



- Basic Smoke Control Strategy and Tactics
- Engineered Smoke Control Systems
- Fire and Smoke Control Containment Dampers

## Actuated Dampers in Smoke Control Systems



Discover the advantages  
[www.belimo.us](http://www.belimo.us)

**BELIMO**<sup>®</sup>

Contents

- I. Basic Smoke Control Strategy and Tactics ..... 3
  - Introduction ..... 3
  - Balanced strategy ..... 3
  - Smoke control tactics ..... 5
  - Compartmentation – containment Dampers..... 5
- II. Engineered Smoke Control Systems ..... 7
  - Fire fighters’ smoke control system panel ..... 7
  - Stairwell pressurization..... 8
  - Elevator lobby pressurization..... 10
  - Hoistway shaft pressurization ..... 10
  - Atria smoke exhaust or extraction..... 10
  - Smoke vents ..... 11
  - Smoke shafts ..... 11
  - Zoned smoke control..... 11
  - Corridor pressurization ..... 11
- III. Fire and Smoke Control Containment Dampers..... 13
  - Compartmentation/containment vs. engineered system dampers..... 13
  - Fire dampers..... 14
  - Smoke dampers ..... 15
  - Combination fire and smoke dampers..... 16
  - Older combination fire and smoke dampers..... 17
- IV. Engineered Smoke Control System Damper Controls (Chapter 9) ..... 18
  - Auxiliary switches for smoke control system dampers..... 18
  - Wiring for reopenable smoke control system dampers ..... 19
- V. Engineered Smoke Control System Applications..... 20
  - Introduction..... 20
  - Building, zone, and floor pressurization systems ..... 21
  - Corridor dampers ..... 23
  - Smoke exhaust – large spaces ..... 25
  - Other smoke exhausts and smoke purge ..... 27
  - Stairwell Pressurization..... 27
  - Hoistway Venting ..... 29
  - Elevator Hoistway Pressurization ..... 29
  - Underfloor air conditioning systems ..... 29
  - Summary ..... 30

Larry Felker was the primary author of this document. He is a mechanical engineer and member of the International Code Council, National Fire Protection Association, Society of Fire Protection Engineers, and a life member of ASHRAE. He is Product Manager Fire & Smoke Actuators for Belimo Americas. He has specialized in fire and smoke dampers and actuators since 2002. Previously he was a temperature control system designer and before that a mechanical and electrical contractor. He is the author of *Dampers and Airflow Control*, (with Travis Felker) published by ASHRAE Special Publications, 2010.

# I. Basic Smoke Control Strategy and Tactics

## Introduction

The International Building Code (IBC, 2012) is the model code for most building codes in the United States. Along with the mechanical and fire codes, it defines the requirements for fire and smoke dampers and their operation in case of fire. The various codes have exceptions and specific cases where one or more of the smoke control methods discussed here may or may not be required.

The purpose here is to explain how dampers operate in those systems so that the fire fighter, fire prevention officer, code official, consulting engineer, or building owner can better understand the technology. The specific code requirements are not the subject, but it is sometimes necessary to keep them in mind.

Chapter 3 of the IBC gives use and occupancy classifications; that is, the different activities and uses that define, for example, a mercantile occupancy or high-rise business occupancy. Chapter 4 gives special detailed requirements based on the classifications. Chapter 7 gives the requirements for construction, including fire and smoke dampers in barriers and walls. Chapter 9 covers the requirements for sprinklers, alarms, and smoke control systems. Chapter 10 is Egress Solutions and Chapter 30 covers elevators. These chapters cover most of the code provisions for fire and smoke dampers. Most of the provisions in the code are based on experience either in building construction or lessons learned in past fires or disasters.

Some cities have damper requirements in the Mechanical and/or Fire codes also. For example, the New York City Codes have provisions in all three codes (NYC 2008). The NYC Mechanical Code, section 405, covers some of the requirements for high-rise business building manual or automatic control of some dampers and section 513 covers some requirements for smoke exhaust systems. Sections 606 and 607 cover smoke detector and some remote control requirements. The NYC Fire Code section 704.1 covers floor openings and shafts.

Many other cities and states have codes with modified provisions based on the model codes. Many states have strong smoke

control provisions as seismic activity can tear gas lines from the ground causing fire hazard and simultaneously breaking water lines thus disrupting sprinkler action.

## Balanced strategy

Good fire and smoke protection and life safety practices involve use of any and all the different tactics that have been developed. The strategy is the overall plan and the tactics are the components of the mechanical systems. One could say the fire alarm, sprinkler flow switches, and smoke control *programming logic* are primarily strategic and the sprinkler heads, ducts, fans, and dampers are the *tactical methods*. In actual practice the two blur together. The Fire Fighters Smoke Control System (FSCS) panel is the interface between strategy and tactics. Figure 1 shows the ideas that are more strategic than tactical.

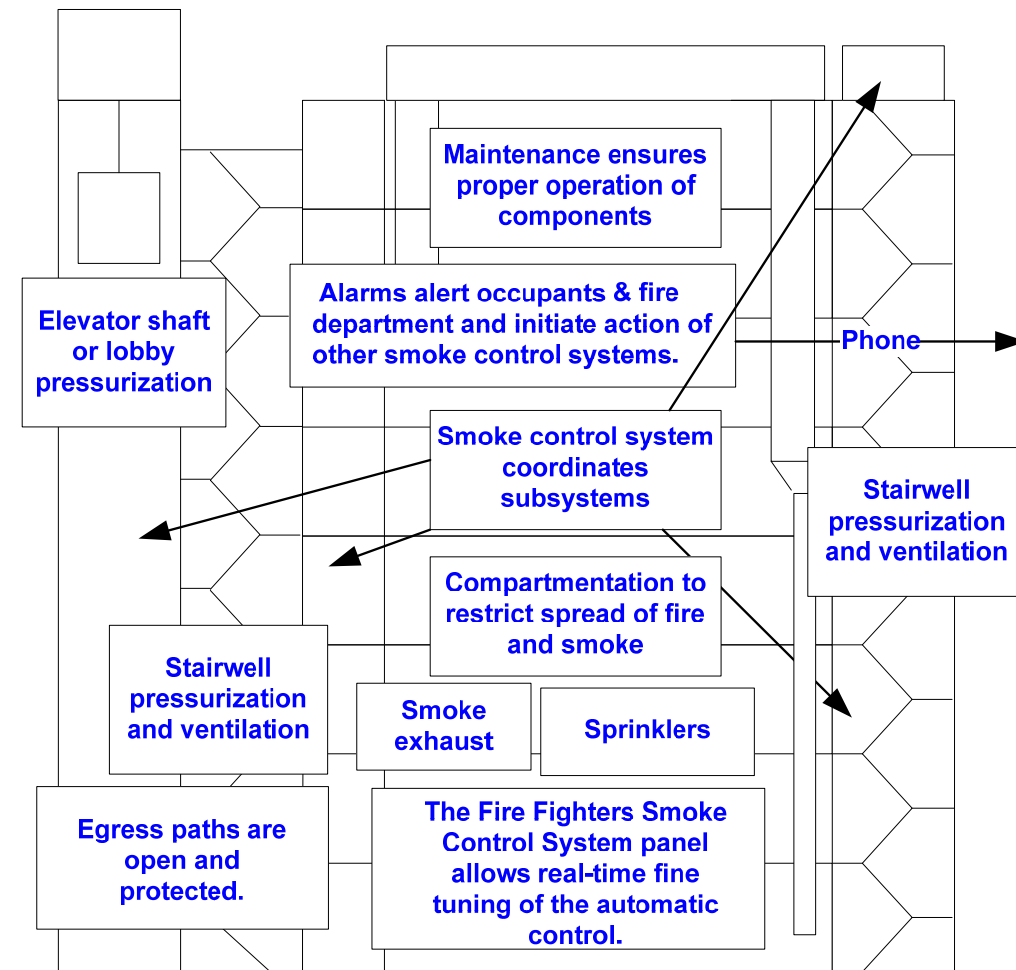
The strategy coordinates the various components in the system. For example, when the fire alarm is activated, the stairwell pressurization system is automatically turned on so that occupants can exit without being exposed to toxic smoke.

The strategy is based on a number of overriding concepts and the codes prescribe certain practices in most buildings. The mix of tactics is a function of the prescriptions in the code and the fire protection engineers' design.

*Fire alarms* alert occupants to danger and the likelihood that they need to exit. *External alarms* bring fire department assistance. *Annunciation* may be used to give directions to occupants, particularly in buildings with large footprints and in high-rise buildings.

*Emergency planning* and fire drills are expected in many buildings although occupation by the general public diminishes the effect of plans.

*Egress paths* from burning buildings allow escape and provide entrance ways for fire fighters. Exit lights & signs, corridor & stairwell smoke control, and elevator pressurization or lobbies protected by smoke barriers are all important in egress.



**Figure 1. Strategic elements in fire and smoke control.**

Codes are not always clear about the primary function of smoke control. Life safety is the first purpose. Protection of the building and furnishings from smoke damage is of secondary importance. However, it is important to note that protecting property, particularly from collapse, protects occupants and fire fighters who may be in the building after occupants have exited.

*Sprinklers* extinguish fires about 20% of the time (Koffel, 2005) and help control the spread of fires. Hidden or sheltered fires – particularly electrical fires in walls, fires that originate outside the building or outside the area covered by sprinklers, low water pressure, closed valves in water lines, explosions, and collapse of buildings can negate the operation of sprinklers. Smoke that has been cooled by water or air-mixing can move down stairwells and open shafts. Smoke control complements sprinklers in some cases. In others, it allows clear egress paths where sprinklers cannot reach the fire.

Statistics vary somewhat; however, it can be said that wet sprinklers are from 68% to 94% effective depending on the type of occupancy (NFPA 2010). Over 50% of failures are attributed to water shut-off before the fire.

*Structural compartmentation* including limited size of areas enclosed by fire and smoke doors, walls, and barriers prevents both smoke and fire spread. Small compartments allow fire-hose streams to reach across to the fire. Smaller spaces mean more walls to restrict the ceiling or roof from collapse. Sealing all wall penetrations in barrier walls helps restrict smoke and fire to the area of origin.

Architectural ceiling reservoirs or drop down curtains to prevent smoke spread and guide it to fan intakes are also used to control smoke movement.

*Fire and smoke dampers* are used in two ways. All fire dampers and about 85% of actuated smoke dampers are used to maintain integrity of fire and smoke barrier walls – they seal ducts and any large openings in fire and smoke compartment walls.

About 15% of actuated dampers are employed in *engineered smoke control systems* and are controlled automatically unless the FSCS panel overrides are used to help suffocate a fire or to ventilate and purge smoke. Smoke control systems include pressurization of some spaces to stop smoke spread and also exhaust fans for smoke removal; dampers are used to direct airflow as necessary.

*Maintenance* is required. Fire prevention consists of any number of good practices including periodic inspections, control of flammable materials, and isolation of fuel burning equipment. Maintenance is critical to prevention and deferred maintenance is a frequent danger.

The various tactics are sometimes divided into active and passive protection. Active protection methods include maintenance, sprinklers, fire and smoke dampers and doors, fire extinguishers, kitchen hood suppression, and exhaust fan systems. Passive methods comprise all the fire and smoke rated wall and ceiling compartmentation, structural component strength, and penetration fire stopping. Homeland security measures can be passive or active. Barricades that prevent vehicles from close proximity to the building and moving air handling intakes away from easy access by the public are more or less passive while sensors to detect toxins are active.

A balanced strategy uses many methods in parallel to achieve the same goal. Back-up systems protect against the failure of one method. For example, water pressure can be lost but then firewalls restrain passage of flames until the fire department can put water on the fire. A synergy can be achieved using several methods – for example, sprinklers are better able to control a fire if the compartment is small and sealed well. Spread of toxic and sometimes explosive smoke is thus also restricted.

### **Smoke control tactics**

Where strategy looks at the overall picture, the individual tactics are used to achieve the goals. The main purpose of this booklet is to explain details of how these mechanical and electrical systems operate with respect to dampers. The Fire Marshals, Building Officials, design engineers, and contractors are often called upon to go beneath the overall operation of a subsystem and look at the details.

Where devices and wiring interconnect two disciplines, there is a tendency for those involved to have only a fuzzy concept of the whole, interrelated design.

