Smoke Damper Testing and Maintenance for Service Life and Performance Assurance

Consultants in the field of fire engineering have long recognized the danger to life and damage to property that can be caused by smoke spread throughout buildings, even when the fire is confined to a small area.

A dramatic illustration of this concept is the 1980 MGM Grand fire in Las Vegas, which caused 85 deaths. Although the fire in this instance was located on the first floor of the hotel, most of the deaths occurred on the upper floors (floors 14–24) due to the migration of smoke. Smoke dampers are an integral part of any system designed to make a building safer by controlling and stopping smoke.

One globally applied concept is compartmentation of buildings using fire restrictive construction, required by all of the major building codes in the United States. Paragraph 8.2.2.1 of NFPA Standard 101 Life Safety Code describes this concept by stating, “Where required by other chapters of this code, every building shall be divided into compartments to limit the spread of fire and to restrict the movement of smoke.” NFPA 101 goes on to describe that smoke barriers subdivide building spaces for the purpose of restricting the movement of smoke, while smoke partitions are provided to limit the transfer of smoke.

Factors such as prevailing winds, stack effect, and the buoyancy of smoke contribute to the movement of smoke throughout a building. The heating, ventilating, and air conditioning (HVAC) ductwork and air-transfer openings in buildings can provide a pathway for the smoke to migrate through the building unless properly protected by smoke dampers. Every building code requires approved smoke dampers designed and tested in accordance with the requirements of UL Standard 555S, Standard for Safety for Smoke Dampers, to protect these types of openings in smoke barriers and smoke partitions (the codes do allow certain exceptions). If the barrier or partition also has a fire resistance rating, then a combination fire/smoke damper is required to protect the opening.

Smoke Dampers vs. Fire Dampers
Although this article addresses smoke dampers, it is important to note that fire dampers are also used in compartmentation and it is important to highlight the difference between these two types of dampers.
A fire damper can be defined as “a device installed in ducts and air transfer openings of an air distribution or smoke control system designed to close automatically upon detection of heat. It also serves to interrupt migratory airflow, resist the passage of flame, and maintain the integrity of the fire-rated separation.” Its primary function is to prevent the passage of flame from one side of a fire-rated separation to the other. Fire dampers are generally operated by a fusible device, typically a melting link. They are designed and tested under UL Standard 555: Standard for Safety for Fire Dampers, to maintain the integrity of the fire-rated separation.

Smoke dampers are defined as “a device installed in ducts and air transfer openings of an air distribution or smoke control system designed to resist the passage of air and smoke. The device operates automatically and is controlled by a smoke detection system. They can be opened or closed from a remote fire command station if required.” Their primary function is to prevent the passage of smoke through the heating, ventilation, and air conditioning system, or from one side of a smoke-rated separation to the other. Smoke dampers are operated by either a factory-installed electric or a pneumatic actuator. They are controlled by smoke detectors and/or fire alarms. Smoke dampers are qualified under UL Standard 555S, Standard for Safety for Smoke Dampers. Combination fire/smoke dampers meet the requirements of both UL Standards 555 and 555S.

For more information about the characteristics of smoke, fire, and combination fire/smoke dampers, refer to the article, “Fire Dampers and Smoke Dampers: The Difference is Important,” by John Knapp, in the 2011 issue of AMCA inmotion, which is available at www.amca.org/publications/magazine.aspx.

**UL Safety Testing**

The 2011 article briefly mentioned that smoke dampers must undergo extensive testing to obtain a label from Underwriters Laboratory (UL) under Standard UL555S. To classify their smoke dampers, manufacturers must send several different sizes of dampers to UL for tests that include, but are not limited to, cycling, temperature degradation, leakage and operation, as follows:

**Cycling Test:** A damper must function as intended after being mechanically operated for 20,000 full strokes (closed and re-opened). If the damper is to be operated as a smoke damper and a volume control damper, employing position devices that enable the damper to remain in positions other than fully open or fully closed, then it must go through 100,000 full strokes. As an alternative to the 100,000 full strokes, the damper may be cycled 20,000 full strokes and then 100,000 “repositioning” cycles of a minimum of 5 degrees.

**Temperature Degradation Test:** The dampers used for this test are to be those previously subjected to the cycling test and prior to subjecting them to the leakage test. The elevated temperatures are to be in increments of 100 °F (56 °C), and the minimum temperature to be UL qualified is 250 °F (121 °C). The damper is exposed to the elevated temperature for 30 minutes in the completely closed position. After the 30-minute period and while at the elevated temperature, the damper shall function as intended while operated through three complete operation cycles. The damper is cycled by using the actuator that has also been subjected to the test temperature. All building codes in the USA require smoke dampers to have a minimum elevated temperature rating of 250 °F (140 °C).

**Leakage Test:** The amount of leakage measured during this test shall determine the leakage class of the damper. For smoke dampers the leakage test is a continuation of the operation test. At the conclusion of the operation test, while the damper is in the closed position, the pressure and test temperature are to be maintained against the closed damper. The resultant leakage through the damper is then determined.

**AMCA Commissioning and Testing Guide**

A building’s fire protection or life-safety system is comprised of many types of products, including, but not limited to, fire dampers, smoke dampers, combination fire-smoke dampers, and ceiling radiation dampers. All of these products must function properly as part of a comprehensive system during a fire or life-safety emergency. Proper installation, commissioning, and periodic performance testing are required to ensure these dampers function as intended in a fire emergency.


