SPACE AGE
ELECTRONICS

1:00 – 1:30 Welcome & Introduction

1:30 – 2:20 Smoke Control Systems

2:30 – 2:45 Break *(Snacks, Coffee & Beverages Served)*

2:45 – 3:45 Why Prefabrication?

3:45 – 4:00 Break *(Hordourves & Open Bar)*

4:00 – 4:30 Surge Protection, Project Close-out & I.T.M.

4:30 – 5:00 Formal Q&A Session with Presenters

5:00 – 6:00 Happy Hour & Networking *(Optional)*

July 20, 2016

SPACE AGE
ELECTRONICS

AFAA
New England

July 20, 2016

Michael J. Ventola, CFPS

TODAY'S DISCUSSION

Why Control Smoke

- ❑ The Code drivers

Codes & Standards for Smoke Control (Overview)

- ❑ Current Code & Technical Requirements

System Design

- ❑ Smoke Movement Principals
- ❑ Rational Analysis

Smoke Control System Types

- ❑ Passive/Active

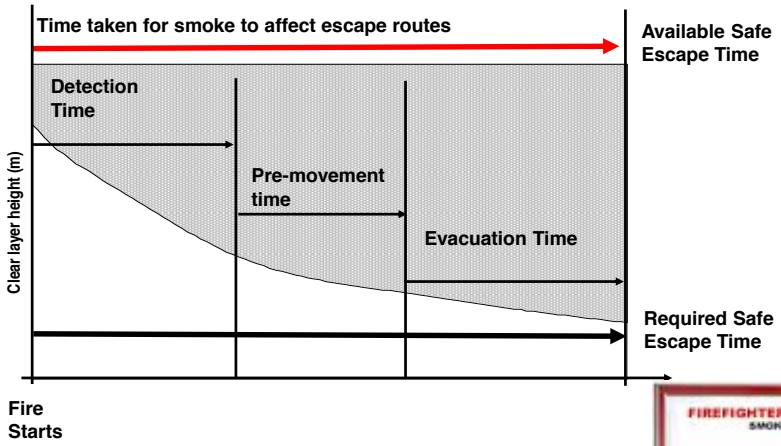
Q&A

Primary goals for this presentation:

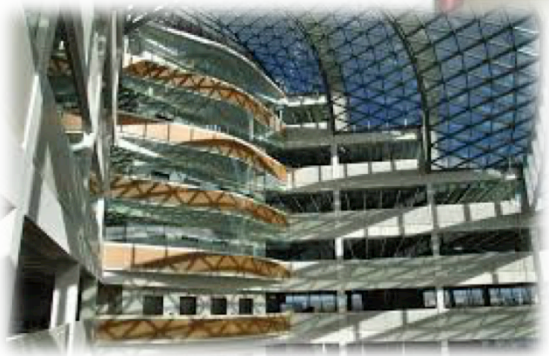
- *Provide high level overview of smoke control solution available along with smoke movement principals*
- *Understand why smoke control systems are needed and the design types available*
- *Code compliance requirements and application*

WHY CONTROL SMOKE?

- ❑ Life Safety
- ❑ Increase Egress Time
- ❑ Minimize Smoke Spread
- ❑ Fire Fighting Tool
- ❑ Reduce Explosion Risk
- ❑ Prevent Roof Collapse
- ❑ Protect Inventory/Eqpt
- ❑ Architectural Design Tool



GM Hydromatic Fire 1953



KNOWN RISKS TO CONSIDER

Jan 25, 2008

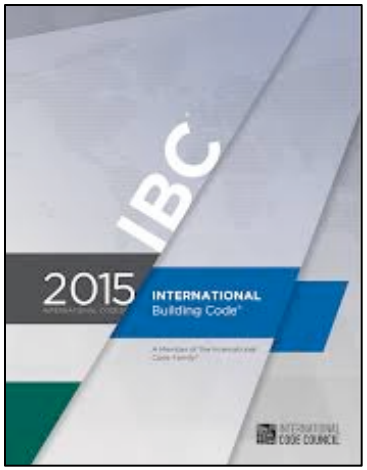
Love Field - Dallas

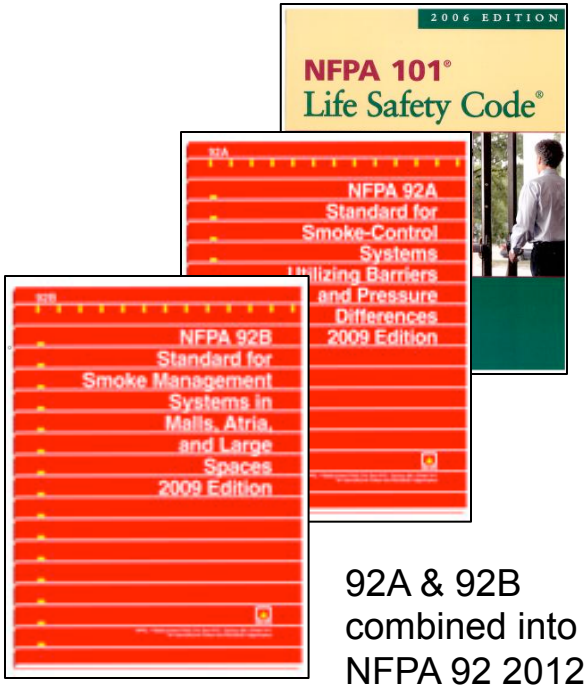
- ❑ Early detection doesn't ensure evacuation
- ❑ Sprinklers save lives, however there is a 10% failure rate
- ❑ Smoke can still spread
- ❑ Environmental conditions
- ❑ Arson or Malicious Intent

BUILDING CODES

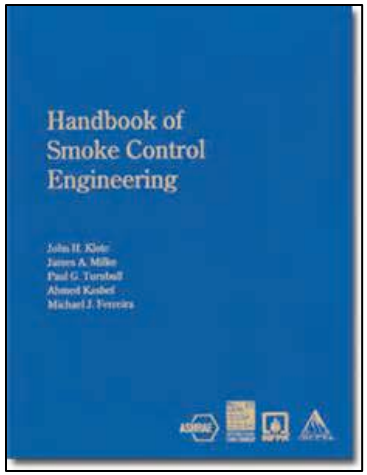
APPLICABLE CODES & GUIDELINES

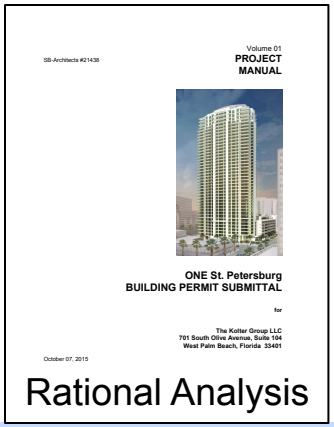
- International Building Code (IBC Section 909)
- NFPA 101 – Life Safety Code
- NFPA 92A – Smoke Control
- NFPA 92B – Smoke Management Atrium, Malls, Large Spaces
- ASHRAE – Guide 5 Commissioning
- ASHRAE – Smoke Management Handbook
- Authority Having Jurisdiction (AHJ, Fire Marshal, Bldg Dept)
- Product Listings – ANSI/UL864, ANSI/UL 555/555S/555C, FM





92A & 92B combined into NFPA 92 2012





Rational Analysis

Florida: FBC 2010, FFPC 2010
Georgia: IFC 2015, NFC, NFPA 1, IBC
Mass: NFPA 72 2013, NFPA 92, ASHRAE 2010, IBC*

Code Adoption Varies state by state

GENERAL REQUIREMENTS

Where Required

- ❑ Atriums over two stories
- ❑ Enclosed Malls
- ❑ High Rise Building
- ❑ Underground or Windowless Buildings (Tunnel or Prison)
- ❑ Smoke Protected Seating
- ❑ Health Care Facility
- ❑ Stair Towers/Elev Shaft (>75ft above or <30ft below egress)
- ❑ Enclosed Stages

Design Requirements

- ❑ UL864 & UUKL listed FACP or BMS control station
- ❑ UL864 & UUKL Listed FSCP*
- ❑ Activation in 10s, Proof Timing Limits (60s Fan – 75s Damper)
- ❑ Confirmation Proof (LEDs)
- ❑ Back-up Power (NFPA 110 - 15 min)
- ❑ Duration of operation 20min or 1.5X evacuation time (IBC 2015)
- ❑ All materials UUKL Listed for smoke control (End to End)
- ❑ Shall be an engineered system with supportive data CONTAM

*Not all FSCP are UUKL Listed as Smoke Control Station

TECHNICAL REQUIREMENTS

Mechanical

- ❑ Fans – 2 belts min, Hi-Temp, UL Listed
- ❑ Duct Spec – Hi-Temp, 1.5X design PSI
- ❑ Smk Damper – Open when air needed
- ❑ Fire Damper – High temp heat links
- ❑ BAS – UUKL listed, positive feedback

Power

- ❑ Primary & Secondary Power Source
- ❑ Dedicated fire proof power room (1hr)
- ❑ Transfer in 60s maximum
- ❑ 15min UPS back-up for BAS
- ❑ Monitor & Supervise
- ❑ TVSS Protection Installed

