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JENSEN HUGHES

Clearing the Confusion & Smoke with Smoke Control System Commissioning

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Learning Objectives

1. Articulate some of the code requirements of smoke control systems from the International Building Code.
2. Describe the unique challenges of integrating fire protection and life safety system testing.
3. Articulate the NFPA 4 commissioning process for Fire Protection and Life Safety Systems.
4. Understand the increased level of responsibility as Fire Commissioning Agent vs Traditional Commissioning Provider.

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Agenda

- Why Care About Smoke Control
- Codes
- Types of Smoke Control Systems
- Smoke Control Design
- Smoke Control Special Inspection
- Firefighters Smoke Control Panel
- BMS Used for Smoke Control
- NFPA 4 Integrated Testing and ITa
- Most Common Pitfalls
- Takeaways

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Why Care about Smoke Control?

- MGM Grand Fire 1980 Las Vegas
- First Floor Fire Spread Smoke to the high-rise levels including guestrooms
- 90 min Fire - 64 of the 85 people died on upper floor
- Smoke kills more than fire
- 700 people injured
- Smoke went up stair and elevator shafts to spread to upper floors
- Sweeping code changes including smoke control system still in place today

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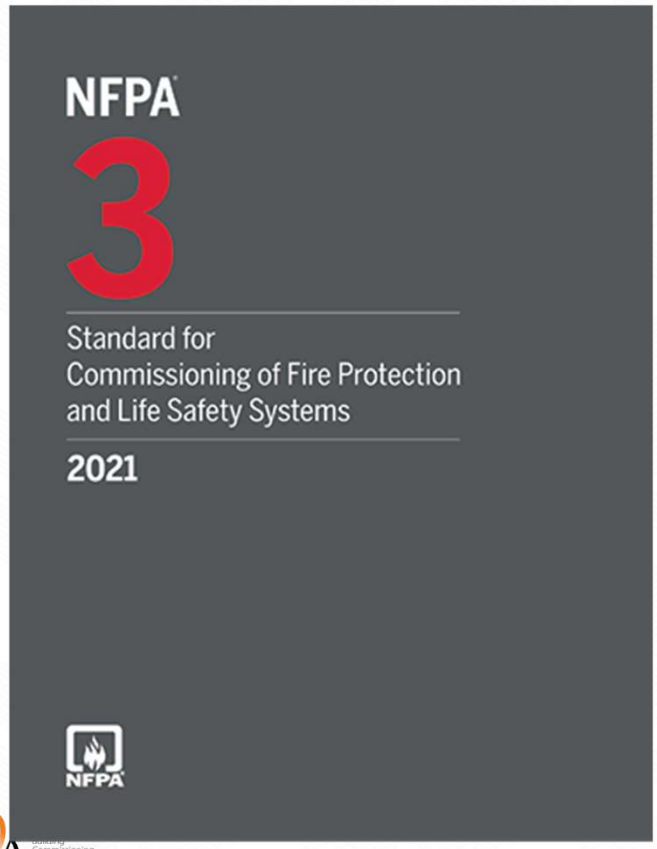
NFPA 3

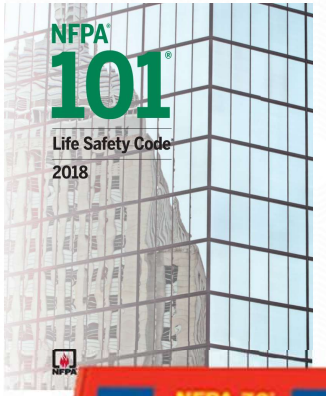


NFPA 3, Standard for Commissioning Fire Protection and Life Safety Systems Testing

1. Commissioning – "A systematic process that provides documented confirmation that building systems function according to the intended design criteria set forth in the project documents and satisfy the owner's operational needs, including compliance with applicable laws, regulations, codes, and standards."
2. NFPA 3 just focuses on the process, not how to Cx specific FLS or how to test the various FLS in the field.
3. It relies on the other NFPA standards that each individually cover a specific FLS.
4. You commission individual Fire and Life Safety systems.

Building and Fire Codes

- NFPA 101 – Life Safety Code
  - Section 9.3 – Smoke Control
- NFPA 92 – Standard for Smoke Control Systems
- National Fire Alarm Code (NFPA 72)
  - Tells you HOW to put in the fire alarm system
  - Fire Alarm Systems need to meet UL864
  - A subset of UL864 is UUKL
    - UUKL deals with Smoke Control Equipment



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IBC – Section 909

IBC Section 909 Smoke Control Systems

- Provides design criteria
- Provides passive and mechanical methods of protection
- Provides inspection criteria (IBC 909.3)
- Smoke Control Special Inspections (SCSI)–IBC code mandated Smoke Control Cx)
  - SCSI required to have expertise in fire protection engineering and mechanical engineering
- NFPA 4 ITa goes beyond just smoke control, it goes into other systems interfaced with fire/life safety systems

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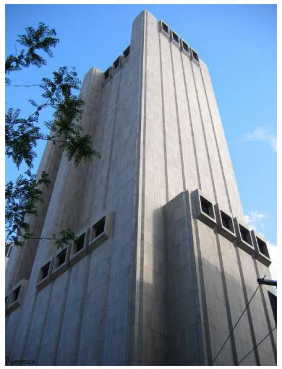
Where is Smoke Control Required?

