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FIRESTOPPING

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in Information Technology Equipment Areas

While information technology equipment (ITE) has changed dramatically over the past decades, one property that has not changed much is its susceptibility to nonthermal damage from exposure to the combustion products of a fire—what most people would call smoke damage. Even brief exposure to products of combustion can start the process of corrosion and electrical bridging that can lead to the permanent damage of circuitry and electrical contacts. The damage may not be immediate or immediately detectable. But humidity and oxygen in the air will combine with any trace deposits of corrosive products of combustion to potentially cause equipment to become unreliable or stop functioning.

Two standards that exist to provide guidance for the fire protection of ITE areas are the National Fire Protection Association (NFPA) 75 (2013), "Standard for the Fire Protection of Information Technology Equipment," and FM Global Property Loss Prevention Data Sheet 5-32 (2012), "Data Centers and Related Facilities." Both NFPA 75 and FM DS5-32 provide extensive protection recommendations for fire detection and extinguishing of a fire originating within the ITE room. Depending on the results of a risk analysis, both provide for the possibility of a gaseous extinguishing system for the equipment in the room and the space under a raised floor, which would normally have a significant loading of combustible power and data cables.

> Orientation and training of personnel involved with cabling changes, including all outside vendors, can help ensure that cabling changes will not compromise the fire and smoke resistance of penetration firestops.

Passive Fire Protection

The primary means of protection from fire exposures occurring outside the ITE room is the use of fire resistance-rated construction to separate the ITE room from all surrounding rooms and from occupied areas on the stories above or below.

NFPA 75 explains the hazard this way:

A.5.1.3 Experience with fires affecting information technology equipment rooms has demonstrated that the fire often starts in areas other than the information technology equipment area and that the fire and its related products, including smoke, soot, and heat, can enter the information technology equipment room if it is not adequately separated by sealed, rated walls.

Both NFPA and FM recommend one-hour fire resistance-rated walls and fire resistance-rated floors to box in the ITE room. Surrounding areas also should be provided with automatic fire sprinkler protection.

What is Firestopping?

Firestopping is a generic term used to describe the practice of suitably sealing penetrations through a fire resistance-rated assembly (wall or floor) in a manner that maintains the full fire resistance of the assembly. Firestop is not a product; it is a system that must be used to restore the fire resistance rating of an assembly when it is breached by a penetration.

A firestop system is a specific, tested combination of the following parameters:

▶ Substrate (wall or floor) and its specific properties (e.g., material, fire rating, thickness).
▶ Penetrating item type, size and shape.
▶ Hole size and shape.
▶ Cable fill (percent of hole cross-sectional area filled by cables).
▶ Devices and materials used to seal the hole.

Without more information, it is impossible to guess or calculate whether any given combination of these variables would provide the needed fire resistance rating. To evaluate the fire resistance rating of firestop systems, they are tested by independent third-party test laboratories; Underwriters Laboratories® (UL) is the predominant test laboratory. The tests are done in accordance with published consensus standards ASTM E814 or UL 1479. The fire testing is essentially identical for each of these standards. The UL standard additionally provides standardized test procedures for an air leakage rating (L rating) and water leakage rating (W rating).

Successfully passing the fire resistance test results in a listed firestop system (hereafter referred to as a system). The device and material used in the system to seal the hole—colloquially referred to as firestop— is referred to by UL as a classified material. It is important to note that use of a classified material, in and of itself, does not mean a penetration is properly firestopped; it must be used in strict compliance with the system requirements. Applications outside the system parameters may not provide the hourly fire resistance rating that is desired.

Approximately 7,000 systems are listed by UL. Although only a fraction of these are applicable to the penetrations in an ITE room, some guidance is warranted to help sort through the large number of choices.

To select the most suitable systems for an ITE room, the user should pay close attention to two main variables. One is whether the firestop will need to accommodate cabling modifications over the life of the facility, and if so, how often and how large the changes might be. The other important consideration is the L rating that will be provided by the system.

