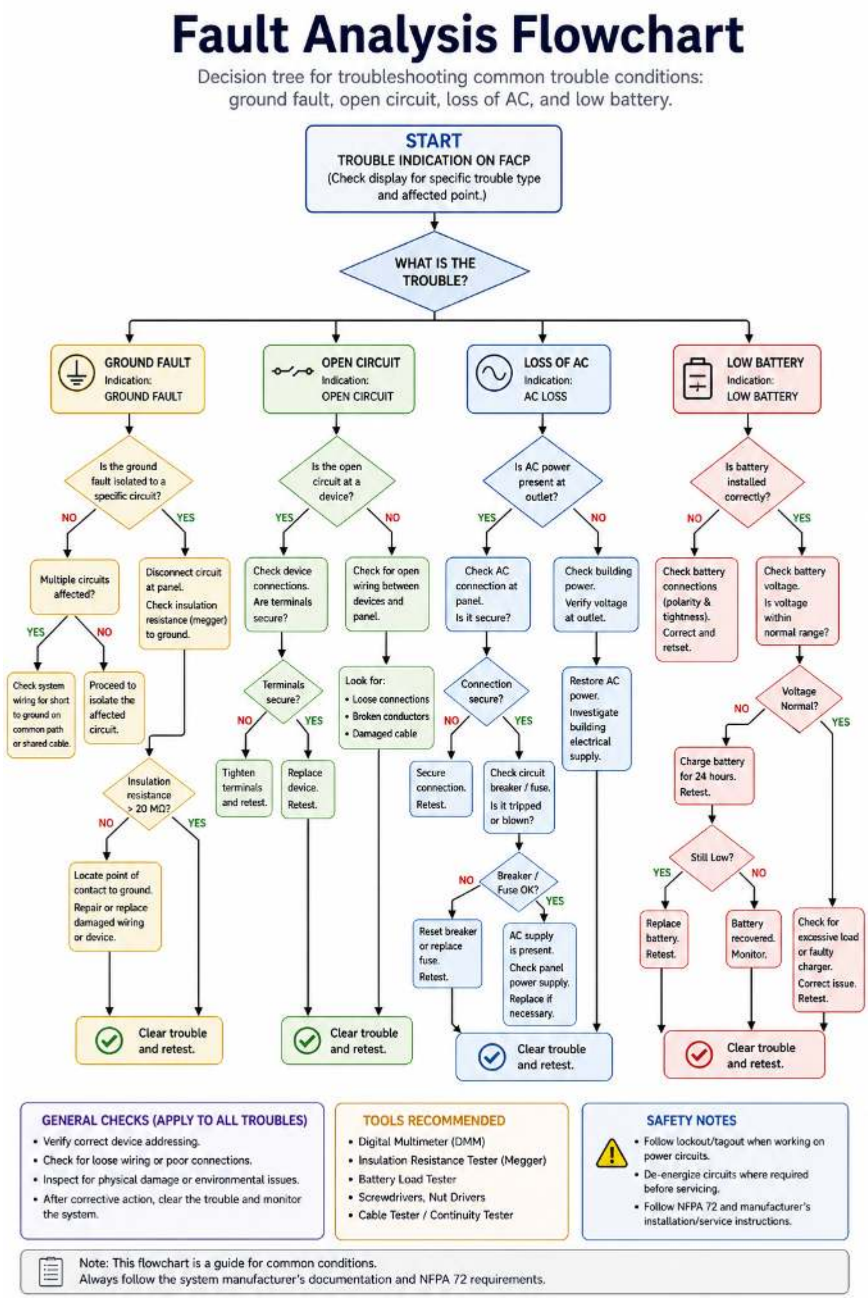

Figure 25. Fire Alarm System – Fault Analysis Flowchart

C. Final Deliverables

- Record (As-Built) Drawings
- Record of Completion (NFPA 72 §7.5)
- Testing and Commissioning Reports
- Maintenance and Inspection Schedule
- AHJ Approval Letters
- Operator-training documentation and copies of the programmed cause-and-effect matrix

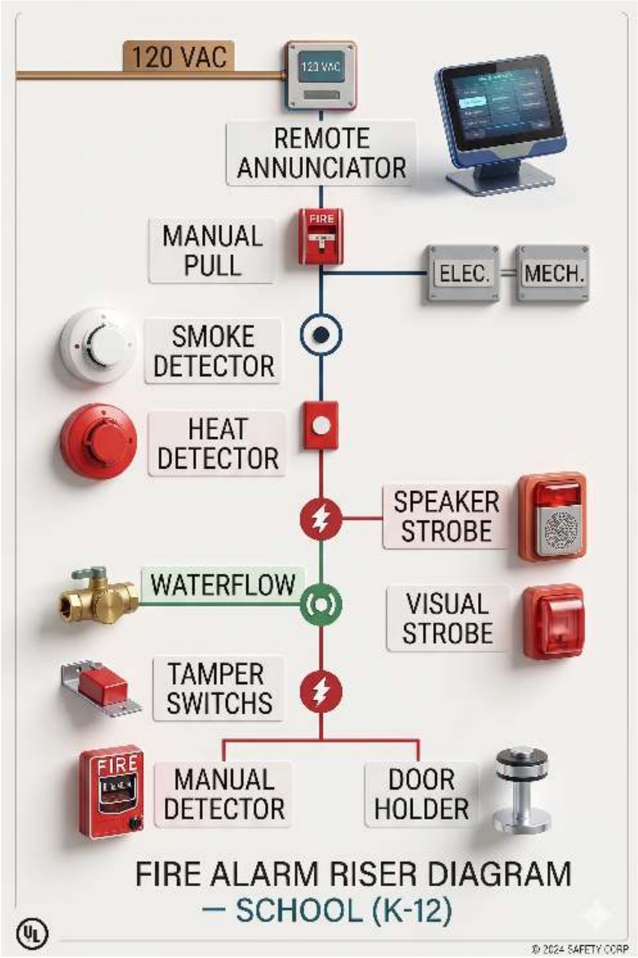

Figure 26. Sample fire alarm riser

Appendix A. Cross-Referenced Codes and Standards for Fire Alarm Compliance

While NFPA 72 provides the foundational framework for fire-alarm system design and installation, it is not the only code involved. Fire-alarm professionals must also consult several other codes and standards to ensure full compliance with building, electrical, life-safety, and accessibility regulations.

