HEAT AND SMOKE VENTING AND DRAFT CURTAINS

INTRODUCTION

Automatic roof-mounted heat and smoke vents and draft curtains have long been recommended by AXA XL Risk Consulting for manufacturing and storage facilities. It is generally acknowledged that venting is beneficial for unsprinklered facilities. The benefit and interaction of heat and smoke vents and draft curtains when automatic sprinkler protection is provided has been debated within the fire protection community. Previous fire research was, of necessity, based on testing that was conducted in facilities that were limited in size or otherwise less than fully suitable. The Fire Protection Research Foundation (FPRF) assembled a consortium to conduct a research project to address the question and find the answer.

The project results indicate the following for a facility protected by an operating sprinkler system of proper design for the occupancy hazard:

- Heat and smoke vents had no significant effect on the performance of the sprinkler system when the origin of the fire was not directly underneath an open vent. When the vent was located directly over, or close to the origin of a fire, sprinkler operation was delayed, but not enough to significantly affect sprinkler performance.
- When the fire was ignited away from vents, in most cases the vents did not operate. In cases where they did, venting did not significantly affect the temperatures at the ceiling, the number of sprinklers activated, or the quantity of combustibles consumed.
- The significant cooling effect of sprinklers prevented the automatic operation of vents in most cases. In one case a vent failed to open when the fire was ignited directly beneath it. Water droplets, carried aloft by buoyant gases, condensed on the vent's fusible element.
- In tests performed with draft curtains, the results showed slightly faster sprinkler response times, and up to twice as many sprinkler activations compared to tests performed without draft curtains. However, draft curtains had no significant effect on the sprinkler performance except in the case where the ignition of the fire took place near a draft curtain and the fuel array extended underneath the curtain. In this case, disruption of the sprinkler spray by the draft curtain led to a fire that consumed more commodity compared to the other cases where the fire was ignited away from the draft curtains.

Information on the research project can be found in the FPRF's *The International Fire Sprinkler-Heat & Smoke Vent-Draft Curtain Fire Test Project* reports.

POSITION

Based on an analysis of the FPRF project results:

- Installation of heat and smoke venting and draft curtains will no longer be routinely recommended for manufacturing and warehouse occupancies.
- Consider power venting for occupancies that are highly susceptible to smoke damage. Additional research is needed regarding power venting and how to best remove smoke from building where the sprinklers are effectively controlling the fire.
- Draft curtains will still be recommended to separate sprinklers with different response factors, ESFR sprinkler systems from standard response sprinklers and at major changes of roof elevations.
- Where building codes require automatic heat and smoke vents, AXA XL Risk Consulting will not oppose their installation because the testing showed that the vents did not have a detrimental effect on sprinkler operation. Where installed, heat and smoke vents should be arranged for manual operation. If automatic operation is required, minimum vent operating temperature when ESFR or Large Drop sprinklers are installed is to be 360°F (182°C) using standard response links. With other sprinkler types, the vent operating temperature is to be a minimum of one rating higher than the ceiling sprinklers using standard response links.
- Where building codes require draft curtains, AXA XL Risk Consulting will not oppose their installation as the detrimental effect on sprinklers where the draft curtain happened to be directly over the point of ignition was not significant. Where installed, they should be located over aisles.

See NFPA 204 for additional information on heat and smoke venting and draft curtains for sprinklered and unsprinklered buildings.

Management Programs

Incorporate written programs addressing heat and smoke venting and draft curtains into each facility’s management programs for loss prevention and control. Pay particular attention to the following areas:

Hazard Evaluation

Evaluate each occupancy and ceiling sprinkler protection scheme for the need of heat and smoke venting and draft curtains.

Management of Change

Include a review for the need of heat and smoke venting and draft curtains in all new construction specifications and in renovations of existing buildings.

Maintenance and Fire Protection Equipment Inspection

When installed, include heat and smoke vents and draft curtains in these programs. Correct any deficiencies at once.

Types of Vents and Venting Designs

This section provides information on various types of heat and smoke vents and venting designs. Vent types include:

- Unit type vents using a mechanical means of opening such as spring lift, pneumatic lift or electric motor driven;
- Unit type vents using a gravity-opened means of operation using plastic shrink-out panels;
- Mechanically powered venting systems;
- Ordinary glass and continuous gravity vents (ridge vents).

