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Fire/Smoke Damper Applications

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Combination fire/smoke dampers (FSDs) are required by code to protect duct openings in common fire barriers and partitions (such as duct shafts) against passage of fire and smoke. In this month's column, I discuss several common as well as advanced applications for FSDs.

Bottom of Duct Shafts

Building codes require that duct shafts be protected at the bottom with a fire-rated barrier. There are three common options for installing FSDs at the bottom of shafts:

1. Build a rated drywall enclosure that hangs down below the shaft that allows vertical FSDs to be installed in the walls of the enclosure, as shown in *Figure 1*. This may be the most common design because for years it was the only one allowed by code until horizontal FSDs were approved for this application. But this option is almost always the most expensive and it usually leaves less space for ductwork because of the depth of the bottom of the enclosure, typically 5.5 to 9 in. [140 to 230 mm] depending on the shaft dimensions and enclosure fire-rating.
2. Make the bottom of the shaft a continuation of the concrete (or concrete on metal deck) floor, with horizontal FSDs as shown in *Figure 2*. This approach

*The floor openings must be sized for the FSDs plus the clearance the manufacturer requires for expansion, on the order of 1 in. (25 mm) larger than the FSD dimension. The exact opening size cannot be known until the FSD manufacturer is selected because installation details vary by manufacturer. It is best for the structural engineer (or architect) to show the dimensions to scale about 1 in. (25 mm) larger than the FSD but to not include specific dimensions; instead include a note saying "dimensions by mechanical contractor."

requires coordination with the structural engineer and architect to show the duct openings and structural framing around the openings on their drawings.* Access to the FSD for installation, inspection, and maintenance can be either from the top (as shown in *Figure 2*) or from the floor below (as shown in *Figure 3*). Top access requires an access door be provided in the shaft wall on the floor above, usually one large enough that maintenance personnel can enter and crawl or walk around the inside of the shaft to gain access to the FSD. Top access is usually preferred because access from the floor below can be difficult due to obstructions from beams framing the FSD opening and the duct itself. Top access also provides more room for a smooth duct elbow since the FSD sleeve is shorter on the non-actuator side (about 3 in. [75 mm] vs. about 9 in. [225 mm] on the actuator side, depending on actuator type, manufacturer, and model). Bottom access often requires an elbow with splitters or turning vanes due to height constraints, as shown in *Figure 3*. Option 2 is usually the best approach for buildings with flat concrete floors (e.g., two-way or post-tension slab) because there are usually no additional framing costs for

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FIGURE 1 Option 1: Drywall enclosure with vertical FSD.

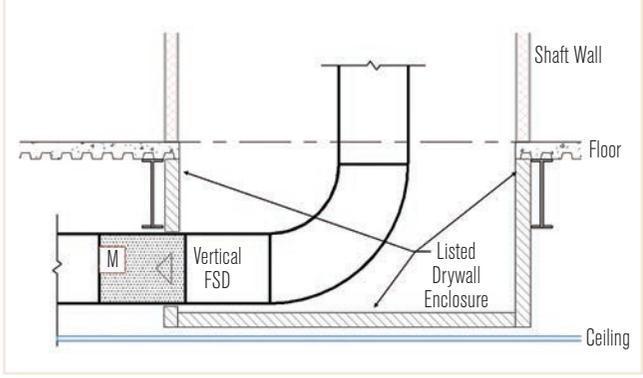
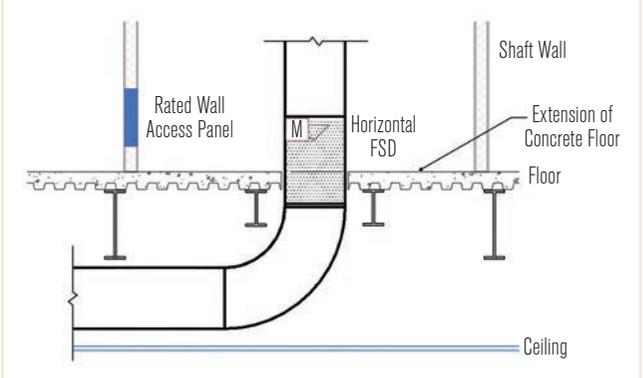