- High-Rise Buildings (IBC 403.5.4) Stair Pressurization (IBC 909.20.5)
- Hoistway Opening Protection Pressurization Alternative (IBC 3006.3(4))
- Atriums/Malls (IBC 404.5)
- Underground Buildings (IBC 405.5)
- Smoke-protected assembly seating (IBC 1029.6.2.1)
- Group I-3 Windowless Buildings (IBC 408.9)



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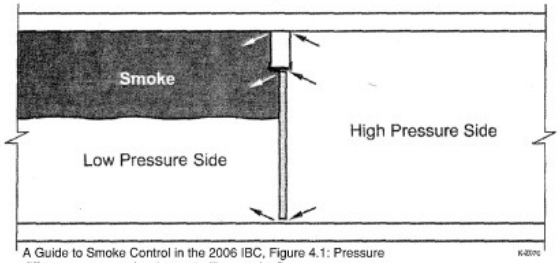
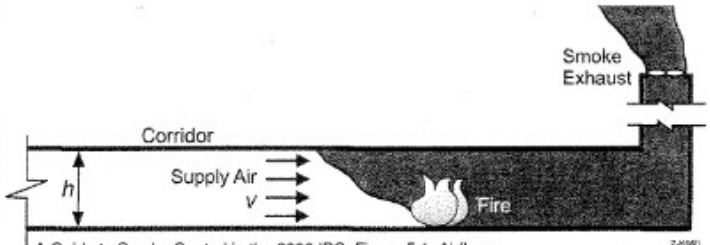
Types of Smoke Control Systems

- Pressurization Method
  - Pressure differential between zones (Ex. Stair Press & Elevator Shaft)
- Airflow Method
  - Utilizing air velocity to prevent smoke spread
- Exhaust Method
  - Maintaining tenability 6.0 ft above the occupied floor for a designed period of time. (Ex. Atrium Smoke Control)



A Guide to Smoke Control in the 2006 IBC, Figure 4.1: Pressure difference across a barrier controlling smoke flow



A Guide to Smoke Control in the 2006 IBC, Figure 5.1: Airflow to control smoke flow in a corridor

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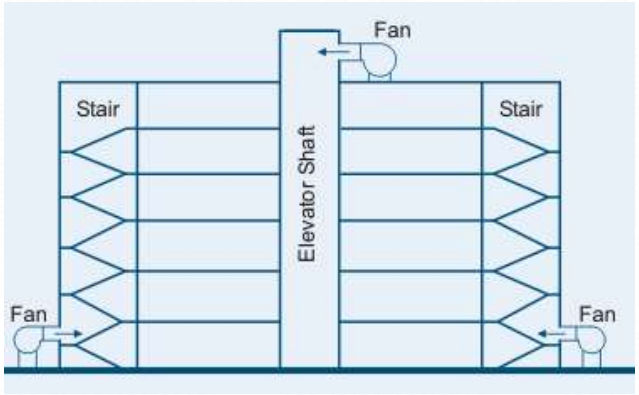
Types of Smoke Control Systems - Continued

Stair and Elevator Shaft Pressurization

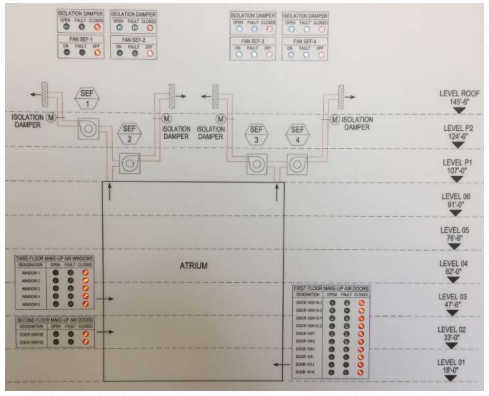
- Pressure Differential at Door Openings
  - 0.1-inch water gage minimum (Stairs and Elevators)
  - 0.25-inch water gage maximum (Elevators)
  - 0.35-inch water gage maximum (Stairs)
- Elevator Shaft Press eliminate lobbies need smoke control rational analysis
- Opening Forces
  - Max 30 lbs



Types of Smoke Control Systems - Continued

Atrium Smoke Control

- Automatic Smoke Exhaust
- Maintain a smoke layer 6 feet above walking surfaces
- Will open dampers and turn on exhaust fans upon an alarm
  - Maximum makeup air velocity is 200 fpm (unless system is modeled)
  - Makeup air can be mechanical supply or operable doors/windows