This appendix provides a practical reference to the most commonly cross-referenced codes used alongside NFPA 72.

A.1 Key Codes and Their Roles

Code or Standard	Issuing Body	Scope and Application
NFPA 70 (National Electrical Code)	NFPA	Governs electrical wiring methods, conduit, grounding, cable ratings, and installation practices. Article 760 covers fire-alarm circuits.
NFPA 72 (National Fire Alarm and Signaling Code)	NFPA	Governs design, installation, performance, testing, and maintenance of fire-alarm and emergency communications systems.
NFPA 101 (Life Safety Code)	NFPA	Addresses occupant protection, evacuation, and life-safety features that dictate alarm signaling and notification requirements.
NFPA 1 (Fire Code)	NFPA	A comprehensive fire code adopted by many states; incorporates NFPA 72 by reference and includes fire-alarm enforcement and inspection criteria.
NFPA 92 (Smoke Control Systems)	NFPA	Governs design and testing of smoke-control systems that interface with the FACP.

NFPA 20 (Stationary Pumps)	NFPA	Governs fire pumps that are supervised by the fire-alarm system.
NFPA 25 (ITM of Water-Based Fire Protection)	NFPA	Governs inspection, testing, and maintenance of sprinklers and waterflow/tamper switches monitored by the FACP.
IBC (International Building Code)	ICC	Establishes building-wide requirements including fire-protection-system thresholds (Chapter 9) and integration with construction type.
IFC (International Fire Code)	ICC	Covers ongoing fire prevention and maintenance, including alarm testing, inspections, and documentation.
ADA Standards / ICC A117.1	DOJ / ICC	Requires accessible notification appliances (visual strobes, mounting heights, sound levels) to accommodate individuals with disabilities.
OSHA 29 CFR 1910.165	OSHA	Workplace requirements for employee alarm systems.
UL Standards (UL 217, UL 268, UL 521, UL 864, UL 1971, UL 2572)	UL	Product-listing standards for smoke alarms, smoke detectors, heat detectors, control units, visible appliances, and mass-notification equipment.
Local Amendments / AHJ Requirements	Varies	Many jurisdictions amend national codes. Always verify local building-department or fire-marshal requirements.

A.2 How These Codes Interact

- **NFPA 72:** Provides the 'how' of fire-alarm system design.
- **NFPA 70 / NEC:** Defines the electrical wiring requirements that support system infrastructure.

- **IBC, IFC, NFPA 1, NFPA 101:** Define the 'when and where' — when a system is required, where devices must be located, and what features it must include.
- **ADA Standards and ICC A117.1:** Ensure the system is inclusive and meets legal accessibility standards.
- **UL / FM listings:** Provide product certification — the FACP, devices, and components must be listed to the relevant UL or FM standard for the intended use.

Designers and installers must reference the most current editions of each code adopted in their jurisdiction and coordinate with the AHJ to ensure full approval.

> **Reviewer's Update —** *The first edition contained typographic errors 'NEPA 101' and 'NEPA 5000.' The correct designations are NFPA 101 and NFPA 5000. NFPA 5000 (Building Construction and Safety Code) is published by NFPA but is rarely adopted in U.S. jurisdictions — IBC remains the prevalent model building code.*

A.3 Summary

Fire-alarm compliance goes beyond NFPA 72. A well-designed system reflects a coordinated understanding of multiple codes, each contributing essential requirements. This reference should be used throughout design, permitting, and inspection phases to ensure complete and enforceable solutions.

FIRE ALARM INSPECTION AND TESTING REPORT

OWNER / OCCUPANT	ADDRESS
ADDRESS	CONTRACT NUMBER

SCOPE

Annual inspection ad testing of the fire alarm system in accordance with NFPA 72.

INSPECTION	RESULTS
Batteries	Pass / Fail / NA
Control units	Pass / Fail / NA
Notification appliances	Pass / Fail / NA
Annunciator panels	Pass / Fail / NA
Output functions	Pass / Fail / NA
Interface equipment	Pass / Fail / NA
Power supply	Pass / Fail / NA
Initiating devices	Pass / Fail / NA
Signal transmission to monitoring station	Pass / Fail / NA

NOTES

Figure 27. Sample Fire Alarm Inspection and Testing Report Form — documents results of fire alarm system testing, device status, functionality verification, corrective actions, and compliance with NFPA 72 inspection and testing requirements.

Appendix B. Design Guidelines, Sample Design, and Calculations

Designing a fire-alarm system involves creating a comprehensive plan that ensures the safety of occupants and compliance with local codes and standards.

When designing a fire-alarm system, it is essential to follow a well-defined and structured process to ensure accuracy, consistency, and reliability throughout the project. Proper documentation at every stage is equally important — not only for construction and inspection, but also for future maintenance and troubleshooting. Code compliance must be rigorously maintained by referencing all applicable local, national, and international standards (NFPA 72, NFPA 70, NFPA 101, IBC). All required calculations — voltage drop, battery capacity, and loop resistance — should be performed to verify system performance under all conditions. Comprehensive and clear design drawings — floor plans, riser diagrams, wiring schematics, and zoning layouts — are critical for effective implementation and coordination with other building systems. Finally, the design must address testing and verification procedures to ensure that the installed system functions correctly, meets code requirements, and performs as intended in an actual emergency.

Here is a step-by-step guide to designing a fire-alarm system:

Step 1: Understand the requirements

- **Building Type and Usage:** Determine the type of building complex (residential, commercial, industrial, mixed-use, healthcare, assembly, etc.) and its purpose.
- **Occupancy:** Identify the number of occupants and the maximum occupant load in various zones.
- **Regulations and Codes:** Refer to applicable codes and the AHJ-adopted edition (NFPA 72, NFPA 70, NFPA 101, IBC, IFC).

- **Hazard Analysis:** Assess the fire risk in different areas of the building (kitchens, mechanical, hazardous materials, atria).

