Stage ventilation: Clearing the heat and smoke

BY WILLIAM CONNER, ASTC

Set low on a roof and easily overlooked literally and metaphorically, smoke vents are important in the event of a fire to allow time for the audience to exit unimpeded by smoke.

BUILDING AND FIRE CODES have required ventilation over stages since at least the early 1900s. The purpose is to draw smoke and heat and other products of combustion from a fire on stage away from the audience. It is not much different from treating the stage like a fireplace and the fly loft like a chimney. Real stage fires with the auditorium occupied, albeit rare since the development of the light bulb and demise of open arc and open flame stage lighting, have shown these vents to be a very helpful feature in allowing time for the audience to egress, free from smoke. One can argue that these vents are indeed more important than a traditional fire safety curtain and possibly as valuable as fire sprinklers today.

From the beginning, the concept has been that the vents are opened manually in an emergency and only later automatically. Automatic emergency opening today is most commonly done by a fusible link and in a few cases by a heat or smoke detector. Manual opening is to allow an occupant to open the vents in an emergency from the stage floor, and there are several means. In addition, non-emergency opening and closing is required for testing, and this should be from the stage floor or another readily accessible interior location and not require getting on the roof. Regrettably, this entire system is not well understood by the design and construction industry nor by some code authorities, and it is frequently improperly implemented. Most stages have vents, and most will open by means of the fusible link that is integral to the vent. Few, however, are operable manually from anywhere other than the roof or just under the vent, far above the floor. This is a significant defect since, as computer modeling shows, the fusible link will not open until well after people have left the auditorium. Conversely, detection of a fire by an occupant and manual emergency opening of the vents will likely occur very early in the incident on a properly designed and operated stage.

If installing new or replacing vents, it is a good idea to select vents with the motor option so they can be easily opened and closed from the floor by a switch. These motorized vents can then be interconnected to a heat detector that detects a fire condition faster than fusible links for emergency opening. Switches or other operators for manual use should be located near a stage door to allow occupants to open the vents when leaving, and the fire service to open the vents when responding.

How big, how many vents, and what stages require vents is often misunderstood.

Quite simply a stage with a stage area over 1,000 sq. ft. requires vents. The area is to include all of the stage area, wings, forestage, and other contiguous area not separated from the stage by minimum one hour fire-rated construction. A frequent inquiry is about the black box theatre. The entire room, audience area, and stage area combined, often does exceed 1,000 sq. ft. In my company's work, we simply show several various seating and stage arrangements, typically end stage, thrust, and arena, and indicate the stage area. Rarely does that exceed 1,000 sq. ft. On the other hand, the stage area of a thrust stage backed by a stage house with fly may easily exceed 1,000 sq. ft. and the area of the vents, usually above the fly loft, must be calculated to include the thrust stage area. Once the stage area is calculated, it's a fairly simple task to determine how much net-free vent area is required and select the appropriate sized vents. A minimum of two are required—an attempt at single failure-proof planning—and they are logically to be above the highest part of the stage.

Installing a fire sprinkler below a vent is a common mistake that makes it likely that one or both will not function as intended. Also, the manual release, suitable for use on a 20' warehouse roof, is frequently inaccessible to occupants on a stage.

This vent is motorized with easy operation from the floor for emergency and testing use. Unfortunately, the vent with this factory option is not labeled.

Computer modeling shows that a fusible link mounted on the vent will not open until well after the audience has left the auditorium. This vent has been modified for stage floor operation, which has nullified the conditions of it being labeled.

A look back

The origin of the concept of venting the stage seems to be from research following the great theatre fire in Vienna in 1885. The Austrian Society of Engineers built a 1/10th-scale model of the Ring Theatre and conducted experiments with no vents and various sizes of vents. With no vents, a simulated scenery fire on stage quickly pushed all curtains and smoke through the proscenium within about 20 seconds. The increase in atmospheric pressure was significant, and, after first blaming a technician for turning off the gas lights and leaving audience and actors trying to egress in the dark, they determined the atmospheric pressure was greater than the gas pressure and the cause of loss of lighting. In fact, with the vents closed, air pressures were developed momentarily 20 to 30 seconds after lighting the fire as high as 7" of water column or approximately 36 lb. / sq. ft. With the vents opened, the excess of air pressure on the stage was only momentarily equivalent to 0.07" of water column or less than .5 lb. / sq. ft., with no excess pressure observed in the auditorium. Another direct lesson was that with netting or screening covering the vent opening, ash and debris from the fire would quickly block the vents. Finally, further Austrian experiments in 1905 used a 1/3rd scale model. The engineers determined, based on this research, that the net-free area of 11% was sufficient to assure a smoke free auditorium. (I have not found an explanation why codes today only require 5% other than to speculate that it is a result of no recent big theater fires and economics.)