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Smoke Control Design

FDS Model

- 3D Smoke Model represents interior of building.
- Entire interior is divided into cubes (grids)
- Based up maintaining tenability for time required for occupants to egress from the space (Computer Egress Model)
- Can Measure Established Tenability Parameters
- Justify makeup air velocities > 200 fpm

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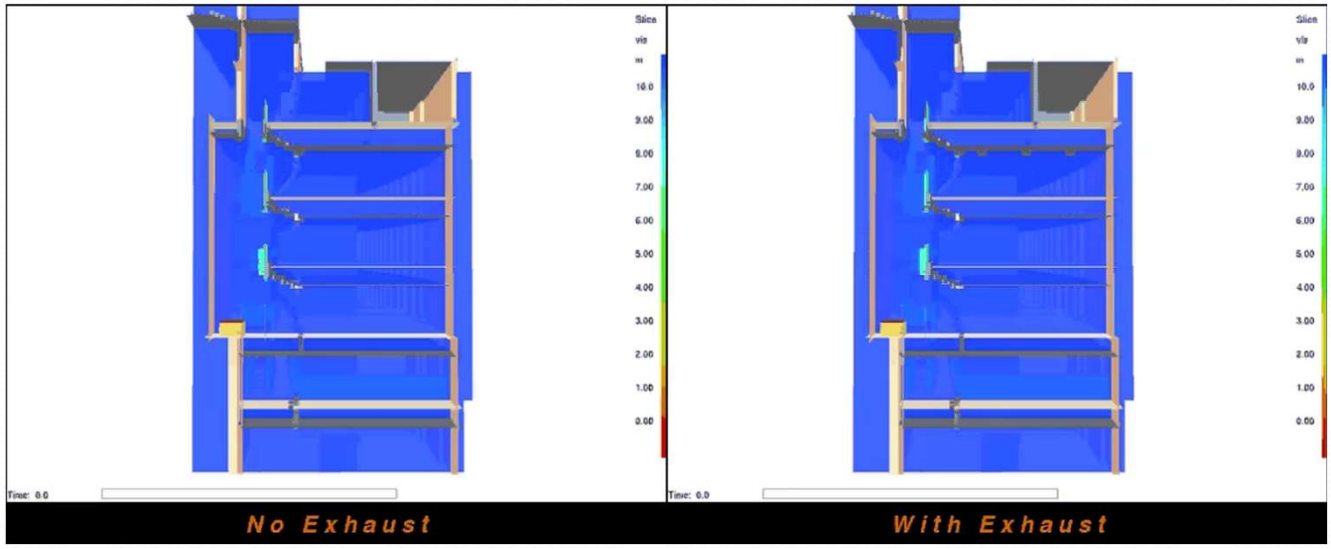
Smoke Control Design – Computer Modeling

Example Project with and without Smoke Control



(For this Model, Areas in Yellow, Orange, and Red Fail the Tenability Criteria)

Design – Rational Analysis Report

Rational Analysis Report (909.4)

- Determines smoke control fan sizes
- Details system operation and activation
- 7 Key required items
  - Stack effect, Temperature effect of fire, Wind effect, HVAC System, Climate, Duration of Operation, Smoke control system interaction
- Details both prescriptive and performance requirements
  - Available Safe Egress Time vs. Required Safe Egress Time
    - Egress Modeling
  - Supply velocity for atrium smoke control and the 200-fpm prescriptive max unless computer modeling was done to show higher velocities complied with performance-based computer model.

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Smoke Control Special Inspection (SCSI)

- Required by code
- Verify that the smoke control system meets the applicable codes and standards and listings
- Includes review of construction documents, rational analysis, data sheets, specifications
- Review of Smoke Control Panel
- Inspection and testing of ducts prior to concealment
- Verification of system components
- Testing of devices (Normal and Fault)
- System Inspection
- Pressurization testing
- Exhaust/Supply testing
- Integrated Test (includes drop building power)

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SCSI Documents to Provide

- Commissioning Plan
  - How the Special Inspector intends on testing the system.
- Daily Field Reports
  - Summary of the testing and inspections conducted each day.
- Non-Conformance Reports (NCRs)
  - List of any and all deficiencies noted during the testing of the system.
- Special Inspection Report
  - The Special Inspectors final report stating the smoke control system has been fully tested and complies with the design and code requirements. All of the above items should be attached and needs PE stamp and signature from smoke control system engineer of record.

