AIR CONDITIONING AND REFRIGERATION
Journal
The magazine of the Indian Society of Heating, Refrigerating and Air Conditioning Engineers

Issue : April-June 1999

Fire and Smoke Dampers

Express Towers, Nariman Point, Mumbai on fire in Jan. 1997.
Photo courtesy of Pfizer Ltd.

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At the start of the century free projection systems consisted of fire bells and buckers of replaced by conical shaped wall mounted fire extinguishers. As we approach the new millenium we have available fire and smoke control systems capable of being integrated with computerized Building Management Systems.

Unfortunately for our architects and engineers, there is no comprehensive standard Safety Code for the country as a whole or individual state or major city to guide them in the minimum design requirements of a new building other than the National Building

Code of India which is quite elementary. See pages for an extract. The local city Fire Officer's word is the only enforced guideline and this too depends on the whims of the concerned officer and the importance of the building.

This article has been written in an effort to compile information from different sources so that the work of HVAC engineers and professionals can be simplified and efforts can be made by Fire Developments in major cities to introduce comprehensive Safety Standards in printed form at the earliest.

Life Safety and Loss Prevention

- The task of preventative wire protection is to protect life, limb and property from damage by smoke and fire. It is a fact that the largest amount of damage is not caused by the flames but by the smoke fumes and heat given off by the fire. These factors are why it is vitally important in an air-conditioned building that the flames and smoke should not be allowed to pass through the HVAC ductwork system. It would be safer if they could be contained in the incident area to minimize deadly fumes, for evacuating personnel, and prevent smoke damage and its corrosive effects in other areas of the building.
- The owners, operators and users of buildings are also gradually becoming more aware of the life-saving nature of the subject of Preventive. Fire Protection, and especially so since they are the ones who are likely to suffer most from a fire. They are beginning to realize that although insurance is important, it cannot replace a human life or lost production.
- The fire services and insurance companies are constantly emphasizing that smoke causes a tremendous amount of damage to property, even in places that the fire does not reach. It has also been seen that most deaths which occur in fires are due to the effects of smoke.

Understanding the Fire Sequence

The manifestation of a fire usually appears in a sequence of four stages. See **Figure 1**.

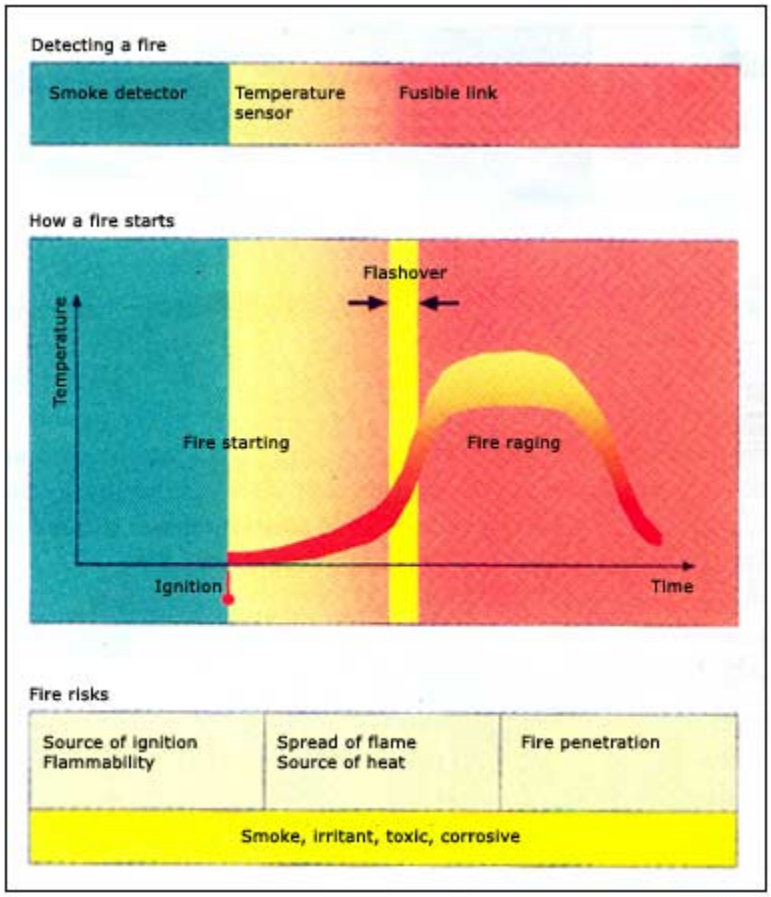

Fig. 1: How a fire starts

Courtesy of Belimo Automation AG, Switzerland.