Unit Vents Fusible Link Operated

Vents listed or approved by a nationally recognized fire testing laboratory are acceptable to AXA XL Risk Consulting. Plastic dome vents subject to a severe flying brand exposure and those installed in a Class A roof system require protection from flying brands.

Sprinklers should not be placed under or closer than 8 in. (203 mm) to the perimeter of the vent opening.

During shipment and installation, retaining clips and safety chains are used to prevent accidental operation of the unit. Carefully inspect vents and test them once installed to ensure all such items have been removed and that the units are in proper operating order.

Unit Vents Plastic Shrink-Out Type

Vents listed or approved by a nationally recognized fire testing laboratory are acceptable to AXA XL Risk Consulting. Units subject to a severe flying brand exposure and those installed in a Class A roof system require protection from flying brands.

Sprinklers should not be placed under or closer than 8 in. (203 mm) to the perimeter of the vent opening.

Since they leave an opening in the roof after they operate, two replacement domes or other materials should be kept on hand to cover the potential openings.

Powered Exhaust Ventilation

Powered exhaust and gravity ventilation systems can not be installed in the same fire area due to the possibility of improper airflow patterns of air being drawn in the gravity vents.

Powered exhaust could be a detriment when used in areas protected by an automatic high expansion foam system. If the fans are operating, the light air-entrained foam could be drawn out of the building by the suction of the fans.

Fan Capacity versus Gravity Vent Opening

Mechanical exhaust fans may be used to provide venting in the following building areas:

- Below grade areas;
- Intermediate floors in multistory buildings or similarly trapped areas;
- Low-hazard occupancies;
- Areas where smoke, products of combustion, or corrosive gases is the prime concern, e.g., computer facilities, telecommunication areas, clean rooms, hanging garment storage, etc.

The fan capacity expressed in cfm at 70°F or m^3/min at 21°C is to be at least 300 times the square foot vent area that would be required for a gravity method.

The equivalency of 300 cfm (8.50 m^3/min) fan capacity to 1 ft^2 (0.093 m^2) of gravity venting is derived from the formula for the volume of hot gas that is vented by gravity means:

$$Q = K A \sqrt{H(T - T_o)}$$

Where:

Q =	Amount of gas vented (cfm) (m^3/min)
K =	Coefficient 9.4 for English and 7.84 for metric
A =	Cross-sectional area of the gravity vent (ft^2)(m^2)
H =	Height of the gas column in feet or meter, for draft curtain add 1 ft (0.31 m) for vent
T =	Average temperature of the gas in the vent (°F)(°C)
T_o =	Temperature of the outside atmosphere (°F)(°C)

The temperature differential ($T-T_o$) is considered as 150°F (66°C), which is representative of the temperature differential observed during tests with sprinklers operating and with a curtain board depth of 6 ft (1.8 m). The 6 ft (1.8 m) minimum depth is necessary for proper venting action for gravity vents.

Construction

All components of the powered ventilator exposed to the air stream shall be capable of withstanding an exhaust air temperature of 500°F (260°C) for a minimum of 2 h and 1000°F (538°C) for a minimum of 15 min. Locate motors outside the air stream. Preferably, use metal chain belts. Enclose the belts and bearings in ventilated tubes to isolate them from the high temperature air stream. Two heat-resistant belts may be used in place of the chains. Power ventilators with the motor inside the throat of the vent are unacceptable because the motor windings and power cables cannot withstand high temperature. Only units listed or approved by a nationally recognized fire testing laboratory as heat and smoke vents are acceptable to AXA XL Risk Consulting.

Arrange any dampers in the powered ventilator for fusible link operation as an override to normal powered operation to permit gravity type venting in case of power loss.

Electric Power

Provide electrical power feeders to the fans independent from those for the general building area. This permits disconnection of the power to the building without affecting power to the fans. Locate an emergency manual control center outside the protected area. Route power feeders outside of fire areas, away from fire exposures. Where a power feeder must run into a fire area, use an electrical circuit protective system with a minimum 2 h fire resistance rating. Refer to Electric Circuit Protective Systems (Category Code FHIY) listed by Underwriters Laboratories Inc (UL) on their Online Certifications. Comply with the restrictions identified in the approval of such systems. Alternately, install feeders in accordance with Section 230.6 of the National Electrical Code® NFPA 70.