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SCSI Required Monitoring

Monitoring

- True Positive Indication
- Power downstream of any/all disconnects
- ALL interconnect wiring
- Damper position (Open and Close)
- Proof of Fan Operation

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SCSI – Other Requirments

Installation Requirements

- All Control & Monitor point wiring to be installed in "continuous raceway", i.e. conduit (909.12.1)
- MC Cable is NOT a continuous raceway
- Stair Press Equipment, Power, and Control circuits required to be 2 hour protected inside the building (909.20.6.1.3)
- Entire control SLC to be in conduit
- We recommend separate SLC for smoke control controls circuits due to use of 2-hour Circuit Integrity Cable in Conduit (CIC).
- Smoke Control equipment is to have a secondary (back up) power source
- Equipment needs to be suitable for intended use (909.10) such as temperature ratings

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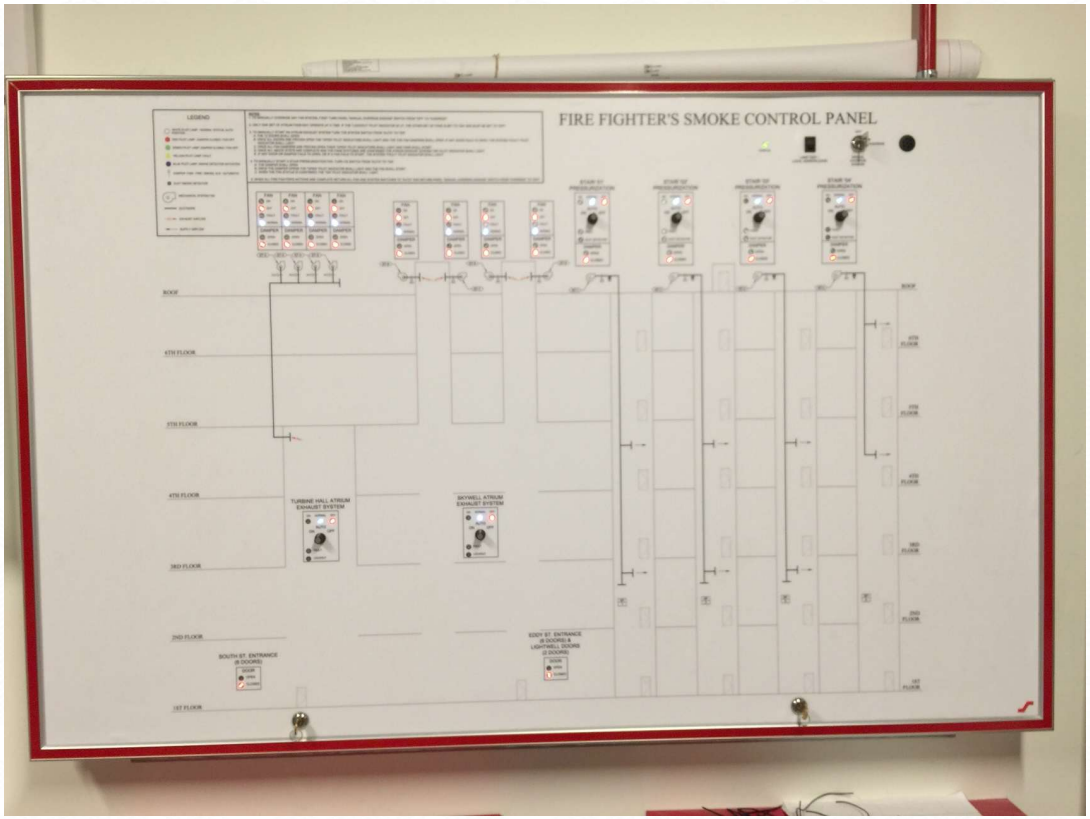
Fire Fighters Smoke Control Panel



SCSI – Other Requirements

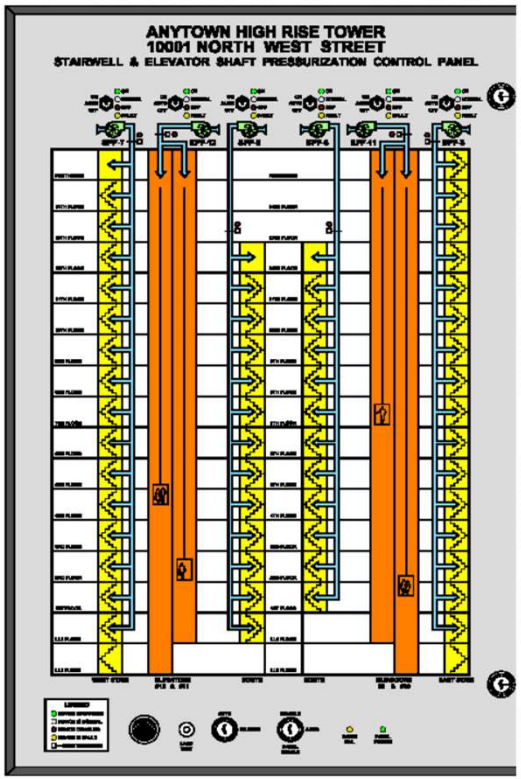
Installation Requirements

- Duct leakage test (909.10.2)
- Location of equipment inlets and outlets (909.10.3)
- Fans 1.5 times the belts and 1.15 motor service factor (909.10.5)
- 2 sources of power in separated locations (909.11)
- Standby power transfer within 60 seconds (909.11)
- Safety interlocks (e.g. supply damper did not prove open. Dampers fail safe open
- Equipment needs to be suitable for intended use (909.10) such as temperature ratings