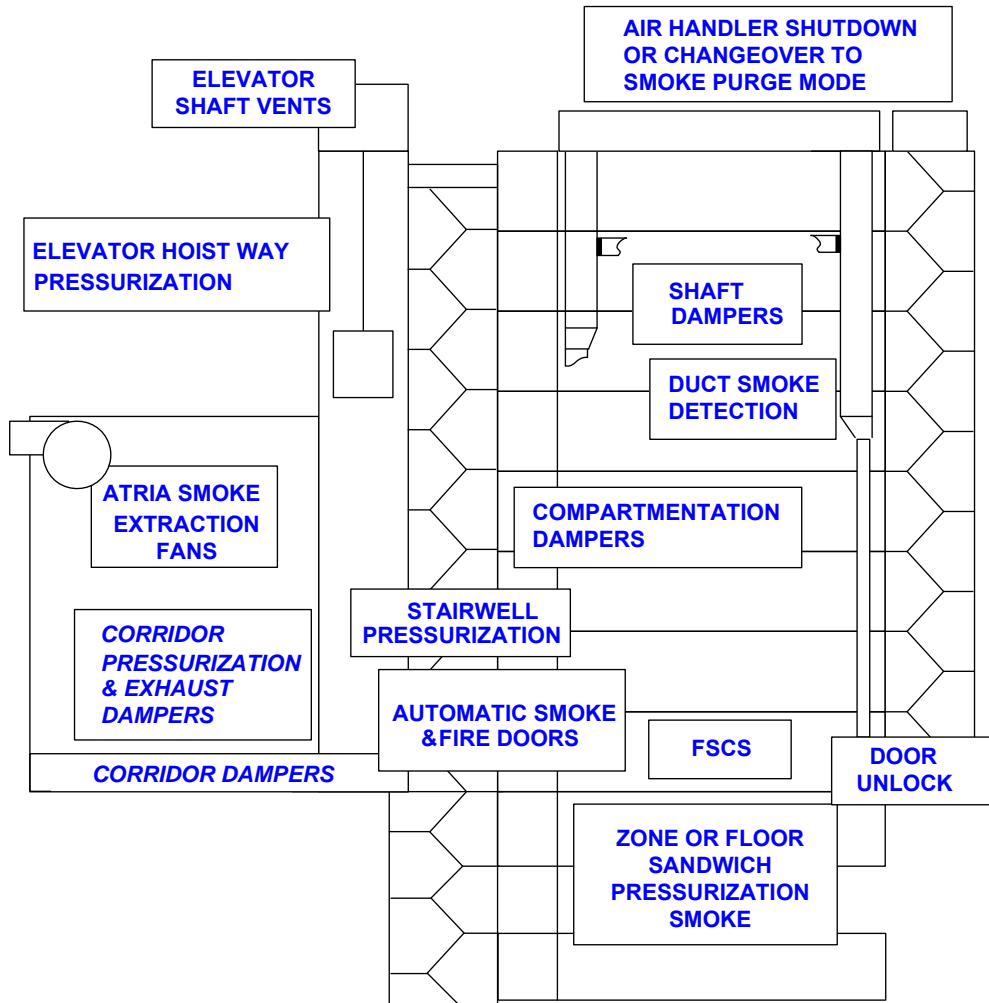
Figure 2 shows the primary mechanical systems that are used in smoke control. While all the different tactics work together in the smoke control system, they can be divided into two basic groups – those that contain fire and smoke to ensure compartmentation and those that use mechanical means to manage the movement of smoke. It is this latter that is more complicated and is the main subject here.

Some system dampers are applied in other ways to control air flow and smoke. Air Handling Units (AHU) are often shut down if any smoke detector in the area they serve senses smoke. However, in engineered smoke control systems the fans may continue to run while the AHU dampers position so that all return air is dumped outside and only fresh air is brought into the building. For large spaces that exhaust smoke in case of an event, dampers located on outside walls (with ducts where appropriate) open to allow outside air to enter to replace air and smoke pulled out by exhausts.

### **Compartmentation – containment Dampers**

Common sense and confirmation by lessons learned from past fires show that restricting the spread of fire and smoke is a significant defense to avoid loss of life and property damage. Fire and smoke doors are required in stairwell entrances and exits to prevent smoke and fire from traveling into the stairwell. National Fire Protection Association (NFPA) Standards 80 (fire doors and other opening protectives) and NFPA 105 (smoke door assemblies and other opening protectives) cover requirements for installation and repair of fire and smoke doors and dampers.

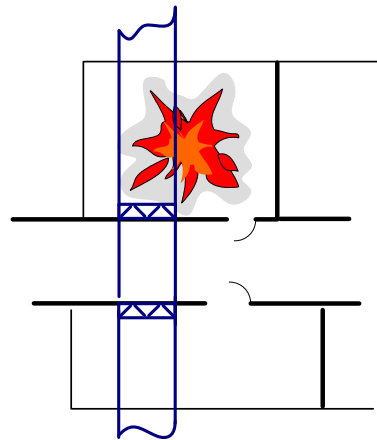
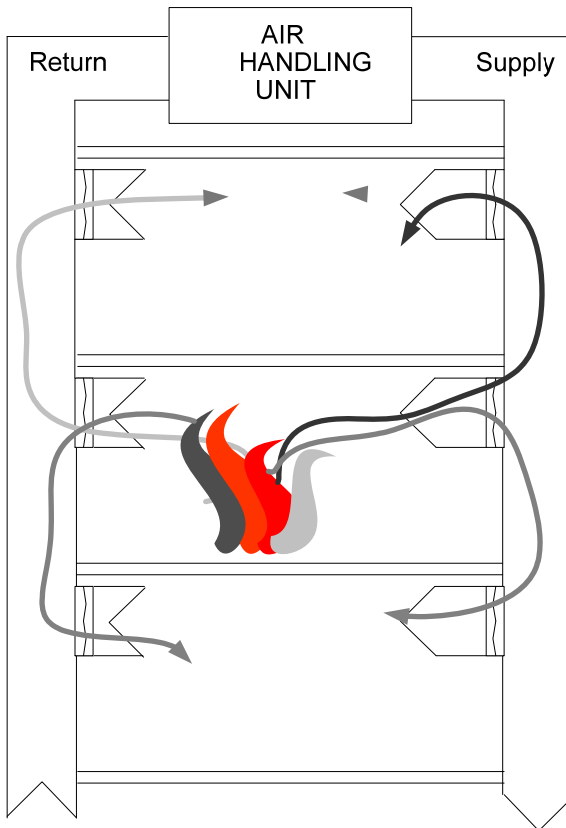
While the distinction is not perfect, it helps clarify applications by distinguishing between dampers that are primarily meant to maintain compartmentation and those which actively control smoke. *Containment* dampers maintain compartmentation. *Smoke control* dampers are used to exhaust smoke or pressurize spaces to prevent movement of smoke. The automated dampers used in an engineered smoke control system are essentially the same as those used for containment. The differences will be in the factory mounted controls and in the field control methods.



**Figure 2. Common engineered smoke control system components.**

With some exceptions, dampers are required in fire walls and smoke barriers where any duct or air-transfer opening passes through. The penetrations of supply and return air ducts in shafts running up and down a building must have dampers. Large amounts of smoke can travel throughout the interconnected air ducts if dampers are not present.

Hot smoke expands and pushes everywhere out of the compartment, tending to rise. As smoke cools, it will drop down shafts and stairwells. It must be contained. Smoke will pass out of fire zones into unprotected zones without dampers to help protect smoke barriers. See Figure 3.



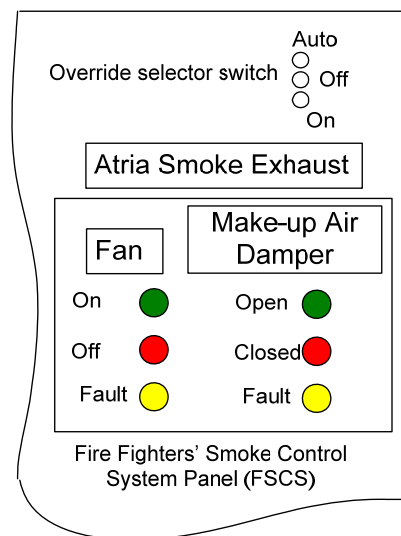
Dampers keep fire and smoke from spreading out of the area where the fire originates

**Figure 3. Left. Without dampers, whether air handler is on or off, smoke will spread via ducts. Right. Containment dampers limit spread of fire and smoke to exit corridor.**

## II. Engineered Smoke Control Systems

### Fire fighters' smoke control system panel

Smoke control systems use any and all methods possible to protect from smoke spread. Doors, fans, sprinklers, dampers, and alarms are unified into one coordinated system. Coordination of all the smoke control tactics is typically performed by a fire alarm/smoke control panel. In most systems, fire fighters have override control from a Fire Fighters' Smoke Control System (FSCS) Panel located in a lobby or a protected area. Overrides and status indication of all equipment are present on the face of the FSCS or a computer screen display. Figure 4 shows a detail of a typical override switch and indicator lights on a FSCS panel.



**Figure 4. Detail of FSCS panel.**

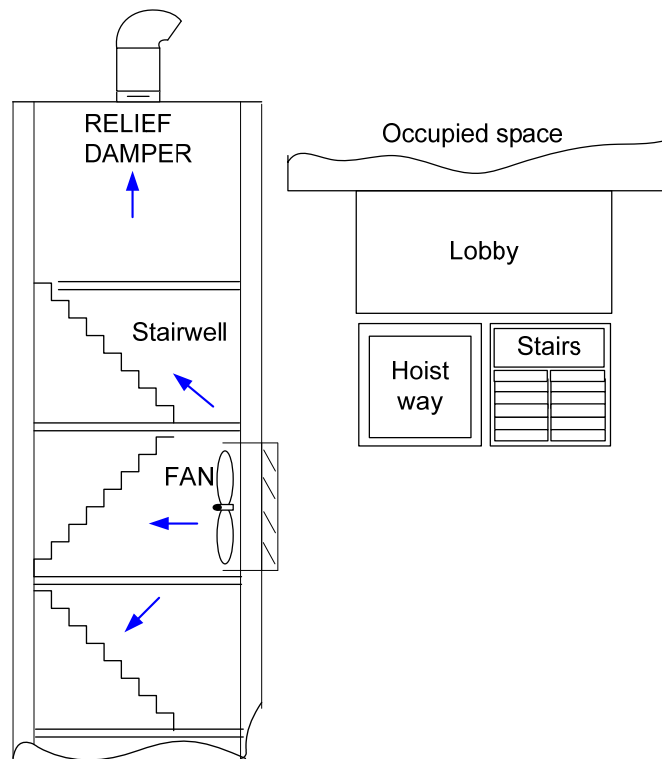


Figure 5. Relief damper variation of stairwell pressurization.

### Stairwell pressurization

Stairwell pressurization can be accomplished a number of ways. The IBC (IBC. 2012) requires vestibules in unsprinklered buildings. This can be supplemented with stairwell pressurization. In sprinklered buildings pressurization alone is allowed. One should consult the IBC for details of requirements.

One method uses a constant volume fan capable of pushing air through any stair door that opens. A barometric damper in the stairwell roof or wall relieves excessive pressure. See Figure 5. In Figure 6 a combination vestibule with barometric is shown.

There are designs by different fire protection engineers that use lobbies under positive pressure and others using negative pressure (IBC method) by exhausting. For the most part these designs do not use automated dampers in the periphery.

Since most buildings are sprinklered, pressurization systems alone are more common. A duct system can be run the height of the stairwell and proportional actuated dampers located every few floors with local pressure sensors. If a floor door opens, the damper(s) nearest it modulate(s) open as necessary to

maintain pressure. A certain amount of smoke may enter the stairwell when any door is opened if there is a lot of pressure behind it. Typically, the expansion of heated air does provide pressure. It takes some time for the sensor, controller, and actuator to respond and open the local dampers further. See Figure 7. The fan may be controlled by a VFD for better control.

Other variations are possible and research is incomplete with regards to which is best in what geometric arrangement of stairs, stack effect, or height of stairs. One variation is a second fan that turns on when the egress level door is opened. Then that door does not relieve all the pressure necessary for the floors. Some research has shown that sufficient ventilation alone during a fire will keep the stairwell tenable. This employs a supply fan at the bottom of the stairwell and an exhaust fan at the top. It can be combined with door pressurization by using variable frequency drive (VFD) fans.



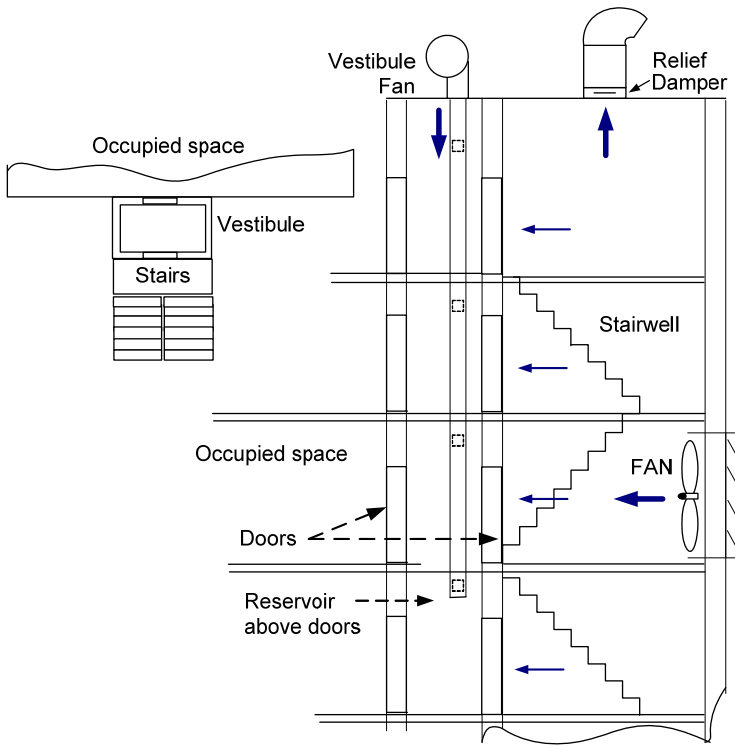


Figure 6. Vestibule variation and supplemental stairwell pressurization.