A free copy of this guide is available in the Publications section of the AMCA website at www.amca.org/publications/damper_maintenance.aspx.
following are recently added tests that affirm the evolutionary improvement of product safety standards and testing:

Because installed smoke control or HVAC system smoke dampers may go for long periods of time without cycling, UL555S has recently added the requirement for a Long Term Holding Test. This test is intended to measure the ability of an actuator to return to its resting (non-powered) position after being held in a normal (powered) position for six months. Each actuator in the sample set is powered, without interruption, for a minimum period of 4320 hours (6 months). Upon removing power from the actuators, all actuators must return to the resting position within their rated time.

UL555S also recognizes that dampers can be built in multi-section arrangements and the standard requires additional testing to ensure the reliability of such arrangements. As mentioned previously, combination fire/smoke dampers must also meet all of the testing requirements of UL555.

Installation Considerations
NFPA 90A Standard for the Installation of Air-Conditioning and Ventilating Systems covers construction, installation, operation and maintenance of systems for air conditioning and ventilating, including dampers, to protect life and property from fire and smoke. Proper application of smoke and combination fire/smoke dampers in different types of barriers, partitions and/or occupancy types can be confusing and does require careful study of the appropriate building code. Engineers and contractors are encouraged to examine Figure A.5.3 in Annex A of NFPA90A, which resolves much of this confusion. The diagram is a building cutaway with many examples of the application of protection requirements of different penetrations.

While codes require fire, smoke, and combination fire/smoke dampers to be installed at required barriers and partitions, they also allow some smoke dampers to be removed or operated separately when installed within an engineered smoke control system.

The design and operation of the system requires careful planning, placement and control of the dampers to:

a) Provide for proper smoke control as well as required pressure differences across horizontal exits and smoke barriers when occupants are moved horizontally rather than evacuated, such as in an I-2 occupancy. Note: An I-2 facility is one that accommodates more than five persons “who are not capable of self-preservation.”

b) Provide access for periodic testing. As shown in Figure 1, access doors to smoke and other life-safety dampers can be blocked by construction. Figure 2 shows a proper installation in a duct that penetrates a penthouse floor.

Table 1 below is taken from UL555S and describes the three different leakage classifications that can be derived from the leakage tests. The leakage classification is determined from the highest leakage value obtained from the specimens tested. All building codes in the USA require smoke dampers to meet a minimum of Class II leakage rating as defined in Table 1.

**Operation Test:** The minimum air velocity and closed damper pressure rating for dampers is 2000 fpm (10.2 m/s) and 4 in. of water (1.0 kPa). Air velocity and pressure ratings higher than the minimum are established in increments of 1,000 fpm (5.1 m/s) and in increments of 2 in. of water (0.5 kPa). Actual tests are performed at these pressures and velocities and include an additional safety factor. Under conditions of maximum specified air velocity, smoke dampers (including any actuators) must function without damage to the dampers or their components and shall completely close and open under the conditions. Dampers are to be tested with airflow in each direction.

**Additional Product Tests**
The evolution of the smoke damper and the testing requirements through the years has resulted in a product that is both high performing and reliable in its intended operation. The

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<th>Leakage Classification</th>
<th>Leakage, cfm/ft² at Standard Air Conditions</th>
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<tr>
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<td>4.5 in-wg</td>
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<td>20</td>
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Table 1: Underwriters Laboratories Standard UL555S Leakage Classifications.
As energy reduction initiatives continue to shape the future of the world, the demand for more efficient products is growing in the fan industry. That is why Twin City Fan has taken a leading position in obtaining AMCA’s FEG Certification on 65 fan models. For more information about the benefits of FEG certified products, contact a Twin City Fan representative or visit the AMCA website at www.amca.org.
Field Testing and Maintenance
Smoke and combination fire/smoke dampers require very little maintenance but codes do require periodic testing after initial installation and commissioning. Information on periodic testing of smoke dampers can be found in NFPA105 Standard for Smoke Door Assemblies and Other Opening Protectives and of fire dampers in NFPA80 Standard for Fire Doors and Other Opening Protectives. These standards both require periodic testing one year after installation and then every 4 years, except in hospitals, where the frequency is every 6 years. NFPA92 covers testing of engineered smoke control systems, including dampers. The standard states that dedicated systems shall be tested at least semiannually and non-dedicated systems shall be tested at least annually.

Summary
Stopping smoke from migrating through HVAC systems during a fire helps save lives and minimize property damage. As stated earlier, all of the major building codes in the USA require the use of approved smoke dampers with a minimum elevated temperature rating of 250 °F (140 °C) and a minimum of Class II leakage rating. Whether the smoke control system is a passive “fans off” design or a dynamic “fans on” system, smoke dampers are up to the challenge of the heat and pressure. The evolution of the smoke damper and the test requirements of UL555S ensure a cost-effective, high performing and reliable product designed for this demanding application.
Loren Cook Company introduces FanDrafter® 3D – MEP, an “add-in” for use in Autodesk® Revit®. Building on Cook’s complete catalog of Revit® models, this add-in simplifies placement and customization of the Cook models in your projects.

Our program links to Cook Compute-A-Fan® job files and automatically populates parameters when models are placed.

The add-in includes a customization module that allows you to match Cook data to your company’s standard parameters ensuring uniform equipment schedules.

You no longer have to manually enter the performance data for each fan!

Online resources


Simply click on the “Design Tools” link to download and start using these tools on your projects.