Selecting Firestop Materials/Systems

For a construction or renovation project, firestop systems and materials should be selected based on:

- Qualification testing.
- Installation efficiency.
- Maintenance convenience.
- Future cable MACs.
- Architectural or environmental requirements.

Firestop systems consist of the floor or wall assembly, the penetrating items, and the firestop materials. The complete system is rated—not the individual materials or components. Substitution of any system component may invalidate the system.

Selecting the right product for the specific application is equally important. If some degree of movement is required, selecting a flexible product is essential. If moisture resistance is a concern, selecting a product that will not re-emulsify from water exposure is critical.

Qualified Components

Firestop materials should always bear the appropriate markings from a third-party listing and labeling agency. This ensures that the products are manufactured in accordance with a strict quality assurance program. Most third-party agencies that perform listing and labeling will periodically inspect manufacturing facilities or source products from the open market to verify that products continue to conform to program requirements.

The appropriate marks should be verified. If the product in question is a firestop material, the listing mark will bear a reference to firestop or to the applicable fire test standards described by this chapter. Products that do not bear the appropriate markings may not be approved for use as firestop products and should be avoided.

Third-party listing and labeling agencies make the verification process easy by publishing annual directories of listed products or including appropriate information on fully searchable websites.

Qualified Electrical Apparatus

Some electrical apparatus are tested under exposure to fire and qualified for use in fire-rated assemblies.

These include:

- Boxes.
- Junction boxes.
- Fixtures.

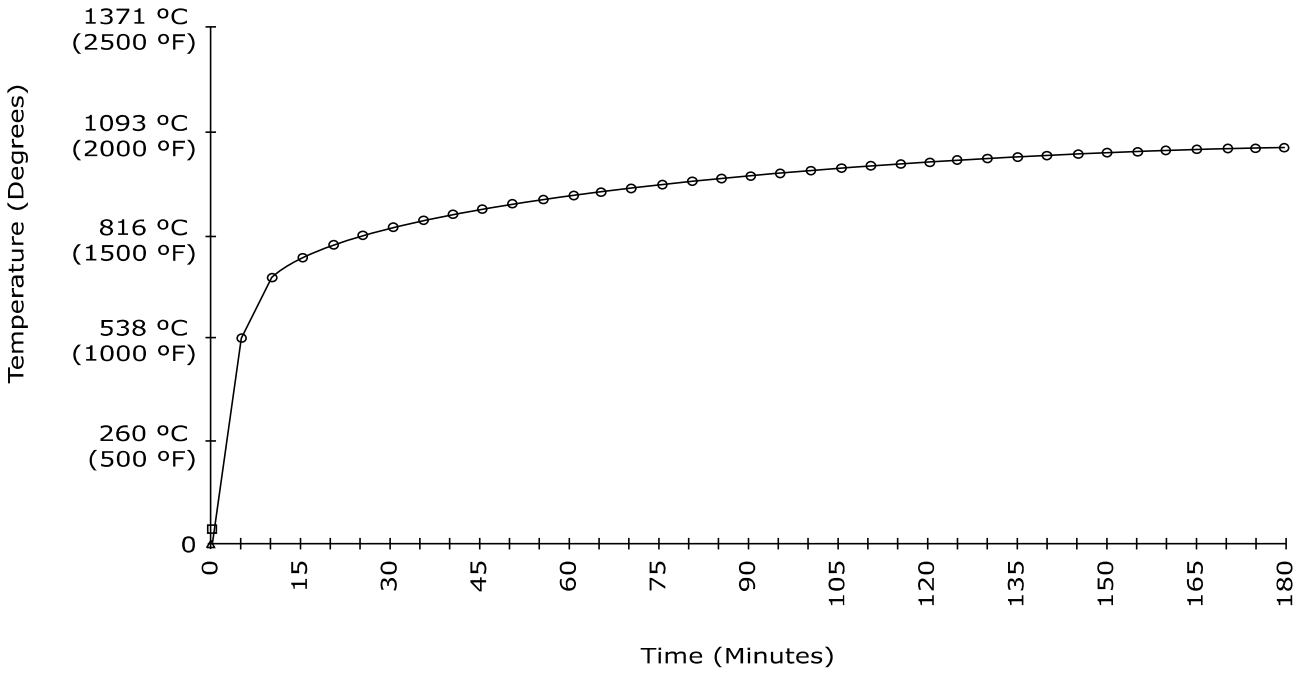
These are designed so that no additional firestop is needed (e.g., other than normal patching where the item penetrates a fire-rated assembly). Installation criteria are listed in the manufacturer's installation instructions for each component.