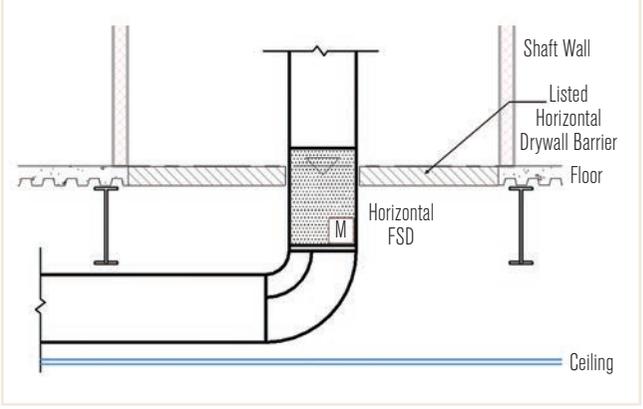
FIGURE 2 Option 2: Concrete floor with horizontal FSD.



the duct openings. For steel/metal deck buildings, this approach can be expensive because each duct opening must be framed with steel beams.

3. Make the bottom of the shaft a rated horizontal drywall barrier with the top flush with the floor above with horizontal FSDs, as shown in *Figure 3*. This is a relatively new option – up until a few years ago, horizontal FSDs from most manufacturers were only listed[†] for concrete floors (Option 2 above). That is true even today with some manufacturers, so it is important that the mechanical engineer specify that the FSD be listed for this application. Similarly, the architect must ensure that the horizontal partition is listed for this application—currently there is only one approved assembly, UL Design³ I503 (2-hour non-load bearing horizontal barrier). With this option, access usually must be from the floor below since the drywall barrier is not strong enough to support the weight of maintenance personnel. In some cases, access from the top is possible if shaft wall access doors can be located close enough to the FSD actuators and duct access door that they can be reached without having to enter the shaft. This option is usually the least expensive, but maintenance access can be problematic as noted in the discussion of Option 2 above.

FIGURE 3 Option 3: Drywall floor with horizontal FSD.



Open/Close Indicator Switches

FSDs used for “engineered smoke control,” such as those in high-rise buildings, are usually required by

code to have two status switches wired to the fire alarm system[‡] (along with damper open/close control contacts) as proof that the damper is fully-open or fully-closed. Until 2001, the only listed status switches were electro-mechanical switches that attach to the damper blade with a plunger or rotary arm that closes a contact when the damper is sensed to be fully-open or fully-closed. Because they are mechanical, these switches tend to be relatively unreliable, and they are usually located inside the ductwork, accessible only via a small duct access door, so they are difficult to maintain or replace. Fortunately, UL 555S now allows status to be from end-switches (aka auxiliary switches) built into direct-coupled actuators, a standard option from almost all FSD actuator manufacturers. Actuator end-switches are less expensive, more reliable, and more readily

[†]The term “listed” is used in building codes to refer to materials and products tested in accordance with a test protocol developed by an organization acceptable to the building official and found to be suitable for a specific purpose. In the U.S. codes, the relevant standards are ANSI/UL 555 Standard for Fire Dampers¹ and ANSI//UL 555S Standard for Smoke Dampers.² Combination FSDs must meet both standards.

[‡]Fire alarm systems (FASs) in this column refers to the UL 865 (UUKL) listed control system used for fire alarm and engineered smoke control. Building automation systems (BASs) may also be UUKL listed for this duty but the more common design (and the design assumed in this column) is to use separate FASs and BASs, so the BAS need not be UUKL listed.

accessible for maintenance compared to damper position switches.[§]

For buildings that do not require engineered smoke control, FSD position status switches are generally not required by code. However, they are a convenient feature for building engineers because they can readily warn of a damper failure before it causes comfort complaints, and (based on recent NFPA revisions)⁴ they obviate the need for regular visual inspections required by code, reducing maintenance costs. The cost premium had been too high to justify in the past, but first costs have fallen due to the lower cost of actuator end-switches and to the prevalence of addressable fire alarm systems (FASs), which reduce status switch wiring costs with remote input/output modules mounted adjacent

to the FSDs and networked to the FAS. The FAS generally includes damper command and status feedback visualization so there is no need for local testing switches and status lights located near the FSD; all testing can be done remotely without any access required to the FSD itself. The FAS can also be programmed to generate an FSD failure alarm to building operators, e.g., via text message or a hardwired connection from the FAS to a building automation system (BAS) alarm input; operators can then use the FAS interface to determine which FSD has failed. Hence there is little value to tying FSD status switches into the BAS instead of the FAS, and costs of doing so are significantly higher because the FAS must wire FSD open/close controls anyway while BAS controllers are seldom located near FSDs.