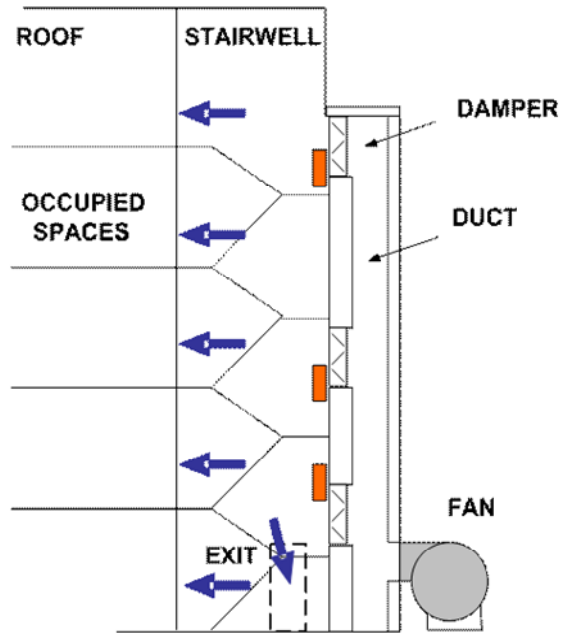


Figure 7. Stairwell pressurization system using proportional damper control.

Stairwells are built to be smoke proof compartments. The occupants can escape into the stairwells and be protected from smoke while they escape the building. When floor doors are opened, smoke must not enter the stairwell. Since several architectural and control design methods are used examination of each system is necessary to understand its intent. Testing using smoke generators helps to ensure the system works as required. Pressure in the stairwell must be below that which would hinder the opening of doors.

### Elevator lobby pressurization

The lobbies of elevators can be pressurized to keep smoke from entering. These lobbies are sometimes areas of refuge and must be kept clear of smoke. The codes typically require that the elevator lobbies, where pressurized as a smoke compartment, be kept positive with respect to the occupied spaces. This is achieved by balancing the air systems to provide more air to the lobbies or by injecting air with a separate unit.

### Hoistway shaft pressurization

Any hoistway, for example a dumbwaiter, provides a path for smoke to travel throughout a building. Elevators are typically the largest shaft in a building and provide a path for smoke travel.

In order to protect elevator (or other the hoistway) shafts, the shaft can be pressurized with fresh air. The pressure prevents smoke from entering the shaft itself and from traveling to other areas via the hoist way. Due to the large volumes of air and consequently very large fans required, a more common alternate is to provide lobbies with smoke barriers. The geometry of the application is very similar to that in Figure 5 for stairwells. Use of elevators that are in protected hoistway shafts is a developing area of study as of this writing. In single elevator car shafts, fans above and below the car may be necessary if the free space between the car and the shaft walls is insufficient for air movement when needed.

### Atria smoke exhaust or extraction

In large spaces, there is no way to pressurize the large area to prevent smoke movement into the space. It is best to exhaust high volumes to remove the smoke. Atria and large spaces, particularly malls, have exhaust fans to remove smoke and keep it at least six feet above the occupied levels for 20 minutes to allow escape. Lower level make-up air dampers open to the outside to admit fresh air to replace the smoke. See Figure 8.

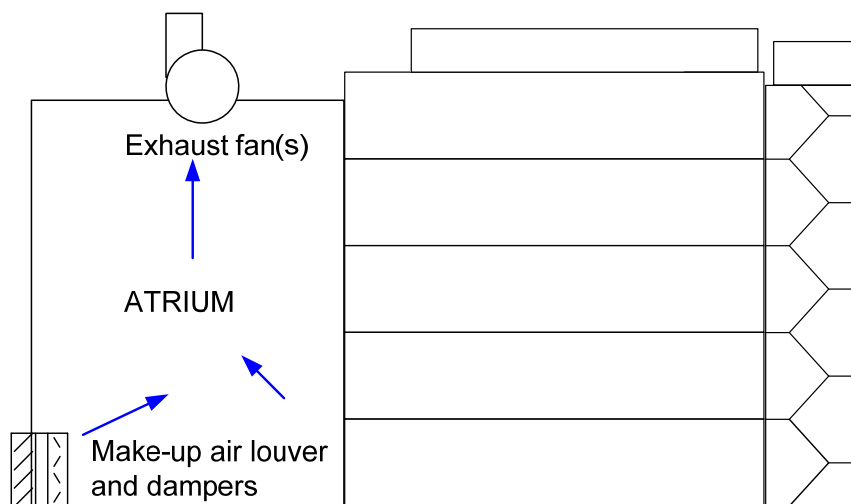


Figure 8. Atrium with exhaust fan.

### Smoke vents

In certain warehouse and storage occupancies, smoke vents are prescribed by the codes. These can be automatic or manually operated. The goal is to remove hot, buoyant smoke to provide clear air for occupants and fire fighters. When wind is a potential problem, powered fans are used. These are part of an engineered system with the switches to operate them located outside the building where the fire service has quick access. (Section 910. IBC2009.)

### Smoke shafts

In some buildings there are shafts extending the height of the building. Fans are mounted at the top and closed dampers are mounted in the wall of each floor. In case of fire, the fan turns on and the damper on the fire floor opens. Smoke is pulled out of the fire floor.

A variation of this is the use of the HVAC ducts to pull smoke out of a building by sucking with the return air fan and opening the exhaust damper and closing the return air damper.

The HVAC components are not typically designed for this application and the volume of smoke removed may be insufficient.

### Zoned smoke control.

In some buildings entire zones or floors are

exhausted or pressurized to prevent smoke migration. The fire zone or floor is placed under a negative pressure, often by the HVAC return duct damper and fan. The adjacent floors are placed under a positive pressure to prevent smoke migration. This is a “sandwich pressurization system.” If all the floors except the fire floor are positive, the system is known as a “building pressurization system.” Zoned smoke control was mandatory in high-rise buildings in the legacy codes, but the present IBC does not require them. They may still be found in some local codes and in underground buildings which are particularly dangerous since escape paths are highly restricted. See Figure 9.

### Corridor pressurization

If only the corridors are zone pressurized as above, the system is called a corridor pressurization system. When smoke fills a corridor, it is very hard to see exit signs and people become disoriented. A combination of intake and exhaust fans can clear smoke.

Corridor dampers normally provide ventilation air and exhaust stale air. However, they can be converted to smoke control dampers very easily. If a fire starts, the floors above and below the fire floor open their corridor ventilation dampers 100% to pressurize the floors while they close their return air dampers. This is identical in concept to the floor pressurization system discussed above. See Figure 10.

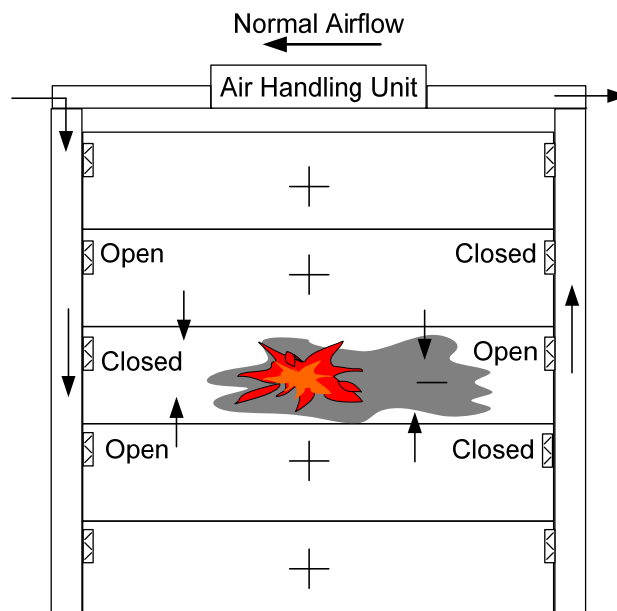
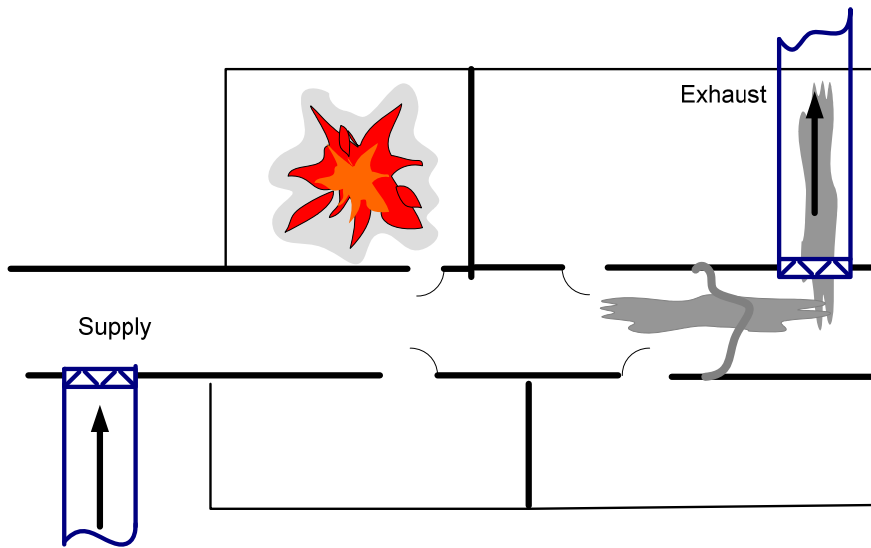


Figure 9. A building pressurization system



**Figure 10. Supply and return ducts in corridor protected by fire & smoke dampers.**

Special fire and smoke proportional or three-position actuators can be used to control the corridor dampers. The dampers must be partially closed for balancing, however they must reopen 100% to pressurize the floors adjacent to a smoke floor or to exhaust smoke as quickly as possible. Two speed fan motors or VFD's prevent noise due to dampers that must be near closed during normal operation to avoid imbalance in design flow. Standard balancing dampers would restrict the full flow when needed. All other floors' corridor dampers close so that a higher pressure and more air movement are available for the sandwich floors.

Smoke causes most of the deaths in fires and smoke exhaust or pressurization methods can constrain it. However, in all of the methods discussed, too much oxygen cannot be injected and thus feed the fire. When fans are used to pressurize or add air for smoke removal, smoke detection on the inlet of the fan is used to avoid injecting smoke if the fire is near the inlet of the fan.

Sprinklers are essential for fire protection. However, they are insufficient for fully balanced protection in large buildings. A balanced approach between active and passive measures produces the safest conditions.

Compartmentation is the primary protection method for fire and smoke control. Maintaining the integrity of walls prevents fire

passage and smoke spread. Containment duct and shaft dampers protect from smoke transport across compartment walls. About 85% of smoke dampers are used to maintain compartment containment. All means of egress must be protected – stairwells, elevator hoistways, lobbies, corridors, and paths to the outside.

In addition, dampers are required where ducts penetrate shaft walls. Shaft dampers are the only way to restrict smoke movement. Air handling unit shutdown is insufficient alone.

Large spaces like atriums, stages, malls, and stadium seating require smoke exhaust to keep the smoke layer above the level of the occupants' heads.

Engineered smoke control systems use mostly pressurization to prevent smoke migration. About 15% of actuated dampers are installed in them.

### III. Fire and Smoke Control Containment Dampers

#### Compartmentation/containment vs. engineered system dampers

Figure 11 shows a building with typical locations of fire and smoke control dampers. Dampers in barrier walls are usually open and close in case of fire or smoke. Fire dampers close only if the temperature at the damper rises to typically 165°F (74°C) melting the fusible link. Smoke dampers can open or close much sooner since smoke spreads quickly and is sensed faster than temperature by the electronics. Fire dampers have one action – they close if temperature is high. Smoke dampers can close to block smoke spread through duct systems or, in engineered smoke control systems, they can be opened to

exhaust smoke or to push air into a space to manage smoke movement.

Dampers that are employed in maintaining compartmentation are referred to as “containment” dampers. They maintain the integrity of fire and smoke compartment walls and automatically close if fire or smoke is sensed. The dampers used in engineered smoke control systems are referred to as “smoke control” dampers.

They are of the same general construction and are often identical except for the controls. These are UL555 (fire) and UL555S (smoke) rated dampers (UL555; UL555S). Many smoke dampers are installed in barrier walls to stop smoke transport and are controlled by duct smoke detectors. Some containment dampers are controlled by area smoke detection and a central panel.