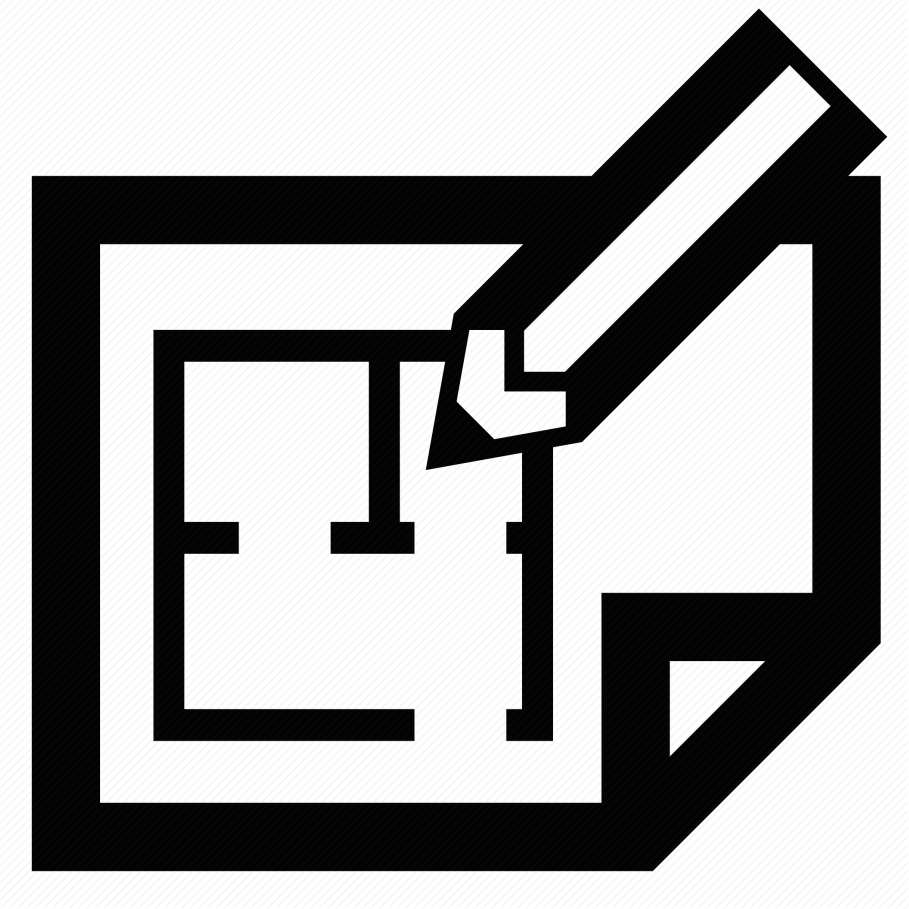
Wiring

- ❑ Comply with NFPA 70 NEC 760
- ❑ All wiring enclosed in raceways
- ❑ Type MC and AC cable not allowed (Fire Alarm Components)
- ❑ FPL-CI high temp cable allowed (FA)
- ❑ Terminations made on terminal blocks
- ❑ Control relays within 36” of fan/damper
- ❑ NFPA ?? 18.1 Support Relays in box
- ❑ Fail safe supervision acceptable

Markings

- ❑ All fire alarm raceway identified
- ❑ All terminal cabinets identified
- ❑ Damper access panels identified
- ❑ NFPA 72 Chapter 27.7.1
- ❑ NFPA 70 Chapter 760.30
- ❑ 120VAC branch circuits marked/locked
- ❑ Specification based requirements

SYSTEM DESIGN



ECOSYSTEM OF RESPONSIBILITY

- Primary Power
- Secondary Power
- Raceway
- Wiring

- Fans
- Dampers
- Air Supply
- Air Exhaust
- Duct System
- Balancing
- Controls

Mechanical Engineer

Electrical Engineer

Fire Protection Engineer

- Rational Analysis
- Smoke Movement
- HVAC Consideration
- Egress Calculations
- System Zoning
- Fire Detection
- Fire Suppression
- Interfaces
- Smoke Control Panel

- Aesthetics
- Structure Design
- Materials Used
- Code Compliance
- Hardware Type
- Systems Location

Architect

Smoke Control System

Authority Having Jurisdiction

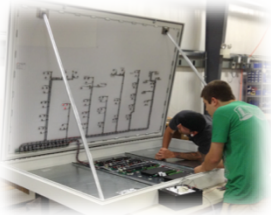
- Code & Standard
- Plan Approvals
- Acceptance Test
- Enforcement
- Re-certification

Mechanical

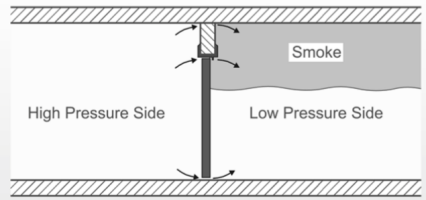
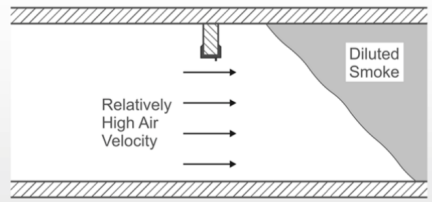
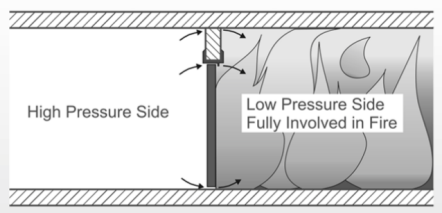
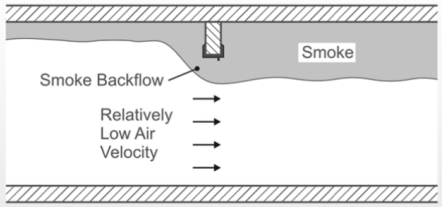
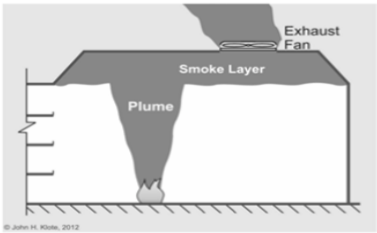
Electrical

Fire Alarm/Spklr

FSCP

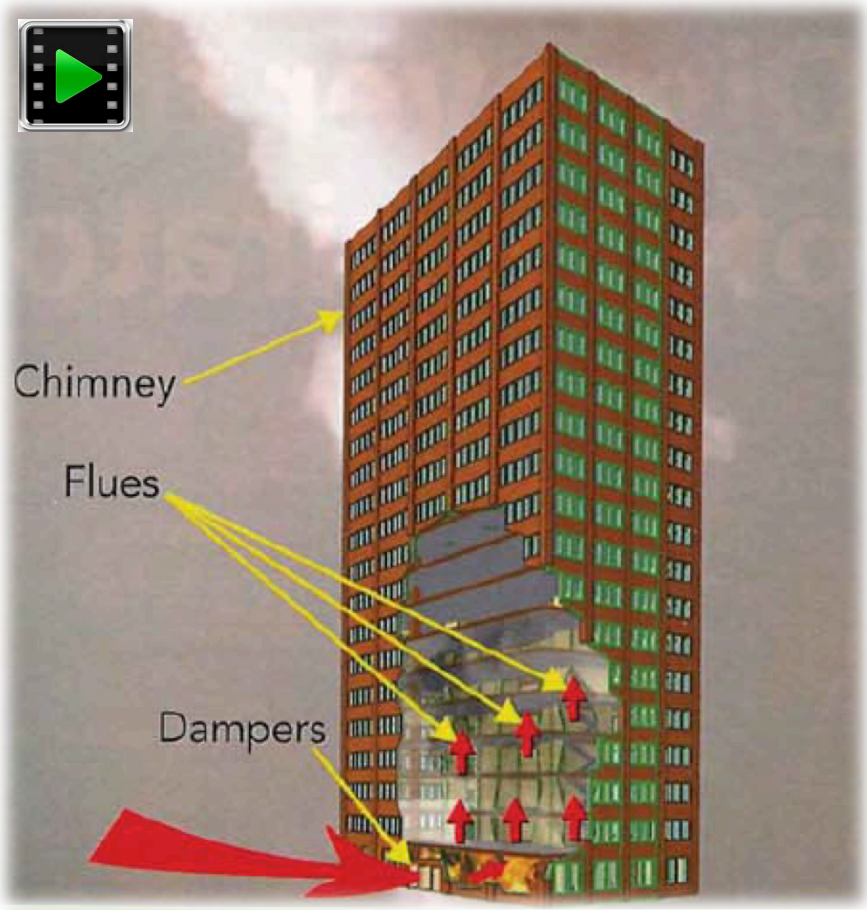


5 SMOKE CONTROL MECHANISMS

	Examples	System Type	Attributes
Compartmentation		▪ Active – NFPA 92A ▪ Passive – NFPA 92B	▪ Barriers with fire endurance ▪ Smoke barriers automated ▪ Compartmentation alone ▪ Compartmentation w/ pressurization ▪ Smoke Sink
Dilution		▪ Passive – NFPA 92B	▪ Only recommended for Atriums ▪ Smoke purging ▪ Smoke removal ▪ Smoke extraction ▪ Post fire
Pressurization		▪ Active – NFPA 92A	▪ Pressure differentials by zone ▪ Positive pressures ▪ Negative pressures ▪ Balanced air flow
Airflow		▪ Passive – NFPA 92B	▪ Natural venting ▪ Use stack effect as advantage ▪ Designed make-up air ▪ Low air flow can cause backflow
Buoyancy		▪ Active – NFPA 92A ▪ Passive – NFPA 92B	▪ Hot gas & smoke rises ▪ Stratification ▪ Spill over ▪ Low air flow can cause backflow ▪ Plugholing

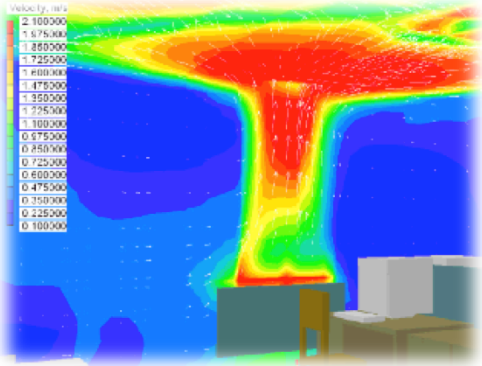
STACK EFFECT (COLD OUTSIDE)