The design process involves classifying the premises according to standards and applicable codes. The physical characteristics and occupancy of the premises determine the identification of alarm and detection zones.

Codes that define where fire-alarm systems are required:

- International Building Code (IBC)
- NFPA 101: Life Safety Code
- NFPA 5000: Building Construction and Safety Code
- State and local building codes

> **Reviewer's Update —** *Original text used 'NEPA' for NFPA in this section — corrected throughout. NFPA 5000 is rarely adopted in U.S. jurisdictions today; IBC remains the prevalent model building code.*

Codes that regulate fire-alarm systems after their requirement is determined:

33. **NFPA 72 — National Fire Alarm and Signaling Code.** Specifies application, installation, location, performance, inspection, testing, and maintenance of fire-alarm systems.
34. **NFPA 101 — Life Safety Code.** Addresses safety from fire and related hazards, including fire-alarm requirements for different building types.
35. **IBC (International Building Code).** Provides regulations for the design and installation of fire-alarm systems in new and existing buildings.
36. **NEC / NFPA 70.** Covers wiring and installation practices for electrical systems, including fire alarms (Article 760).
37. **ADA (Americans with Disabilities Act).** Specifies requirements for accessibility, including visual alarms and notification devices.
38. **Local Building and Fire Codes.** Jurisdiction-specific codes may have additional requirements beyond national standards.
39. **UL Standards.** UL 217 (residential smoke alarms), UL 268 (commercial smoke detectors), UL 521 (heat detectors), UL 864 (control units), UL 1971 (visible appliances).

40. **OSHA.** 29 CFR 1910.165 specifies fire-safety requirements for workplaces, including alarm systems.
41. **ISO 7240.** ISO 7240 specifies requirements for the components and design of fire-alarm systems (international standard).
42. **BS 5839.** BS 5839 — UK code of practice for the design, installation, commissioning, and maintenance of fire-alarm systems.

Step 2: Identify Components

A typical fire-alarm system includes:

- **Fire Alarm Control Panel (FACP):** The brain of the system, connecting and monitoring all devices.

Detection devices:

  - **Smoke Detectors:** Photoelectric, ionization, or multi-criteria detectors. Photoelectric or multi-criteria are preferred in most residential and commercial applications.
  - **Heat Detectors:** Fixed-temperature or rate-of-rise detectors for heat detection.
  - **Flame Detectors:** Used in areas with high fire risk (petrochemical, hangars, processing plants).

Notification devices:

  - **Audible Alarms:** Sirens, horns, or bells.
  - **Visual Alarms:** Strobes or beacons.
  - **Voice Evacuation Systems:** For clear instructions in larger buildings.
- **Manual Pull Stations (Manual Call Points):** Allow manual activation.
- **Power Supply:** Includes primary power and backup batteries (sealed lead-acid sized for 24 h standby + 5 min alarm, or 15 min for EVACS).

Additional features:

  - **Sprinkler Monitoring:** If a sprinkler system is installed.
  - **Gas / CO Detection:** For hazardous gas areas and CO detection.

Supervisory initiating devices

Supervisory devices monitor systems that support fire safety, ensuring they are in proper working order. These devices alert the system in case of abnormalities that may affect fire response, without triggering an evacuation alarm.

Common supervisory devices:

43. **Sprinkler System Monitors.** Valve tamper switches detect if a sprinkler-system valve is closed or tampered with. Flow switches detect water flow in sprinkler pipes, indicating system activation.
44. **Pressure Switches.** Monitor fire-pump or sprinkler-system pressure levels.
45. **Fire Pump Supervisory Signals.** Monitor pump controllers for readiness, power supply, phase reversal, and pump-running condition.
46. **Dry-Pipe / Pre-Action Valve Supervisory Signals.** Monitor air pressure in systems where water is released only during a fire.
47. **Generator Status.** Monitor the backup power generator for faults or operational readiness.
48. **Duct Smoke Detectors.** Supervise HVAC systems for smoke, preventing smoke spread through ventilation.

Emergency control functions

Emergency control functions allow the fire-alarm system to control other building systems during an alarm event, ensuring the safety of occupants and efficient emergency response.

Key emergency control functions:

49. **HVAC Shutdown.** Shuts down air-handling units to prevent the spread of smoke and fire.
50. **Elevator Control.** Activates elevator recall, bringing elevators to a designated safe floor and disabling normal operation.
51. **Door Release.** Releases electromagnetic door holders to close fire-rated doors.

52. **Stairwell Pressurization.** Activates pressurization fans to keep stairwells smoke-free for safe evacuation.
53. **Smoke Control Systems.** Activates smoke-exhaust fans or dampers to manage smoke movement.
54. **Lighting Systems.** Turns on emergency lighting and exit signs.
55. **Gas Shutoff.** Disables gas supply to prevent explosions or fire exacerbation.
56. **Public Address (PA) Systems.** Coordinates voice-evacuation messages with fire-alarm signals.
57. **Sprinkler Activation.** Triggers water release in pre-action or deluge sprinkler systems.

> **Reviewer's Update —** *Corrected the first-edition typo 'Tums on emergency lighting' to 'Turns on emergency lighting.'*

Step 3: Zoning and Layout

Divide the building into zones:

- Each floor or specific area should be a separate zone for easier identification during emergencies.
- High-risk areas like kitchens or mechanical rooms might need their own zones.
- Zone boundaries should align with fire-rated construction wherever possible, so that one zone equals one fire compartment.

Placement of devices:

- Smoke detectors should be placed in hallways, stairwells, elevator lobbies, and rooms (excluding spaces where specifically permitted to be omitted).
- Heat detectors are suitable for areas prone to false alarms from smoke, like kitchens, garages, and shops.
- Notification devices should be audible and visible in every occupied space.

Step 4: System Design

- **Detection Network:** Plan the wiring (or wireless mesh) for all detectors, ensuring redundancy and survivability where required.
- **Control Panel Placement:** Position the FACP in a secure, easily accessible location (e.g., near the main entrance or security office). In high-rise applications the FACP often resides inside the fire command center.
- **Power Supply:** Provide a reliable connection to the building's electrical system with a battery backup. Per NFPA 72 §10.6, the secondary supply must support 24 hours of standby plus 5 minutes alarm (or 15 minutes for EVACS/ECS).

