



SMOKE VENTILATION AND FIRE CONTROL

1. Principles and Objectives of Fire Ventilation

Fire ventilation reduces the danger and damage from fire by allowing the products of fire combustion; heat, smoke and noxious gases to exhaust to the exterior of a structure. Venting will not extinguish a fire, but early ventilation may reduce the spread of fire and allow the fire to be extinguished more easily.

The column of heat and smoke that rises from a fire draws in the cooler surrounding air. The mixture rises as a plume which becomes larger and on reaching the ceiling, spreads out as a layer of smoke. If unimpeded at high level, the smoke layer continues to spread until its temperature drops almost to ambient by heat loss to the building fabric and by radiation. The smoke layer loses its buoyancy, falls and is drawn back at floor level as input air to the fire. As the perimeter of the fire increases so does the rate of air entrainment and smoke production.

In a short time the building in which the fire is occurring is filled with smoke and other products of combustion. In a very small room the fire may then die because of lack of oxygen. In a large building this will not occur because there are always sufficient paths for air leakage. But the combustion process may no longer be complete, so that flammable gases are part of the products of combustion. Eventually these will form an explosive gas/air mixture, and if oxygen is introduced to the room at this stage “flash-over” will result.

As the smoke layer spreads, it heats the building fabric and contents and when a sufficiently high temperature is achieved these will, if combustible, ignite and contribute to the fire spread.

In most circumstances, an unventilated fire will burn at a similar rate to a ventilated fire until the oxygen concentration in the atmosphere of the building falls below 17 percent. By then the un-vented building would be smoke logged. Scale tests showed that in general ventilated fires burn more rapidly than similar unventilated fires, but the average smoke temperatures produced are less for ventilated fires. Temperatures in the smoke plume above the fire are normally increased by ventilation. The temperature of objects close to the fire will be greater due to increased heating by direct radiation from the fire.

2. Automatic Fire Ventilation Systems

An automatic smoke ventilation system comprises ventilators to exhaust the products of combustion, either ventilators or natural openings to provide fresh air supply and screens where large roof spans require compartmenting. Controls to the ventilators must include both manual and automatic operation responding to heat rise, smoke or action by the Fire Brigade. To achieve a rapid response to fire, ventilation should always be able to be initiated automatically.

In common with most fire protection equipment, automatic ventilation systems must be designed to suit a particular risk and to achieve defined results. The risk will depend upon factors such as the building, its contents, the process taking place, the fire protection equipment which is present, and the likely Fire Brigade response time. From a study of the risk, it is possible to decide on a likely size of fire on which to base the system design.

Automatic fire ventilation can be achieved either naturally or mechanically. In a natural ventilation system a number of fire vents are opened when a fire is detected. The smoke and hot gases are driven through the vents by their natural buoyancy.

While it is often triggered by a smoke or heat detection system, this control should be backed up by a fusible link that acts on a rise of temperature.

3. Design Factors

The target for the design will be to confine the smoke from the design fire to within a specified area, with a certain maximum depth of smoke layer.

The depth and the area will depend upon whether the system is to be installed to enhance life safety (egress and access), to protect plant, machinery and stock or to protect the whole structure. A roof compartment area for smoke containment of 2000m² with a linear spread of 60m would be regarded as absolute maximum design factors. To restrict the maximum area for smoke spread it may be necessary to install passive components such as smoke curtains and roof screens.

The design of the building and its use will control additional factors such as the height to which smoke will rise before reaching a vent and the likely position and sizes of fires.

When these design factors have been established, the detailed design can be carried out to find the theoretical ventilation area required. This will normally be made up from a number of fire vents and the actual area of the vents must be larger than the theoretical value to allow for air flow through an aperture.

The quantity of smoke to be vented must be replaced by an equivalent volume of inlet air. The total inlet opening area should be at least equal to the free area of the exhaust ventilators, and for better efficiency it should be twice this area.

The actual number of vents required and the air supply necessary makes allowance for flow resistance based on their exhaust and inlet coefficients. The positioning of the vents is also critical in order to exhaust the smoke without mixing and cooling.