PHYSICS OF SMOKE MOVEMENT



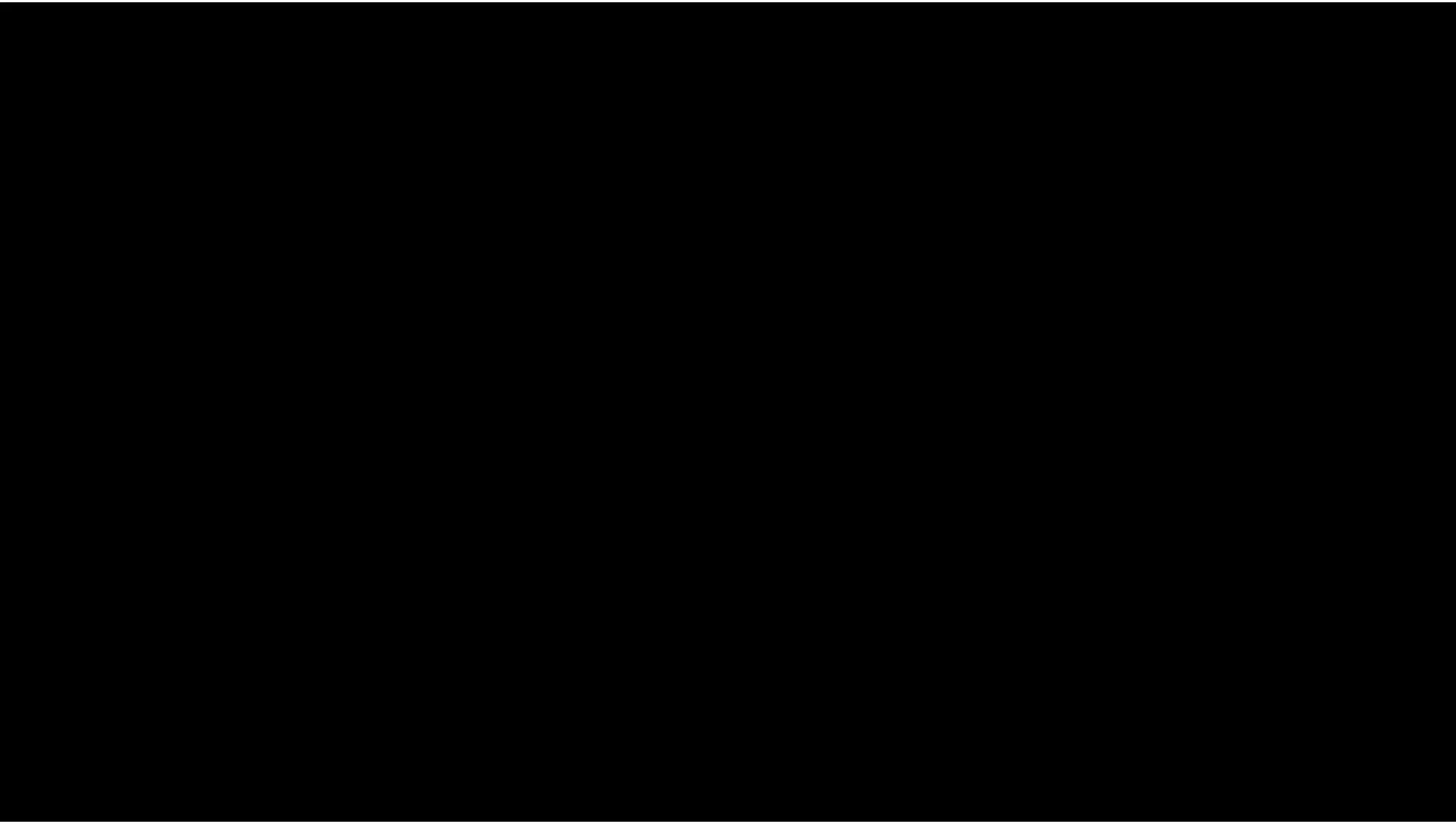
Stack effect — the vertical airflow within a building caused by pressure differences between the building interior and exterior. (**Reverse Stack Effect** – Warm outside)

Temperature effect of the fire — the energy (buoyancy) of the heated smoke, which causes it to move.

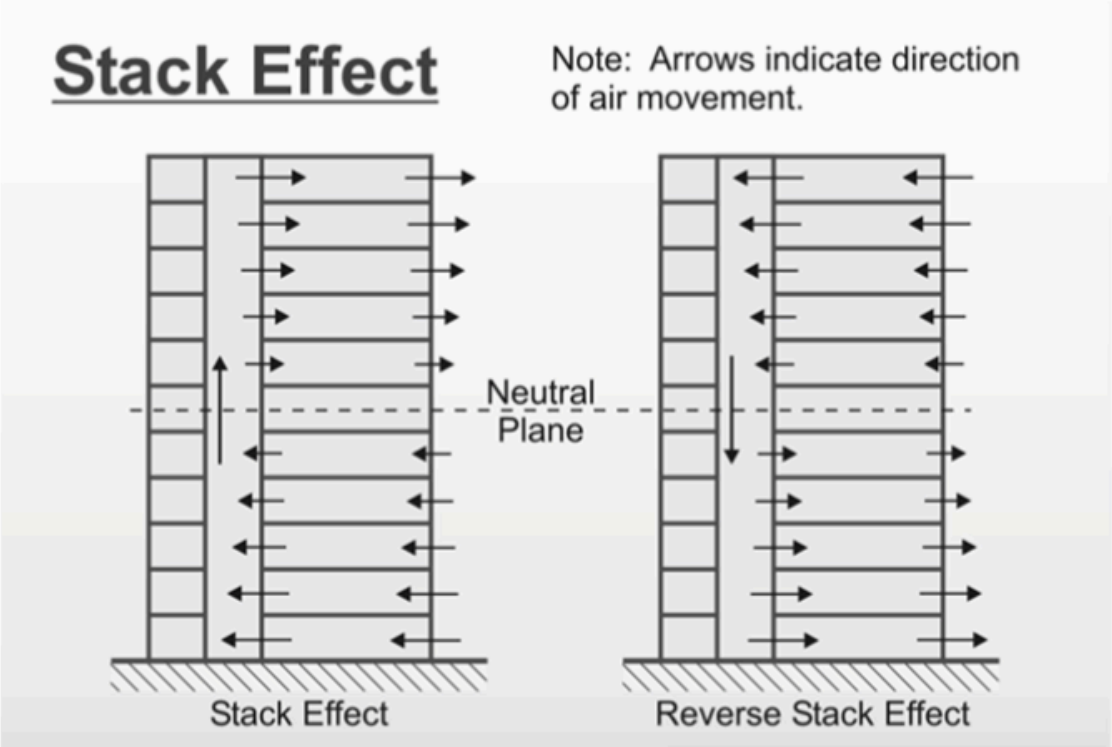


Weather conditions — wind direction and velocity along with temperature changes all contribute to a buildings ability to minimize smoke spread

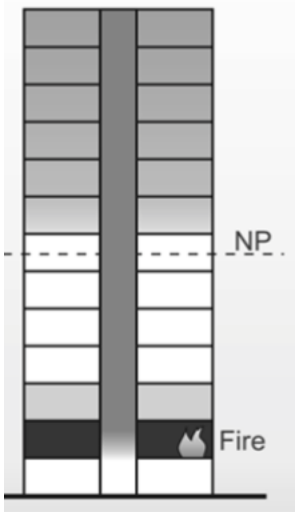
REVERSE STACK EFFECT (HOT OUTSIDE)



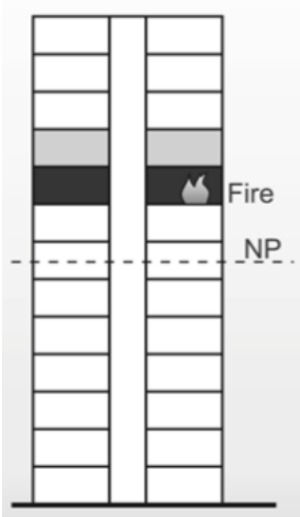
STACK EFFECT BASICS



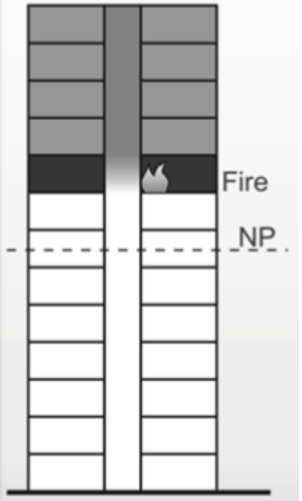
- Stack Effect – Upward flow - cold outside
- Rev Stack Effect – Downward flow - warm outside
- Taller the building the more significant the effect
- Complicated scenario's require computer model



Winter Stack Effect - Bouyancy forces smoke into shaft and onto floors above Neutral Place

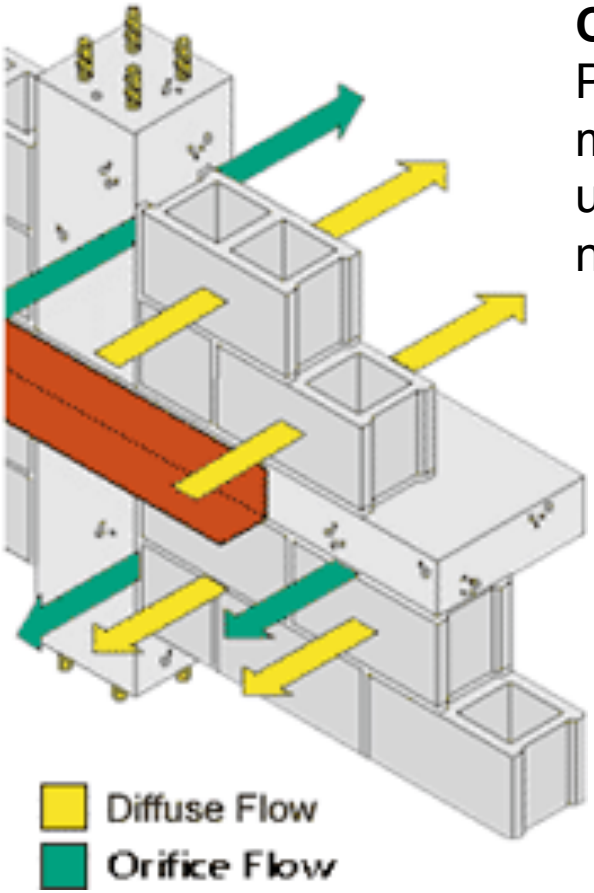


Stack effect dominates bouyancy, no smoke into shaft and limited on upper floors



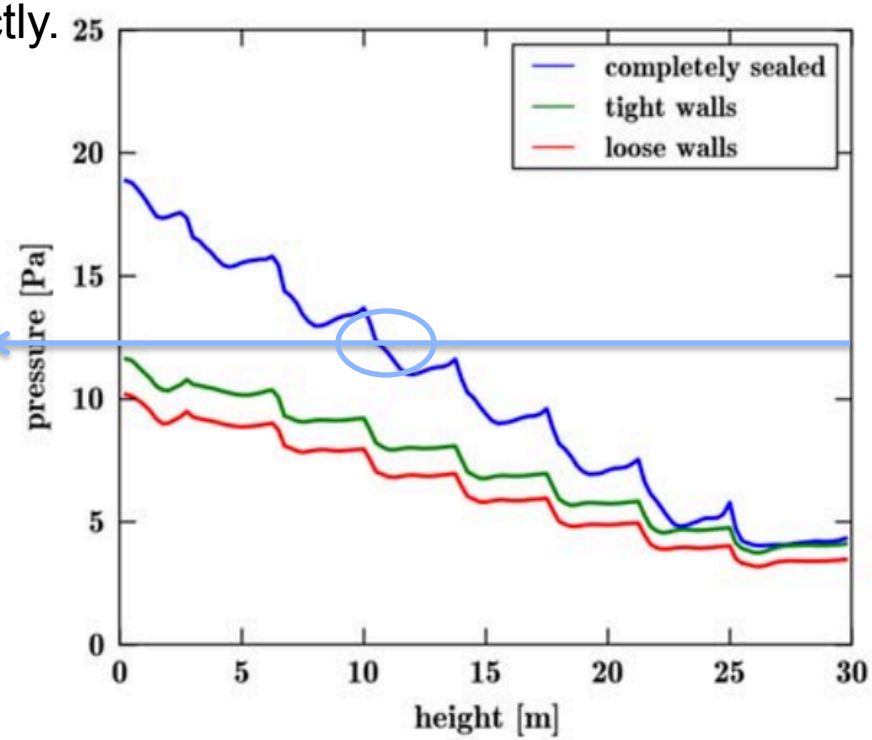
Smoke bouyancy dominates stack effect forcing smoke into shaft and upper floors

BUILDING LEAKAGE



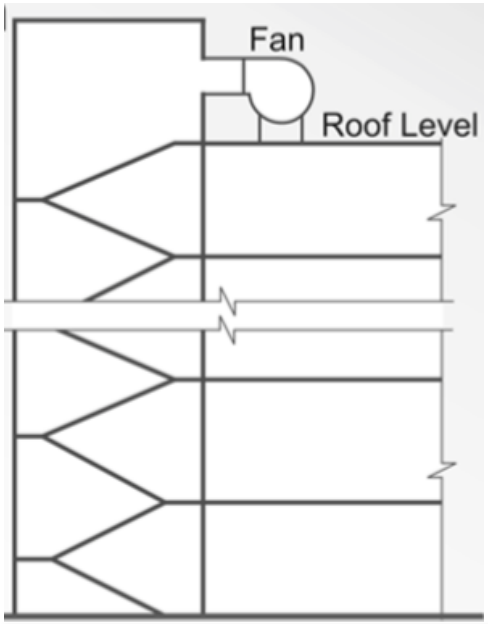
Cinder Block Stairwells— Proper pressurized stairwells may be unachievable if unfinished or block sealant is not applied correctly.