Ongoing Maintenance

Depending on the system, the fire resistance rating (F rating) and the L rating of a facility can be compromised if, during the life of a facility, an area has cable changes that disturb the installed firestop. This can impair the effectiveness of a gaseous extinguishing system if one is present.

Figure 1 shows a cable penetration that was firestopped using a firestop bag. As cables were added, the bag no longer fit into the free space in the sleeve, and the penetration was left without any firestop. This would allow fire and smoke propagation. It should be noted that firestop using the bag would not have been effective anyway. Firestopping a combustible penetration such as cables inside a plastic sleeve requires a firestop solution positioned on the face of the wall that also applies pressure from outside the sleeve to seal it off as the sleeve melts or burns in the event of a fire.

Because ITE rooms are dynamic environments that will have cabling changes over time, FM DS5-32 requires annual verification of the integrity of penetration firestop. It should be verified that all penetrations are firestopped in accordance with a listed system and that penetration firestops have not been changed to a different firestop with a higher (worse) L rating, especially in areas protected by gaseous extinguishing systems.

Orientation and training of personnel involved with cabling changes, including all outside vendors, can help ensure that cabling changes will not compromise the fire and smoke resistance of penetration firestops. It is helpful to have detailed specifications indicating the exact methods and products that are acceptable to firestop ITE area wall and floor penetrations. These should be provided to all vendors and installers working in the ITE area.

Choosing Firestop Technologies That Meet the Facility's Needs

Each category of firestop products has advantages and disadvantages. The choices are presented in Table 1, including guidance to help users select the best option for their specific application.

The choice of firestop types generally depends mostly on the level of activity that is expected within the service penetration. If cables are to be installed, firestopped and remain undisturbed for years (inactive openings), low-cost solutions exist that essentially cement the cables into the wall or floor. If cable additions or removal may occur every few years (moderately active openings) or even more than once a year (highly active openings), many firestop product and device choices exist that make it relatively easy to add and subtract cables with little to no extra time or cost required to firestop after the change. Such devices have seen greatly increased usage over the past 10 years or so, particularly as cable mining has increased in importance due to mandates in the *National Electrical Code (NEC®)* and other standards.

Use of Pre-formed Firestop Devices

The most significant change to the firestop industry over the past 15 years has been the dramatically increased availability of preformed firestop devices. These pre-engineered products sometimes

FIGURE 1: Firestop bag initially inside of sleeve was not replaced after cabling additions or modifications.

TABLE 1: Guide for selection of firestop sealant and device types based on application.*

FOR INACTIVE SERVICE PENETRATIONS

FIRESTOP TYPE	ADVANTAGES	DISADVANTAGES	BEST USED FOR	NOT SUITABLE FOR
Intumescent caulk (Fig. 2)	+Low cost	-Many are hard when cured		-Large gaps
Intumescent foam (Fig. 3)	+Nearly perfect L ratings +Highly water resistant	-Many are hard when cured -High cost	+Sealing gaps difficult to access (e.g., within large cable bundles)	

FOR MODERATELY ACTIVE SERVICE PENETRATIONS

FIRESTOP TYPE	ADVANTAGES	DISADVANTAGES	BEST USED FOR	NOT SUITABLE FOR
Flexible intumescent putty (Fig. 4)	+Reusable (nonhardening) +Easy to install		+Single cables or small bundles +Irregular-shaped holes	-Large gaps in the wall or floor (annular space > ≈125 millimeters [mm (5 inches [in])])
Flexible intumescent foam plugs (Figs. 5, 6)	+One-sided installation +Excellent smoke seal +Stays flexible +Reusable +Very quick installation		+Blank openings up to ≈100 mm (4 in) diameter	-Noncircular holes
Firestop boards (Fig. 7)	+Excellent smoke seal +One-sided installation +Cost-effective for large openings +Some types easy to cut	-Some types difficult to cut -Requires mechanical fastening to wall	+Large holes (> ≈300 mm [12 in] x ≈600 mm [24 in]) +Cable trays +Blank openings	-Small holes - Multiple spaced/ separated penetrating items within one hole
Firestop pillows/ bags (Fig. 8)	+Reusable	- Compression required (often difficult) - Cannot be cut to fit - Higher smoke leakage -Irregular shape makes large openings awkward to fill - Wire mesh or cover plate usually required	+ Cable trays + Busways	-Very large openings (> ≈300 mm [12 in] x ≈600 mm [24 in])