Another notable incident affecting stage vents was the venerable Iroquois Theatre Fire in 1903. For the sake of brevity, I refer you to the excellent *On the Safeguarding of Life in Theaters* by John R. Freeman PE, available online for free, but do quote the following as true today as it was in then. Freeman writes:

"The recurring formula is:
(1) A stage crowded with scenery.
(2) The sudden spread of the flames over this scenery.
(3) The opening of a door in the rear of the stage, an inrush of air.
(4) Scant smoke vents over the stage, an outburst of smoke under the proscenium arch.
(5) Death to those in the galleries."

And in Freeman's foreword:
"The three great safeguards are found to be:

1. The providing of ample, automatic, quick-opening smoke vents over the stage.
2. The thorough equipment of the stage with automatic sprinklers by means of which the action of the heat will promptly release, over the burning scenery, a rainfall tenfold heavier than the heaviest thundershower, drenching the scenery and extinguishing the flames.
3. The providing of especially ample exits and stairways from the gallery.
4. That the foregoing transcend all other requirements. The fire proofing or flame proofing of scenery is found to be of doubtful value under the practical conditions of use. The so-called fireproof paints are of very small fire-retarding value. The asbestos curtain is found to possess much less endurance against heat and flame than had been supposed. The steel curtain covered with non-conductor on the stage side is far better than the asbestos curtain but may give trouble in lowering or may permit large quantities of suffocating gas to be forced into the auditorium around its edges.
5. Dry-powder fire-extinguishers and hand grenades are likely to prove worse than useless, by promoting waste of valuable time."

Another common defect found on stages is the location of fire sprinklers directly under the vent. Either the vent opening will cool the air around the sprinkler, preventing it from opening, or the sprinkler will cool the fusible link in the vent, preventing it from opening. Both are required to operate and work in a fire incident, and neither should impede the other in working. Of course, of great importance in the design and installation

Labeled and Listed

There is frequently confusion and misuse of the terms Labeled and Listed. These are the official NFPA definitions:

3.2.4 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3.2.5 Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

of the vents is that the vents, and their rigging, does not obstruct the stage rigging and other systems over the stage.

There is a significant contradiction in the building and fire codes that can complicate all this. The codes require vents to be labeled, and modifying them in any significant way nullifies the labeled designation. Even the manufacturer's options for motor operation carries with it, in fine print, that the unit cannot be supplied labeled if that option is included. This is a long and complex subject but, until the codes are changed, we rely on the requirement for emergency manual operation from the floor to be sufficient indication of intent to allow a modification. Also requiring a change in regulations are specific requirements for periodic testing and inspection. I hope to address both of these in the code development process.

Ultimately, only the authority having jurisdiction (AHJ) can say what will be accepted in new construction and if non-compliant installations must be modified or are permitted to be left in place in existing buildings. ■

Bill Conner, ASTC has been a theatre consultant for more than 30 years and has represented the ASTC in the areas of codes and standards since 1987. Among his work on codes and standards, he is now the senior member of NFPA's Assembly Occupancy committee; was awarded the NFPA Lifetime Achievement award in 2008; is a member of the ANSI A117.1 committee and several UL technical standards panels; testified at hearings of the ATBCB; and served more than 10 years as ASTC's first representative to the PLASA TSC as well as the Rigging Working Group. Bill can be reached at bill@bcaworld.com. Visit www.theatreconsultants.org to learn more about ASTC and www.bcaworld.com to learn more about Bill's work.

Code requirements for roof vents over stages

From the *2012 International Building Code*:

■ 410.3.7.1 Roof vents. Two or more vents constructed to open automatically by approved heat-activated devices and with an aggregate clear opening area of not less than 5% of the area of the stage shall be located near the center and above the highest part of the stage area. Supplemental means shall be provided for manual operation of the ventilator. Curbs shall be provided as required for skylights in Section 2610.2. Vents shall be labeled.

From the *2012 Life Safety Code*:

■ 12.4.5.5.2 Roof Vents.

■ 12.4.5.5.2.1 Two or more vents shall be located near the center of and above the highest part of the stage area.

■ 12.4.5.5.2.2 The vents shall be raised above the roof and shall provide a net free vent area equal to 5% of the stage area.

■ 12.4.5.5.2.3 Vents shall be constructed to open automatically by approved heat-activated devices, and supplemental means shall be provided for manual operation and periodic testing of the ventilator from the stage floor.

■ 12.4.5.5.2.4 Vents shall be labeled.

■ 12.4.5.5.3 Other Means. Approved, alternate means of removing smoke and combustion gases shall be permitted.

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