Minimum of 0.05 in H2O (12.45Pa) Recommended IBC 909.20.5 2010

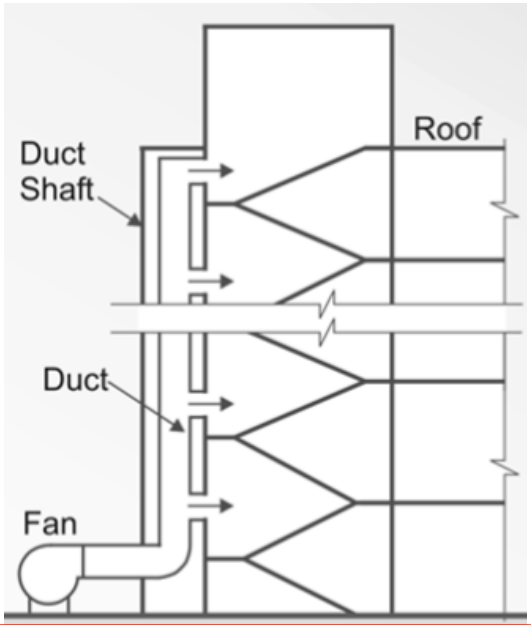


Inch's of H2O = Non SI unit for pressure. Measures a small amount of pressure difference across an orifice or pipeline or shaft. Defined as the pressure exerted by a column of water 1in in height at defined conditions. (Temperature and standard acceleration of gravity)

STAIRWELL PRESSURIZATION

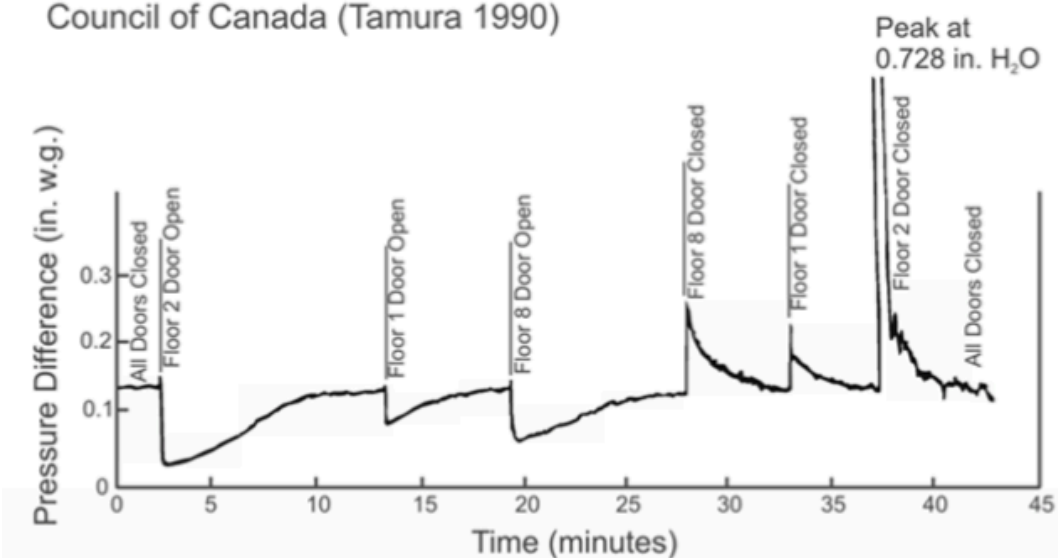


- Not for tall stairwells > 100ft
- Top or bottom injection point
- Multiple injection points may be required
- Engineering analysis may be required for multiple fans
- Stairwell Compartmentation not recommended today
- Pressure compensation systems my be needed



Response times of VAV—Variable Air Volume Systems have difficulty maintaining proper pressure in stairwell.

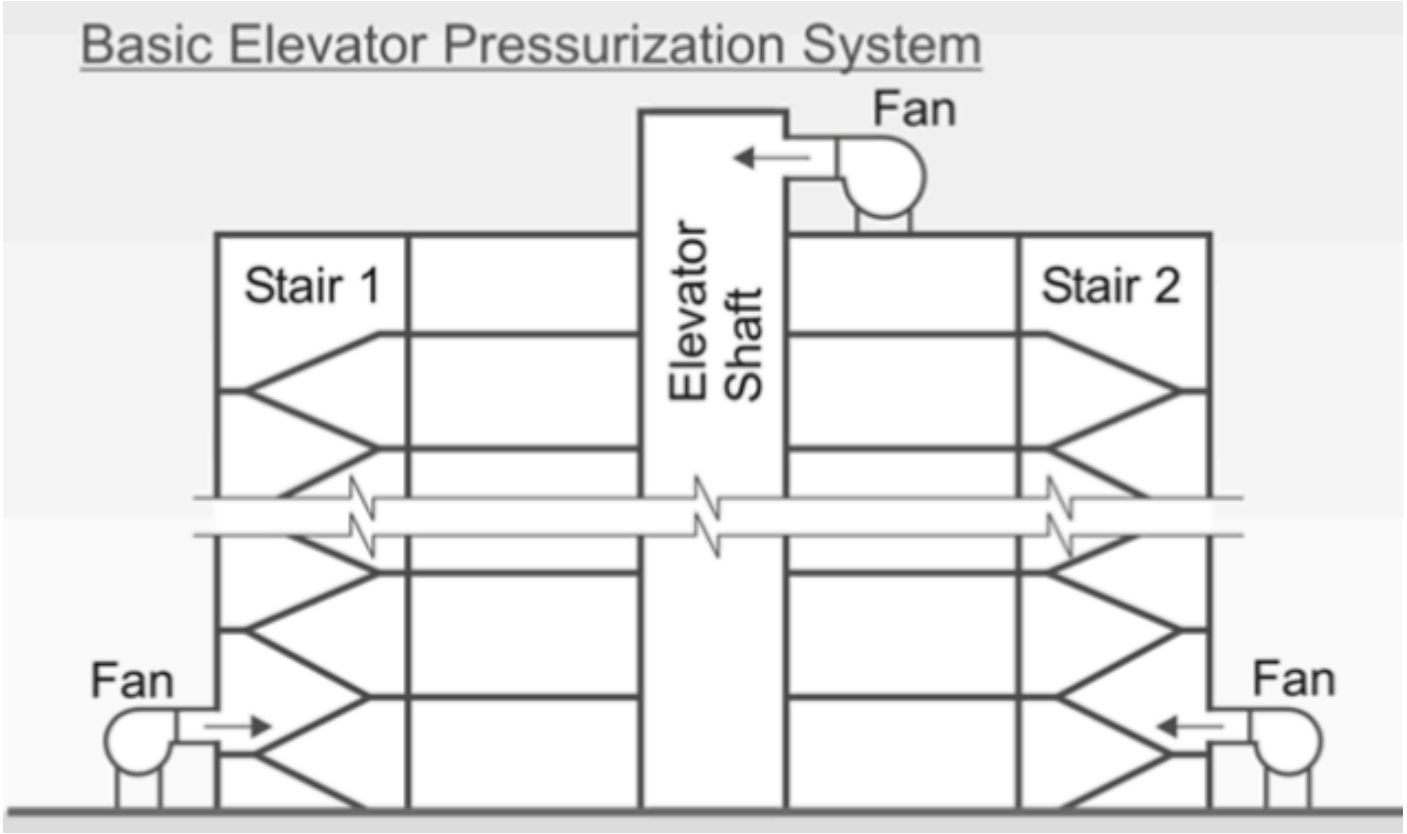
Test data from the National Research Council of Canada (Tamura 1990)