[§]Since actuator end-switches are relatively new, there has been confusion among fire alarm contractors how to wire end-switches from FSDs with multiple actuators. Per UL 555S, status switches are required for each independent damper section; sections that have multiple actuators and that also have jackshafts connecting the dampers in each section together only require one status switch pair regardless whether it is a damper position indicator type or actuator end-switch type. So the wiring costs of the two status switch types will be the same, but it can be confusing to installers when all actuators have end-switches (the current common manufacturer practice) even when only one is required to have them. No doubt, as actuator end-switches become more popular, FSD manufacturers will start supplying end-switches only on the actuators required to have them.

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Using FSDs as Control Dampers

FSDs are allowed by most codes to be used for other purposes provided the life safety function controlled by the FAS takes precedence. For systems not used for smoke control, FSDs only need to be closed (not both opened and closed) by the FAS, so wiring of FSDs for two position open/close control by the BAS is simple: just wire the FAS and BAS contacts in series. Wiring of FSDs used for modulating duty, a common example of which is supply air FSDs at shafts modulating airflow into the underfloor plenum of an underfloor air distribution system, is more complicated, especially if the FSD is used for smoke control and must be capable of being both opened and closed by the FAS.

FIGURE 4 Wiring of FSDs used for modulating BAS control and open/closed FAS control (black = provided with FSD; blue = provided with BAS; red = provided with FAS and Division 26).

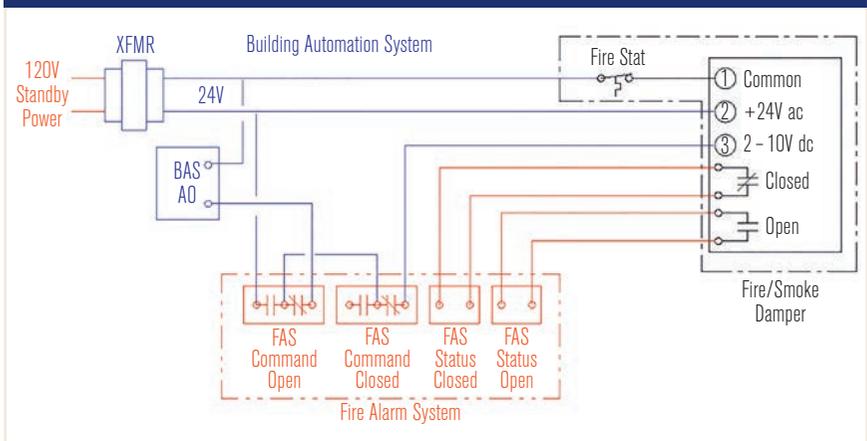


Figure 4 shows how this can be accomplished: the BAS damper analog output (AO) signal is wired through two FAS relays, one that causes the FSD to fully open (by connecting 24V to the actuator input signal)[#] and

[#]The diagram shows 24V alternating current (ac) being applied to the actuator's direct current (dc) input. This works with most low voltage actuator manufacturers.

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one that causes the FSD to fully close (by zeroing the actuator input signal). The “fire-stat” (aka “electronic fusible link”) is the high limit thermostat provided with the FSD to close the damper (actuators are spring-return, fail-closed) when air temperature exceeds the fire-stat setpoint, typically 165°F (74°C) but usually increased to 250°F (121°C) for FSDs used for smoke exhaust. The FSD must be on standby power (like all FSDs used for smoke control) and a transformer is required because 120V modulating actuators are not available. FSDs with available airfoil blades, opposed blade action, and modulating actuators control airflow exactly the same as a standard modulating damper, so there is no value to using separate FSDs and control dampers in series.