Firefighters Smoke Control Panel

Functionality/Priorities

- Purpose is for initiating smoke control sequences, ***or*** for Manual override of Automatic Smoke Control Sequences
- Total Response Time for individual components to reach their desired state
  - 75 seconds for Dampers
  - 60 seconds for Fans
- Interconnect wiring must be monitored unless less than 20 feet AND in conduit
- Must have both Audible and Visual indicators
- Keep it Simple Stupid (KISS)



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Firefighters Smoke Control Panel - Continued

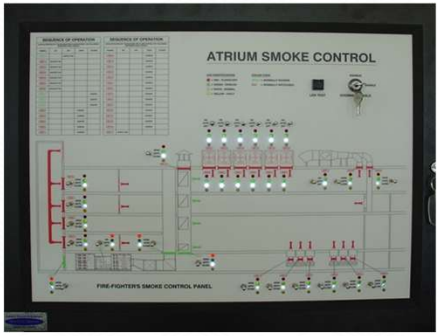
LED's

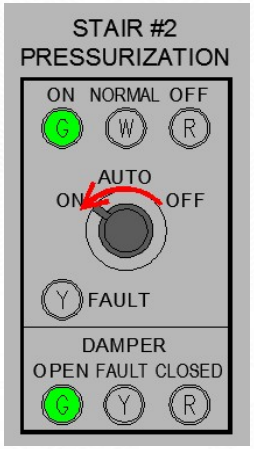
- WHITE (Normal) is for when switch is in the AUTO position
- RED – indicates Fan OFF or Damper CLOSED
- GREEN – indicates Fan ON or Damper OPEN
- AMBER – indicate a fault condition
- BLUE – used in Boston & Vegas – indicates a duct detector activation
- FSCS shall visually indicate the "current" status of all smoke control components (even when not in alarm)

Firefighters Smoke Control Panel - Continued

Switches

- Have Highest Priority
- Override program controls





BMS/BAS Used for Smoke Control

Permitted if the Design meets UUKL listing requirements

- Most Often requires additional components and configurations for added reliability and redundancy as part of the original listing

All of the IBC 909 requirements are applicable to the BMS system used for smoke control

UUKL any Volatile Memory be supplied with a UPS with minimum 15 minutes

Lack of availability of 2 hour control wiring a problem

Most smoke control systems (atrium and stair pressurization) are dedicated equipment (not used for normal HVAC)

Smoke Control is a Fire & Life Safety with much more requirements than HVAC

Fire Alarm Systems better suited to control smoke control system

BMS contractors do not understand NFPA 72 and UUKL

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On Going Testing Requirements

Automatic Weekly Self-Test

- Performed once a week
- Automatically activates all dedicated smoke control equipment (i.e. Fans, Dampers, etc.)
- Audible and visual indication of all components that failed to operate
  - Printout showing test started, items that failed (if any), test completed
- Only required for "dedicated" equipment (i.e. Air-Handlers used for daily operations are not required to be exercised during the self-test
- Code Alternate to not provide with some requirements and Building official approval

SEMI-ANNUAL TESTING (Dedicated) ANNUAL (Non-dedicated)

- All smoke control systems for the life of the building.
- Smoke candle testing is not required nor is it an accurate test.

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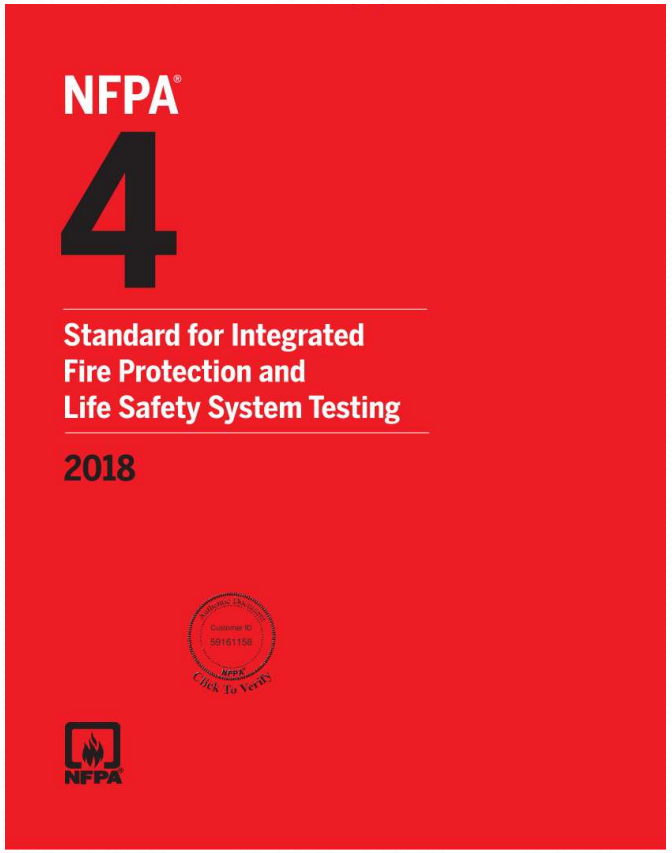
NFPA 4