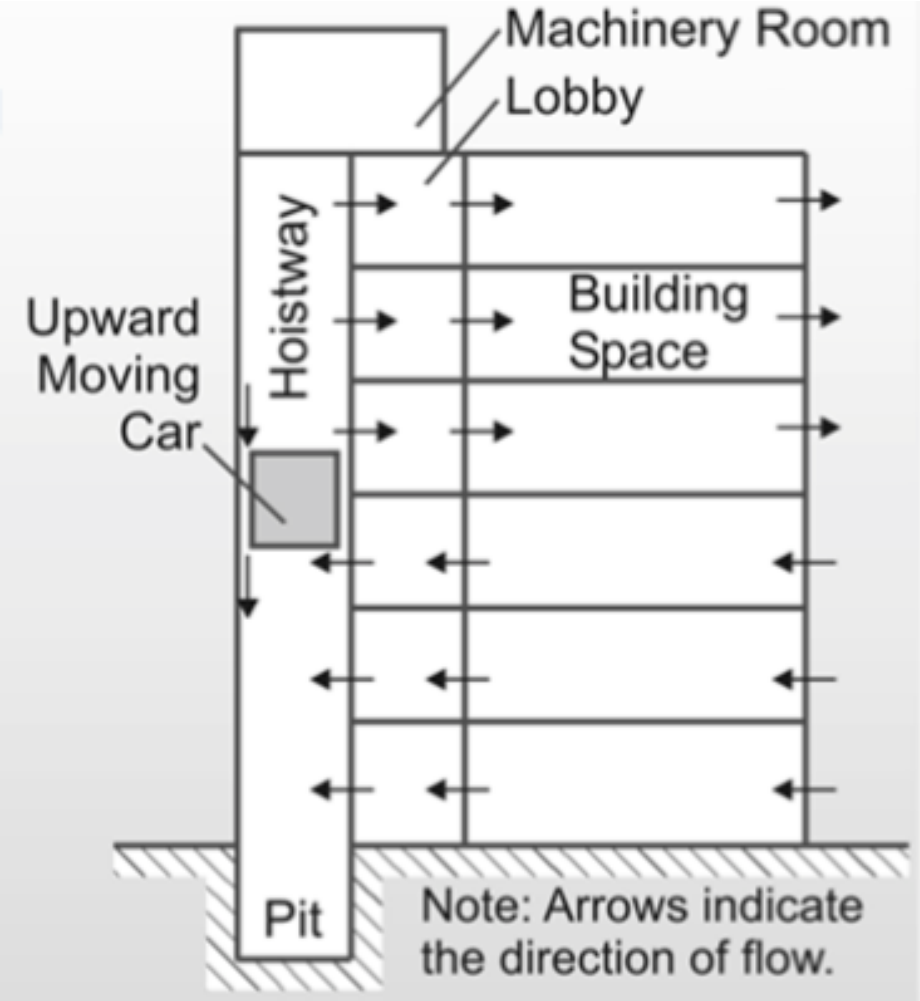
Max 30Lbs of force to open doors

ELEVATOR SHAFT PRESSURIZATION

- More challenging than stairwell pressurization
- Prevent smoke migration through hoistway
- Protect fire service when used for evacuation
- Pressure range 0.1 to 0.25 in H20
- Large air supply needed most applications



ELEVATOR PISTON EFFECT



- Piston Effect can result in adverse smoke conditions in shaft & floors
- Theory developed by Klote & Tamura
- Additive to building air flows
- Forces air out of shaft onto floors
- Sucks air into shaft off of floors
- Pressurized shafts will reduce car speed up and/or down
- Shaft venting required by IBC to compensate for piston effect
- Smoke/Fire dampers are required

PHYSICS OF SMOKE MOVEMENT

Plugholing— the pulling of "fresh" air into a smoke exhaust, which can happen when the smoke exhaust flow rate is relatively high. High CFM fan can pull through the smoke layer into the fresh air layer below, reducing the effectiveness of smoke removal.

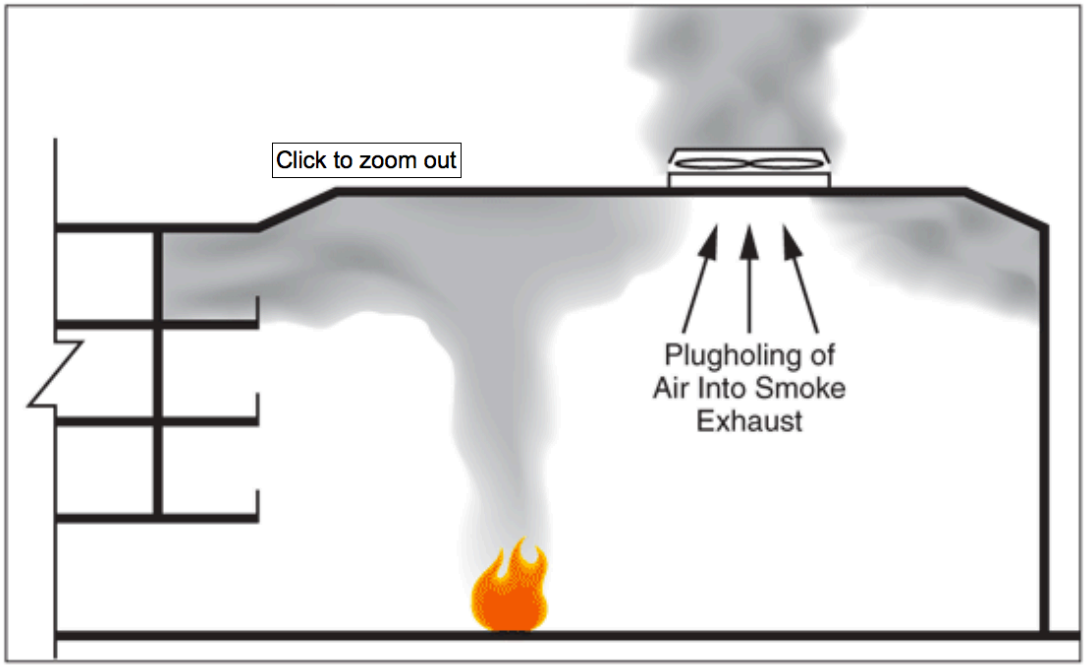


Figure 1 *Plugholing can result in exposing occupants to smoke.*
Source: John Klote

Theoretical Performance
Fig2: Uniform temperature under ceiling, air flow even.
Fig3: Bouyancy of smoke & thickness of layer forces smoke into exhaust zone

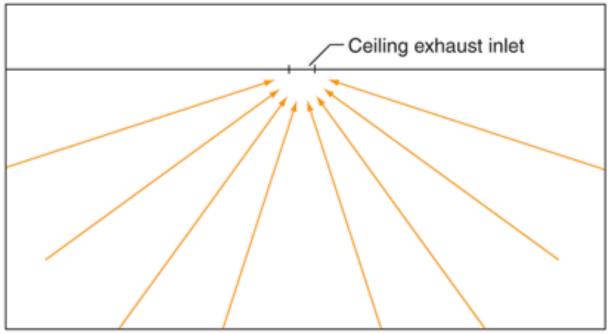


Figure 2 *This shows the flow pattern near a ceiling exhaust inlet with no smoke layer.*
Source: John Klote

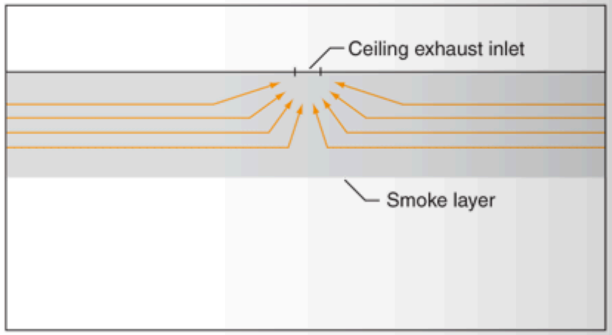


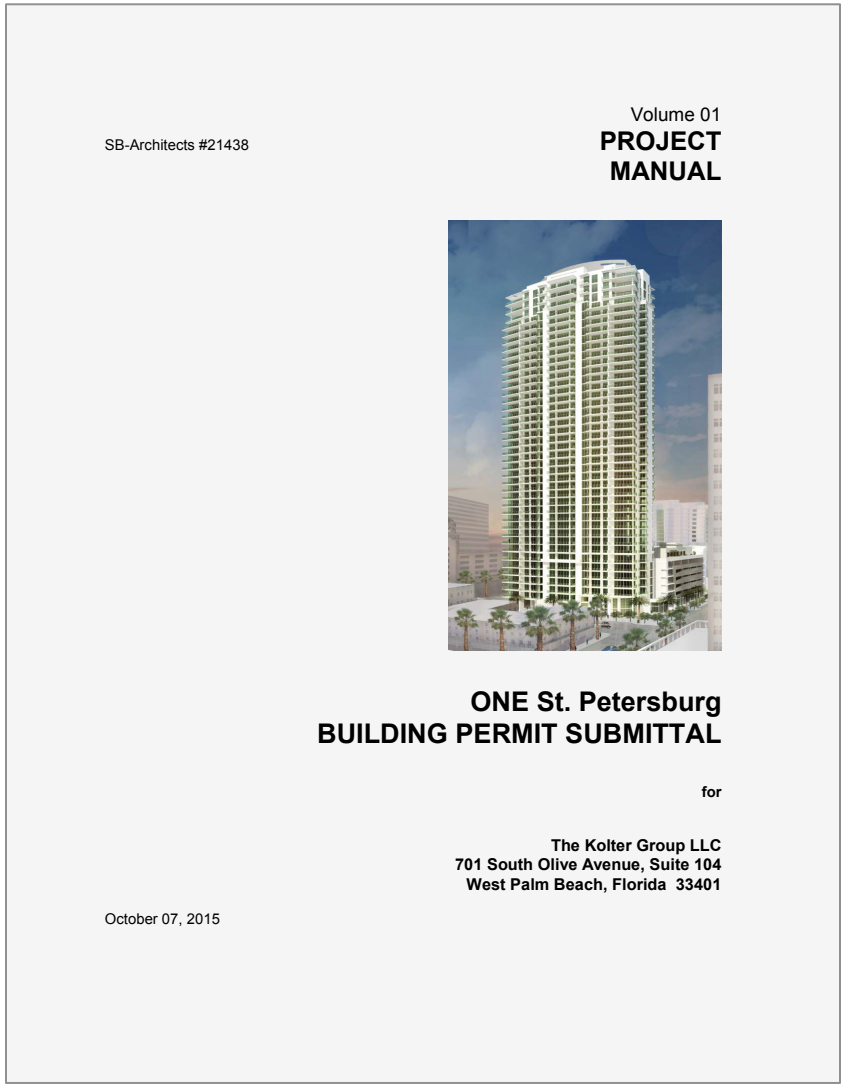
Figure 3 *This shows the flow pattern near ceiling exhaust inlets with a smoke layer.*
Source: John Klote

RATIONAL ANALYSIS

Design Objective:

The goal of this analysis and intent of the FBC requirements is to prevent the migration of smoke beyond the floor of incidence within the building thereby providing a tenable environment for evacuation or relocation of occupants beyond the floor of incidence. A secondary objective is to provide a smoke-free staging area for fire fighters on floors below the floor of incidence (FOI).