Incipient Stage

- The first in the sequence is the incipient stage. In this stage, invisible aerosols and combustion gases are emitted without visible smoke, flame or appreciable heat being present. The aerosols and combustion gases for the most part are made up of materials such as carbon particles, water vapor and carbon dioxide. The smell of something burning in the oven, before visible smoke can be seen is an example of the incipient stage.

Smoldering Stage

- In the smoldering phase, products of combustion are visible as smoke appears. About 10% of the combustion particles are large enough to be seen and are recognized as smoke.

Flame Stage

- In the flame stage, an actual fire starts and flashover takes place.

Conflagration Stage/Raging Fire

- The final stage is the heat release stage, where combination of uncontrollable heat and rapidly expanding air and gases creates the violent, dangerous condition.

- The time period for the incipient stage can vary from minutes to hours or days. The smoke, flame and heat stages, however, progress more rapidly. They usually occur in either minutes or seconds. If a fire is detected in the incipient stage, action can be taken to prevent a minor hazard from becoming a major catastrophe involving loss of property, equipment and possibly life. The precious time between the beginning of combustion and the development of a truly destructive hazard can be used to prevent development of the fourth stage of fire and also to permit the safe evacuation of he building. A fire detected in its incipient stage usually can be brought under control and extinguished before the arrival of the fire department.

Fire Damper Application

Fire Damper are required by all building codes to maintain the required fire resistance ratings of walls, partitions, and floors when they are penetrated by air ducts or other ventilation openings. One of the basic requirements of building fire protection as required by all buildings using fire rated walls, floors or other partitioning method. This compartmentation concept is intended to contain any fire to the compartment of fire origin and thereby to minimize damage to property and protect the lives of people living and/or working in the building. See **Figure 2**. A duct or ventilation opening in any of the fire rated partitions would permit a fire to spread from the compartment of origin to adjoining compartment of origin to adjoining compartments or spaces. Fire dampers are installed in these duct or ventilation openings. They close automatically upon detection of heat (usually by the melting of a fusible link at 165°F) blocking the opening and preventing the spread of fire into the adjoining compartment. See **figure 3**. Once closed such fusible link dampers can only be opened or reset manually at the damper itself.

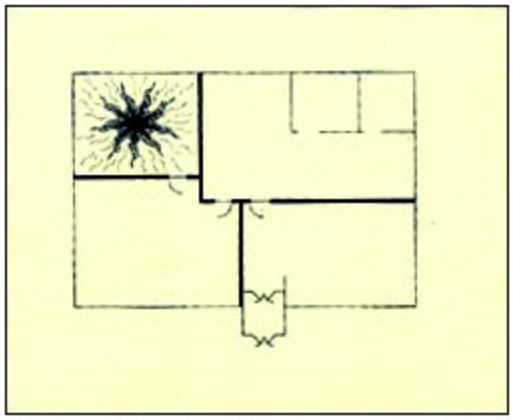

Fig. 2: Fire rated partitions contain fire damage to the compartment of fire origin.
Courtesy of Greenheck, USA.

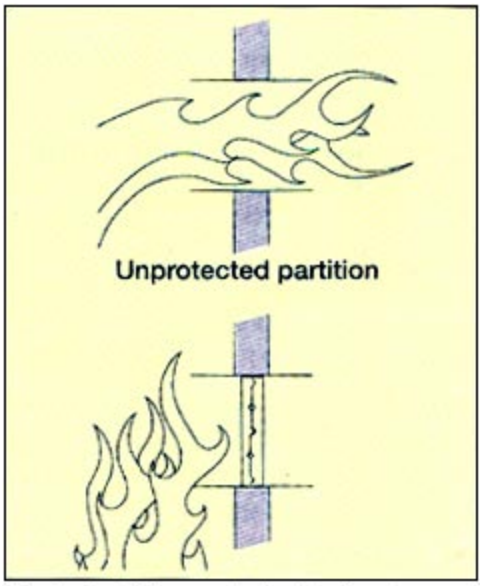

Fig. 3: Partition protected by fire damper.
Courtesy of Greenheck, USA.