FOR HIGHLY ACTIVE SERVICE PENETRATIONS

FIRESTOP TYPE	ADVANTAGES	DISADVANTAGES	BEST USED FOR	NOT SUITABLE FOR
Intumescent foam blocks (Fig. 9)	+Reusable +No compression required +Can be cut to shape for irregular openings +Systems with very low smoke leakage +Some one-sided installation systems	-Mesh or cover plate needed when annular space > ≈100 mm (4 in)	+Multiple separate penetrants +Can be used together with firestop board as hole gets bigger	
Preinstalled or postinstalled firestop sleeves (Fig. 10)	+Simple installation +Excellent smoke seal (for some models) +Some suitable from 0 percent to 100 percent visual fill	-Some require a reassembly of components -Some cannot be used as retrofit	+Any low-voltage cabling application	
Cast-in-place firestop devices (Fig. 11)	+Eliminates need to core holes in floor +Simple installation +Quick and easy cabling changes	-Additional materials may be needed around cables (e.g., mineral wool, putty) -Must be pre-planned (prior to concrete pour)	+Large cable bundles that fill the device opening +Large diameter conduit	-Small bundles or individual wires

*Not all firestop types are available for all configurations. Always consult the system details.

FIGURE 2: Conduit penetrations permanently firestopped with caulk-based system.

FIGURE 3: Intumescent (heat-expanding) firestop foam can provide nearly perfect L ratings as it flows and hardens between cables.
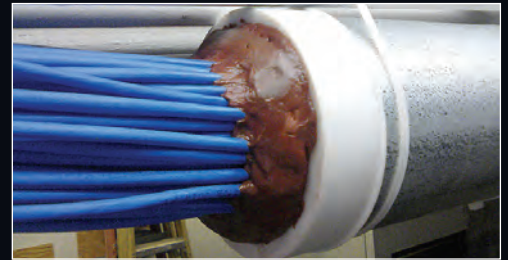

FIGURE 4: Penetration firestopped with flexible intumescent putty.

FIGURE 5: Penetration firestopped with intumescent flexible foam plug.
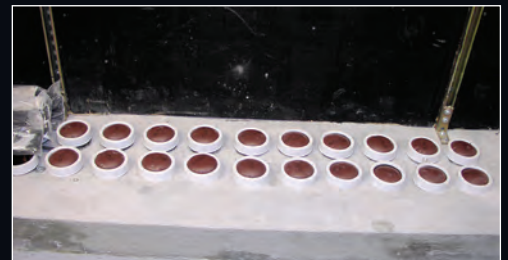

FIGURE 6: Intumescent flexible foam plugs used to firestop blank openings (for future cable use).

FIGURE 7: Service penetration opening with firestop board.

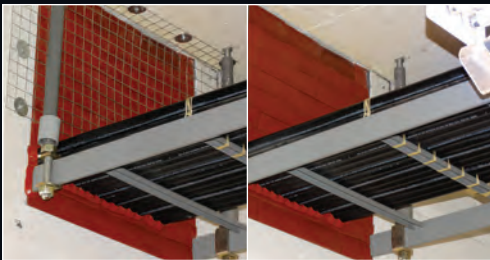FIGURE 8: Firestop bags (note that mandatory retaining wire mesh on each side of the wall is missing).

FIGURE 9: Penetration firestopped with intumescent foam blocks (shown with and without mandatory retaining wire mesh).

FIGURE 10: Preinstalled firestop sleeves.