Table of Contents:



SB-Architects #21438

Volume 01
PROJECT MANUAL

ONE St. Petersburg
BUILDING PERMIT SUBMITTAL

for

The Kolter Group LLC
701 South Olive Avenue, Suite 104
West Palm Beach, Florida 33401

October 07, 2015

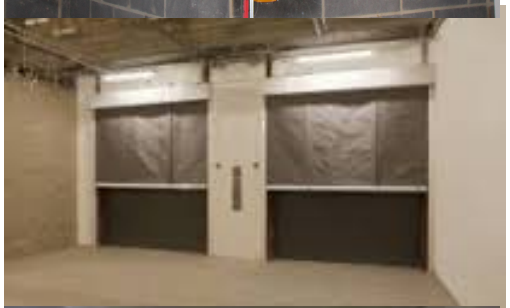
SYSTEM TYPES

PRINCIPAL DEFINITION

Smoke-Control System

A smoke-control system can be defined as an engineered system that uses mechanical fans and dampers to produce pressure differences across smoke barriers to inhibit smoke movement. A smoke-control system is used to achieve one or more of the following design objectives:

- **Inhibit smoke from entering stairwells**, means of egress, areas of refuge, elevator shafts, or similar areas
- **Maintain a tenable environment** in areas of refuge and means of egress during the time required for evacuation
- **Inhibit the migration of smoke** from the smoke zone
- Provide conditions outside the fire zone that **enable emergency response personnel** to conduct search-and-rescue operations and to locate and control the fire
- Contribute to **the protection of life** and to **the reduction of property loss**



UL LISTINGS

UL Smoke Control Listings

- UL864 Control Unit & Accessories for Fire Alarm System
- UL864 Smoke Control System
- UUKL (Category of UL864)
- UOJZ (Category of UL864)
- UOXX (Category of UL864)
- UL 555/555S/555C (BAS Dampers)
- UL 705, UL762 (BAS Fans)

	UL864	UL555..	UL705 UL762	UUKL	UOJZ	UOXX
FACP	X			X	X	
FSCP	X*			X		X
BMS	X*			X		
Dampers	X*	X		X		
Fans	X*		X	X		
Ann.	X*					X
Other	X*			X		

SMOKE CONTROL SYSTEM TYPES

Passive System

- Smoke resistant construction
- Smoke barriers – 20min rated openings
- Large volume smoke sinks
- Smoke Curtains, Doors, etc.

NFPA 92B

Active System

- Pressurization Systems

  High Rise, Health Care
- Atrium Smoke Exhaust

  Exhaust & Make-up air
- Stair Towers – Elevator Shafts

  Pressurize
- Parking Garage

  Exhaust & Make-up air
- Prisons & Tunnels

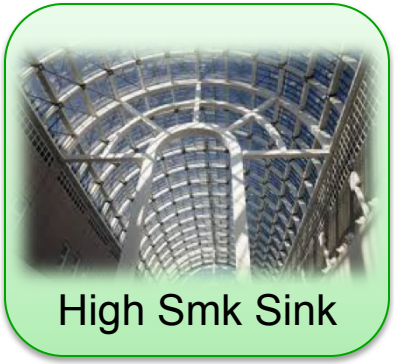
NFPA 92A

PASSIVE SYSTEM


Door Shields


Smoke Curtin


Smoke Sink


High Smk Sink


Fire Stopping


Fire Proofing

Typical Design Methods

- ❑ Smoke partitions & baffles
- ❑ Automatic & Natural venting
- ❑ Sprinklers limit fire spread
- ❑ Automatic door closure
- ❑ Air inlet provisions
- ❑ Limit smoke spill to one void
- ❑ Limit smoke reservoir length


Product Demo:
Fire Curtain
DHPACE
Everything Doors Since 1926

ACTIVE SYSTEM

Smoke Damper

Fans

Stair Press

Elevator Press

FSCP

Smoke Doors

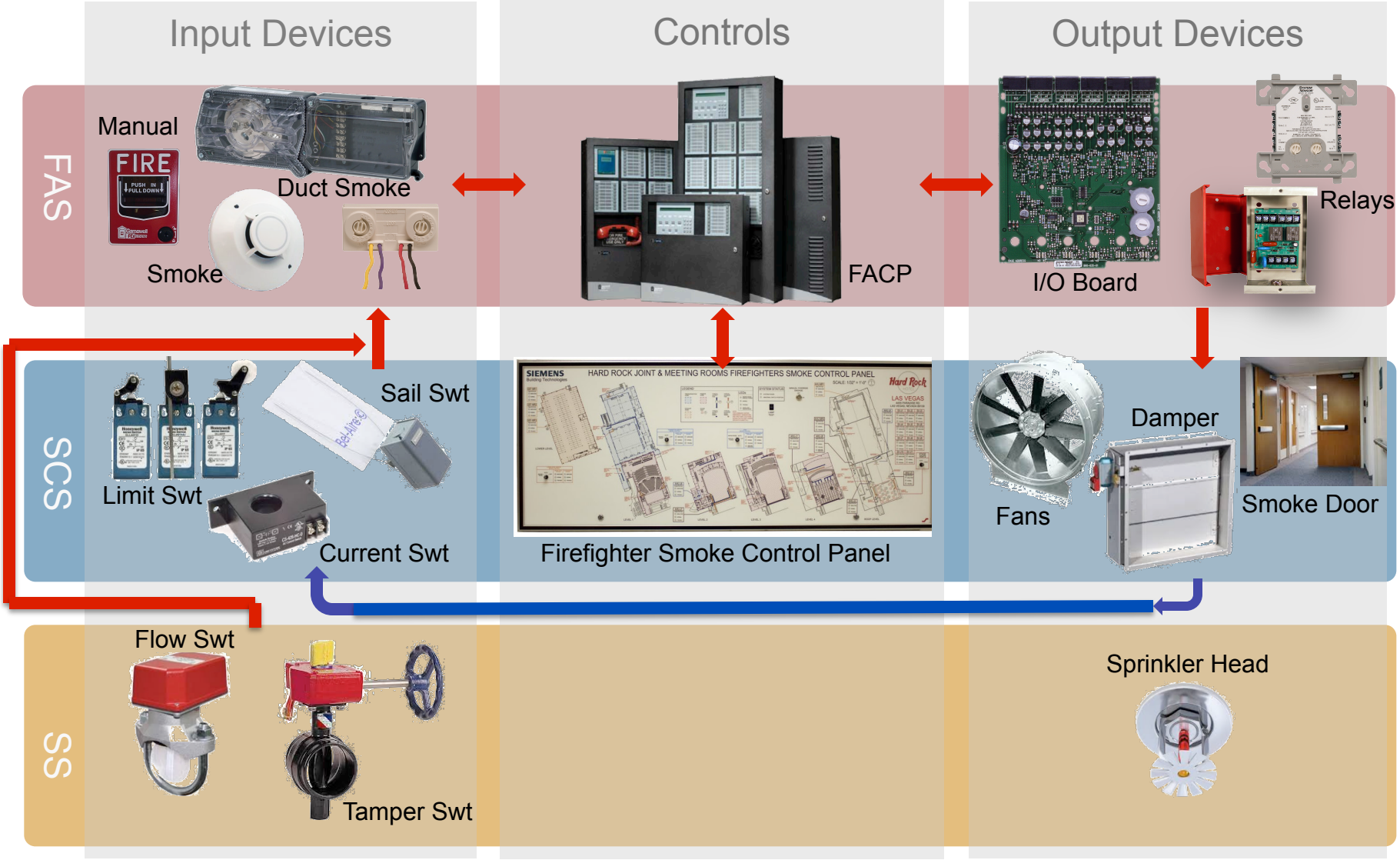
Roof Vents

Proof Sensors

Typical Design Methods

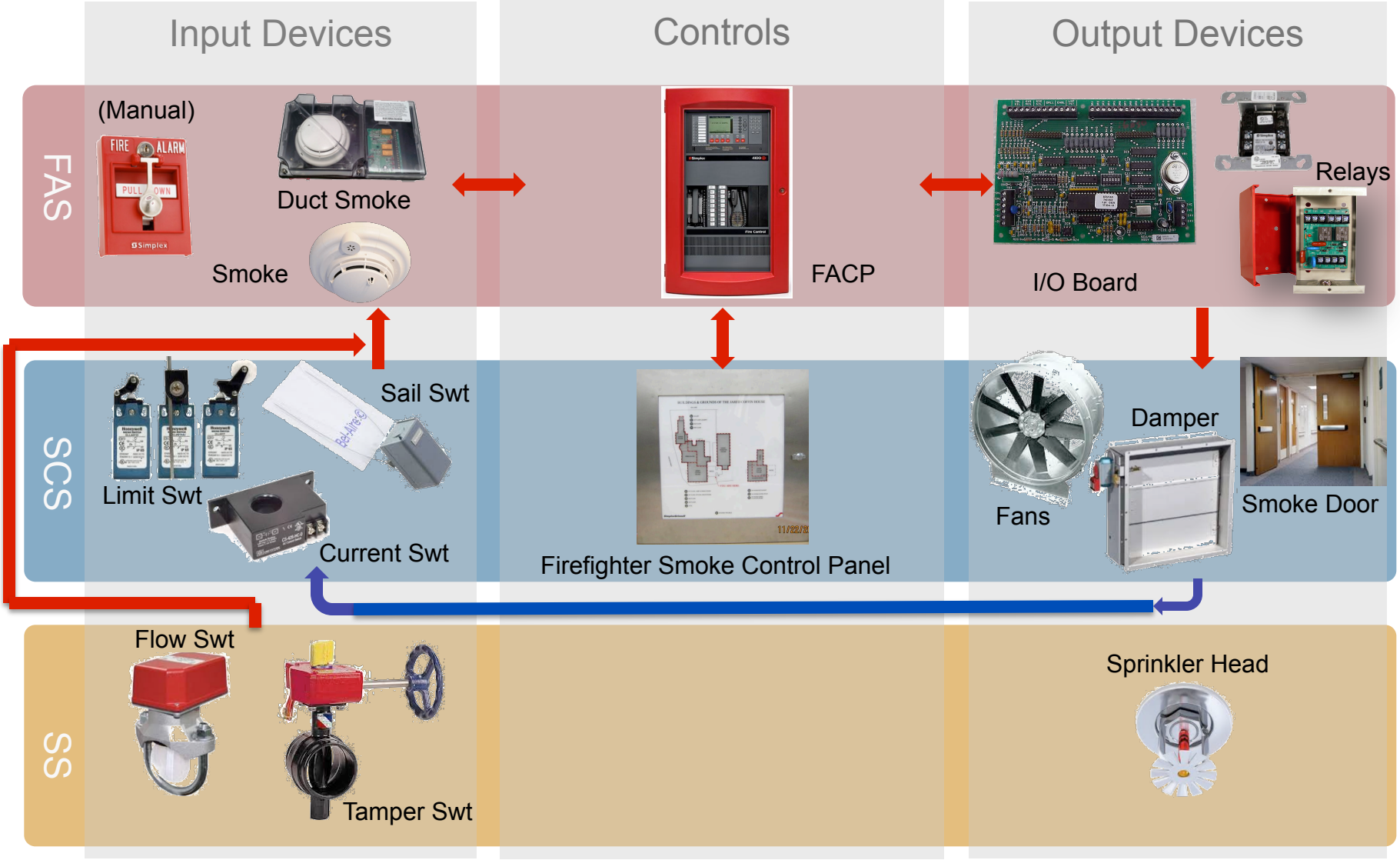
- ❑ Smoke Zones
- ❑ Pressurization
- ❑ Compartmentation
- ❑ Smoke Exhaust
- ❑ Automatic doors (open or close)
- ❑ Pressurized Stairwells
- ❑ Pressurized Elevator Shafts
- ❑ Pressurized Lobby
- ❑ Firefighter Smoke Control Panel