Fusible Link Dampers are commonly used and are very economical in first cost. Some Fire Dampers available in India are equipped with a solenoid actuator which is energized by a signal from the smoke or fire alarm system. A fail-safe system of solenoid actuators closing the damper when de-energised is preferred but since solenoid coils which can withstand 24 hour constant electric supply are not available the first system is used. Solenoid operated fire dampers are more expensive than fusible link dampers.

If the fire damper is motorized is can be incorporated into control of the HVAC system more effectively. When the HVAC system is switched off, for example, all dampers remain closed in order to prevent the spread of smoke without fire. Functional checks at regular intervals are easy to carry out from a central point so that time consuming local checks can be reduced to the minimum. It is a very cost-effective way of detecting faults at an early stage so that maintenance can be planned more efficiently. Motorised fire dampers are much more expensive than fusible link or solenoid actuated types but have important advantages to compensate.

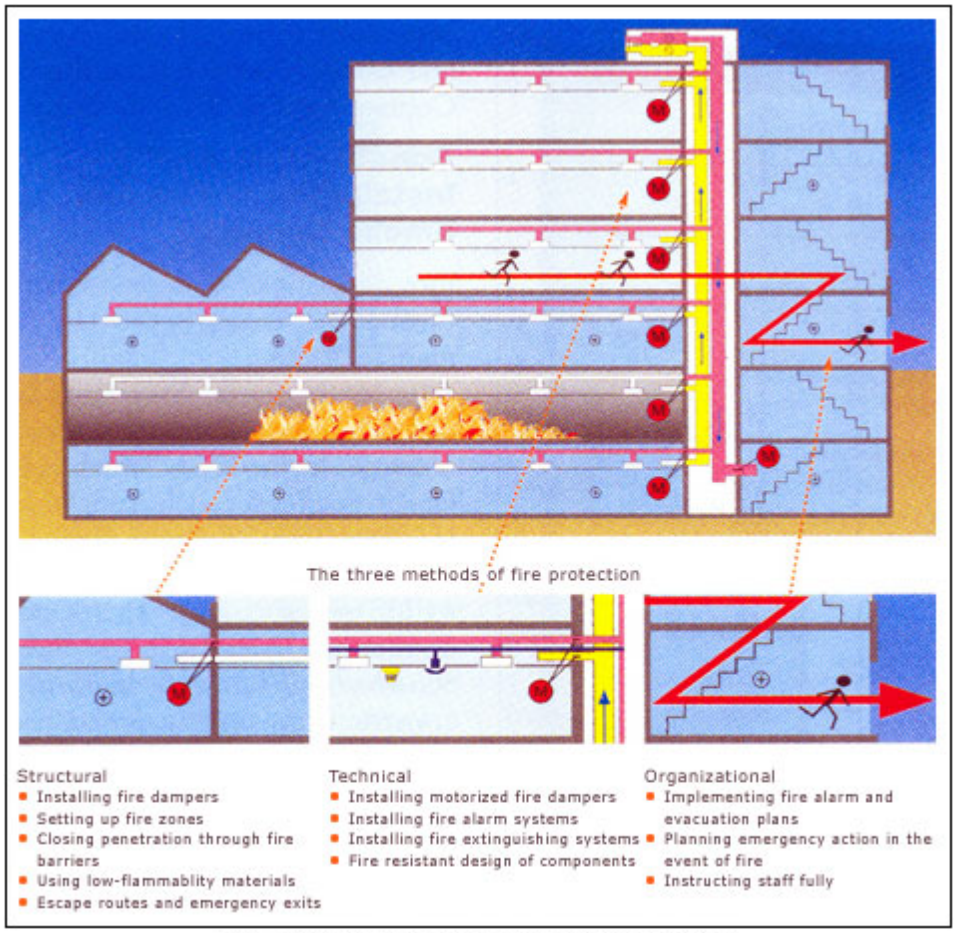

Fig. 4: The three methods of fire protection
Courtesy of Belimo Automation AG, Switzerland.