Methods of Actuation

There are four ways of actuating powered exhaust ventilation:

- Actuation of each fan separately by a fusible link or fire thermostat mounted in the throat of each fan or smoke detection;
- Manual actuation of individual or groups of fans from a remotely located control station;
- Actuation of all fans in a sprinklered area upon detection of water flow in the supply riser;
- Actuation of all fans in a given zone or in the entire building by smoke, products of combustion, or heat detection systems.

The last two methods are most appropriate for areas where the prime concern is the removal of smoke, products of combustion, or corrosive gases.

In all cases, provide an emergency manual control station outside the fire area. If comfort controls are also provided (permitting use of the powered vents for personnel comfort reasons), such controls should be arranged so they cannot interfere with automatic or emergency control station operation of the fans. Identify the location and use of the emergency manual control station during pre-emergency planning for fire department and fire brigade response. Fire equipment inspection and maintenance programs should include periodic operation of powered venting facilities and control circuits to verify the proper operation of these devices.

Spacing of Vents

Unit Vents

When unit vents are used, space them on 60 ft (18.3 m) centers or less. Each vent should not exceed 32 ft^2 (2.98 m^2) in area.

Powered Vents

Arrange powered vents symmetrically within a building. Spacing between powered vents will be governed by the size fan selected but should not exceed 120 ft (36.6 m). Maximum size fan utilized should be 30,000 cfm (850 m^3/min).

Ordinary Glass

Ordinary glass should not be recommended or considered the equivalent to unit or powered roof vents. Wired glass is not considered a means of venting. When wired glass is broken, the glass is retained in the frame by the wire and obstructs the flow hot gases and smoke. Where installations of ordinary glass are accepted as compromise solutions, the following conditions should apply:

Exterior Building Wall

- This method should be used only in flat roofed buildings or at the intermediate floors of multistory buildings.
- The glazed area should extend downward from the eave line, or the ceiling levels of a multistory building, to a depth of at least 4 ft (1.2 m). Horizontally, the glazed areas and any intervening nonventing areas should be positioned in a uniform pattern so the total linear dimensions of the glazed sections will be equal to at least 50% of the length of the wall.
- Glazed areas so installed are considered as meeting the venting requirements for a distance of 50 ft (15.3 m) in from the wall. Other venting facilities will be required for those portions of the building more than 50 ft (15.3 m) in from such walls.
- Venting provided by ordinary glass in exterior walls is not expressed in terms of a venting ratio. The building area credited to ordinary glass venting (see previous item) is subtracted from the total building area and it is this remaining area that must be vented by other means.

Monitors

The effective venting area of a monitor is the horizontal cross-sectional area of the throat or the glazed area in the walls of the monitor, whichever is smaller.

Continuous Gravity Vents (Ridge Vents)

Any movable shutters or dampers used to control temperature should be arranged to open automatically by either fusible link, or heat or smoke detectors. The cross-sectional area of the vents must take into account the obstructions created by the shutters and dampers.

Negative Pressure

Make provisions for supplying make-up air to the vented area, particularly when powered vents operate automatically. The make-up air should be from the low levels of the building. The quantity of make-up air should be the same as the amount of air being exhausted through the powered vents.

Draft Curtains

When required, to separate sprinklers with different response factors, ESFR sprinkler systems from standard response sprinklers and at major changes of roof elevations, provide draft curtains of substantial, noncombustible construction. Prevent interference to sprinkler discharge by centering the curtains between sprinklers. Extend them down from the ceiling at least 2 ft (0.6 m) and locate them over aisles.

Maintenance

Inspect all vents annually for proper operation. On mechanically opened units, the releasing device and the opening mechanism should operate normally. Following any painting, check for paint that could glue parting surfaces together. On gravity opened vents this includes the joint between the plastic shrink-out panel and the frame. Maintenance on powered exhaust vents is to include inspection of all operating mechanisms for proper operation and inspection and test of all actuation methods. Inspect draft curtains, when installed, for mechanical damage.

DISCUSSION

General Background

Some have questioned the validity, or even the desirability, of automatic heat and smoke vents. This has resulted from large scale fire tests conducted without vents, or from one or two tests where it was postulated that venting had worsened fire conditions. In addition, some state that venting is totally ineffective in a sprinklered building because the discharged water at the ceiling drives the smoke downward.

In large scale fire tests where unsatisfactory results were achieved, the so-called venting did not simulate venting as visualized by this guideline or NFPA 204. In one large scale rack test, the "venting" consisted of having doors and windows along two perimeter walls open prior to and during the test. As a result of this artificial ventilation with subsequent distortion of hot gas flow from the fire, twice as many sprinklers operated and twice as much damage was done to rack contents as compared to a similar test without venting.

