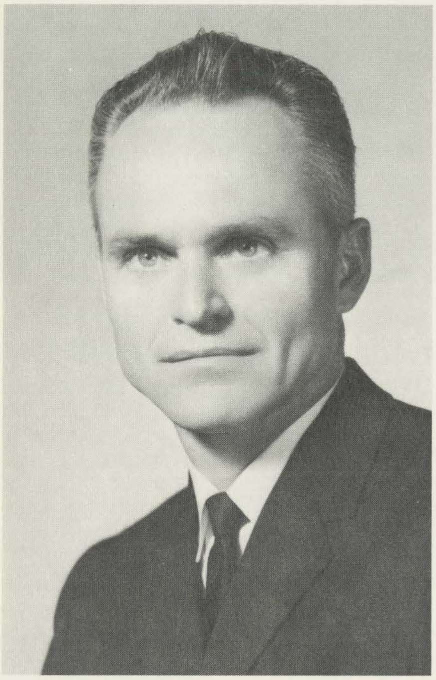
# CONTROL OF VENTILATION AND SMOKE

in high-rise buildings



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The need for smoke control in high-rise buildings is a fundamental requirement for life safety, and the fire-protection industry is now in the throes of determining which methods can best accomplish control in the variety of building designs.

This discussion very briefly reviews the approximate state of the art for high-rise air-conditioning systems and the present state of the art of smoke and fire detection.

High-rise buildings involve several types of occupancies, including the typical office building, apartments, hotels, dormitories and hospitals. Since the typical office building generally requires – because of the needs of flexibility in rental space – the most complicated air-conditioning system, this discussion will focus only on the office occupancy. The principles applied to this type of building could, with few exceptions, apply to other occupancies as well.

From studies made by the National Research Council of Canada and others, and through the results of some actual fire tests, we now recognize that almost every existing high-rise building is a potential disaster. We expect a really big fire one day and just hope that it doesn't happen. For new buildings, the problem must be corrected through better building codes developed from a thorough understanding of the problem. Existing buildings may benefit by this knowledge. It is possible that minor changes could provide smoke-free exits in many instances.

The most widely used code in the control of air movement in buildings is the NFPA Pamphlet 90A. It requires, on fans in excess of 15,000 cfm, a smoke detector downstream of the filters and a smoke detector in the return air prior to exhaust or dilution. On sensing smoke in either of these locations the detection shall shut down the supply fan and prevent smoke distribution.

Typically, a supply fan is designed to deliver 10 to 15 percent more air than is totally exhausted from a building. This provides a slightly positive pressure to reduce infiltration through the perimeter walls of the building. The temperature control system would require modulating dampers in the fresh air and return air to maintain a temperature entering the air-conditioning system that would prevent coil freezing and provide the least load on heating or cooling equipment The outside air, return air and exhaust dampers operate in unison with the minimum outdoor air required for ventilation in most systems to deliver from three to fifteen air changes per hour, depending on ventilation and thermal requirements.

**MISAPPLICATION OF DETECTORS**

Duct detectors probably have been the most misapplied devices in the detection industry. As a rule of thumb, smoke or products of combustion will be well mixed in traveling about six duct widths. Therefore, one detector can be indiscriminately located in the cross sectional area of the duct when installed a minimum of six duct widths downstream from the nearest inlet. This is rarely possible, however, and we are then faced with the problem of how to sample all of the air of the duct. If a detector is located immediately downstream of the air filters, it is in the lowest air flow and the largest cross section of the duct system. Smoke from the return air duct may bypass the detector sampling tubes if the detector is not properly positioned. Where there is not sufficient air mixing in the system, it is recommended that detectors be placed no further apart than four feet on center vertically and not further than two feet from the top or bottom sides of the duct. If duct widths exceed 12 feet, duplicate detectors should be mounted from the opposite side.

Duct detectors have also been used as substitutes for complete area fire detection. This is a gross misapplication. It is not allowed under Pamphlet 90A.

**TESTING DETECTORS**

A common desire is to test duct detectors by building a fire somewhere in the building. Not only is this hazardous, but usually very fruitless. Another rule of thumb is that a listed duct detector will alarm from burning newspaper in a large wastebasket in five to ten thousand cfm, depending on the fire characteristics. Therefore, in typical fan systems of ten to fifty thousand cfm, the test fires may have to be several times larger to cause a smoke *density* at the detector sufficient to alarm or shut down the fan.

How do you test the detector for proper operation? Since every detector of this type is listed under label service (Factory Mutual and Underwriter's Laboratories), you have the assurance that the sensitivities are maintained in accordance with the original approval tests. It is important, however, to test the functional operation of the device by simply blowing smoke into it or inserting smoke directly into the sampling tube.

**IMPROVE THE CODE**

An amendment was proposed by the 90A committee at the May, 1972 convention of NFPA, but was defeated. The proposal required that upon detection of smoke in the occupied space, that a damper should automatically close, shutting off the supply air to the fire zone and simultaneously exhausting all return air directly to the outside. Such is an attempt to create a negative pressure in the fire zone, leaving the supply fan running to pressurize the balance of the building and force smoke out the return or exhaust system. This was not an unreasonable approach; however, in some cases this could exaggerate the smoke problem due to the unknown quantity of gas expansion in the fire zone and the relatively low capacity for exhaust.

As the *Record* goes to press, another amendment is being proposed for the consideration of the NFPA membership during the May, 1973 convention. This proposal is that the building where evacuation is not practical "shall have the duct systems arranged so that, in the event of a fire, flow of smoke from the fire zone will be inhibited from spreading to required exit routes and designated refuge areas. Such an arrangement may involve air-conditioning systems alone or in combination with other systems such as emergency venting, pressurizing systems and fire suppression systems, taking into account possible stack and wind effects on multi-story buildings. Smoke control systems are required to be engineered for the specific occupancy and building design. This shall not preclude the use of other engineered approaches to provide equivalent protection to life and property when acceptable to the authority having jurisdiction." This amendment, if approved, will leave the design engineer with an enormous responsibility.

**WHAT CAN AND WHAT IS BEING DONE?**

Much information is currently available. Only a few fire tests have been conducted, since a high-rise building is hardly an inexpensive test fixture.

Beginning about 1967, the National Research Council of Canada began a series of studies of the problem. Periodic papers have been presented to the fire-protection industry and to the air-conditioning industry.

The American Society of Heating, Refrigerating and Air Conditioning Engineers has become progressively concerned with fire protection in high-rise over the past two years and has prepared a new chapter for the systems volume of their *Guide and Data Book*. The principles involved in smoke movement, with the exception of rapid gas expansion from fire, is well known to the mechanical design engineer. The fire-protection industry must create a stronger liaison with ASHRAE to effectively develop better codes.