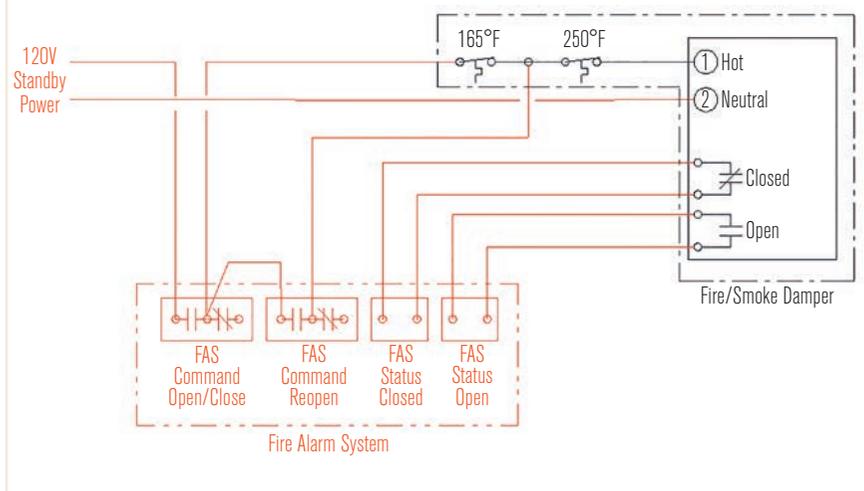
Using FSDs as Balancing Dampers

FSDs can also be used as balancing dampers where the damper is partially closed to deliver the desired airflow rate during normal operation then fully opened by the FAS for smoke control (e.g., smoke exhaust) duty. The classic example is exhaust from corridors in high-rise residential buildings: during normal operation, air is exhausted equally from each floor, but for smoke control mode, only the “fire floor” is exhausted at a high exhaust rate. For this duty, the FSD would have a modulating 24V actuator with a built-in potentiometer, often called a 3-position actuator (fully open, fully closed, and partially open as determined by the potentiometer adjusted during system balancing). Wiring is similar to *Figure 4* with a transformer and three wires for the three positions.

FSD Smoke Detectors

Factory installed duct smoke detectors (DSDs) are available from most FSD manufacturers, but, at least in the area where the author practices, they are seldom used because the smoke detectors usually are required to be compatible with the FAS, often proprietary and not always available from FSD manufacturers, and also because there are other ways to control

FIGURE 5 Wiring of reopenable FSDs.



FSDs (e.g., area detection) so DSDs are not always required. But regardless who provides the DSD, the designer must ensure that it is compatible with the air velocities that can be expected through the FSD. In almost all cases, this means the DSD must function with zero velocity since most systems shut off during unoccupied hours (zero airflow). Even 24/7 systems can have very low airflow rates if they are VAV with low minimum airflow setpoints.⁵ So sampling tube-type DSDs can seldom be applied to FSDs since they typically have a minimum velocity requirement of 200 to 300 fpm (1 to 1.5 m/s).

Reopenable FSDs

Almost all FSD manufacturers have an option using two fire-stats, one to close the damper at a relatively low temperature, e.g., 165°F (74°C), and a separate one closing the damper at a higher temperature, e.g., 250°F (120°C), allowing the FAS (usually through manual firefighter control overrides) to reopen the damper if air temperature first rises above the low temperature limit but is below the high temperature limit. This requires a non-standard 3-wire connection from the FAS as shown in *Figure 5*. To the author’s knowledge, there is no code that requires this additional control, and unless it is well coordinated with the FAS design, installation errors can occur.

The author had a project where the FSDs were provided with dual fire-stats, one for 165°F (74°C) and one for 350°F (177°C) (the FSD’s maximum rated

temperature), despite specifications and submittals showing a single fire-stat set for the desired 165°F (74°C). The FAS contractor provided the specified 2-wire design but, given a choice of two termination points for the 120V hot connection, incorrectly terminated it to the 350°F (177°C) override contact. Because local code had a maximum limit for closure of 286°F (140°C), every FSD in the building had to be rewired to the low temperature termination, at very large expense. This option should therefore only be used where it is truly desired and coordinated with the FAS design to include the extra wiring, relay contact, and programming logic.

Conclusions

Combination fire/smoke dampers are used in almost every HVAC design and there are many special FSD applications and options. This column discusses a few of these applications and how to incorporate them into design drawings and specifications.

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