NFPA 4, Standards for Integrated Fire Protection and Life Safety Systems Testing

- Integrated System Test

  "A test performed on fire protection and life safety systems to confirm that operation, interaction, and coordination of multiple individual systems perform their intended function."

- NFPA 4 Developed to address GAP
- End to End Testing
- Integrated Testing Agent (ITa)
- Applies to New and Existing Systems



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NFPA 4 Qualifications

- Qualified ITa required
- Advanced knowledge & experience in installation, operation, and interfaces between the various systems
- Comparisons not only done to OPR but to the applicable building, fire, and life safety codes
- Responsible for reviewing, documenting, and testing the needed integration between fire and life safety systems across various systems
- AHJ to determine if ITa is qualified

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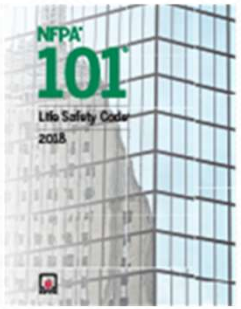
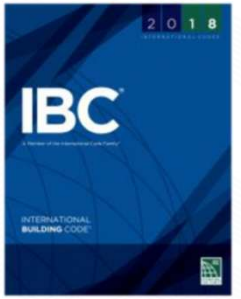
Codes Adopted NFPA 4

Applicable Codes

- NFPA 4, Standard for Integrated Fire Protection and Life Safety System Testing is adopted and referenced by:
  - 2018 / 2021/2024 International Building Code (IBC)
  - 2018 /2021/2024 International Fire Code (IFC)
  - 2018 / 2021/2024 NFPA 101 Life Safety Code
  - 2018 /2021/2024 NFPA 1, Fire Code
- In these codes NFPA 4 required for high-rise buildings, buildings with smoke control, or buildings with two or more fire protection and life safety systems integrated
- Jan 2024 30+ States adopt 2018 or 2021 IBC with more states in process of adopting 2018, 2021, or 2024 IBC
- Simple integrated test plan for simple buildings and more complex integrated test plan for more complex building





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Integrated Testing Team

- At a minimum, the integrated test team shall consist of the integrated testing agent (ITa) and the installation, testing, or maintenance personnel for each integrated system.
- The integrated system test team shall be identified and documented in the test plan.
- Personnel responsible for integrated system testing be qualified for their portion of the integrated test

1. Team may consist of:
   - ITa
   - Fire Alarm
   - Sprinkler
   - Fire Pump
   - HVAC
   - BMS
   - Lighting Control
   - Emergency/Standby Power
   - Audio Controls
   - Access Controls
   - Certified Air Balance Contractor (TAB)
   - Electrical
   - Elevator
   - Security
   - Cx Agent

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NFPA 4 Key Documents

- Owner's Project Requirements (OPR)
- Basis of Design (BOD)
- Integrated Testing Plan
- Integrated Test Report