FIGURE 11: EMT through cast-in-place firestop devices.

Firestop is not a product; it is a system that must be used to restore the fire resistance rating of an assembly when it is breached by a penetration.

are almost ready to drop in place, whereas others at least offer simple assembly or installation. One advantage is that their custom design provides quickly and reliably installed firestop solutions for the specific types of penetrating items for which they are tested and listed.

The user must verify the relevant systems to determine the acceptable penetrating items, the required installation methods, and the resulting F ratings, L ratings and W ratings. With that information, installation is usually faster (and less dependent on the installer's attention to detail) than the more conventional solutions using firestop sealants and their supporting insulation (if required). The biggest advantage of these pre-engineered solutions is that they usually can be easily reconfigured to allow a different number, type or arrangement of penetrating item without destroying the purchased firestop materials and damaging the penetrating items.

This movement to pre-formed devices started with cast-in-place firestop devices. These products, initially designed for pipe and tube firestop, are preassembled during manufacture using the right type, size, shape and position of inlaid intumescent products. On the construction site, they are laid down with the form work and cast into the floor, providing a sleeved opening with the firestop already built in. All that is required for installation is passing the pipe or tube through the device.

This approach quickly evolved to provide solutions for cabling applications. Since one of the characteristics of cabling is that it involves the periodic removal or addition of cabling, solutions were developed to allow such changes while reusing the already installed materials. The first such solutions involved firestop bags that were stacked in the openings and compressed by the required amount, often up to 50 percent. This stacking and compressing was often challenging and sometimes not done properly, so more user-friendly solutions were developed. For large openings, the solution was composite sheets of metal and some fire-resistive materials sandwiched together. To avoid the hazards and inconvenience of cutting and working with metal, nonmetallic boards were later developed.

Many of these re-penetrable systems involve some assembly. For example, firestop for the penetration of a cable tray through a wall may involve firestop composite board to close the bulk of the opening; blocks, pillows or bags (depending on the manufacturer) to provide a section at the cable tray that is easy to open, adjust and close; and some reusable firestop putty to create a smoke- and fire-resistive seal at the interface between different materials. Because of the modest effort and degree of knowledge required for this reassembly, these types of solutions have been categorized in Table 1 as being suitable for moderately active service penetrations.

The latest evolution is a trend toward devices that do not require reassembly to accommodate the addition or removal of cables. Because of their nearly error-free use, they have been categorized in Table 1 as suitable for highly active service penetrations, as any cable installer should be able to make adjustments to the cabling and leave the work well firestopped without much knowledge of the firestop application. These types of devices typically have some sort of open and close mechanism that makes it relatively simple to increase or decrease the size of the protected opening and leave behind a seal that will provide the needed F rating and some L rating as described in the specific system.

Importance of a Firestop System's L Rating

System listings typically provide several standardized ratings. The first rating of interest is the F rating. The system must have an F rating at least equal to the fire resistance rating of the wall or floor penetrated, as required by NFPA 75, FM DS5-32 and the International Building Code, if applicable.

The next rating of importance to an ITE room is the L rating. Detailed in standard UL 1479, it provides a measurement of the air leakage that can flow through the firestop system under test conditions. The test is conducted at both an ambient temperature of 24 degrees Celsius (°C [75 degrees Fahrenheit (°F)]) and an elevated temperature of 204 °C (400 °F). This indicates the leakage resistance of the system to both cold smoke and warm smoke depending on how far away the actual fire is from the penetration.

The L rating is optional, so it will not be reported in every system. Most manufacturers will obtain and include an L rating in the listing for their firestop systems that have inherently high resistance to air leakage. The lack of an L rating for a firestop system could be a warning that the system may have poor air leakage resistance.