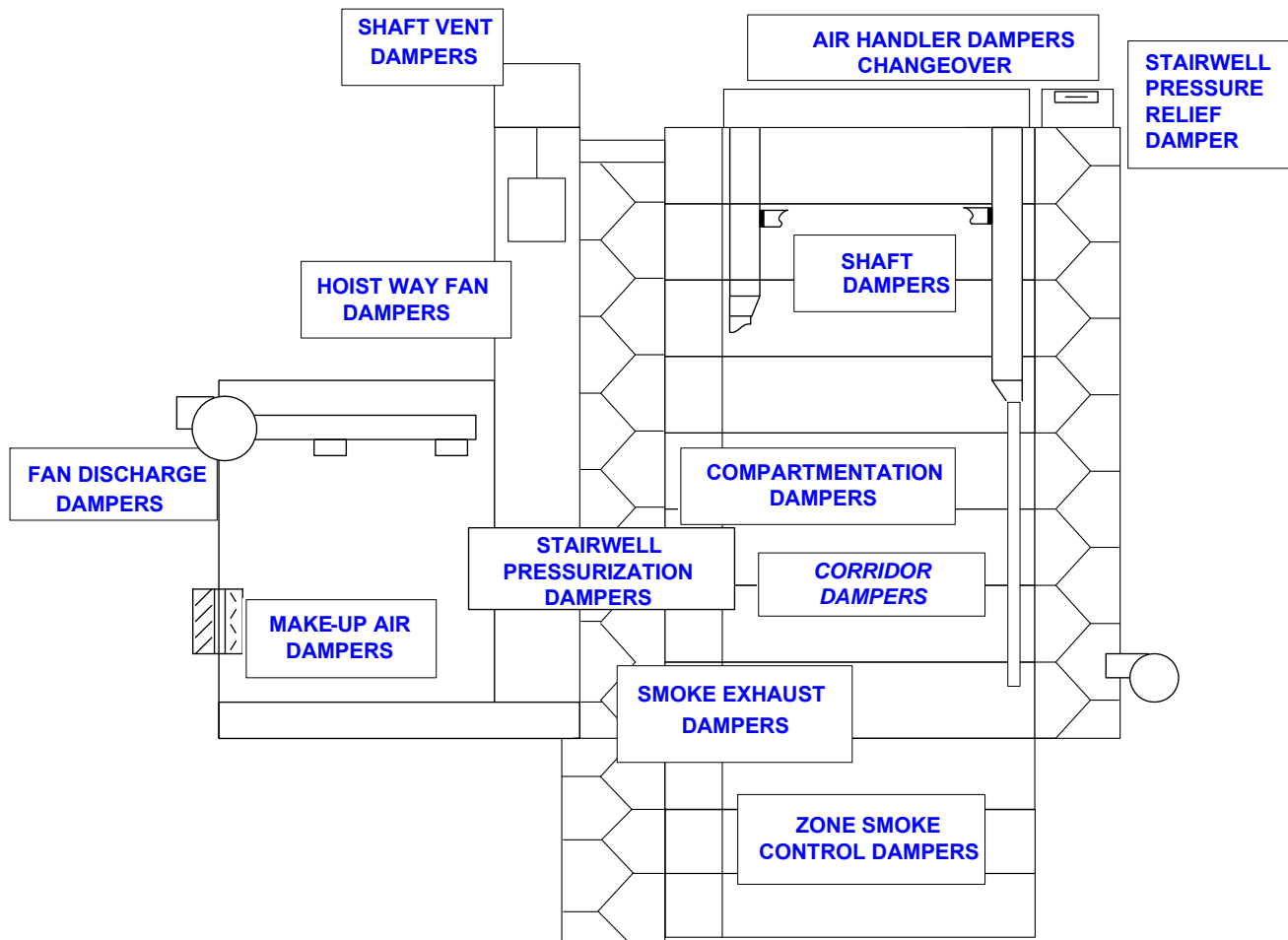


Figure 11. Locations of fire and smoke dampers.

Fire dampers are not typically actuated and have fusible links or temperature sensors that cause them to close when the duct rises to 165°F (74°C). Building codes describe where each type of damper is required. Figure 12 shows what the typical damper looks like and the thermal sensors for closing the damper in case of fire.

It simplifies thinking to distinguish between containment dampers and those used in engineered systems. Containment dampers cannot be overridden and are not usually monitored and do not give position indication to the Fire Fighters Smoke Control System (FSCS) panel. Applications of smoke control system dampers are covered in Section 4 below.

While the UL testing of the dampers is the same, installed testing requirements are different for the different applications. Per the IBC, both fire and smoke containment dampers are tested at commissioning, one year after installation, and then once every 4 years, except hospitals where they are tested again after every 6 years. Engineered smoke control systems and their dampers are tested once a year. Some jurisdictions require that dedicated systems – those used for smoke only – be tested twice a year.

## Fire dampers

Fire dampers are installed to prevent the passage of fire through walls or ducts from one space to another. Fire dampers are compartmentation dampers.

*Curtain dampers* installed in heating and air conditioning ducts which pass thru fire walls or floors are the most common fire dampers. They are held open by a fusible link which typically melts at 165°F (74°C) allowing the blades to fall into the air stream and block high temperature air. In some cases 210°F (100°C) or higher are used. See Figure 13.

Unless specially made for out-of-wall installation, fire dampers must be within the plane of the wall they are protecting. For this reason, when combination fire and smoke dampers, discussed below, are installed, jackshafts are used (see Figure 12). This allows attaching the actuator to the jackshaft where it is accessible from outside while the damper blades are still within the wall plane. Many smoke dampers are jackshafted also as the same damper is used in the combination fire and smoke application. However, a smoke damper may be installed up to two feet away from the wall.

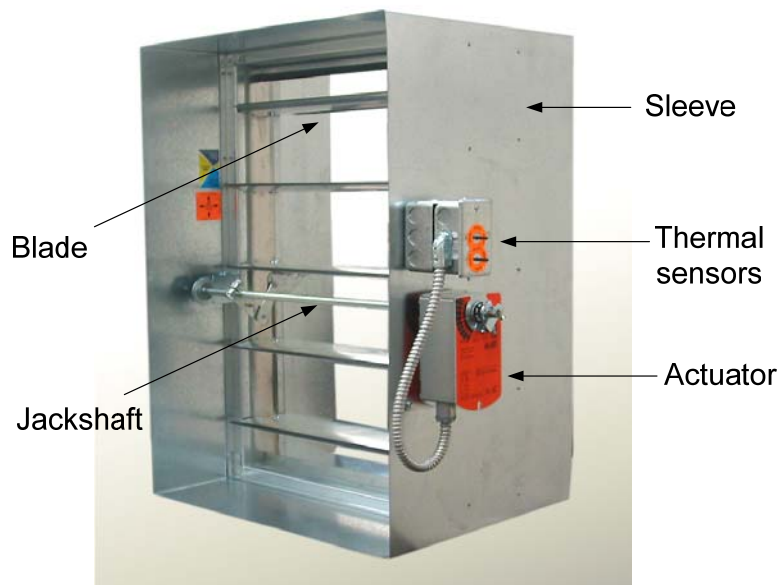
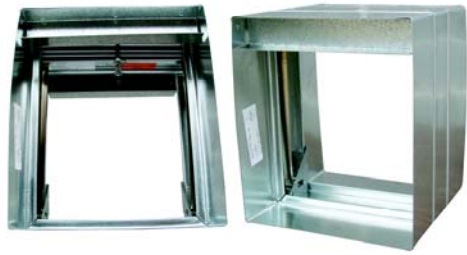


Figure 12. Combination fire and smoke damper. (Photograph courtesy of Pottorff.)



**Figure 13. Curtain fire dampers**  
(Photograph courtesy of Pottorff.)

*Ceiling radiation dampers* guard diffusers which supply or return air. These are usually fusible link operated although some applications use actuated dampers. UL555C regulates construction and installation of ceiling dampers. These assist in restraining fire to the compartment where it originates. See Figure 14.



**Figure 14. Ceiling radiation damper**  
(Courtesy of Ruskin Manufacturing)

There are uncommon cases where a fire damper is very large and requires multiple sections. All the sections must close simultaneously and fusible links would not achieve that as each can melt at a different time. An electrical thermal sensor is used to cut power to the actuator(s), thus closing all sections simultaneously. This is the same method used for multiple combination fire and smoke dampers discussed below.

*Heat and smoke vents* can be found frequently in warehouse storage roofs. They are normally closed and can open to release heat and smoke. Fusible links, electric, and pneumatic methods are all used to open them. These are not covered here.



**Figure 15. Multisection fire damper with actuator.** (Photograph courtesy Greenheck Fan Company.)

### Smoke dampers

Smoke dampers have no temperature sensors. See Figure 16. Note that there is no temperature sensor like there is in the damper in Figure 15.



**Figure 16. Two section smoke damper with actuator.** (Photograph courtesy of Pottorff.)

There are two main applications where smoke dampers are used:

- 1) In smoke barriers where they close to maintain the smoke proof compartment which they protect. Once a smoke detector or area smoke detection has closed them, they stay closed until the event is over and they are manually reset. Smoke dampers that are installed in smoke barriers serve to maintain

compartmentation; typically a smoke detector within five feet closes the damper.

2) In many applications, discussed at length below, they can be controlled by the smoke management system to open or close as needed to pressurize, relieve, or exhaust a space. The FSCS panel has override switches that connect to them. These are frequently termed “reopenable dampers” since they can be operated remotely open or closed from the FSCS panel.

About 10% of motorized dampers are smoke dampers only. Since most smoke barriers are also fire barriers, 90% of motorized dampers are combination fire and smoke. Combination dampers are installed in them – they are both fire and smoke dampers. At one time in the past two dampers would have been installed. Modern systems use a combination.

All dampers in engineered smoke control systems, regardless of whether they are smoke only or combination fire and smoke have position indication that shows at the smoke control panel. Damper blade switches, magnetic switches, or actuator auxiliary switches are used for the signaling. See Figure 4 for an example of FSCS indication.

Figure 17 shows the power wiring for a smoke damper. (Switches will be covered in a following section.) In reality, the wiring often looks like a confusing pretzel; however, here a ladder diagram shows how simple it actually is.

Hot power enters from the left. If the smoke detector or smoke relay contact is closed, power continues to the actuator H terminal and drives it open. When power is removed, the actuator springs the damper closed. Power is sometimes disconnected on the Common terminal of the actuator. This is a two position application – full open or full closed. The fire alarm system must be notified that smoke has been detected. This is accomplished by another contact on the smoke detector or by the fire alarm panel if an area smoke detection system is used.

### Combination fire and smoke dampers

Combination fire and smoke dampers are installed in walls that are both fire and smoke barriers. These dampers combine the smoke and the fire function. A thermal sensor is placed in the duct and if the temperature rises to typically 165°F it springs closed. Figure 18 shows a damper with electrical control of the actuator in both smoke and fire functions.

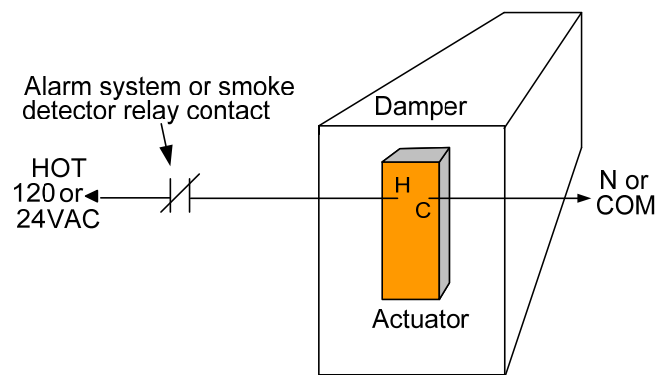
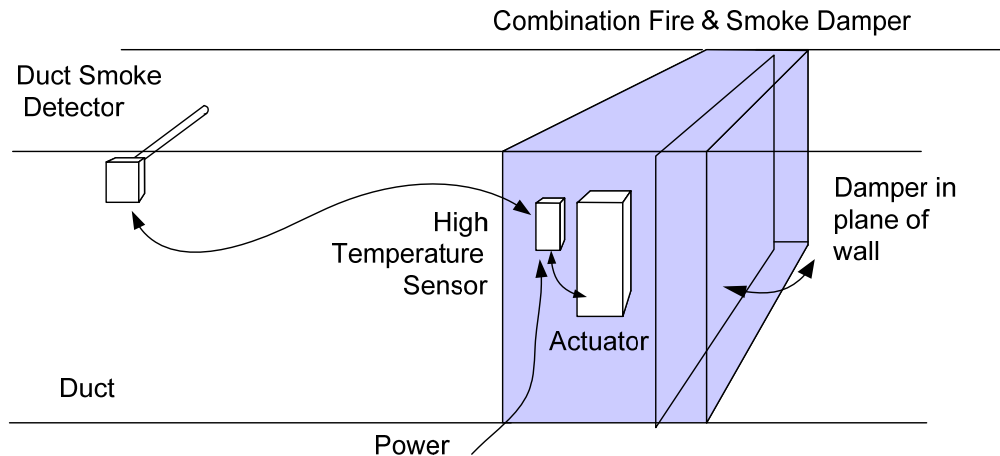


Figure 17. Typical wiring for smoke damper actuator in Chapter 7 containment application.