Develop Test Scenarios from IO Matrix

		Control Unit Annunciation							Notification					Required Fire Safety Control					
	Initiating Devices	Actuate Common Alarm Signal Indicator	Actuate Audible Alarm Signal	Actuate Common Supervisory Signal Indicator	Actuate Audible Supervisory Signal	Actuate Common Trouble Signal Indicator	Actuate Audible Trouble Signal	Actuate Respective Floor Alarm Indicator	Actuate Floor Of Incident & Floor Above & Below	Display/Print Change Of Status	Transmit Fire Alarm Signal To Supervisory Station	Transmit Supervisory Signal To Supervisory Station	Transmit Trouble Signal To Supervisory Station	Release Magnetically Held Smoke Doors	Recall Elevator To Primary Recall Floor	Recall Elevators To Alternate Recall Floor	Close Smoke/Fire Dampers In Rated Walls	Open Elevator Hoistway Damper (Top Of Shaft)	Unlock Egress Doors
1	Manual Fire Alarm Stations	X	X					X	X	X	X			X					X
2	Area Smoke Detectors	X	X					X	X	X	X			X				X	X
3	Elevator Recall Smoke Detector - Elevator Lobby (Floors 2-7)	X	X					X	X	X	X				X			X	X
4	Elevator Recall Smoke Detector - Elevator Lobby (GND Floor)	X	X					X	X	X	X					X		X	X
5	Elevator Recall Smoke Detector - Elevator Machine Room	X	X					X	X	X	X			X	X			X	X
6	In-Duct Smoke Detector (RTU)			X	X					X		X							
7	In-Duct Smoke Detector (SF-1)			X	X					X		X							
8	In-Duct Smoke Detector (SF-2)			X	X					X		X							
9	In-Duct Smoke Detector (SF-3)			X	X					X		X							
10	In-Duct Smoke Detector - Fire/Smoke Damper			X	X					X		X					X		
11	Sprinkler Water Flow Switch	X	X					X	X	X	X			X			X	X	X
12	Sprinkler Tamper Switch Valve			X	X					X		X							
13	Sprinkler Low Water Pressure Switch			X	X					X		X							
14	Fire Pump Running	X								X	X								
15	Fire Pump Power Failure/Phase Reversal			X	X					X		X							
16	Fire Alarm AC Power Failure					X	X			X			X						
17	Fire Alarm System Low Battery					X	X			X			X						
18	Open Circuit					X	X			X			X						
19	Ground Fault					X	X			X			X						
20	Initiating Devices Short Circuit					X	X			X			X						
21	Notification Appliances Circuit Short					X	X			X			X						
22	Bi-directional Amplifier Failure					X	X			X			X						
23	Emergency Generator Failure					X	X			X			X						
24	Stair Pressurization Systems																		
25	Forum Atrium Smoke Evacuation Systems																		
26	Area Smoke Detectors or Beam Detector within Forum Atrium	X	X					X	X	X	X			X					X
27	In-Duct Smoke Detector (SF-4)			X	X					X		X							
28	Sprinker Water Flow Switch Associated with Separate Forum Atrium Zone	X	X					X	X	X	X			X			X	X	X
29	Pre-action Sprinkler System - Area Smoke Detector	X	X					X	X	X	X			X				X	X
30	Pre-action Sprinkler System - Manual Releasing Pull Station	X	X					X	X	X	X			X					X
31	Pre-action Sprinkler System - water flow	X	X					X	X	X	X			X			X	X	X
32	Pre-action Sprinkler System - low air pressure			X	X					X		X							
33	Kitchen exhaust hood ansul system within Forum atrium - activation	X	X					X	X	X	X			X				X	X
34	Kitchen exhaust hood ansul system outside of Forum atrium- activation	X	X					X	X	X	X			X				X	X
35	Main Water Flow - Actuate Common Supervisory Signal Indicator	X		X	X					X		X					X	X	
36	Smoke Detectors Within Stairwell or Outside Stairwell	X	X					X	X	X	X			X				X	X
37	Dry Sprinkler System	X	X					X	X	X	X			X			X	X	X
38	Dry Sprinkler System-low/high air			X	X					X		X					X	X	
	Emergency Generator Running					X	X			X									