The L rating of a system to be used in the ITE room's walls or floors is of critical importance. If the ITE room is protected by a gaseous extinguishing system, penetration firestops that allow excess leakage right from initial construction could cost thousands of dollars to compensate for the leakage with additional gas discharge. For several decades, L rating values have been reported as cubic feet per minute (cfm) of air leakage per square foot (sq ft) of wall or floor opening. FM DS5-32 mandates that the L rating for each penetration firestop protecting the ITE room should be 7 cfm/sq ft or less. To indicate how tight that would be, think of that number as providing an almost watertight seal. Most systems in the UL fire resistance directory will not meet the 7 cfm/sq ft maximum value, so using only those systems meeting this strict threshold will eliminate many choices.

L Rating May Be Reported in Different Units

UL has recently allowed some systems to report their L ratings in cubic feet per minute (cfm) when the geometries of the system are constant (i.e., the size and shape of the hole in the floor or wall is fixed and the firestop device is unchanging). To allow a direct comparison of performance between the two ratings, divide the cfm rating by the size of the hole in square feet (not square inches) to convert it to a value of cfm/sq ft. In many cases, the converted cfm/sq ft value will be 10 to 20 times higher than it would be in units of cfm. Make sure the system does not undermine expectations because of failure to notice this detail in the unit of measure.

In addition to the possibility that L ratings may be reported in different units for different firestop systems, two other factors could cause confusion in evaluating the published L ratings.

Variation of L Rating with Percent Cable Fill

The L rating for a cable firestop system can depend strongly on the percentage of the available opening that is filled by cables (percent fill). The best (lowest) L ratings are often achieved when a device or hole is completely empty (blank opening), meaning no cables have passed through it. This would happen when firestop products or devices are installed earlier to seal an empty hole that would accommodate future cabling. The second best L rating is often achieved with 100 percent cable fill, meaning the number of cables through the firestop system is at the physical maximum limit. With cables bundled together and packed tightly into the hole or device, the paths for leakage between cables and around the cable bundle can be minimized.

Some firestop systems only report an L rating for 0 percent and for 100 percent fill to show a promising (low) L rating number. It is important to note that, unless the listing indicates otherwise, the L rating for an actual percent cable fill cannot be interpolated between reported values. Depending on the type of firestop technology used, a 50 percent cable fill (for example) could have L rating values much higher (worse) than the values reported for 0 percent and 100 percent. If cable penetrations are other than 0 percent or 100 percent full, look for a system that has L rating values published for the range of percent cable fill that would be expected in the actual installation so that the leakage through that system is known and is determined to be acceptable.

Variation of L Rating with Shape of Cable Bundle

A second source of confusion arises because many L ratings depend strongly on the shape and layout of the cable bundle. The system listing should indicate the required cable bundle shape, layout and bundling method that must be complied with to achieve a reported L rating. If the cable arrangement is different from what is described in the listing, the actual leakage could be multiple times higher than the published L rating value. Refer to the independent test laboratory system listings for this information.

Summarizing the Selection Process

As mentioned earlier, UL has more than 7,000 listed firestop systems. The system must state that it is suitable for the intended application exactly: the fire resistance rating and construction details of the wall or floor assembly penetrated; the penetrating item type, size and number; the hole size and shape, including the gap size that needs to be sealed; the percent of the hole area that is filled by cables (percent fill); and the firestop products and their installation method.

The L rating that a system can deliver is critical for ITE room applications. FM Global recommends an L rating of 7 cfm/sq ft or less for each penetration firestop, which is a stringent performance level. Remember to convert L ratings expressed as cfm to cfm/sq ft when comparing performance between systems and to enable a comparison with FM Global's recommended performance level.

The frequency of cabling changes is the other vital consideration. Refer to Table 1 for a summary of the firestop types and technologies that can accommodate various repenetration frequencies.

Due to the lack of any advanced sort or search function based on firestop system attributes, browsing for firestop solutions using the UL online listing directory is difficult and time consuming, although it does provide a one-stop source for almost every system tested and listed in the United States. An easier way to browse for solutions is to use the online system selectors that most firestop manufacturers provide at their websites. The guidance provided in this article should enable a reasonably informed choice. ◄

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