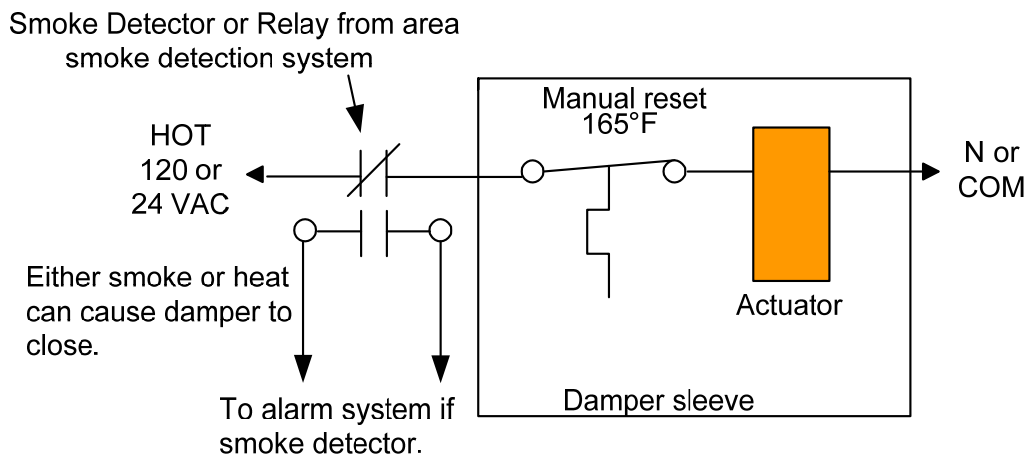
**Figure 18. Typical installation of a fire and smoke damper in Chapter 7 containment application.**

Figure 19 shows the typical, modern combination fire and smoke damper wiring. There are no switches providing position indication if the damper is not in an engineered application. The smoke detector signal does go back to the fire alarm panel and would provide the location of the alarm. This is the most common wiring scheme that will be found in the field. Most installations are wired like the drawing in Figure 19.

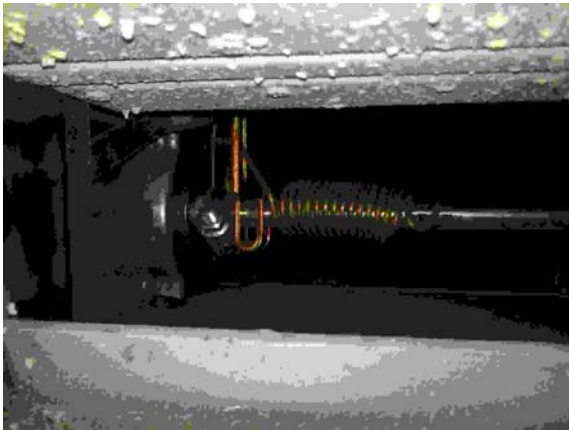
If the duct temperature rises to 165°F (74°C), then power is cut to the actuator and it springs closed. Alternately, for the smoke function, if the contact on the smoke detector or smoke relay opens, power is cut and the damper closes.

#### Older combination fire and smoke dampers

Several slightly different methods of controlling combination dampers have been employed over the years. When repairing them or replacing defective actuators, some investigation is necessary. Many older dampers used a fusible link similar to those on the curtain fire damper for the fire function and an actuator for the smoke function. Figure 20 shows this type of damper with a detail of the fusible link and a spring on the damper shaft. The smoke closing function and reopening if needed is performed by the actuator.

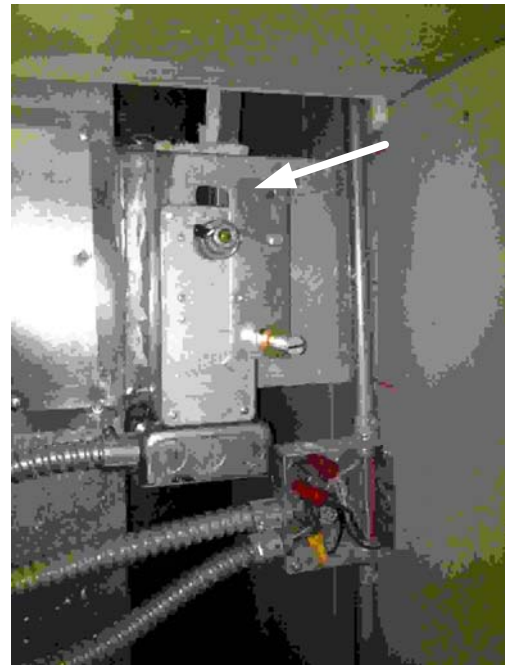


**Figure 19. Typical wiring of a smoke detector, high temperature limit, and actuator of a combination fire and smoke damper.**



Above. Detail showing fusible link, arm, and shaft spring. Regardless of the motor's position, if the fusible link melts, the spring slams the damper closed.

Right. Motor is used to open the damper. Arrow shows external spring which closes damper when power is removed from the motor.



**Figure 20. Fusible link, shaft spring, motor with 2<sup>nd</sup> external spring.**

There is a spring on the outside for the actuator. The fire function is performed by the fusible link and 2<sup>nd</sup> internal shaft spring. The wiring for the fusible link variation is the same as that in Figure 17. The electric power is cut only by the smoke detector or relay. The high temperature fire function is performed by the fusible link opening.

In all cases the end result is the same. If the ambient air passing through the damper reaches 165°F (74°C), then the damper closes. If smoke is detected, then the damper closes.

UL has clearly stated that they do not regulate repair or replacement issues. The local Fire Marshal or Building Official is usually the Authority Having Jurisdiction.

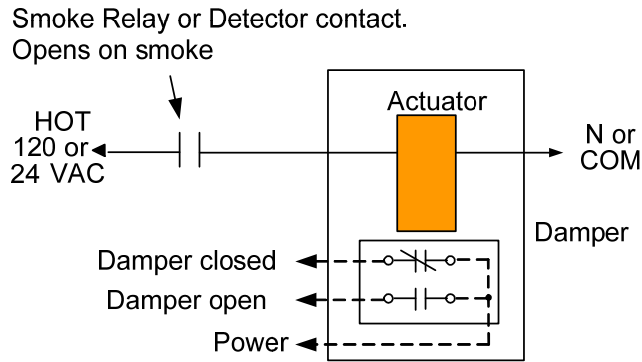
Equal or better actuators are required in most cases. The specifications include equal or better in torque, temperature tolerance, time to drive and spring, and lower or equal in amperage draw. Voltage must be equal. The damper must be tested for performance afterwards. NFPA 80 and 105 require that a record of repair be kept on premises. (NFPA 80, NFPA 105.)

#### **IV. Engineered Smoke Control System Damper Controls (Chapter 9)**

##### **Auxiliary switches for smoke control system dampers**

In engineered smoke control systems the position of the damper is normally indicated at the FSCS panel. In some cities or states, the codes do not require the indication; however, the IBC requires them. In addition, the wiring must usually be checked for integrity, usually by end of line resistors – this is not covered here as the fire alarm code has extensive information. There are some codes that require that fire dampers are also controlled – for example, New York in B occupancy high rises.

Figure 21 shows the addition of switches for damper position indication. Actuator auxiliary switches, damper blade switches, or magnetic switches can be used. If the smoke relay contacts open, the actuator springs the damper closed. The contacts on the switches change from damper-open to damper-closed. This is not typically seen in containment applications, only in engineered smoke control systems where status must be indicated at the FSCS panel.



**Figure 21. Switches provide indication to the FSCS for damper open or closed.**

In older systems, wires actually ran from the damper to the control panel. In modern systems, a network relay receives the switch indication and the data is passed along the network wires to the central control system. In the drawings here, hardwired connections are shown for the override switches and networks are assumed for the position indication.

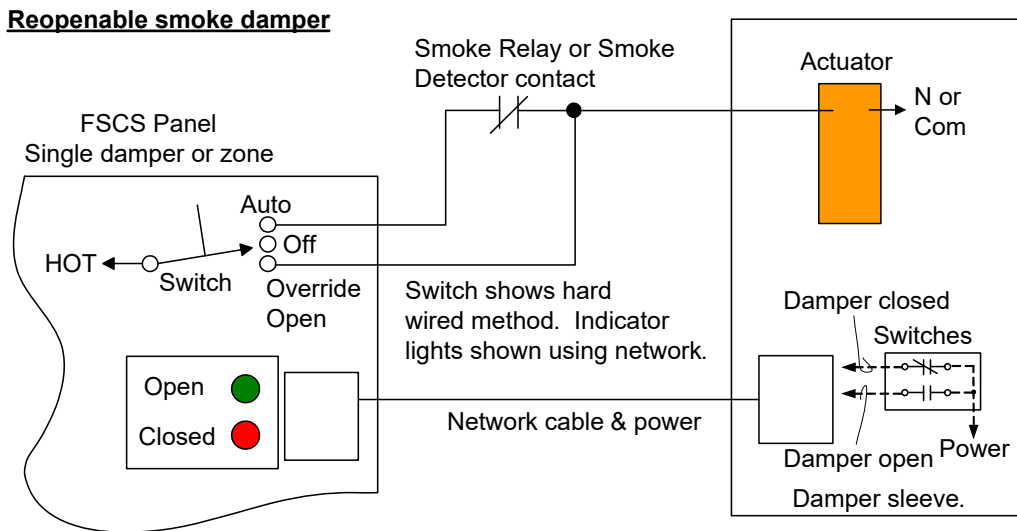
**Wiring for reopenable smoke control system dampers**

Figure 22 shows the wiring for a reopenable smoke damper in a smoke control system. Note that the damper construction is the same as any UL555S containment damper – the controls are

the difference. The smoke detector or relay is not integral to the damper and is shown outside the damper sleeve. The smoke detector and any thermal sensors are manual reset. In the auto mode, the smoke relay can close the damper. However, if the override switch at the panel is set to “On,” then the damper opens. There is no temperature sensing.

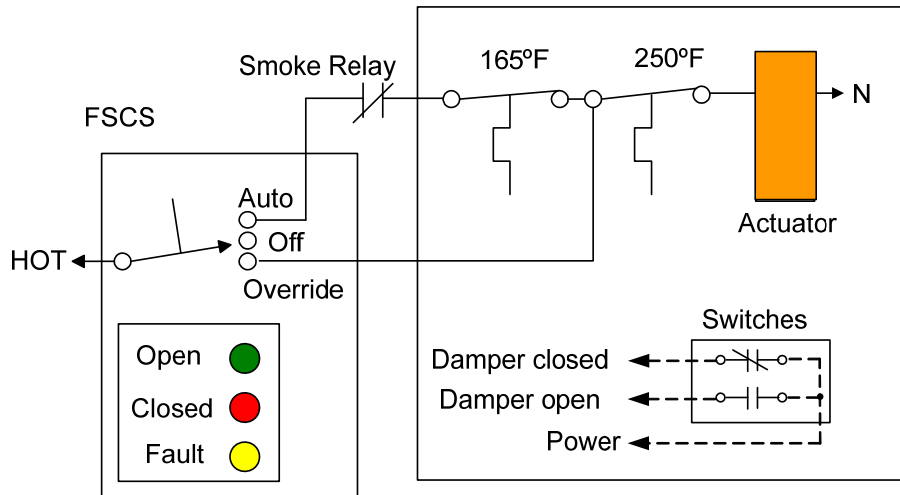
A combination fire and smoke damper typical wiring is shown in Figure 23.

Dampers are used for two general purposes in fire and smoke control. They assist in maintaining compartmentation and in engineered smoke control systems they help to pressurize and exhaust spaces.



**Figure 22. FSCS panel, override switch, switch indication, and smoke damper.**

### Reopenable fire and smoke damper



**Figure 23. Wiring of a FSCS panel, primary and secondary sensors, and actuator on a reopenable damper.**

The damper construction is the same for those used for containment as those used in engineered smoke control systems. All are UL555 (fire) and/or UL555S (smoke) listed by the manufacturer. Some variations occur among makes or models. Dampers can have single thickness blades or double skin airfoil. Fire dampers and combination are steel where smoke can also be aluminum. However, in general, there is little difference in construction.

The controls do vary as indication switches on the dampers are typically used for engineered systems so that the FSCS panel can show status of the dampers. In addition, override is possible to reopen the damper manually. Variations to fit the particular system and building are common.

