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SMOKE HAZARD MANAGEMENT AND TESTING (Version 3)

Fire and Security Consulting Services is frequently asked about the requirements for "Smoke Hazard Management" systems in buildings, what smoke testing should be carried out and how such testing can be arranged.

"Smoke Hazard Management" is the process by which occupants in buildings and attending fire fighters are protected from the effects of smoke and hazardous emissions from a fire in a building.

WHAT TYPES OF SMOKE HAZARD MANAGEMENT ARE PRESCRIBED

Part E2 and Tables E2.2a and E2.2b in the BCA prescribes various types of smoke hazard management as follows:-

1. Smoke alarms in Class 1, 2 and 3 occupancies designed to detect smoke and alert sleeping occupants.
2. Automatic smoke detection and occupant warning systems in Class 3 occupancies with a rise in stories of more than 2 above ground level or accommodates more than 20 residents in part of a school designed to detect smoke and alert sleeping occupants.
3. Natural smoke venting utilizing high level roof and low level wall vents in Class 7 warehouses and Class 8 factories. This is a passive buoyancy driven system using the heat from the fire to drive the lighter fire and smoke products up through the roof vents. Note that QFRS have interpreted the BCA requirement for "readily openable" low level vents and this interpretation is provided later in this paper. Natural ventilation is designed to provide adequate tenability for occupant egress and fire fighter access. The tenability includes the requirement that the smoke level does not fall below 2.1m above floor level. The 1.5% of floor area requirement has been proven to provide sufficient natural ventilation for typical fire sizes in the specified Classifications. Where unusually high heat release rates may be expected in the tenancy, increased areas may be required.
4. Smoke and Heat Vents. These are mechanically or electrically openable roof vents with normally permanently open low level vents. The system requires either smoke or heat detectors to actuate the opening of the vents. The resultant natural ventilation after the vents are opened are designed to provide adequate tenability for occupant egress and fire fighter access as described in dot point 3 above.
5. Smoke Exhaust systems utilize mechanical smoke extraction fans and either fixed openings or supply air fans for air make up. The design intent is to designed to provide adequate tenability for occupant egress and fire fighter access
6. Pressurisation systems are use either in fire isolated stairs in buildings exceeding 25m effective height, fire isolated passages exceeding 60m in length or as part of :sandwich pressurisation" system in high rise buildings where certain floors below and above the fire floor are pressurized. The design intent is to exclude smoke from these areas.

Where natural ventilation is used, the BCA specifies that the low level ventilation should be "readily openable". This implies that roller shutter door(s) are acceptable.

FSCS has consulted with QFRS and both parties have concerns as to the efficacy of this approach. QFRS have issued the following guideline:-

QFRS advises that translucent sheets are not acceptable as a means of providing permanent openings at roof level in a natural smoke venting system. QFRS considers ridge vents an acceptable means of providing permanent openings at roof level.

The QFRS also advises that open-able roller doors are not acceptable as a means of providing permanent or readily open-able low level openings for make-up air. The QFRS considers permanently open ventilation grilles or slots in roller doors, or fixed open grilles in walls, to be acceptable means of providing make-up air for a natural smoke venting system.

The issue regarding the doors is that under fire conditions it is highly likely that either or both the door roll or door guides will have distorted and jammed thus preventing the door from being opened.

WHEN IS A SMOKE TEST REQUIRED?

When a building is subject to an Alternative Solution, the Fire Engineer frequently conducts fire and smoke modelling to demonstrate compliance with the Performance Requirements of the BCA and whilst the Certifier or QFRS may require smoke testing of the completed building to verify the Fire Engineer's calculations and assessment, FSCS advises that the test protocol in AS4391 should be adopted for all but simple testing.

The most common scenarios are when buildings such as large warehouses or buildings with an atrium have egress travel distances in excess of the maxima prescribed in the BCA. In these circumstances the Fire Engineer is required to demonstrate by modelling that the smoke (or hot) layer is of such a height above the egress path that evacuation can be safely completed. This evaluation will take into account the provision of natural ventilation, smoke and heat vents or smoke exhaust fans.

Considering the various types of smoke ventilation discussed earlier (natural ventilation, smoke and heat vents, smoke exhaust and pressurisation) FSCS considers that all smoke control system should be verified by smoke testing. The exception to this recommendation is in a single compartment where natural ventilation is provided, there is no issue with extended travel distances and the ventilation system is symmetrical as discussed below.

With the exception of natural ventilation, all smoke control systems rely on the proper design, installation and commissioning of the various activation systems such as smoke detection, fan controls, fan control and integrity, wiring integrity, damper operation and most of all the proper integration and interfacing of these systems. Out of 30 smoke tests conducted by a colleague in Sydney, 18 failed because of failure of the various activation systems and interfacing.

Accordingly a smoke test is not just about observing the smoke movement and venting but also about the overall system efficacy.

One system that is not affected by interfacing to other systems is natural ventilation. Buoyancy driven natural ventilation is a highly efficient method of using the heat from the fire to purge the compartment of smoke, the hotter the fire, the greater the smoke buoyancy. However the location and dispersal of the ventilation openings, especially those at the lower level will influence the effectiveness of the system. Figures 1 and 2 below show a natural ventilation system in a single compartment with a ridge vent and low level vents on each of the longer side of the building. FSCS calls this Symmetrical venting and irrespective of where the fire is located, the buoyancy driven ventilation will purge the entire compartment. In this case FSCS considers that smoke testing <u>will not</u> be necessary and would be a waste of resources.