Integration with other systems:

- Connect to the building's HVAC system to shut off airflow during a fire.
- Integrate with sprinklers and elevators for a coordinated response.
- Coordinate with access-control and security so egress doors unlock automatically.

Step 5: Create Drawings

A clean schematic helps visualize the system. It should include:

- All zones.
- Device locations.
- Wiring paths and circuit class designations.
- Control panel placement.
- Power sources and battery calculation.

A typical fire-alarm system design includes several types of drawings to ensure clear communication, proper installation, and compliance with codes:

58. Floor Plan Layouts
59. Riser Diagrams
60. Device Wiring Diagrams
61. Sequence of Operations Matrix

62. Zoning Diagrams
63. Schematic Diagrams
64. Panel Layout and Internal Wiring
65. As-Built Drawings
66. Emergency Control Diagrams
67. Mounting Details

Floor plan layouts

- **Purpose:** Shows the placement of devices and components throughout the building.

Content:

- Locations of smoke detectors, heat detectors, pull stations, and notification devices.
- FACP placement.
- Pathways for wiring and cabling, with circuit-class designations.
- Room names and functions for context.

Riser diagrams

- **Purpose:** Illustrates the vertical connections between floors in multi-story buildings.

Content:

- Fire-alarm system zones by floor.
- Wiring and device connections to the FACP.
- Supervisory and notification circuits.

Device wiring diagrams

- **Purpose:** Provides detailed wiring information for connecting devices.

Content:

- Circuit configurations (Class A, B, X, N).
- Connections for smoke detectors, pull stations, notification appliances, and relay outputs.

- Wire type, size, and pathways, including survivability where required.

Sequence of operations matrix

- **Purpose:** Outlines how the system responds to various input conditions.

Content:

- Input conditions (smoke detector activation, pull station activation, waterflow, supervisory).
- Corresponding output responses (HVAC shutdown, elevator recall, alarm notification, door release, smoke control).

Zoning diagrams

- **Purpose:** Highlights the division of the building into fire-alarm zones.

Content:

- Zone boundaries and identifiers.
- Device assignments to specific zones.

Schematic diagrams

- **Purpose:** Provides an overview of the entire fire-alarm system's architecture.

Content:

- Connections between the FACP, power supplies, devices, and auxiliary systems.
- Integration with other building systems (HVAC, elevators, sprinkler systems).

Panel layout and internal wiring

- **Purpose:** Details the internal components of the FACP.

Content:

- Arrangement of input/output modules, power supplies, and batteries.
- Wiring connections inside the panel.

As-built drawings

- **Purpose:** Reflects the system's actual installation, including any changes during construction.

Content:

  - Updated device locations and wiring routes.
  - Finalized system architecture.

Emergency control diagrams

- **Purpose:** Shows how the fire-alarm system interfaces with other emergency systems.

Content:

  - Connections to HVAC controls, elevator recall, gas-shutoff valves, and sprinkler systems.

Mounting details

- **Purpose:** Guides proper device installation.

Content:

  - Device heights and mounting locations (wall-mounted pull stations between 42 and 48 in. AFF; ceiling-mounted spot detectors).
  - Special instructions for challenging environments (ceiling height > 10 ft, beam pockets, raised plenums).

Fire Alarm System Design for a Mixed-Use Building Complex — Sample Design

Objectives

- Provide early detection and notification of fire hazards.
- Monitor and supervise fire-safety systems for operational integrity.
- Integrate emergency control functions to ensure occupant safety and efficient fire response.
- Comply with applicable fire codes and regulations (NFPA 72, NFPA 70, IBC, NFPA 101).

System Overview

The fire alarm system will include the following components:

Detection and Initiation Devices

a. Smoke Detectors:

- Photoelectric detectors for general areas (preferred for most occupancies).
- Multi-criteria detectors in nuisance-prone areas such as corridors near kitchens.

b. Heat Detectors:

- Fixed-temperature detectors (135 °F ordinary; 200 °F intermediate) for kitchens and boiler rooms.
- Rate-of-rise detectors for areas with fluctuating temperatures (loading docks, mechanical rooms).

c. Manual Pull Stations:

- Strategically placed within 5 ft of each exit and at intervals so that maximum travel distance to a pull station is 200 ft.

d. Supervisory Initiation Devices:

- Valve tamper switches for sprinkler-system valves.
- Flow switches for monitoring sprinkler activation.
- Pressure switches for fire-pump pressure monitoring.
- Duct smoke detectors to supervise HVAC systems.

Notification Devices

a. Audible Alarms: horns, bells, or sirens for general alarm notification (temporal-three pattern).

b. Visual Alarms: strobe lights for ADA compliance in public areas, synchronized within fields of view.

c. Voice Evacuation: required in the high-rise residential portion and recommended for the assembly portion.

Emergency Control Functions

- **HVAC Shutdown:** Prevents smoke circulation via air-handling units.
- **Elevator Control:** Phase I recall and Phase II firefighter service; shunt trip for sprinklered hoistways/machine rooms.
- **Door Release:** Releases magnetic door holders to close fire-rated doors.
- **Stairwell Pressurization:** Activates pressurization fans to keep stairwells smoke-free.
- **Smoke Control Systems:** Operates exhaust fans and dampers to manage smoke movement per NFPA 92.
- **Gas Shutoff:** Shuts off gas supply to commercial-kitchen and laboratory-fuel systems.
- **Public Address (PA) Systems:** Coordinates evacuation messaging with fire-alarm signals.

Zoning and Device Placement

Zones:

- Each floor will be a separate zone for easy identification.
- High-risk areas (kitchens, mechanical rooms, electrical rooms) will have dedicated zones.

Device placement:

- Smoke detectors in hallways, stairwells, elevator lobbies, and rooms.
- Heat detectors in kitchens and mechanical rooms.
- Pull stations near exits and in common areas.
- Notification devices in all occupied spaces.