## V. Engineered Smoke Control System Applications

### Introduction

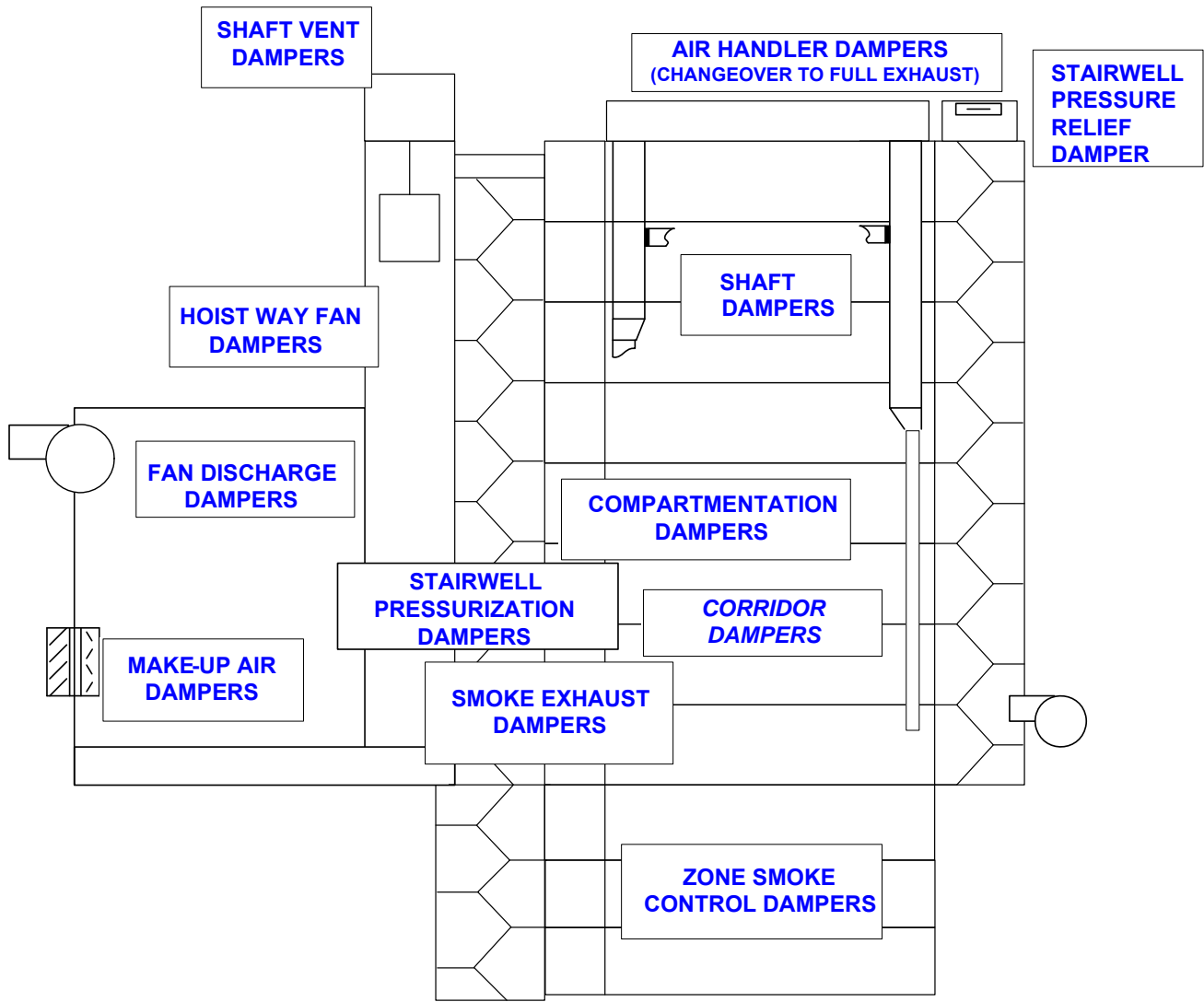
The preceding material presented the various smoke control system methods or tactics,

damper types, and the controls. This section brings them together and discusses how these dampers are controlled and wired in engineered smoke control systems. It is more strategic.

In general, any damper that is part of a smoke control system must be a UL555 (fire) and/or a UL555S (smoke) rated damper. In some cases exceptions are allowed since the damper is not meant to stop smoke. Examples are outside make-up air intakes and exhaust dampers on the outside of the building. They are usually open during an event and do not stop spread of fire and smoke.

Another exception case is where existing dampers have been operating for years and are being reused while the system is being refurbished. Each application needs to be examined specifically to determine real needs. For new installations, UL rated dampers ensure quality and factory or actuator mounted switches are needed for position signaling.

Figure 24 shows the smoke control system components that can have dampers associated with them. The following sections go into details about the most common subsystems and how dampers are applied.



**Figure 24. Locations of fire and smoke dampers.**

**Building, zone, and floor pressurization systems**

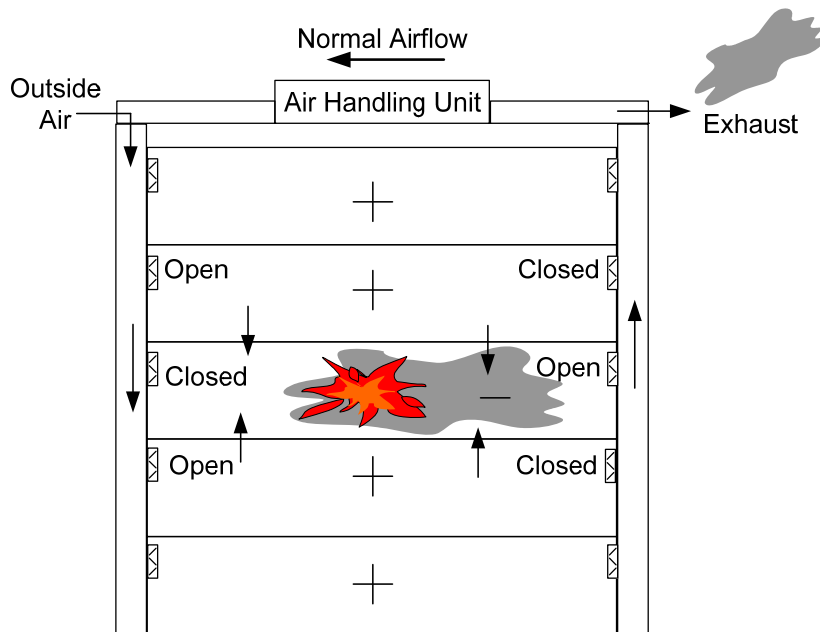
Pressurization systems are sometimes required in high-rises and underground buildings. The principle behind them is used in many systems: pressurize an area with respect to an adjacent area and smoke entry is restricted. Alternately, pull an area negative with respect to adjacent spaces and the smoke will move in that direction. In all cases, the fire floor is negative. The fire protection engineer may choose to simply pull the fire zone negative. Since the other floors are positively pressurized to avoid infiltration of unconditioned outside air, smoke will flow out of the floor but not into other occupied spaces. The

difference in pressures must be high enough to achieve the goal.

Figure 25 shows a typical application with a fire and accompanying smoke on floor three.

The supply damper on the fire floor is closed. The return damper is open and smoke is pulled out as the floor is negative. Smoke extraction shafts and fans could produce the same result; these are not discussed here.

The dampers in the air handling unit change over and air is exhausted from the return to the outside, thus removing smoke. See Figure 26. In the floors above and below the fire floor, the supply dampers are open and the return dampers are closed. These floors have excess pressure in order to minimize smoke movement into adjacent floors through cracks due to the expansion of hot air.



san

**Figure 25. Sandwich pressurization system.**

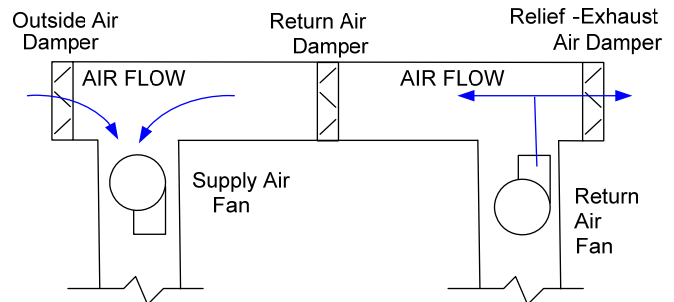
If only the floors adjacent to the fire floor are pressurized, the system is referred to as a “sandwich” pressurization system. The unaffected floors continue to have both their supply and return dampers open; they should be slightly positive. If all the floors except the fire floor have open supplies and closed returns, then it is a “building” pressurization system. If the floors are so large that a number of zones are on the same floor and those adjacent to the fire zone are pressurized, then it is referred to as a “zone” pressurization system.

The fan and damper arrangement here is a “non-dedicated” system. The regular HVAC equipment is used for smoke control if ever required. A “dedicated” system would have separate fans for pressurizing with air and/or exhausting smoke. Figure 26 shows the air handling unit dampers.

**Figure 26 (right). Air Handling Unit damper changeover from Normal to Smoke Exhaust. The return air damper is fully closed while the Outside Air and Exhaust Air dampers are full open. Relief fan operation is similar.**

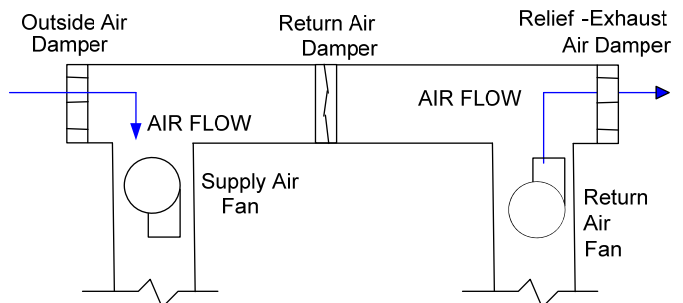
Normal operation

Dampers modulate for temperature control functions. Some return air is recirculated.



Smoke exhaust operation

OA damper is full open. RA damper is full closed. Relief or exhaust damper is full open. Smoke is exhausted.



Normally, air can flow through the unit. In smoke mode, the supply fan delivers only outside air to the zones or floors without fire. The return air fan becomes an exhaust. The relief or exhaust damper opens fully to relieve smoke.

In the configuration shown, the Return Air Damper should be a UL555S rated damper. It must be low leakage so that smoke is not pushed back into the supply air. If a relief fan were used, the damper is not pressurized by the return fan and smoke leakage should not occur.

### Corridor dampers

When normally occupied, the corridor should be ventilated with fresh air and stale air must be exhausted. The supply must deliver slightly more air than the exhaust pulls out in order to keep the space pressure positive with respect to the outside. For this reason, balancing is necessary and it is rare that a damper is fully open; the dampers are closed part way to adjust the air flow differences.

In event of a fire the corridors are used for egress; the corridor must be kept free of smoke.

Corridor dampers can provide both functions. See Figure 27 for a typical application. In this case, under normal conditions, there is a constant air flow into the corridor from the supply damper on the left and a constant exhaust via the damper on the right.

If there is a fire on the floor, then the supply damper closes and the exhaust opens fully. Smoke is pulled out of the corridor so that occupants can escape. This is like the floor or zone pressurization system above.

The actuators are balanced by the balancing and controls contractors so that the right amount of air enters each floor in normal operation. The dampers are sized so that when full open they pull sufficient smoke out of the corridor.

Figure 28 shows a special actuated damper designed for corridor wall mounting and the control wiring for the actuator. The FSCS panel switches are the typical Auto-Closed-Override; however, the actuator works differently to accommodate the needs to balance the air in normal operation.

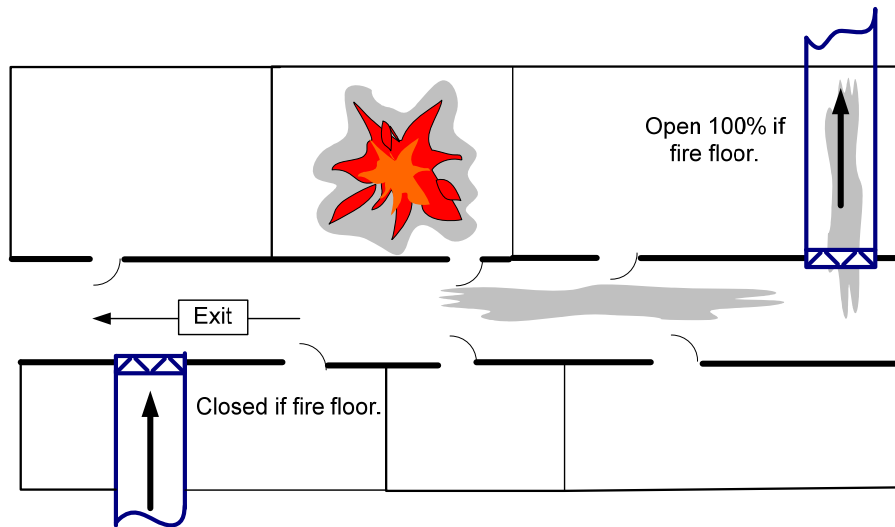
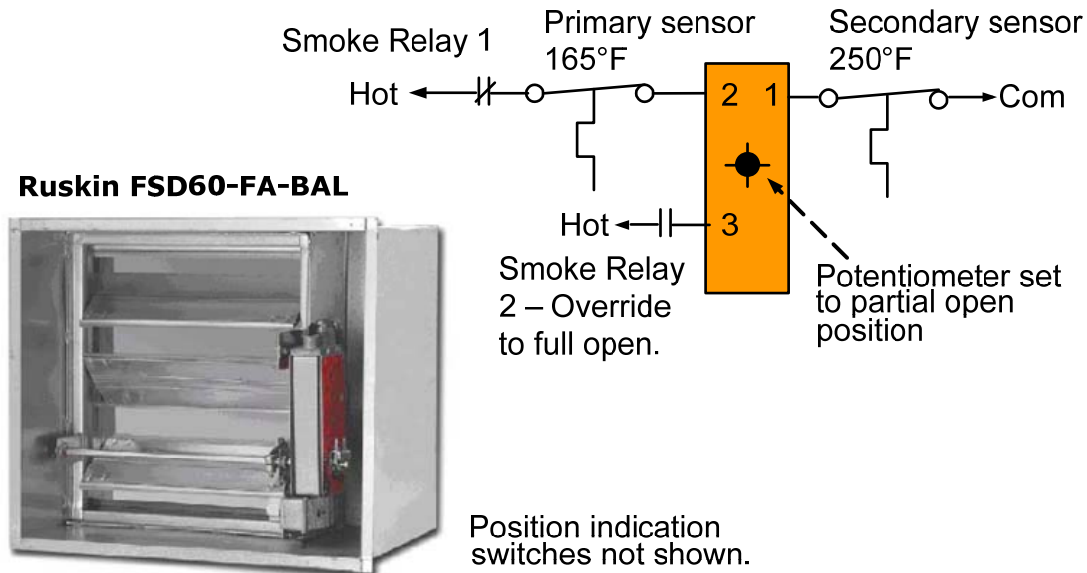


Figure 27. Corridor damper and application.