Smoke Damper Applications

Smoke Dampers have two general applications. They may be applied in a "Passive Smoke Control system" where they simply close and prevent the circulation of air and smoke through a duct or ventilation opening as a smoke barrier. Or they may be applied as part of an "Engineered Smoke Control System" designed to control the spread of smoke using walls and floors as barriers and using the building's HVAC system and/or dedicated fans to create pressure differences. See **figure 5**. Higher pressures surround the fire area and prevent the spread of smoke from the fire zone into other areas of the building. Smoke Dampers are nearly always motorized with electric or pneumatic actuators. They may be controlled by a smoke or heat detector signal, a fire alarm signal or in a variety of ways by the building control system to accomplish the intent of the design.

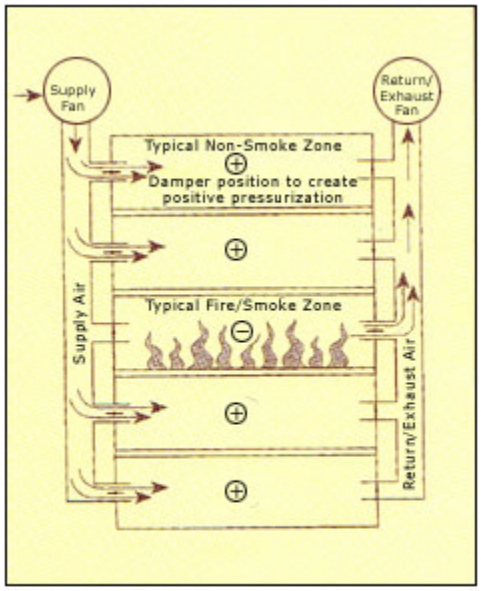

Fig. 5: Smoke is contained to the fire zone by higher pressure in adjacent zones.
Courtesy of Greenheck, USA.

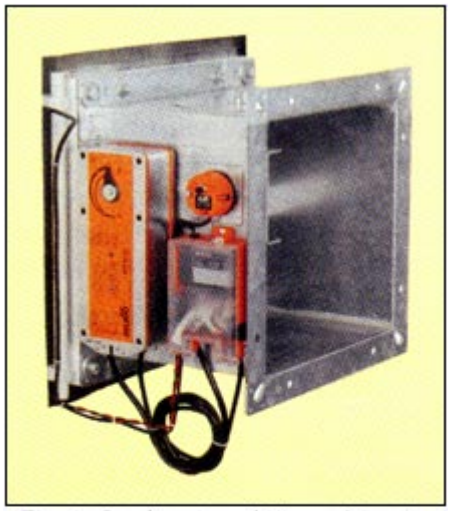

Fig. 6: Combination of Fire and Smoke Damper with externally mounted actuators.
Courtesy of Belimo Automation AG, Switzerland.

Combination Fire Smoke Damper Application

A combination fire Smoke Damper performs the function of both a Fire Damper and a Smoke Damper. Building layouts and designs often combine fire rated partitions with smoke barriers requiring the installation of both a Fire Damper and a Smoke Damper at the same location.

Smoke Extraction from Buildings

After being tripped automatically by a smoke detector, motorized smoke dampers immediately run to their safe position. Optionally they can be operated by the fire fighters from a central point. The dampers also help to keep escape routes free from smoke so that evacuating the buildings is made much easier. When all the smoke has been exhausted and everyone has been evacuated, thermally insulated actuators can be used to close the dampers again so that the source of the fire can be starved of as much oxygen as possible. See **figure 7**. Motorized Smoke Dampers are easy to incorporate into HVAC systems and can be operated from the Fire Control Centre of the building.