SMOKE CONTROL HARDWARE MATRIX



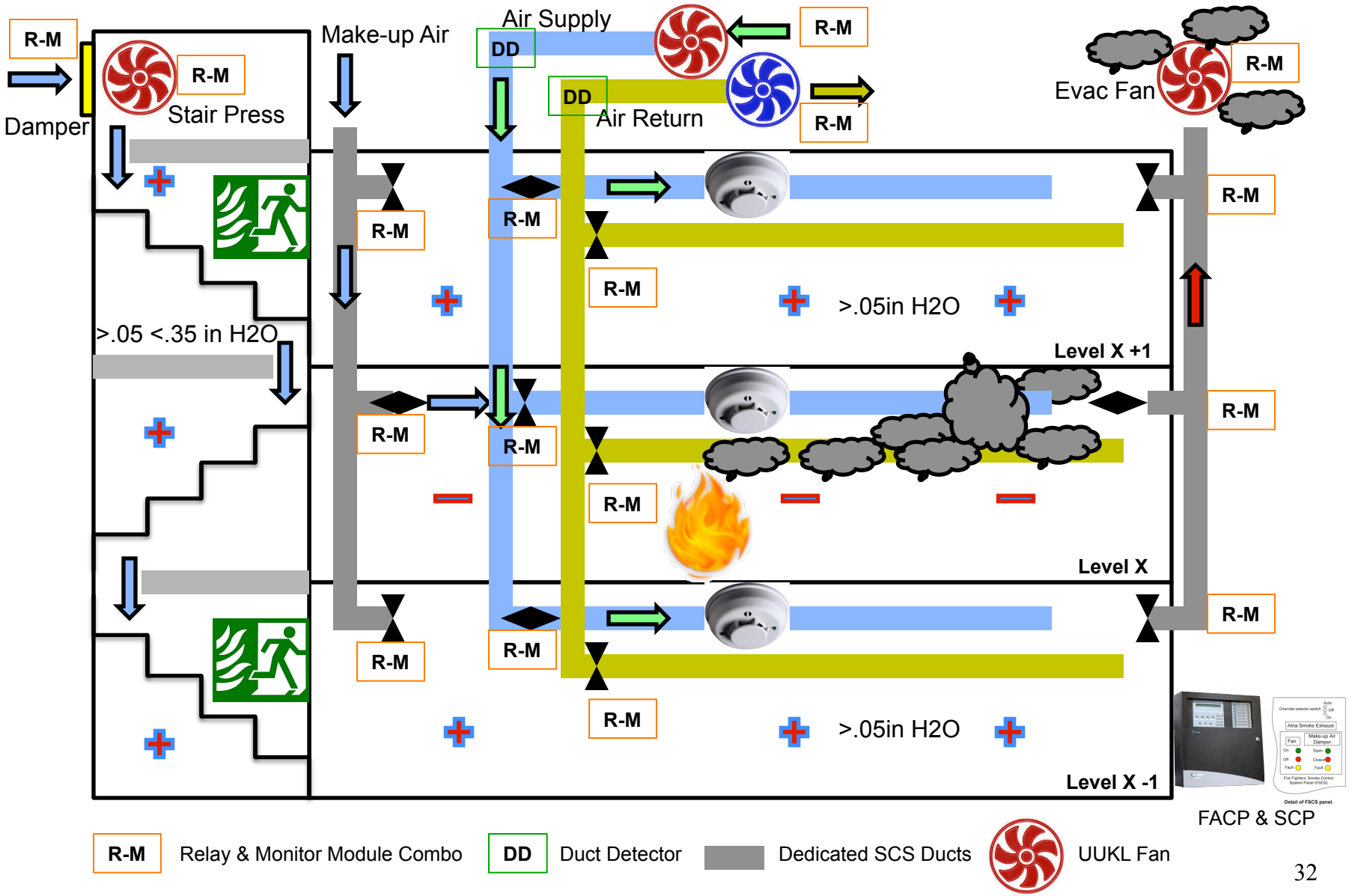
FAS = Fire Alarm System, SCS = Smoke Control Systems, SS = Suppression Systems

SMOKE CONTROL HARDWARE MATRIX

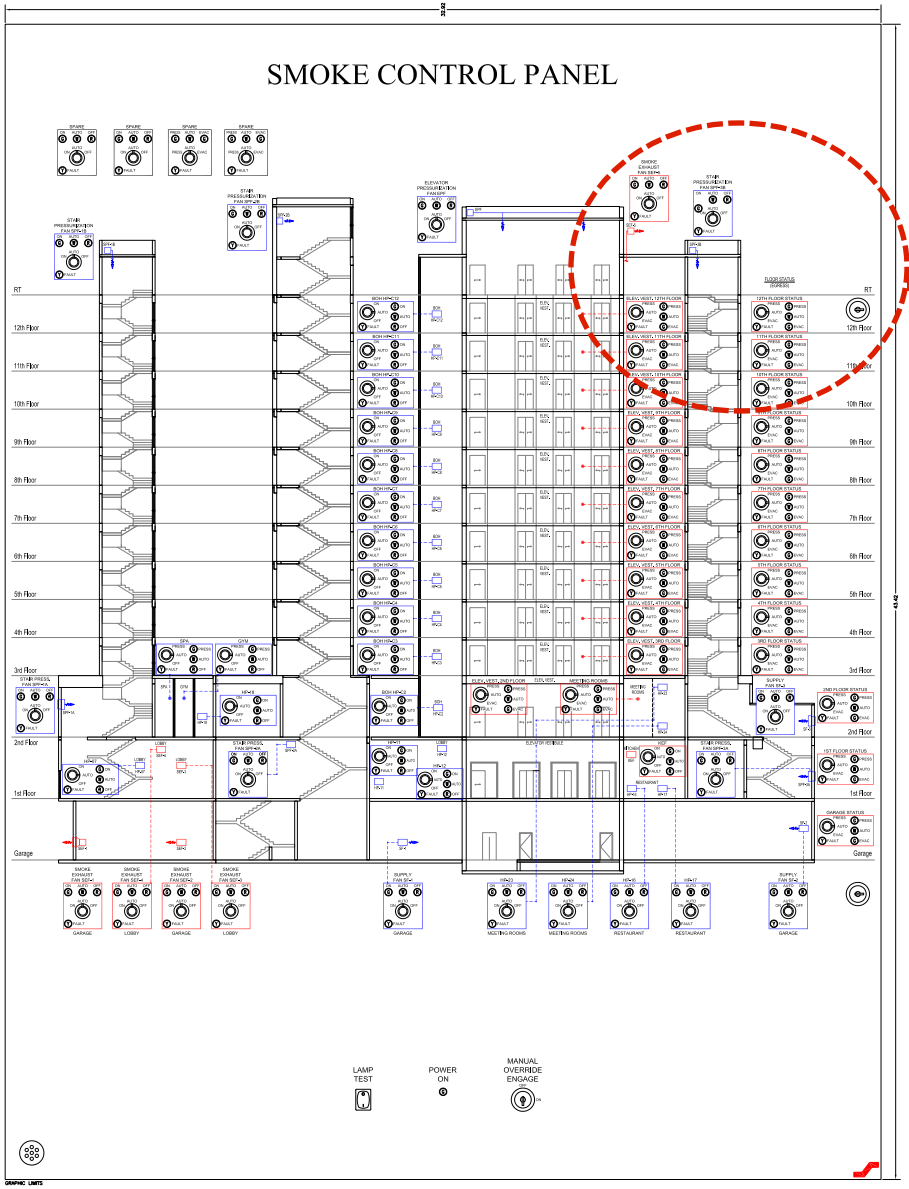


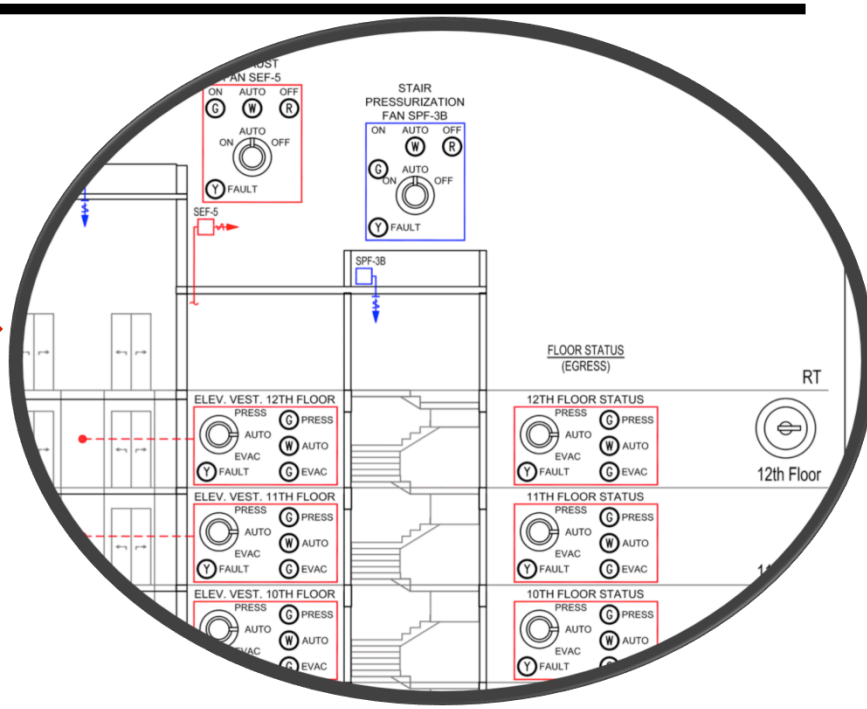
FAS = Fire Alarm System, SCS = Smoke Control Systems, SS = Suppression Systems

ACTIVE SYSTEM - COMPARTMENTATION



EXAMPLE OF HIGH RISE SCP





- ❑ Pressurize & Exhaust Control
- ❑ Dampers Auto Configured
- ❑ 4 LED's per switch
  - Green = Press/Open/On
  - White = Auto
  - Red = Evac/Close/Off
  - Yellow = Fault

SYSTEM COMMISSIONING

COMMISSIONING PREPARATION

Prior to final testing, the system should be pre-tested, all functional aspects of the system should be verified.