## Combination Balancing and Fire & Smoke Corridor Damper and Actuator



**Figure 28. An actuated balancing fire and smoke damper. (Photograph courtesy Ruskin Manufacturing.)**

In normal operation when power is applied across 1 and 2, the actuator drives the damper open to the position to which the potentiometer is set. The balancer adjusts the potentiometer to get the required normal ventilation supply airflow. This is performed at all dampers.

If fire or smoke is detected on any other floor, then the fire alarm or smoke control system, via the smoke relays at the supply damper, does not change the damper's position and it stays open. At the exhaust damper, the smoke relay 1 is powered and the contact opens. The damper then springs closed. Since there is no exhaust, this corridor is pressurized.

If the fire is on the dampers' floor, the opposite happens. At the supply damper, smoke relay 1 opens and the damper closes. At the exhaust damper, smoke relay 2 closes its contacts and the actuator drives full open to make the corridor negative in pressure and to exhaust smoke.

If the fire is close to the damper, the primary sensor opens up at 165°F (74°C). The exhaust damper closes. This prevents fire from entering the shaft. If, however, the switch on the FSCS panel is set to "Override" or "Open," then smoke relay 2 closes and the damper again opens. But again, if the fire is intense or close enough to reach 250°F (121°C) at the damper, then the

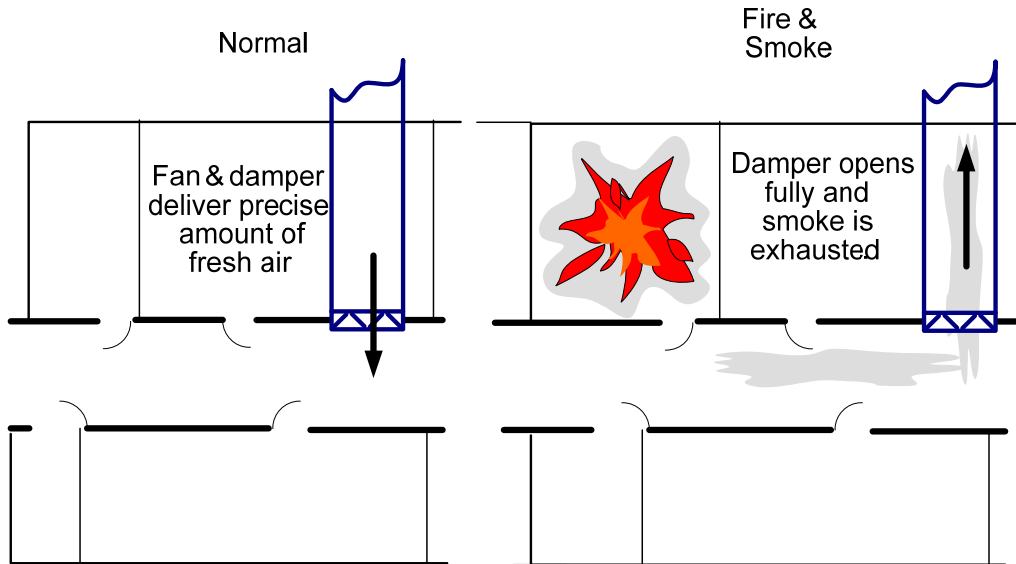
secondary sensor opens and the damper closes. Both sensors are manual reset. The smoke system logic controls these functions.

A number of variations exist. A sandwich or building pressurization type of corridor arrangement is sometimes used. The floors above and below the fire floor are fully pressurized. That means their supply dampers open fully and their return or exhaust dampers close completely. However, the other floors continue normally. During this process, the fans may ramp up to higher speeds if needed.

If make-up air is supplied by some other source than a ducted supply, the floor may have only an exhaust duct and damper. In order to make the fire floor negative with respect to the other floors, all exhausts except the one on the fire floor close. The open fire floor exhaust damper will pull smoke out.

Another variation is use of a single damper and duct on each floor which change roles as needed. The fan normally runs forward to supply air. In event of a fire, the dampers switch over so that the fire floor damper is open and the other floors are closed. The fan reverses flow direction so it pulls air. Since the fan is pulling from only one damper, the pressure is very negative and smoke can be pulled out. See Figure 29.





**Figure 29. Single damper serving as supply or exhaust when fan reverses flow.**

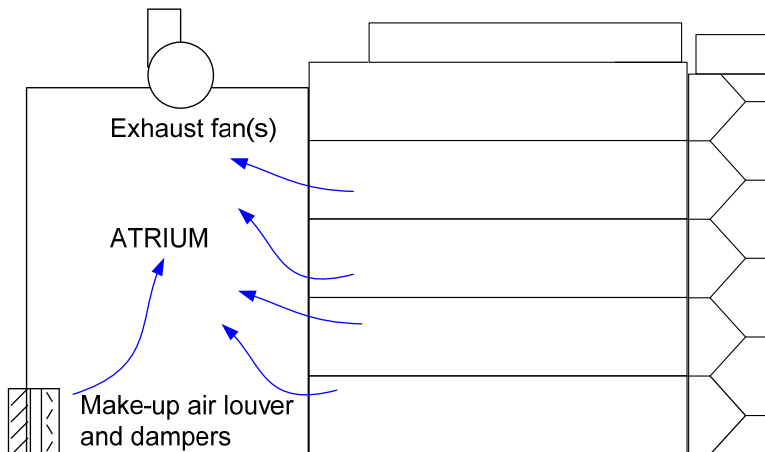
Other variations may not have the two temperature sensors so that the fire fighters have full and final control over the dampers. The fire protection engineer designs the system to combat the most likely and most dangerous scenarios. The mechanical engineer does the final design that meets both the fire and smoke protection requirements while meeting the ventilation codes.

**Smoke exhaust – large spaces**

In very large spaces like covered shopping malls, auditoriums, and atria, it is nearly impossible to use dampers and fans to pressurize the space. In addition, smoke quickly fills the

space and the typically large number of people in the space are in danger. The solution is to exhaust large volumes of smoke. This can prevent the entire space from filling and maintain a smoke-free lower region to allow escape. It also prevents smoke from spreading into the spaces adjacent to the large space. See Figure 30 for a typical concept.

In malls and some spaces there are architectural features that are sometimes included to assist removal of smoke. A smoke reservoir can be made by using barriers or curtains that hang from the ceiling. They can prevent smoke from spreading while the fans pull the smoke out.



**Figure 30. Atrium with multiple entries.**

On the lower left corner of the atrium in Figure 30 make-up air dampers are shown. In order to provide air to replace the smoke that is cleared out of the space, make-up air dampers are provided. If smoke is detected in the atrium, the exhaust fan turns on and the dampers are opened for make-up air. The dampers may be installed in an outside wall or ducts may be used to obtain outside air from a more remote location.

One fear is the effect of providing air that might feed the fire. The exact effects of where the air might hit the fire or its smoke plume are unknown and largely uncontrollable. The American Society of Heating, Refrigeration, Air-Conditioning Engineers (ASHRAE) is researching this subject.

The codes require that any dampers used in a smoke control system be UL555S Listed. If the wall is a fire wall or in some cases if it is within a

certain distance of another building or close to grade, then it is also a UL555 Listed fire damper. Homeland security concerns would require that the opening to the outside be high on the wall. A smoke detector is placed in the inlet of the damper to ensure that if there is a fire active at the inlet that smoke is not pulled into the building.

Regardless of whether the damper is UL555S or both UL555 and UL555S, there will be auxiliary switches to signal the damper's position to the FSCS panel. This damper can be overridden at the FSCS panel.

Figure 31 shows a typical wiring scheme for the smoke detection, fan, and the dampers' wiring. If the damper is smoke only – not fire – the thermal sensors are not present. While the wiring is shown between the override

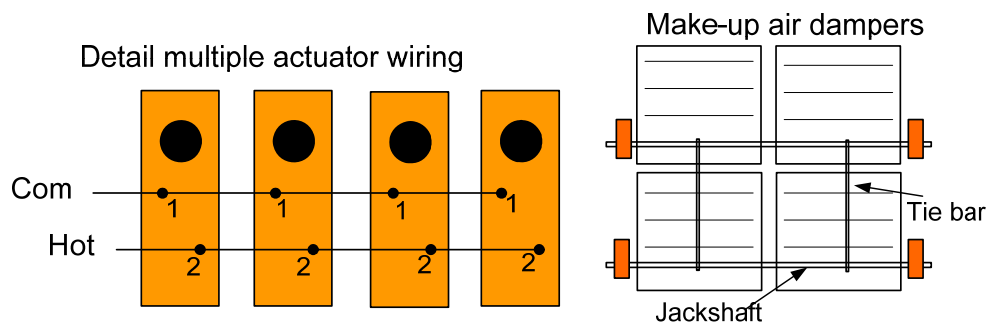
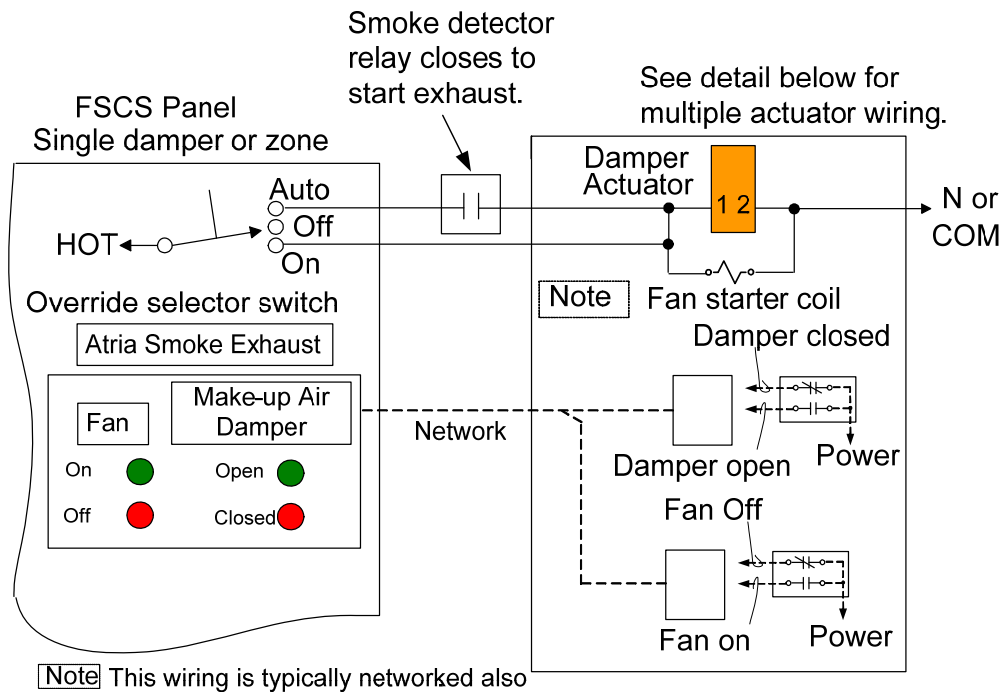


Figure 31. Typical FSCS and wiring to fan and actuators.

switch and the actuator and fan starter coil, in modern systems the fire alarm/smoke control network carries the commands between local input-output devices.

In the Auto mode, power goes thru the smoke system relay to the actuator. If the relay closes, the damper opens to allow make-up air into the atria and the fan starts. Auxiliary switches feed the indicator lights on the control panel. In the Off mode, the relay has no power and the dampers close and the fan is off. In the On or override mode, power is sent to the actuator and fan relay directly to start the exhaust. This is just an example with the wiring shown for educational purposes. In modern systems, a digital network and program logic provide all the correct actions.