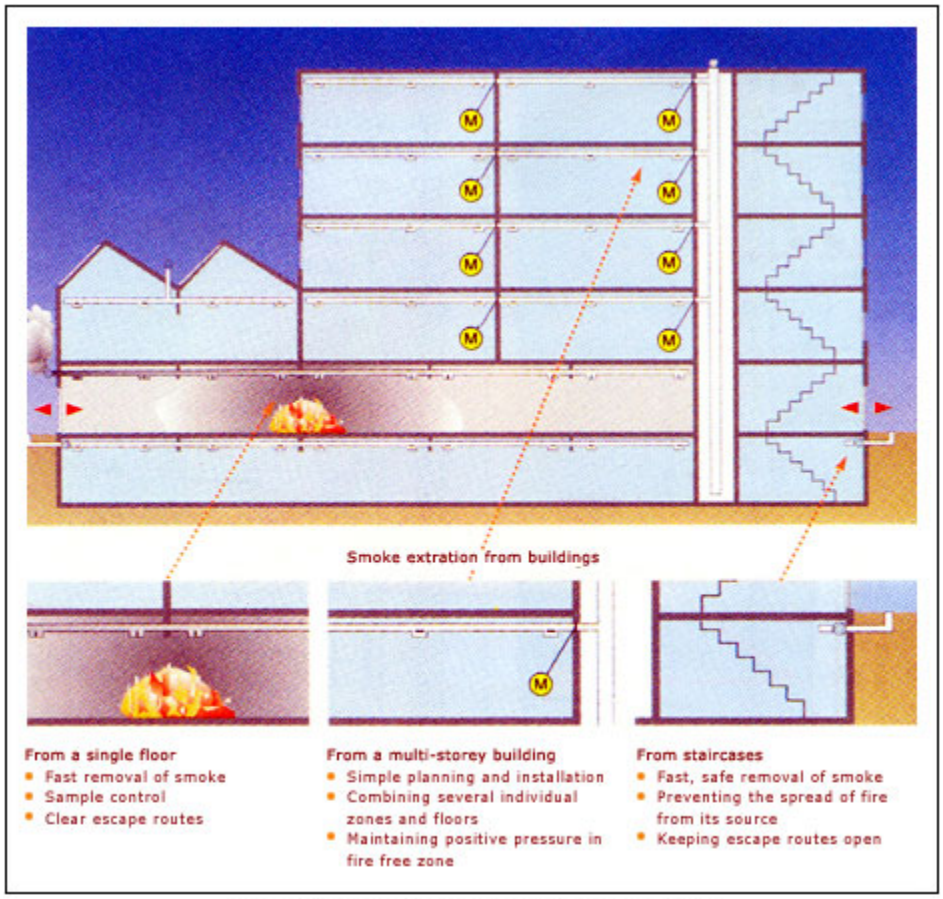

Fig. 7: Smoke Extraction from Buildings.
Courtesy of Belimo Automation AG, Switzerland.

Construction and Installation of Fire and Smoke Dampers

Fire and smoke dampers must be uniformly constructed by all manufacturers in accordance with relevant National Standards laid down by every major developed country. In the USA, which is the largest market for such dampers UL (Underwriter's Laboratories) 555 Fifth Edition is the relevant standard for US manufacturers. This 30 page document specifies in detail construction standards, material of construction, testing procedures, maximum leakage rates, installation and operating instructions. The UL 555S Elevated Temperature Rating is a 30 minutes emergency rating to ensure the damper (and its installed actuator) can resist a short exposure to elevated temperature and still operate as required. 121° C (250° F) is the minimum, elevated temperature rating.

These requirements cover damper assemblies rated ½, 1, 1½ or 3 hours for use in HVAC duct systems in accordance with the Standard For Installation of Air Conditioning and Ventilating systems, NFPA 90A.

Such fire dampers are intended for use in either

- Static systems that are automatically shut down in the event of a fire or
- In dynamic systems that are operational in the event of a fire or
- In dynamic systems that are operational in the event of a fire.

Fire dampers intended for use in dynamic systems are investigated for closure under their maximum specified airflow.

A sleeve must be provided unless a damper has a frame of a width to permit direct attachment of perimeter mounting angles on each side of wall or floor opening. The thickness of the damper frame when the sleeve is not to be provided, shall comply with the requirement for sleeves, which is clearly specified.

The length of sleeve required depends on the thickness of the wall or floor being penetrated and on what actuator, accessories and options are to be provided with the damper. UL imposes the following maximum sleeve length restrictions:

Sleeves may not extend more than 6" beyond the wall or floor (except on the actuator side of the opening the sleeve may extend 16"). If the sleeve is provided with an access door, it may extend 16" on the side equipped with the access door. Sleeves must extend far enough beyond each side of the wall or floor to accommodate the retaining angles required for installation (usually 1-1/2") plus whatever is required for the duct to sleeve connections (usually a minimum of 1-1/2"). On the actuator side of the damper, the sleeve must be long enough to install the actuator and any options that may be required.