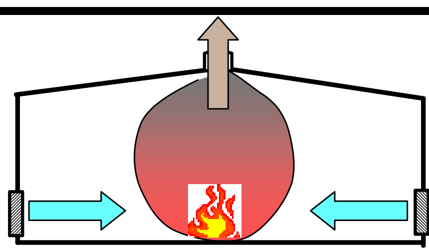

Figure 1 - Symetric Vents & Central Fire Location

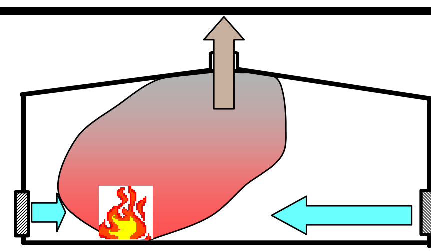

Figure 2 - Symetric Vents & Offset Fire Location

Conversely a natural ventilation system in a single compartment with a ridge vent and low level vents on one side of the building as shown in Figures 3 and 4 which FSCS calls Asymmetrical venting, and irrespective of where the fire is located, the buoyancy driven ventilation will fail to purge the lower boundary extremities of the compartment. In this case FSCS considers that smoke testing *will* be necessary.

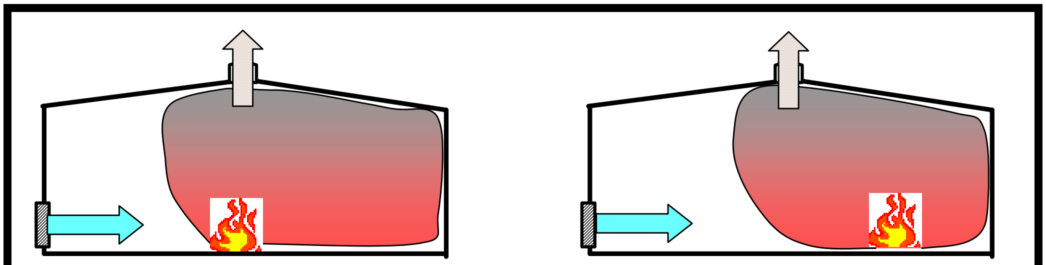

Figure 3 - Assymetric Vents & Central Fire Location

Figure 4 - Assymetric Vents & Offset Fire Location

WHAT SORT OF SMOKE TEST SHOULD BE CONDUCTED?

The Fire Engineer's modelling computes various input data including:-

1. The size of the design fire and the materials involved in the fire; and
2. The activation of the occupant alarm system by detection, sprinklers or manual cues; and
3. The response time of the occupants; and
4. The evacuation time of the occupants; and
5. The growth rate of the fire including the smoke evolved and the rise in temperature; and
6. The available ventilation at both high and low level.

The most critical issue in fire modelling is that the smoke evolved from the fire will be hot and therefore have a greater or lesser degree of buoyancy dependant on temperature. This buoyancy and the available ventilation drives the smoke venting rate and consequently the fire model computes the difference between the smoke filing and venting rates in the compartment.

Consequently, smoke testing should replicate as far as practicable, the fire model assumptions and results. Obviously when the design fire is several Megawatts (MW), it would be impracticable to have a test fire of equivalent size.

FSCS is frequently presented with smoke testing proposals that use cold smoke generated by chemical or fluid smoke production equipment. Whilst such equipment may be useful for training fire fighters in smoke logged compartments, the cold smoke generated will tend to remain at floor level and not demonstrate the venting of hot smoke with its natural buoyancy.

Figure 5 below show a typical smoke generator with the cold smoke settling at floor level.

Figure 5 – Cold Smoke Test

Obviously what is required is a smoke test that can generate the temperature in the smoke. Certain testing engineers (as detailed later) have suitable equipment that generates smoke from chemical cartridges and, with associated LPG burners in the smoke stream, can provide the necessary buoyancy so that the smoke rises within the compartment, thus replicating a real fire scenario.

Figures 6 and 7 below show smoke testing in large compartment where the low level venting is Asymmetric. The sprinklered warehouse in Figure 6 has low level ventilation on two adjacent but not opposite sides. The test results showed acceptable tenability for fire fighter access, occupant egress was DtS and not affected by the test results.

Figure 7 shows testing of an electric railway locomotive testing building where by necessity the low level ventilation was at each end. The testing revealed faults in the operation of the beam detectors and allowed the Contractor to rectify the system.

In both tests note the smoke rising in the compartment and the formation of a smoke layer high in the compartment. The smoke, because of its temperature and buoyancy, remains at high level and little, if any, cools to such a degree that it falls to the floor.

Figure 6 – Asymmetric Test

Figure 7- Asymmetric Test

WHO CAN CONDUCT THESE TESTS?

Whilst there are probably many commissioning and testing engineers who have appropriate equipment and experience, FSCS has found that the following Company can provide the necessary service.

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