System Design Components

Fire Alarm Control Panel (FACP)

- Central hub for monitoring and controlling the fire-alarm system.
- Capable of receiving signals from detection devices and initiating notifications and emergency controls.
- Networked or voice-integrated chassis where EVACS is provided.

Supervisory Circuits

- Separate addressable supervisory points for tamper, flow, and pressure.
- Alerts for abnormal conditions without triggering full evacuation alarms.

Emergency Control Relays

- Listed and supervised relay modules for interfacing with HVAC, elevators, and gas-shutoff systems.
- Programmed for automatic or manual activation during fire events.

Power Supply

- Primary connection to building power on a dedicated, identified circuit (NEC §760.121).
- Backup batteries sized for 24 h standby + 5 min alarm (15 min if EVACS), with optional generator integration.

Testing and Maintenance

Regular inspections:

- Monthly visual checks of FACP and battery condition.

- Quarterly checks of supervisory circuits and waterflow.
- Semi-annual checks of waterflow switches.
- Annual functional test of all initiating devices, notification appliances, and emergency control functions per NFPA 72 Table 14.4.5.

Maintenance schedule:

- Clean and test smoke detectors annually.
- Replace batteries every 3–5 years (or sooner if load test indicates degradation).
- Sensitivity-test smoke detectors at 1 year and every other year thereafter.

Schematic and Layout

Detailed example:

Ground Floor

- Function: Retail stores and lobby.
- Smoke Detectors: Hallways, lobby, and stairwells.
- Heat Detectors: Kitchens in restaurants.
- Pull Stations: Near exits.
- Notification Devices: Strobe lights and horns in common areas.
- Supervisory Devices: Flow switch and tamper switch for sprinkler riser.

First Floor

- Function: Office spaces.
- Smoke Detectors: All rooms and hallways.
- Pull Stations: At each exit door.
- Notification Devices: Strobes and voice-evacuation speakers in corridors.
- Duct Smoke Detectors: HVAC system ducts.

> **Reviewer's Update —** *Corrected typos from the first edition: 'exit dour' → 'exit door' and 'tamper switth' → 'tamper switch.'*

Second to Fifth Floors

- Function: Residential apartments.
- Smoke Detectors: Living areas and bedrooms.
- Heat Detectors: Kitchens in individual units.
- Pull Stations: Near stairwells and exits.
- Notification Devices: Audible and visual alarms in corridors; 520-Hz low-frequency sounders in sleeping rooms for new construction.

Basement

- Function: Parking garage and mechanical room.
- Heat Detectors: Mechanical room and areas prone to heat buildup.
- Smoke Detectors: Parking areas where permitted (note: many AHJs require heat-only in garages to avoid nuisance activations).
- Supervisory Devices: Pressure switch for fire pump.
- Notification Devices: Audible and visual alarms.

Roof Level

- Function: Rooftop amenities and mechanical equipment.
- Smoke Detectors: Elevator machine room.
- Supervisory Devices: Tamper switch for rooftop water tank.

Sequence of Operations

7. Sequence of Operations Matrix

Input Condition	Output Response
Smoke Detector Activation	Activate notification appliances (horns, strobes); HVAC shutdown; elevator recall; PA system active
Heat Detector Activation	Activate notification appliances (horns, strobes); HVAC shutdown; elevator recall; PA system active
Pull Station Activation	Activate notification appliances (horns, strobes); PA system active
Sprinkler Flow Activation	Activate notification appliances (horns, strobes); HVAC shutdown
Valve Tamper Switch Activation	Supervisory signal to FACP only (no general alarm)
Duct Smoke Detector Activation	Shut down affected HVAC zone; activate notification appliances
Fire Pump Pressure Drop	Supervisory signal to FACP; monitor pump operation
Manual Override via FACP	Custom response based on manual inputs
Power Failure	Switch to backup batteries; supervisory signal to FACP

Figure 28. Sequence of Operations

The sequence of operations defines how a fire-alarm system responds to specific inputs or events, detailing the step-by-step actions the system takes during a fire or emergency situation.

It outlines what happens when devices like smoke detectors, manual pull stations, or sprinkler flow switches are activated, including:

- **Detection →** Alarm is triggered by a device.
- **Notification →** Audible/visual alarms activate (horns, strobes, voice messages).
- **Control Functions →** Elevators recall, HVAC shuts down, doors release, smoke control engages.

- **Communication →** Signals sent to fire department or central monitoring station.

This sequence ensures coordinated safety responses, meeting code requirements and protecting life and property.

Compliance and Certification

Compliance and certification ensure that a fire-alarm system meets national and local codes, industry standards, and safety regulations. This process involves:

- Design compliance with NFPA 72, NFPA 70 (NEC), and local building/fire codes.
- Product certification by recognized labs (UL, FM Approvals).
- Installation compliance, verified through inspections and AHJ approval.
- Testing and commissioning to confirm proper operation and documentation (NFPA 72 §14).
- Ongoing ITM and re-certification to maintain system reliability.

Certification provides assurance that the system will perform correctly in an emergency and meets legal and insurance requirements.

- Verify system design against local fire codes and standards.
- Obtain Record of Completion (NFPA 72 §7.5) and AHJ acceptance upon completion.

Bill of Materials (BOM)

9. Bill of Materials (BOM)

Item Description	Quantity	Unit Price (USD)	Total Price (USD)
Fire Alarm Control Panel (FACP)	1	5,000	5,000
Smoke Detectors (Optical)	50	50	2,500
Heat Detectors	20	40	800
Manual Pull Stations	15	100	1,500
Strobe Lights	30	75	2,250
Audible Alarms	20	80	1,600
Supervisory Devices (Tamper, Flow, etc.)	10	120	1,200
Power Supply (Primary)	1	1,000	1,000
Backup Batteries	4	250	1,000
HVAC Control Relays	5	150	750
Elevator Recall Relays	3	200	600
Wiring and Cabling (per meter)	500	2	1,000
Installation Labor (per hour)	100	50	5,000
Total Estimated Cost			**24,700**

Figure 29. Bill of Materials

A Bill of Materials (BOM) for a fire-alarm system is a structured document that itemizes all necessary devices, hardware, and accessories needed to implement the system according to the design specifications. It typically includes:

- Item name or part number.
- Quantity required.
- Manufacturer / model.
- Description or specifications.
- Location or reference (panel, floor, zone).