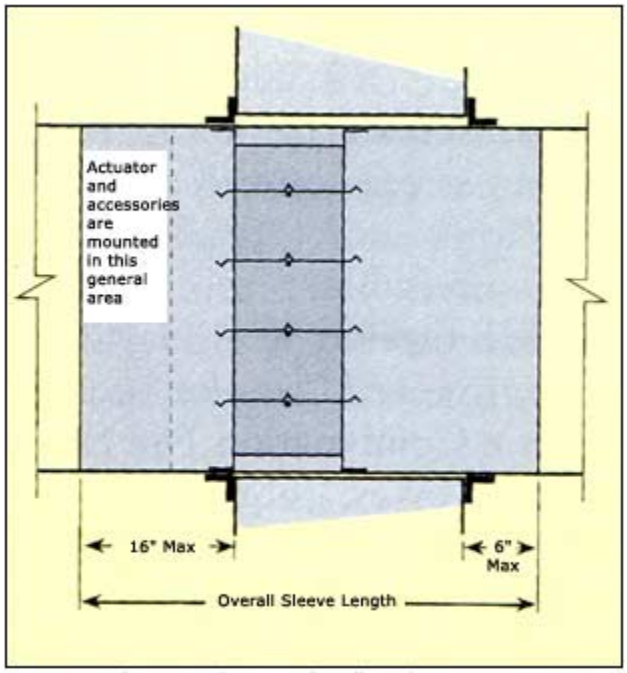

Fig. 8 : Sleeves for fire dampers.
Courtesy of Greenheck, USA.

Most of these requirements are shown in **Fig. 8**. Typical sleeve length requirements are:

Wall Thickness	Sleeve Length Required
4" to 6"	16" to 20"

7" to 10"	20" to 24"
11" to 13"	24" to 28"

Damper performance should not be affected by corrosion and dust loading. It is good practice to install duct access doors below each damper for inspection, testing and resetting in case the fusible link has melted due to fire.

Manufacture of Fire Dampers in India

The Central building Research Institute, Rourkee is the only organization with facilities for testing and approving fire dampers and certifying their rating. This Institute now suggests to manufacturers who want to send their dampers for testing that they first read and familiarize themselves with UL 555 standard in order to ensure better chances of a successful test. Since UL has established a base in India for testing home appliances it is possible that UL and CBRI may jointly test and approve fire dampers as well, in the near future.

At this time there are six manufacturers of fire dampers with a CBRI approval, of who three are in Mumbai and three in New Delhi. All manufacturers have approved ratings of 1-1/2 hours only and 3 hour ratings are so far not available. However in the entire country there are many other manufacturers who build fire dampers but have no CBRI certification and who continue to supply dampers to users and installers, in the absence of any Fire Department or National Building code stipulation that would prevent the use of untested and unapproved dampers.

Existing CBRI approved manufacturers have not formed an association to help standardize construction, materials, sleeve lengths, leakage rates and other details. One manufacturer uses a sandwich type, single blade, with 40 mm thick mineral wool between two metal skins. Most others have a multi louver arrangement using a heavy single metal sheet. Airfoil blades are not yet a standard but one manufacturer with a foreign collaboration plans to manufacture this type of blade as a standard. Airfoil style blades are suitable for higher velocities upto 4000 FPM as they offer a lower resistance to airflow and a somewhat lower pressure loss. Curtain type fire and smoke dampers, so common in USA, are not manufactured in India so far.

Most manufacturers here offer a choice of a fusible link, solenoid actuator or motorized actuator with price being a common determinator of which one to use unless specified by the consultant. Fusible links are the lowest in first cost, motorized the highest and solenoid type in between.