In support of venting, a test was conducted with only 200 ft^2 (18.6 m^2) of windows open along one perimeter wall. Eighteen percent fewer sprinklers operated and 2% less damage occurred, column and rack steel temperatures were 300°F—600°F (149°C—315°C) lower, and time to obscuration was extended an additional 13 min over a comparable test without venting. Further, in a rack test with perimeter venting and both ceiling and in-rack sprinklers, 22% fewer ceiling sprinklers operated than in a comparable test with no venting.

Nevertheless, in all these tests, the venting was not what is normally visualized. The doors and windows were open prior to the test (i.e., they did not respond to the fire condition) and they were in perimeter walls far removed from the fire area. The net effect was to maintain the oxygen level in the building so maximum combustion could continue and to encourage artificial drafts within the building while, at the same time, failing to vent any heat from the fire area directly to the outside.

Other large scale fire tests were conducted with roof vents within the fire area that opened after the start of the fire in response to the melting of a fusible link. Comparing ordinary temperature rated sprinkler performance with vents against performance without vents, it was noted that sprinkler performance increased. The number of operating sprinklers decreased, first sprinkler operated faster, fire loss decreased, ceiling temperature increased over the test fire for the first 5 min of the tests and the pattern of sprinkler operation was more uniform with sprinkler discharge immediately over the test fire.

The AXA XL Risk Consulting's position on heat and smoke vent and draft curtains, presented in this guideline, is based on the results of the FPRF's research project. The FPRF assembled a consortium of eight interested parties including insurance companies, property owners, fire protection equipment manufacturers and researchers to fund and conduct a research project to study the interaction of heat and smoke vents, draft curtains and sprinklers and whether that interaction helps or hinders fire suppression. AXA XL Risk Consulting was a contributor and participated in the project. The National Institute for Standards and Technology (NIST) used their extensive fire modeling capability to give technical direction to the project. The testing was conducted at the large scale test facility of Underwriters Laboratories (UL). The scope of the project included a literature review to document previous research; full scale component and fuel burner tests to study air flow interaction between sprinklers, vents and draft curtains, and full scale commodity fire tests under actual warehouse conditions. Thirty-nine large scale fire tests were conducted.

Fire fighters routinely ventilate the fire area. It is better from a firefighter's viewpoint to be able to unlatch an already provided hatch or dome unit than attempt to make an opening. Many roofs are not easy to penetrate. Extended dwell time on the roof is an uneasy situation when the internal fire has not been fully evaluated.

Unit Vents Fusible Link Operated

The FM Approvals approves automatically operated vents having plastic domes or lids without any protection from flying brands. UL lists automatically operated vents with plastic type domes or lids designed in a manner that will not allow flying brands to lodge on them, or are protected by a steel wire screen above the glazing.

Unit Vents Plastic Shrink-Out Type

Plastic dome heat and smoke vents consist of a PVC or double acrylic plastic dome designed to soften and shrink in initial response to the hot air from a fire below. The dome retracts from its metal frame and drops out, permitting hot gases and smoke to vent from the building.

Spacing of Vents

Arrange vents in a symmetrical pattern on the roof of a protected area and use a number of small vents rather than larger vents in a limited number of locations.

Ordinary Glass

Ordinary glass is the least effective method for achieving heat and smoke venting, particularly in sprinklered properties. Automatic operation follows only when the glass has been subjected to high temperature for a sufficient time to cause the glass to fracture and fall out. This is likely to occur only within the immediate fire area in a sprinklered building. Even then, the reliability of occurrence is questionable.

When glass is installed to provide the fire department a means for manually venting the building, consider accessibility. Glass that cannot be easily reached probably will not be used effectively. Use of hose streams to knock out glass windows may reduce the effectiveness of operating sprinklers and manual hose stream fire fighting efforts.

Negative Pressure

Actuation of a powered exhaust system will tend to create negative pressure within the area involved. Under such circumstance, exit doors swinging outward may be difficult to open, the effectiveness of the vents will be reduced and could cause reverse air flow through process exhaust systems. In some cases, it may be necessary to simultaneously shut down the processes handling hazardous dusts or vapors, with operation of the exhaust system, to minimize the chance for an explosion.