The BOM serves as a planning and procurement tool for installers, contractors, and project managers, ensuring that all required components are ordered, delivered, and tracked throughout the project.

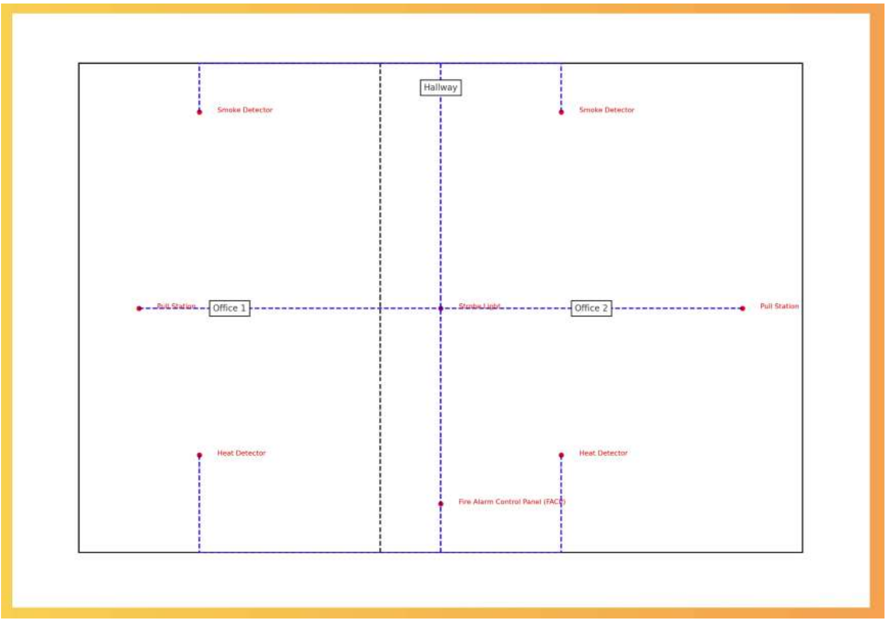

Figure 30. Typical Device Layout Drawing

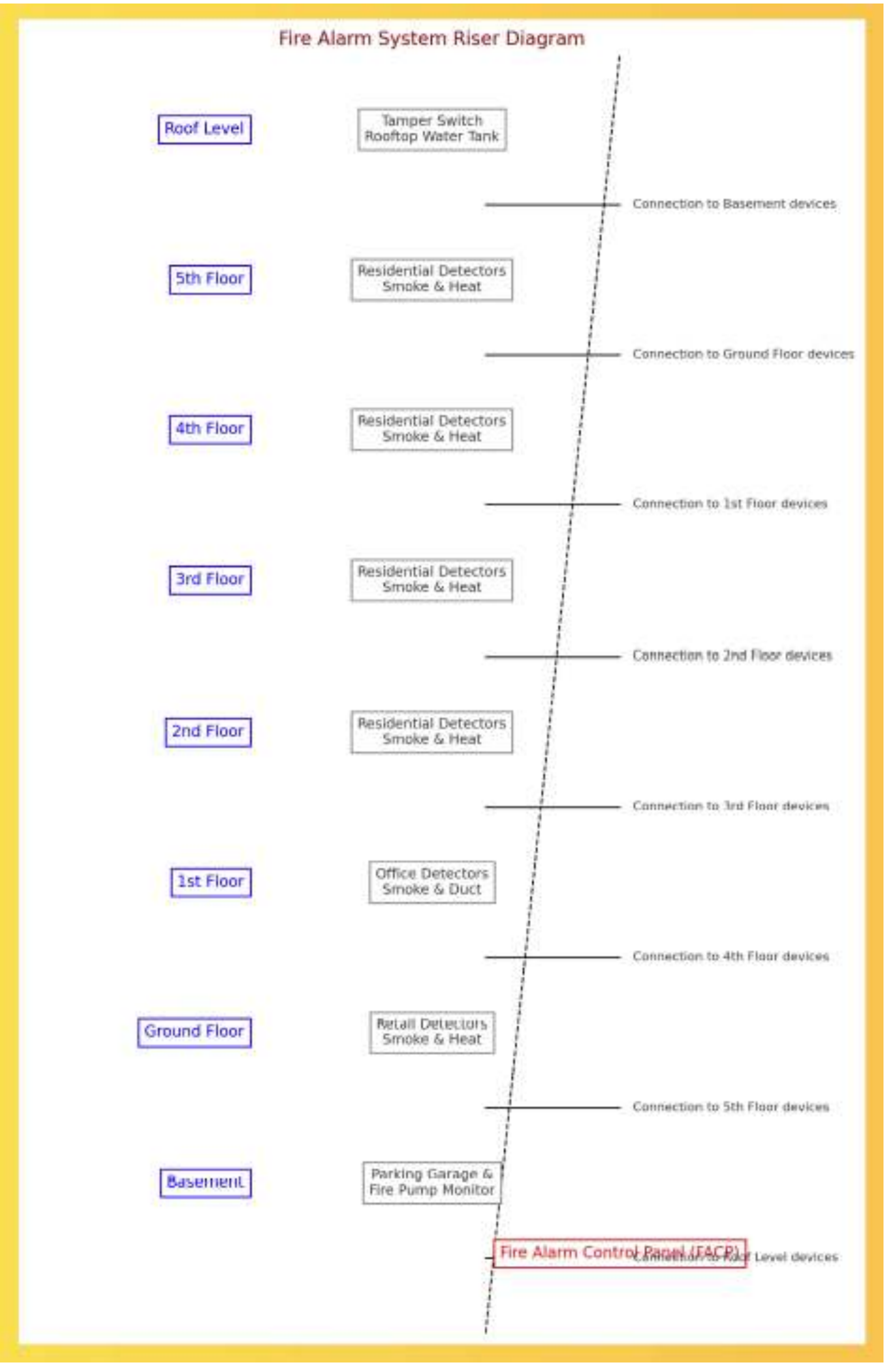

Figure 31. Riser Diagram

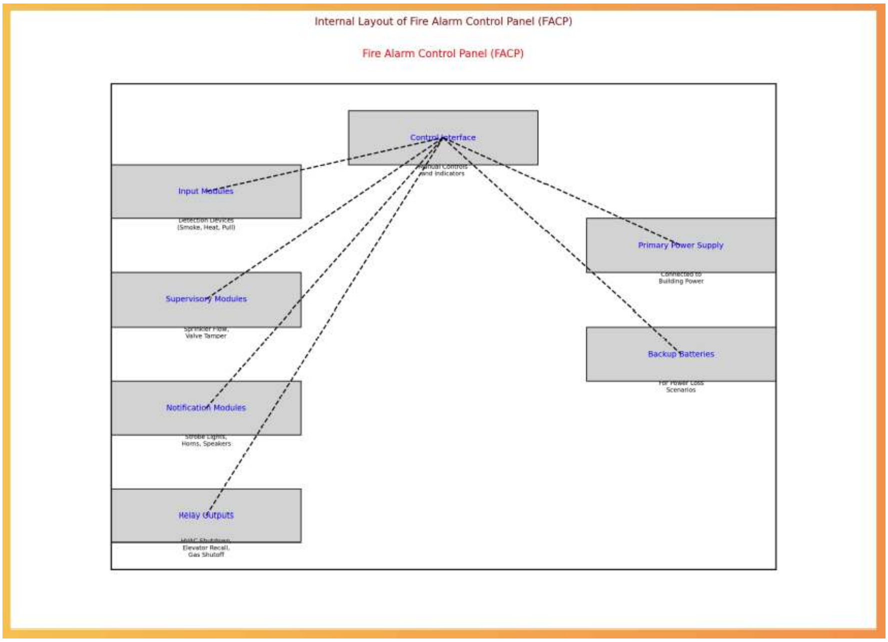

Figure 32. FACP Panel Layout

Battery Backup Capacity (AH) Calculations

To calculate the required battery-backup capacity for the fire-alarm system, account for the standby and alarm power requirements of all components. NFPA 72 §10.6.7 requires sufficient backup-battery capacity for 24 hours of standby operation followed by 5 minutes of alarm operation for a standard protected-premises fire-alarm system, or 15 minutes of alarm for EVACS / ECS.

The general formula is:

Battery AH (minimum) = (Standby Current × Standby Hours) + (Alarm Current × Alarm Hours) × Safety Factor

A safety factor of 1.20 is commonly applied to account for battery aging and temperature.

Component	Quantity	Standby Current (mA)	Alarm Current (mA)	Total Standby Current (mA)	Total Alarm Current (mA)
Fire Alarm Control Panel (FACP)	1	150	600	150	600
Smoke Detectors	50	0.2	20	10	1,000
Heat Detectors	20	0.2	15	4	300
Pull Stations	15	0	10	0	150
Strobe Lights	30	0	150	0	4,500
Horns	20	0	200	0	4,000
Supervisory Devices	10	1	0	10	0
Total	-	-	-	**174 mA**	**10,550 mA**

Calculation	Formula	Result
Total Standby Current	$150 + 10 + 4 + 0 + 0 + 0 + 10 = 174\,\mathrm{mA}$	**0.174 A**
Total Alarm Current	$600 + 1{,}000 + 300 + 150 + 4{,}500 + 4{,}000 + 0 = 10{,}550\,\mathrm{mA}$	**10.55 A**
Standby Capacity (AH)	$\text{Standby Current (A)} \times \text{Standby Time (hours)}$	$0.174 \times 24 = 4.176\,\mathrm{AH}$
