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
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

- 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

Jan 25, 2008

Love Field - Dallas
BUILDING CODES
APPLICABLE CODES & GUIDELINES

- International Building Code (IBC Section 909)
- 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

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

*Rational Analysis*
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

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

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

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

- **Mechanical Engineer**
  - Fans
  - Dampers
  - Air Supply
  - Air Exhaust
  - Duct System
  - Balancing
  - Controls

- **Electrical Engineer**
  - Primary Power
  - Secondary Power
  - Raceway
  - Wiring
  - Rational Analysis
  - Smoke Movement
  - HVAC Consideration
  - Egress Calculations
  - System Zoning
  - Fire Detection
  - Fire Suppression
  - Interfaces
  - Smoke Control Panel

- **Fire Protection Engineer**
  - Codes & Standards
  - Plan Approvals
  - Acceptance Test
  - Enforcement
  - Re-certification

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

- **Authority Having Jurisdiction**
  - Code & Standard
  - Plan Approvals
  - Acceptance Test
  - Enforcement
  - Re-certification
## 5 SMOKE CONTROL MECHANISMS

<table>
<thead>
<tr>
<th>Examples</th>
<th>System Type</th>
<th>Attributes</th>
</tr>
</thead>
</table>
| 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)
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 building's 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 may be needed

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

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 H2O
- Large air supply needed most applications
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
**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.

**Theoretical Performance**
Fig2: Uniform temperature under ceiling, air flow even. Fig3: Bouyancy of smoke & thickness of layer forces smoke into exhaust zone.
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:
07 – Design Method
11 – Engineering Analysis
20 – System Implementation Requirements
28 – Summary of Results
30 – Appendix A: Smoke Control Seq of Ops
31 – Appendix B: Smoke Control Testing/Acceptance
38 – Appendix C: Calculation
SYSTEM TYPES
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)

<table>
<thead>
<tr>
<th></th>
<th>UL864</th>
<th>UL555..</th>
<th>UL705/UL762</th>
<th>UUKL</th>
<th>UOJZ</th>
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</tbody>
</table>
SMOKE CONTROL SYSTEM TYPES

Passive System

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

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 92B  NFPA 92A
PASSIVE SYSTEM

**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
ACTIVE SYSTEM

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

<table>
<thead>
<tr>
<th>Input Devices</th>
<th>Controls</th>
<th>Output Devices</th>
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</thead>
<tbody>
<tr>
<td><strong>FAS</strong></td>
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<td>(Manual)</td>
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<td>Smoke Alarm</td>
<td>FACP</td>
<td>I/O Board</td>
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<tr>
<td>Duct Smoke</td>
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<td></td>
</tr>
<tr>
<td>Smoke Detector</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **SCS**       |          |                |
| Limit Switch  |          | Smoke Door     |
| Sail Switch   |          | Fans           |
| Current Switch|          | Damper         |
| Firefighter Smoke Control Panel | | |

| **SS**        |          |                |
| Flow Switch   |          | Sprinkler Head |
| Tamper Switch |          |                |

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

Acceptance Test Form

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

**NFPA 72 & 92 CH 14 & 8**

- 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**

**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.
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, SpkIr)
- Codes & Standards vary from state to state
THANK YOU – Q&A

A No Excuses approach to life safety!

Learn more about our story