NOTE: Firestop all non-qualified electrical apparatus as appropriate.

Time/Temperature Curves for Ratings Up to Three Hours

Most structures require ratings up to and including two-hour, while some special structures need three- or four-hour rated construction. See Figure 7.1 for time/temperature curves for architectural type structures.

Figure 7.1
Standard time/temperature curves up to three hours



Testing and Guidelines for Firestops

Testing Fire Resistance of Through-Penetration Firestops

The fire resistance of penetration firestops is evaluated under positive pressure, time versus temperature, and furnace conditions. This testing allows assessing the system's capability to provide fire resistance through controlled fire exposure.

The selected product and corresponding listed system should be approved for use in the country or region in which it will be installed.

Test Standards in the United States

The referenced test standards for firestop systems for penetrations are ASTM E814, *Standard Test Method for Fire Tests of Through-Penetration Firestop Systems,* and UL 1479, *Standard Test Method for Fire Tests of Through-Penetration Firestops*. Both are virtually identical in terms of scope and general requirements and as such are interchangeable. They are both equally accepted by major building and safety codes.

Ratings applicable to these test standards are F, T, W, and L.

Test Standards in Canada

The referenced test standard for firestop systems in Canada is CAN/ULC S-115, *Fire Tests of Firestop Systems*. The Canadian test standard is similar to the U.S. standards. The primary difference relates to plastic pipe testing. The Canadian standard requires a higher positive pressure differential for plastic pipe only. This does not relate to other penetrating items such as metal pipe or cable. When dealing with plastic pipes, it is important to verify that the product and listings reference Canadian testing requirements.

Ratings applicable to these test standards are F, FH, FT, and FTH. Some laboratories publish L and W ratings as well, although these are not included in CAN/ULC S-115.

Test Standards in Europe

European test standards vary from country to country. There is, however, a single, consensus standard for use in the EU. For purposes of this publication, the focus will be on the three most commonly referenced standards:

- BS 476-20 (United Kingdom)
- BS EN 1366-3 (parts of the EU)
- DIN 4102-9 (Germany)

Other test methods may exist in individual European nations. Most will be similar to one or more of the referenced test methods. Verify with the product manufacturer to determine compliance.

Ratings applicable to these standards are shown in Table 7.2.

Table 7.2
European test standards

Standard	Title	Ratings Established	Hose Stream Required	Pressure	What it Evaluates
BS 476-20	Method for Determination of the Fire Resistance of Elements of Construction (General Principles)	E and I	No	20 Pa (0.08 in WC)	Cable penetration firestop systems
DIN 4102-9	Fire Behavior of Building Materials and Elements; Seals for Cable Penetrations; Concepts, Requirements and Testing	S (S = T + F ratings)	No	10 ± 2 Pa (0.04 in WC ± 0.008 in WC)	Seals for cable penetrations
BS EN 1366-3	Fire Resistance Tests for Service Installation—Penetration Seals	E and I	No	20 Pa (0.08 in WC) for a large penetration	Cable penetration firestop systems

BS = British Standard
DIN = Deutsches Institut für Normung
EN = European norm
WC = Water column

Ratings Derived from Firestop Testing

Although there are different test standards referenced in different parts of the world and those test requirements may vary in terms of conditions for acceptance or conduct of the test, all test standards provide ratings that are used to select appropriate systems and ensure code compliance. Table 7.3 identifies rating classifications, correlates them to specific standards, and provides definitions of the ratings.

Table 7.3
Rating classifications, standards, and definitions

Rating Classification	Referenced Standards	Definition
F	ASTM E814, UL 1479, CAN/ULC S115	Time period (expressed in hours) that assembly resists flame passage; ASTM E814 and UL 1479 include a hose stream while CAN/ULC S115 does not
T	ASTM E814, UL 1479	Time by which unexposed (non-fireside) of assembly reaches 181 °C (358 °F) over the initial starting temperature
FH	CAN/ULC S115	Same definition as an F rating, but requires the hose stream
FT	CAN/ULC S115	Same as the T rating definition
FTH	CAN/ULC S115	Combination of FH and FT ratings for Canada
L	UL 1479	Air leakage test run at ambient and elevated temperatures 204 °C (400 °F) to simulate smoke leakage through firestop systems
W	UL 1479	Water leakage test where firestop system is subjected to an ≈0.91 m (3 ft) water column for a period of 72 hours
S	DIN 4102	Combines the F and T ratings
E	BS 476 Part 20 and EN 1366	Similar to F rating
I	BS 476 Part 20 and EN 1366	Similar to T rating

ASTM = ASTM International
BS = British Standard
CAN/ULC = Canadian/Underwriters Laboratories of Canada
DIN = Deutsches Institut für Normung
EN = European Norm
NFPA = National Fire Protection Association
UL = Underwriters Laboratories, Inc.