Alarm Capacity (AH)	$\text{Alarm Current (A)} \times \text{Alarm Time (hours)}$	$10.55 \times \frac{5}{60} = 0.879\,\mathrm{AH}$
Total Capacity (AH)	$\text{Standby Capacity} + \text{Alarm Capacity}$	$4.176 + 0.879 = 5.055\,\mathrm{AH}$
Adjusted Capacity (Safety)	$\text{Total Capacity} \times 1.2$	$5.055 \times 1.2 = 6.07\,\mathrm{AH}$

Figure 33. Fire Alarm Backup Battery Power Calculations

Battery selection (per the calculation):

If the calculated requirement is 6.07 AH, a battery with a capacity of 7 AH (next standard size up) is recommended to meet the requirement with margin. Verify the panel's maximum permitted battery size; some FACPs use up to 18 AH internal and require an external battery cabinet for larger capacities.

Loop Resistance Calculations

Loop-resistance calculations for a fire-alarm system help ensure that the system complies with manufacturer requirements and operates correctly.

This involves considering wire resistance, loop length, and the number of devices.

Loop Resistance (Ω) = ρ × (2 × L / A)

where ρ is the resistivity of copper, L is the one-way length in feet, and A is the cross-sectional area (typical 18 AWG: 6.39 Ω per 1,000 ft round-trip; 14 AWG: 2.52 Ω per 1,000 ft).

Parameter	Value	Formula
Wire Gauge	18 AWG	-
Resistance per Foot	6.385 ohms/1,000 feet	-
Loop Length	500 feet (one-way), 1,000 feet total	$L_{\text{total}} = L_{\text{one-way}} \times 2$
Device Current	20 mA	-
Total Current	0.2 A	$I_{\text{total}} = \text{Device Current} \times \text{Number of Devices}$
Loop Resistance	6.385 ohms	$R_{\text{loop}} = R_{\text{wire}} \times L_{\text{total}}/1,000$
Voltage Drop	1.277 V	$V_{\text{drop}} = I_{\text{total}} \times R_{\text{loop}}$
Source Voltage	24 V	-
End Voltage	22.723 V	$V_{\text{end}} = V_{\text{source}} - V_{\text{drop}}$