		Supplemental																	
	Initiating Devices	Actuate Graphics System	Actuate Stair Pressurization	Shut Down Respective Stair Pressurization Fan	Shut Down Respective Roof Top Unit	Shut Down All Roof Top Units	Actuate Exterior Beacon @ (NFD Response Point)	Activate Masterbox	Activate Sprinkler Bell	Actuate Remote Annunciator	Daily Automatic Testing	Weekly Automatic Testing	Weekly Automatic Testing per IBC 909.12	Record Event	Actuate Forum Atrium Smoke Control Fans	Shut Down Forum Atrium Smoke Control Make-up Fan (SF-4)	Shut Down Dining Make-up Air Unit (MUA-1)	Pre-Action Valve Operates - Releases Water Into System	Display "Emergency Generator Running"
1	Manual Fire Alarm Stations	X					X	X		X				X					
2	Area Smoke Detectors	X	X			X	X	X		X				X					
3	Elevator Recall Smoke Detector - Elevator Lobby (Floors 2-7)	X	X			X	X	X		X				X					
4	Elevator Recall Smoke Detector - Elevator Lobby (GND Floor)	X	X			X	X	X		X				X					
5	Elevator Recall Smoke Detector - Elevator Machine Room	X	X			X	X	X		X				X					
6	In-Duct Smoke Detector (RTU)	X			X					X				X					
7	In-Duct Smoke Detector (SF-1)	X		X						X				X					
8	In-Duct Smoke Detector (SF-2)	X		X						X				X					
9	In-Duct Smoke Detector (SF-3)	X		X						X				X					
10	In-Duct Smoke Detector - Fire/Smoke Damper	X								X				X					
11	Sprinkler Water Flow Switch	X	X			X	X	X	X	X				X					
12	Sprinkler Tamper Switch Valve	X								X				X					
13	Sprinkler Low Water Pressure Switch	X								X				X					
14	Fire Pump Running	X								X				X					
15	Fire Pump Power Failure/Phase Reversal	X								X				X					
16	Fire Alarm AC Power Failure									X				X					
17	Fire Alarm System Low Battery									X	X			X					
18	Open Circuit									X				X					
19	Ground Fault									X				X					
20	Initiating Devices Short Circuit									X				X					
21	Notification Appliances Circuit Short									X				X					
22	Bi-directional Amplifier Failure									X				X					
23	Emergency Generator Failure									X		X		X					
24	Stair Pressurization Systems											X	X	X					
25	Forum Atrium Smoke Evacuation Systems											X	X	X					
26	Area Smoke Detectors or Beam Detector within Forum Atrium	X				X	X	X		X				X	X		X		
27	In-Duct Smoke Detector (SF-4)	X								X				X		X			
28	Sprinker Water Flow Switch Associated with Separate Forum Atrium Zone	X	X			X	X	X	X	X				X	X		X		
29	Pre-action Sprinkler System - Area Smoke Detector	X	X				X	X		X				X				X	
30	Pre-action Sprinkler System - Manual Releasing Pull Station	X					X	X		X				X				X	
31	Pre-action Sprinkler System - water flow	X	X			X	X	X	X	X				X					
32	Pre-action Sprinkler System - low air pressure	X								X				X					
33	Kitchen exhaust hood ansul system within Forum atrium - activation	X	X			X	X	X	X	X				X	X		X		
34	Kitchen exhaust hood ansul system outside of Forum atrium- activation	X	X			X	X	X	X	X				X					
35	Main Water Flow - Actuate Common Supervisory Signal Indicator	X							X	X				X					
36	Smoke Detectors Within Stairwell or Outside Stairwell	X	X			X	X	X		X				X					
37	Dry Sprinkler System	X	X			X	X	X	X	X				X					
38	Dry Sprinkler System-low/high air	X								X				X					
	Emergency Generator Running									X		X		X					X

*Note: Activate All Speakers For Partial Evacuation

Visual Inspection per NFPA 72:
1) Control Equipment - fire alarm system unmonitored for alarm, supervisory, and trouble signals (fuses, interfaced equipment, lamps/LEDs, primary power supply)
2) Fire alarm control unit trouble signals

Provide weekly automatic testing of stair pressurization systems per IBC 909.12. A failed weekly test shall notify the Central Station with a trouble signal. Weekly test shall include confirmation of the following:

1. **Activation of motorized damper.**
2. **Verification of power.**

Most Common Pitfalls

- Power monitored downstream of all disconnects
- All wiring in continuous raceways, regardless of voltage
- True Positive Status Confirmation both normal and fault conditions
- Emergency power transfer within code required time
- Standby power transfer switch separate 1-hour room from normal power & ventilated
- Verification Fan Airflow
- Following UUKL listing exactly for BMS/BAS
- Response times
- Environmental concerns -Temp, wind, humidity

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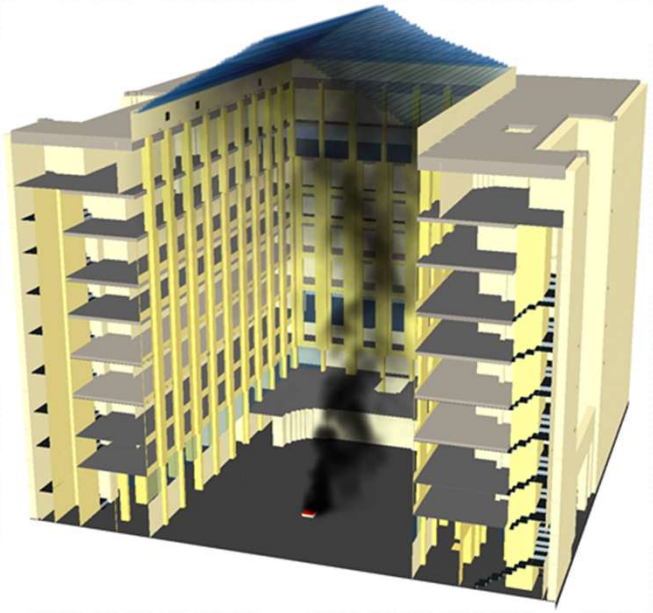
Takeaways



Qualified Smoke Control Special Inspector and Integrated Testing Agent on your team is a code requirement and verifying code compliance

Smoke Control Special Inspector is Required

Smoke Control Special Inspector to be involved ASAP.

Smoke Control Special Inspection Documents

- Commissioning Plan
- Daily Field Reports
- Non-Conformance Reports
- Special Inspection Report
- Final Control Diagrams of the

Weekly Self-Test & Semi-Annual Testing Required

IBC/NFPA4 mandate ITa for smoke control systems that uses test scenarios that go beyond the smoke control system.

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