Actuator Selection

A smoke damper's function is to OPEN or CLOSE to either seal off an opening or to create a pressure difference to prevent the spread of smoke. The damper actuator (often referred to as the damper operator or damper motor) is what drives the damper OPEN or CLOSE and consequently when a Smoke Damper or a Combination Fire smoke Damper is selected, a very important part of the process is the selection of an appropriate damper actuator. Qualification of the damper under UL555 and Ul555S involves testing both the damper and its installed actuator. This means that the actuators must be selected from the damper manufacturer's list of actuators that have been tested with and are UL listed for the fire smoke model that will be furnished. Actuators must be furnished by the damper manufacturer and be installed at the damper factory. To maintain the integrity of the complete assembly, i.e., the damper with its installed actuator, the temperature control contractor should not supply the damper actuators.

Actuators may be Electric or Pneumatic and have damper size limitations based on the velocity of airflow through the open damper and the pressure differential across the closed damper. Select either Electrci or Pneumatic based on te type of control system that will operate the dampers and any other appropriate factors. Pneumatic actuators usually have a lower cost than electric actuators and require 20 psi control air. Operation should be TWO position (On/Off control and not modulating control).

Control Options

Fire smoke Dampers without options are fairly straightforward devices. The damper is linked to the actuator and is moved to its open or closed position by its actuator in response to signals from the building control system, fire alarm system or smoke alarm system. Combination fire smoke Dampers in general are equipped with a fusible link which melts at a specific temperature (usually 165° F), disconnects the damper from its actuator, and causes the damper to close to prevent the spread of fire and smoke. Smoke Dampers are not equipped with fusible link and operate only in response to alarm or control signal.

OCI Option (Open closed Indication):

This option provides two switches, one set to close when the damper blades are at their open position, and the other set to close when the damper blades are at their closed position. These switches are physically linked directly to a damper shaft and therefore give a true representation of the damper's position. Normally these OCI switches are wired to indicator lights (often located in the Fire fighter's smoke control station) however they may be used for other purposes as may be desired.

RRL Option (Resettable Heat Responsive Device):

This option replaces the fusible link on a Combination fire Smoke Damper with an electric sensing device (thermostat). The sensor has a fixed temperature setting (usually 165° F) and performs the same function as the fusible link that it replaces, that is to sense an abnormally high temperature (presumed to be caused by a fire) and to cause the damper to close to prevent the spread of fire and smoke. The sensor interrupts the power supply to the actuator and the actuator's spring return mechanism causes the damper to close. The RRL option can only be furnished when the damper actuator is factory installed and factory wired to the electric sensor before shipment.

One advantage of RRL Option is that it can be reset eliminating the need to replace a fusible link each time the damper is subject to high temperature. This feature is particularly desirable if periodic testing requirements involve application of elevated temperature to the fusible links (or heat-sensing devices) to verify that they will respond I the proper manner to actual fire condition. It is recommended that a careful inspection of the damper and the electric sensor be made before resetting as exposure to actual fire conditions may render these devices unusable.

Override Option

In engineered smoke control systems a Combination Fire Smoke Damper (often required by the codes to close at 165° F) may (when closed) prevent the HVAC system from performing its smoke control function. Most authorities agree that fire dampers can be open during emergency periods so that HVAC system can perform its smoke control functions as long as there is some (higher) temperature limit (usually 350° F) at which these dampers will close and remain closed. All authorities do not agree that the code required 165° F fire damper closure temperature can be waived in favour of a higher temperature for Smoke Control applications. This dual requirement for the Combination Fire Smoke Dampers to close at 165° F and yet to be open to allow smoke control system operation can be accomplished by using an Override Option. These override options allow the 165° F closure command to be overridden by remote electrical signal (reopening the damper) but also provide for the damper to close automatically at some high temperature (usually 350° F,) and remain closed thereafter.

NFPA's 90A standard is in the process of change and will permit use of a single 350° F closure control in Combination fire Smoke Dampers eliminating the requirement to close these dampers at 165° F and to open them for smoke control purposes.

Readers interested in more details on the subject can refer in particular to Greenheck USA brochure "Selection and Application Manual for fire Smoke Dampers" third edition, June 1997 from which considerable material has been extracted for this article.

It is sincerely hoped that industry representatives along with knowledgeable consultants and well known architects will form a committee to study and draft codes for fire Smoke Dampers which can become a self imposed discipline before persuading fire Department authorities in various large cities to adopt such codes for strict compliance in all buildings.

Extracts from National building code of India of interest to HVAC Professionals.