Common Milestones

- ❑ Substantial completion, possible temporary CO issued
- ❑ Pre testing of all FA devices and programming
- ❑ Controls contractor pre testing of their scope
- ❑ System tested on back-up power
- ❑ Test Plan Narrative & Documentation ready
- ❑ Special tools and simulators available/working
- ❑ Smoke generator testing procedure

Coordination of all approving bodies will be a significant challenge at the end of project

TESTING & CERTIFICATION

FIRE ALARM AND EMERGENCY COMMUNICATION SYSTEM INSPECTION AND TESTING FORM

To be completed by the system inspector or tester at the time of the inspection or test.
It shall be permitted to modify this form as needed to provide a more complete and/or clear record.
Insert N/A in all unused lines.
Attach additional sheets, data, or calculations as necessary to provide a complete record.

Date of this inspection or test: _____ Time of inspection or test: _____

1. PROPERTY INFORMATION

Name of property: _____
Address: _____
Description of property: _____
Occupancy type: _____
Name of property representative: _____
Address: _____
Phone: _____ Fax: _____ E-mail: _____
Authority having jurisdiction over this property: _____
Phone: _____ Fax: _____ E-mail: _____

2. INSTALLATION, SERVICE, AND TESTING CONTRACTOR INFORMATION

Service and/or testing organization for this equipment: _____
Address: _____
Phone: _____ Fax: _____ E-mail: _____
Service technician or tester: _____
Qualifications of technician or tester: _____
A contract for test and inspection in accordance with NFPA standards is in effect as of: _____
The contract expires: _____ Contract number: _____ Frequency of tests and inspectio
Monitoring organization for this equipment: _____
Address: _____
Phone: _____ Fax: _____ E-mail: _____
Entity to which alarms are retransmitted: _____ Phone: _____

3. TYPE OF SYSTEM OR SERVICE

- ☐ Fire alarm system (nonvoice)
- ☐ Fire alarm with in-building fire emergency voice alarm communication system (EVACS)
- ☐ Mass notification system (MNS)
- ☐ Combination system, with the following components:
  - ☐ Fire alarm ☐ EVACS ☐ MNS ☐ Two-way, in-building, emergency communication s
- ☐ Other (specify):

Acceptance Test Form

FIRE ALARM AND EMERGENCY COMMUNICATION SYSTEM RECORD OF COMPLETION

To be completed by the system installation contractor at the time of system acceptance and approval.
It shall be permitted to modify this form as needed to provide a more complete and/or clear record.
Insert N/A in all unused lines.
Attach additional sheets, data, or calculations as necessary to provide a complete record.

1. PROPERTY INFORMATION

Name of property: _____
Address: _____
Description of property: _____
Occupancy type: _____
Name of property representative: _____
Address: _____
Phone: _____ Fax: _____ E-mail: _____
Authority having jurisdiction over this property: _____
Phone: _____ Fax: _____ E-mail: _____

2. INSTALLATION, SERVICE, AND TESTING CONTRACTOR INFORMATION

Installation contractor for this equipment: _____
Address: _____
License or certification number: _____
Phone: _____ Fax: _____ E-mail: _____
Service organization for this equipment: _____
Address: _____
License or certification number: _____
Phone: _____ Fax: _____ E-mail: _____
A contract for test and inspection in accordance with NFPA standards is in effect as of: _____
Contracted testing company: _____
Address: _____
Phone: _____ Fax: _____ E-mail: _____
Contract expires: _____ Contract number: _____ Frequency of routine inspections: _____

3. DESCRIPTION OF SYSTEM OR SERVICE

- ☐ Fire alarm system (nonvoice)
- ☐ Fire alarm with in-building fire emergency voice alarm communication system (EVACS)
- ☐ Mass notification system (MNS)
- ☐ Combination system, with the following components:
  - ☐ Fire alarm ☐ EVACS ☐ MNS ☐ Two-way, in-building, emergency communication system
- ☐ Other (specify):

Inspection Form

Initial acceptance testing & periodic inspection testing must be documented and records maintained on site.

NFPA 72 & 92 CH 14 & 8

NEW!

- ❑ NFPA 92 Chapter 8 – All
- ❑ NFPA 92* Chapter 8.6 Periodic Testing – Dedicated systems tested at least semiannually, Non-dedicated systems tested shall be tested at least annually
- ❑ Third part inspections becoming more common
- ❑ Transient protection tested and replaced as necessary - NFPA 780
- ❑ 14.4.4.2 – Conductor testing – Open, Short, Ground, Operating Class, Resistance, Voltage
- ❑ 14.2.2.2 Impairments/Deficiencies
- ❑ 14.2.3.2 Delegation of Responsibility
- ❑ 14.2.10 Test Plan Narrative
- ❑ 14.4.3.2 Format Tables Combined

NFPA 92* – Automatic Weekly System Testing has been removed in 2018 edition

FINAL TESTING

Comply with NFPA, IBC, AHJ

Smokes

Manual

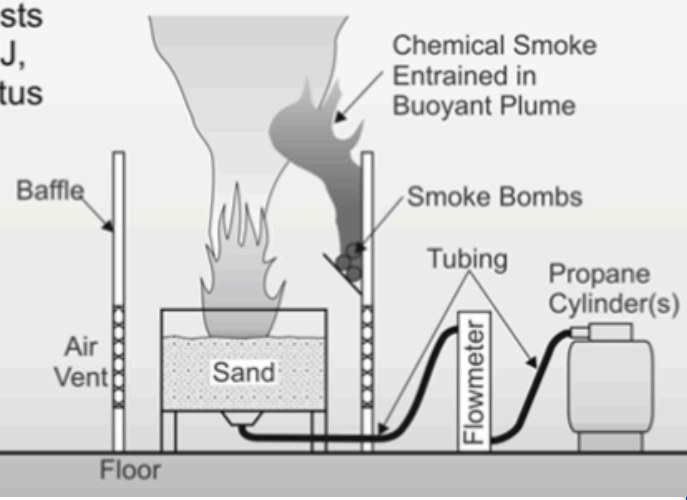
Duct Smokes

Hot Smoke Apparatus

CAUTION: Smoke bomb tests and other chemical smoke tests are not recommended for atria, because they do not produce realistic smoke.

When smoke bomb tests are required by an AHJ, the hot smoke apparatus is suggested.

For more information, see Chapter 23.



Flow

Smoke Test

Fans

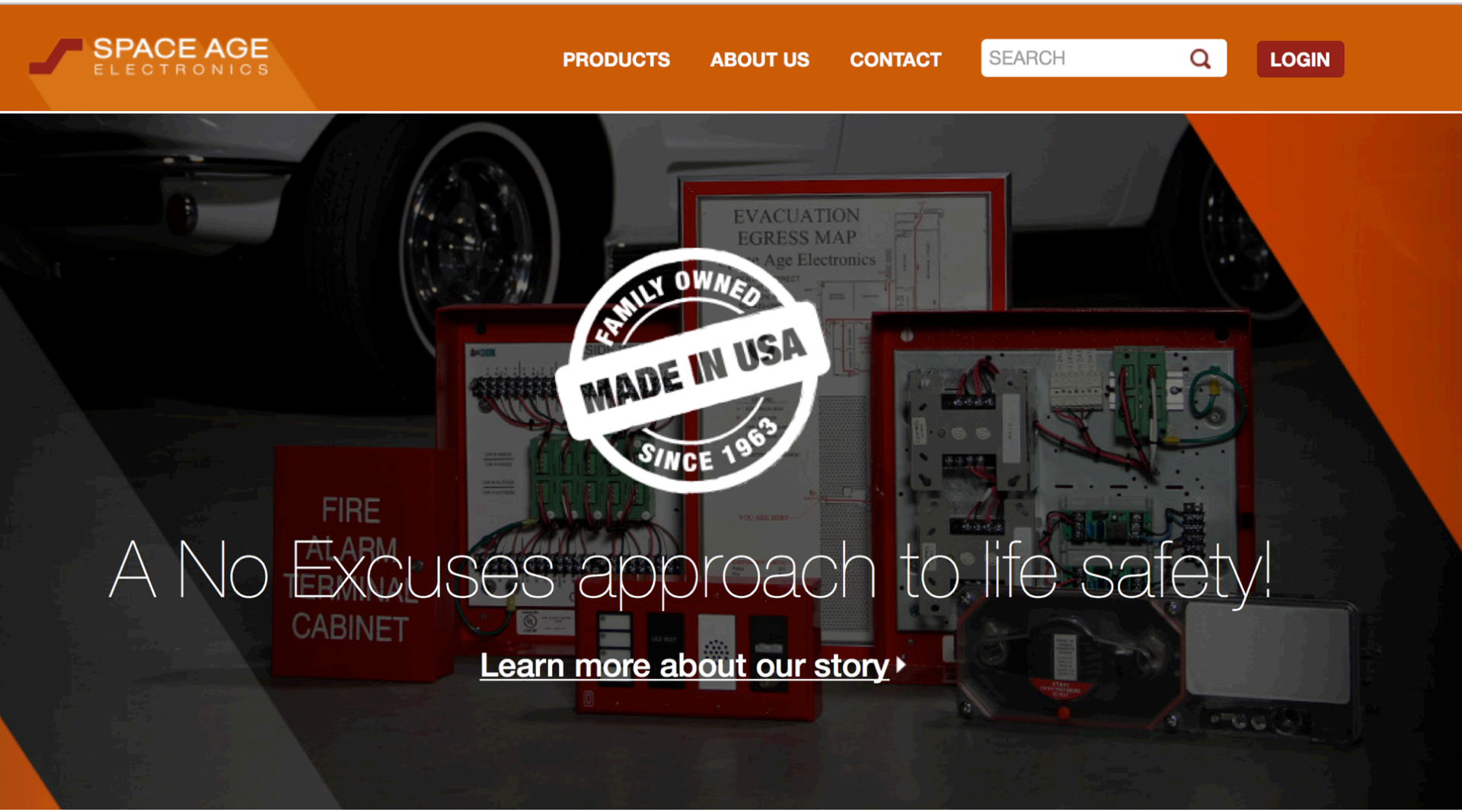
Dampers

SCP

RECAP

- The primary purpose of SCS is to save lives and limit property loss
- All Smoke Control System Designs are unique to every installation
- Proper design, application, installation, testing and maintenance takes place through a wide network of stakeholders
- One of two types of SCS will be used based on occupancy/architecture
- SCS comprise of several independent systems that are integrated together for a complete solution (Bldg, Mech, Elec, FA, Spklr)
- Codes & Standards vary from state to state

THANK YOU – Q&A



References: IBC 2015, NFPA 500 Building Construction & Safety Code 2015, NFPA 92 Standard for Smoke Control Systems 2015, ASHRE Smoke Control Handbook 2015, Dr, John H Klote PE, William E. Koffel, James A. Milke, Internet