Figure 34. Fire Alarm Circuit Loop Resistance Calculations

Glossary of Key Terms

Term	Definition
Acoustically Distinguishable Space (ADS)	An emergency-communications term identifying a space (or contiguous spaces with similar acoustic properties) for which intelligibility must be assessed individually.
AHJ (Authority Having Jurisdiction)	The organization, office, or individual responsible for enforcing code requirements.
Alarm Signal	A notification of a detected fire or emergency condition requiring immediate action.
Annunciator Panel	A display panel showing the status and location of alarm events.
Battery Backup	Secondary power supply that ensures the fire-alarm system remains functional during a power outage.
Class A/B/C/D/E/N/X Circuits	Pathway-performance classifications defined by NFPA 72 §12 based on fault tolerance and survivability.
Control Panel (FACP/FACU)	The central unit that monitors inputs and controls outputs of the fire-alarm system.
DACT (Digital Alarm Communicator Transmitter)	Device that transmits alarm signals over a telephone line. Largely being replaced by cellular and IP communicators.
Detector (Smoke/Heat)	A device that senses the presence of fire by detecting smoke or heat.
ECS (Emergency Communications System)	Per NFPA 72 Chapter 24, the umbrella term for systems providing voice/text emergency communication (includes EVACS and MNS).
EVACS (Emergency Voice/Alarm Communication System)	A subset of ECS that provides verbal instructions during emergencies.
Initiating Device	Any manual or automatic device that activates a fire alarm.
IDC (Initiating Device Circuit)	Circuit used to connect conventional devices that detect alarm conditions.
NAC (Notification Appliance Circuit)	Circuit used to power devices that alert occupants (horns, strobes, speakers).
NFPA 70 (NEC)	National Electrical Code governing fire-alarm

	system wiring (Article 760).
NFPA 72	National Fire Alarm and Signaling Code governing fire-alarm system design, installation, and maintenance.
Pull Station / Manual Call Point	A manual device that allows occupants to activate a fire alarm.
Shunt Trip	A breaker accessory that opens the breaker on a fire-alarm signal; commonly used to remove power from elevator equipment prior to sprinkler operation.
SLC (Signaling Line Circuit)	A circuit that allows addressable devices to communicate with the control panel.
STI (Speech Transmission Index)	A measure of voice intelligibility; per NFPA 72 Annex D, a value of 0.45 is the design threshold for EVACS.
Supervisory Signal	Indicates that a component of a fire-protection system is not in its normal position.
Trouble Signal	Indicates a fault or abnormal condition in the fire-alarm system.
UL 217 / UL 268 / UL 864 / UL 1971	UL listing standards for residential smoke alarms, commercial smoke detectors, control units, and visible appliances respectively.

End-of-Book Review Questions

Chapter 1: Codes and Standards

68. What is the difference between a fire-alarm code and a standard?
69. Which code determines when a fire-alarm system is required in a building?
70. Name three codes or standards other than NFPA 72 that are typically cross-referenced during fire-alarm system design.
71. Who is the AHJ and what is their role?

Chapter 2: Purpose and Components

72. What are the five primary purposes of a fire-alarm system?
73. List the key components of a fire-alarm system and describe the function of each.

Chapter 3: System Types and Communication

74. Compare local, remote-station, and central-station fire-alarm systems.
75. What is the primary advantage of an addressable fire-alarm system over a conventional one?
76. What are the typical communication methods used for remote monitoring today, and which legacy method is being phased out?

Chapter 4: Alarm Signal Types

77. Define alarm, trouble, and supervisory signals.
78. Give one example of a device that might trigger each type of signal.
79. Why is it important to distinguish between signal types both visually and audibly?

Chapter 5–6: Initiating Devices (Alarm & Supervisory)

80. What is the main difference between a smoke detector and a heat detector?

81. What is the role of a tamper switch in a sprinkler system?
82. How does a supervisory device help ensure system reliability?

Chapter 7: Notification Appliances

83. What are the ADA / NFPA 72 requirements for notification appliances?
84. Describe two situations where a voice-evacuation system is more appropriate than horns/strobes.
85. What is the minimum required duration of operation for a standard NAC during an alarm? How does this differ for EVACS?
86. What is the maximum permitted sound pressure at the minimum hearing distance, and what is the absolute maximum permitted anywhere in the occupied space?

Chapter 8: Fire Alarm Control Panel (FACP)

87. What are the main functions of the FACP?
88. How does an addressable FACP differ from a conventional one in device monitoring?
89. Name three outputs the FACP can control during an emergency.

Chapter 9: Emergency Control Functions

90. List four emergency control functions triggered by a fire-alarm system.
91. How does stairwell pressurization support occupant safety during evacuation?
92. What is the difference between Phase I recall and Phase II firefighter service?

Chapter 10: Emergency Response Notification

93. What is the difference between a central station and a proprietary supervising station?
94. Why is redundancy required in communication paths to remote stations? What single-path technologies are now permitted?

Chapter 11: Manual vs. Automatic Operation

95. Where are manual pull stations typically installed? What is the mounting-height range?
96. Name two types of automatic initiating devices and explain their function.

Chapter 12: Emergency Voice/Alarm Communication

97. What are the minimum intelligibility and audibility requirements for EVACS?
98. What is the standby and alarm operation duration requirement for voice systems?

Chapter 13–14: Circuitry, Wiring, and Classifications

99. Describe the difference between IDC, NAC, and SLC circuits.
100. What are Class A and Class B circuits, and how do they respond to wire faults? How do Class X and Class N differ?
101. List three code-compliant wiring practices from NEC Article 760.

Chapter 15: Grounding

102. What is the purpose of equipment grounding in a fire-alarm system?
103. What hazard does poor grounding introduce, and how does it affect fire-alarm supervision?

Chapter 16: System Design and Documentation

104. What documents are typically submitted for fire-alarm system permitting?
105. What information is included in a sequence-of-operations document?

Appendix A: Cross-Referenced Standards

106. Why is ADA compliance critical in fire-alarm system design?
107. How do IBC and NFPA 101 differ in their focus on fire protection?

Inspection and Testing

108. What components are typically tested during an annual fire-alarm inspection?
109. What should be documented on a fire-alarm inspection report?
110. Per NFPA 72 Table 14.4.5, how often must smoke-detector sensitivity be tested after initial installation?