The National Building Code of India, while dealing with many aspects of building construction and intended usage also deals with safety and loss prevention resulting from the hazards of fire, smoke and explosion. Amendment no. 3 to the code issued in January 1997 covers:

- Classification of buildings based on occupancy
- The demarcation of fire zones
- Restrictions on construction of buildings in each fire zone.
- Types of building construction according to fire resistance of the structural and non-structural components, and
- Other restrictions and requirements necessary to minimize danger to life from fire, smoke, fumes or panic before the buildings can be evacuated.
- The code recognizes that safety of life is more than a matter of means of exits and accordingly deals with various aspects, which are considered essential to life safety.

Fire Zones

• The city or area under the jurisdiction of the authority shall for the purpose of the Code, be demarcated into distinct zones, and based on fire hazard inherent in the buildings and structures according to occupancy, which shall be called as **FIRE ZONES**.

• The fire zones shall be identified based on the intended use of space, development plan and shall be designated as follows:

- Fire Zone no. 1:
  Residential, Educational, Institutional, assembly Small business and retail mercantile buildings.
- Fire Zone no. 2:
  Laboratories, Libraries and test houses, Computer installations, Telephone

exchanges, Broadcasting stations, Industrial buildings.

- Fire Zone no. 3:
  High hazard industrial buildings, storage buildings.

Airconditioning and ventilation systems

- Air conditioning and ventilating systems shall be so installed and maintained as to minimize the danger from hazards of spread of smoke or fumes and fire, thereby isolating one floor or fire zone from another, or from outside into any occupied building or structure.
- Air conditioning and ventilating system circulating air to more than one floor or fire zone shall be provided with dampers designed to close automatically in case of detection of smoke and /or fire and thereby preventing spread of smoke, fumes and fire. Such a system shall also be provided with automatic controls to stop fans in case of fire and a local or remote alarm.
- From the fire safety point of view, it will be preferable to provide separate air handling units for the various floors so as to avoid the hazards arising from the spread of fire and smoke through the network of ducts.

Classification of buildings on Occupancy

Group A	Residential Lodging or Rooming house, hotels
Group B	Education buildings
Group C	Institutional building, hospitals and Sanitorium
Group D	Assembly, theatrical or Motion picture building or any other stage.
Group E	Business buildings, Offices, Banks, Professional establishments like offices of Architects, Engineers, doctors, Lawyers and police Stations, Computer Installations, Telephone exchanges.
Group F	Mercantile buildings, like shops, stores, departmental store, markets with area more than 500 sq. meter.
Group G	Industrial buildings on which products or materials are fabricated, assembled, manufactured like assembly plants, power plants, generating units, pumping station, refineries, dairies etc.
Group H	Storage buildings like Warehouses, Cold Stores, Garages etc.
Group I	Hazardous buildings which are used for the storage handling, and manufacture of highly combustible or explosive materials which are liable to burn with extreme rapidity or which can produce highly poisonous fumes.

Smoke Venting

• Smoke venting facilities, where required for safe use of exits in windowless buildings, underground structures, large area factories shall be applicable to particular occupancies only, which may affect the spread of smoke or fumes and fire and thus the safe evacuation of the building in case of fire. Some of these aspects are as follows:

- Interior finish and decoration;
- Seating, aisles, railings and turnstiles in places of assembly;
- Service equipment and storage facilities in buildings other than storage buildings;
- Hazards on stage, in waiting spaces, projection booths, in theatres and cinemas.

Fire Dampers

1. These shall be located in conditioned supply and return air ducts/ passages at the following points:
   - At the fire separation / isolation wall;
   - Where ducts/passages enter the central vertical shaft;
   - Where the ducts pass through the floors;
   - At the inlet of supply air duct and the return air duct of each compartment on every floor.
2. The dampers shall operate automatically and shall simultaneously switch off the air handling fans. Manual operation facilities shall also be provided.
3. Fire/ smoke dampers for buildings more than 24 m in height.
   - For apartment houses - in non-ventilated lobbies operated by fusible link/ smoke detectors and with manual control.
   - For other buildings - On operation of smoke detection system and with manual control.
4. Automatic fire dampers shall be so arranged as to close by gravity in the direction of air movement and to remain tightly closed on operation of a fusible link/ smoke detector.