An example of a large multi-section damper is shown below the FSCS panel. Wiring sends power to all actuators simultaneously to ensure all sections open (or close) at the same time.

### **Other smoke exhausts and smoke purge**

There are other smoke extraction systems that are used. Among them are smoke shafts penetrating every zone in the building, kitchen exhaust hoods, and general exhausts that may be used in event of a fire. The damper principles are similar to the ideas presented above.

In some codes smoke purge systems are required. After a fire, the building can be flushed with outside air and stale or smoky air exhausted. Any of the normal exhausts can contribute to removing smoke. The main air handling units are often used to provide fresh air by opening the OA and Exhaust air dampers 100%.

### **Stairwell Pressurization**

The IBC requires that stairwells be designed as smoke proof enclosures. There are variations allowed by the code for when automatic sprinkles are provided and some architectural differences. Figure 32 shows one type of stairwell system. Here, the exit stairway shaft is pressurized to between 0.10 inches of water (25 Pa) and 0.35 inches of water (87 Pa) in the shaft with respect to the interior building with all the doors closed (2009 IBC 909.20.5).

There are no automated dampers used which makes the system simple; the added cost is the vestibules and the space they occupy.

(There are likely dampers on the inlet of the fans to prevent water from entering the system.) The relief damper responds to pressure and is adjusted by weights on the blades. The vestibules are fed fresh air by a fan which starts when smoke or a fire is detected. An exhaust is required in the proscribed IBC method and it must pull 150% of the supply air out. Therefore the vestibules are under a negative pressure and smoke that enters the vestibule will be exhausted.

A variation of the vestibule system does not have exhaust. It pressurizes the vestibule to prevent smoke from entering.

A large fan pressurizes the stairwell. When doors are open, the relief damper located near the top of the stairwell closes so that pressure is maintained to keep smoke from entering the stairwell. When the doors are closed, the relief damper opens to relieve excess pressure. If wind is a problem, there may be another damper and louver instead of a gooseneck as shown in Figure 32. The pressure in the shaft is required by code to be 0.10 in. w.g. (25 Pa) with respect to the vestibules when the doors are closed. (2009 IBC 909.20.4.4).

In Figure 33 another approach to pressurizing stairwells is shown. The stairwell connects directly to the occupied spaces. A fan pushes air into a duct which is run up or down the stairwell to distribute air evenly. The dampers are controlled by proportional actuators that respond to the pressure in the stairwell. About .1 to .25" of pressure is maintained with respect to the space so that smoke cannot enter the stairwell. Sometimes there is a Variable Frequency Drive (VFD) on the fan that adjusts it also. There are dampers every few floors that respond to the pressure near them. If the pressure increases, the dampers drive towards close. If the pressure falls, typically due to an opening of a door, then the damper opens.

The dampers must be UL555S (smoke) rated as they are part of a smoke system. If they are in a fire wall they must also be UL555 (fire) Listed if the wall in which they are located is a fire and smoke wall. When the duct is run within the stairwell, then the dampers may not need to be listed depending on the local jurisdiction's rules.



The actuator control is shown on the right side of Figure 33. Power is delivered from a transformer which may be energized when the fan starts. The control may be part of the building's automation system or may be discrete components. 4-20mA is common; 2-10V is shown in Figure 33. The system only operates when a fire alarm has occurred. At that time the fan and controls start to operate. When the controller senses that the pressure in the stairwell has fallen below setpoint, it increases the signal to the actuator and opens the damper gradually. This brings the pressure back up. If the controller senses that the pressure has increased too high in the stairwell, then it drives the damper towards closed until setpoint is achieved.

A smoke relay can cut power to the actuator and controller to spring the damper closed if override is required. Several methods are used. Auxiliary switches can be used to indicate position at the FSCS panel.

Other features may be used. In very tall buildings where stack effect is extreme, there may be walls and doors in the stairwell itself to restrict stack effect and smoke movement. A second fan could be used when the exit door is opened. It turns on to prevent loss of pressure through the open exit door.

### **Hoistway Venting**

In some cases the shafts of elevators and dumbwaiters must have smoke vents of specified area at the top of the shaft. These could be dampered with actuators that open them if any alarm goes off or they could be open permanently. Several exceptions exist including the presence of an automatic sprinkler system. (2009 IBC 3004).

### **Elevator Hoistway Pressurization**

Where no code exceptions exist, elevator shafts must be pressurized or lobbies must be provided. The hoistway must be pressurized to between 0.10 inches of water (25 Pa) and 0.25 inches of water (67 Pa) (2009 IBC 708.14.2.1 ). The geometry of the arrangement is very similar to stairwell pressurization. Very large fans are needed for pressurization because elevator doors are quite leaky – about ½ sq. ft. per door. For this reason, sprinklers and lobbies are more common. Control is straightforward with the fan on if either

the alarm or smoke detection system responds to fire or smoke.

Exhaust fans in the hoistway to assist vents are a possible alternative, but their use is complicated and it is not clear that they are a good method. Analysis is beyond the scope of this article.

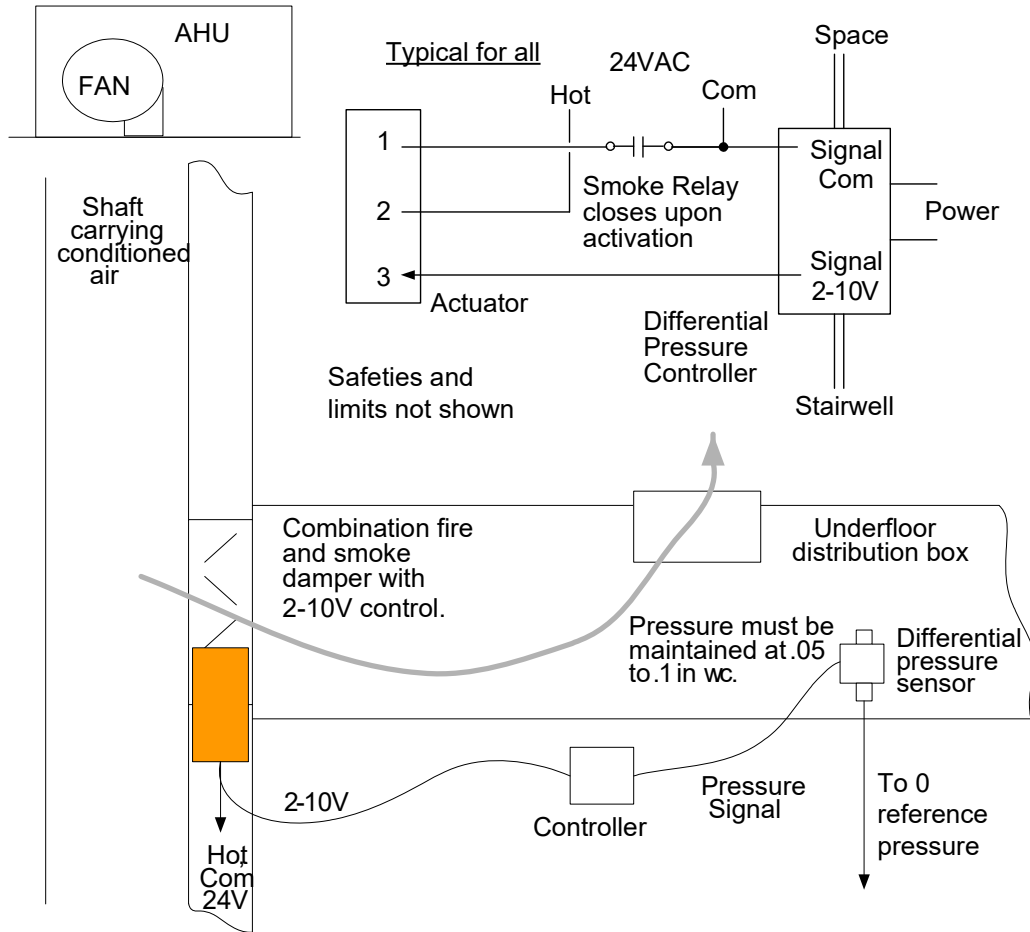
Several ideas are being researched for future consideration. Use of elevators for escape by the handicapped and entry of fire fighters is allowed, but not covered here.

### **Underfloor air conditioning systems**

Another proportional system can be found in underfloor air distribution. The plenum under the floor is pressurized with air to about 0.05 in. w.g. and dampers in boxes set into the floor open and close to provide conditioned air into the space. The walls of the plenum are typically fire and smoke barriers. A fire and smoke damper can be set into the wall and then a 2<sup>nd</sup> damper modulated to maintain the correct air pressure. Alternately, one damper may be provided. It is a fire and smoke damper, but the actuator proportions to a 2-10V signal similar to the method sometimes used in stairwells. See Figure 34. Note that this is not necessarily an engineered smoke control application and status indication may not go back to the FSCS panel.

Elevator lobbies, with some exceptions, must be protected. The lobby walls are smoke barriers if there are sprinklers and fire and smoke walls if there are no sprinklers. All smoke barrier walls are designed to be pressurized 0.05 in. w.g. with respect to the adjacent space so the elevator lobby will resist smoke entrance as long as fans are on; however, a formal pressurization system is not typically used. The lobby will connect to a stairwell. Some lobbies are designated areas of refuge. In those cases the lobby will have its own ventilation air source and engineered controls – it is more than just a lobby that provides part of the means of egress.

Containment dampers are prescribed in the codes as they are critical to maintaining compartmentation. Their operation is relatively simple. Engineered systems are more complex and the fire protection or mechanical engineer must establish the size of design fires; calculate air flows and pressures; size fans and ducts; and ensure coordinated control.



**Figure 34. Underfloor air conditioning with proportional actuation.**

**Summary**

The systems and damper control wiring shown here are typical of the methods used to control dampers in smoke control systems. Variations exist and each application must be examined individually. Testing of smoke exhaust systems by use of smoke generators where appropriate allows confidence in the design and installations.

Dampers are required to maintain compartmentation and restrict fire and smoke from spreading outside of the area of origin. However, full engineered smoke control systems can

actively manage smoke and ensure means of egress for occupants. Exhausting large spaces with fans removes smoke. Preventing smoke from entering exit corridors, lobbies, elevators, and stairwells is critical in allowing escape. Other smoke control methods prevent the spread of smoke in buildings and along with architectural planning can protect occupants.

## References

IBC. 2018 International Building Code, International Code Council, Inc. Country Club Hills, IL. [www.iccsafe.org](http://www.iccsafe.org)

Koffel, 2005. Table 3. Reliability of Automatic Sprinkler Systems. William E. Koffel, P.E., 2005. <http://www.afscc.org/ReliabilityofSprinklerSystems.html>

NFPA 80-2019. Standard for Fire Doors and Other Opening Protectives, 2019 Edition. NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471

NFPA 105-2019. Standard for the Installation of Smoke Door Assemblies and Other Opening Protectives, 2019 Edition. NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471

NFPA 2010. Table B. Combined Sprinkler Performance vs. Sprinkler Success in Confining

Fire to Room of Origin, by Property Use Group. 2003-2007 Structure Fires Reported to U.S. Fire Departments Where Sprinklers Were Present in Fire Area, Fire Was Large Enough to Activate Sprinklers, and Building Was Not Under Construction. U.S. Experience with Sprinklers and Other Automatic Fire Extinguishing Equipment. John R. Hall, Jr. 2010. National Fire Protection Association, Fire Analysis and Research Division, Batterymarch Park, Quincy, MA 02169-7471  
<http://www.nfpa.org/assets/files/PDF/OSsprinklers.pdf>

NYC 2008. New York City Administrative Code, Title 29, New York City Fire Code. [http://www.nyc.gov/html/fdny/pdf/firecode/2009/fire\\_code\\_1126\\_2008\\_amended\\_1137\\_41\\_64\\_2009\\_final\\_complete.pdf](http://www.nyc.gov/html/fdny/pdf/firecode/2009/fire_code_1126_2008_amended_1137_41_64_2009_final_complete.pdf). All NYC codes can be accessed read only at [http://home2.nyc.gov/html/dob/html/model/construction\\_code.shtml](http://home2.nyc.gov/html/dob/html/model/construction_code.shtml)

## Replacement Installation Instructions

[www.belimo.us/firesmoke](http://www.belimo.us/firesmoke).

For cross reference go to:

[https://www.belimo.us/mam/americas/technical\\_documents/pdf-web/fire\\_and\\_smoke\\_doc/fire\\_smoke\\_competitive\\_replacement\\_data\\_reference.pdf](https://www.belimo.us/mam/americas/technical_documents/pdf-web/fire_and_smoke_doc/fire_smoke_competitive_replacement_data_reference.pdf)



Some phone numbers are wrong.  
I am not sure what phone numbers we want.

**United States** **+1 800-543-9038**  
**Canada** **+1 866-805-7089**  
**Mexico** **+1 866-805-7089**  
**Brazil** **+55 11 3643 5656**

I think Black on orange shows up much better.  
But not critical.