Ratings Derived from Firestop Testing, continued

Basic Execution of a Fire Test

Although the ratings vary from test to test, and often country to country, the basic execution of the test is similar. A test assembly is positioned either on top of a furnace (i.e., floor or floor/ceiling) or on the front of a furnace (i.e., wall or partition) and subjected to fire exposure for a specific time period. The temperature is controlled according to a specific time/temperature curve to verify that the systems are tested consistently.

Temperature sensing equipment is used to measure heat transfer through the assembly, the penetrant, and the firestop materials. The fire exposure test is run at positive pressure. The positive pressure differential varies from country to country. The basic PASS/FAIL criterion is to determine whether the system prevents the occurrence of flaming on the unexposed side. For variations of T ratings described in Table 7.3, temperature limitations are placed on the tested configurations. In the U.S. (and when required in Canada), the assembly is removed directly after fire exposure and subjected to a water hose stream test.

Hose Stream Test

The hose stream test is required by U.S. referenced standards and is optional in many other standards used abroad. It is run within 10 minutes of removing the assembly from the furnace fire. A stream of water is discharged from a nominal ≈64 mm (2.50 in) diameter hose fitted with an ≈29 mm (1.125 in) nozzle from a distance of ≈6.1 m (20 ft) from the assembly.

The hose stream pressure and duration are determined by the hourly rating period tested. For three hours and below, the pressure is ≈207 kPa (30 psi) and the duration is 1.5 s/ft^2. For four hours and above, the pressure is ≈310 kPa (45 psi) and the duration is 3.0 s/ft^2. The hose is directed at the assembly and traverses side to side and up and down. To successfully pass a hose stream test, water shall not be observed as passing through to the unexposed side of the assembly at the conclusion of the test.

While other standards intended for use in Europe and Canada may not mandate a hose stream, ASTM E2226, *Standard Practice for Application of Hose Stream*, is a test standard that describes application of the hose stream after a standard fire test. Designers, installers, and regulators can use that document as a reference should they wish to go beyond mandated minimum requirements.

Air Leakage Tests for L Ratings

Air leakage testing is optional and can be done to evaluate the ability of a system to control airflow. It can be useful for many sealing situations such as restricting the spread of particulate dust or in environments such as health care facilities where sealing openings can prevent the spread of airborne, communicable diseases.

The most common use for the L rating is as a predictor of smoke movement in buildings. The test is run in ambient conditions (i.e., room temperature) as well as 204 °C (400 °F). These ratings simulate cold smoke (i.e., smoke away from the fire source) and hot smoke (i.e., smoke near the fire source). Generally, the L ratings improve at 204 °C (400 °F) since intumescent firestop materials begin to expand, and in the case of certain polymeric materials (e.g., plastic jacketed cables), the plastic begins to swell up, thereby reducing void areas within bundled penetrants. Because this is an optional test, not every system carries an L rating.

Ratings Derived from Firestop Testing, continued

Most firestop materials do an exceptional job of sealing openings and will register as having virtually no leakage when installed into empty or blank openings. Most of the air leakage occurs around the penetrating items and within grouped penetrating items. Both cable bundles and cable trays will always leak more than rigid, non-porous penetrants (e.g., metal or plastic conduits). The air leakage in grouped cable applications is within the interstitial space between cables within the bundle.

L ratings are reported in either cubic feet per minute or cubic feet per minute per square foot of opening. The former is actual air leakage; the latter is an area-adjusted leakage value. Systems that report actual leakage are far easier to interpret and understand. Systems that report the area-adjusted value can be problematic since increasing the opening size artificially lowers the reported value. A cable bundle sealed with either firestop sealant or putty is a perfect example. Since establishing that virtually no leakage occurs within a sealant or putty membrane and that all leakage occurs within the interstitial space in the cable bundle, the size of the opening does not matter; the air leakage is always going to be the same.

A cable bundle installed in an ≈100 mm (3.94 in) opening that registers actual leakage of 2 cfm has the same actual leakage as the same size bundle installed in an ≈300 mm (11.81 in) opening. When the value is adjusted based on the area of the opening, the reported values are different. If the area of an ≈100 mm (3.94 in) opening is 0.09 ft^2, the area adjusted L rating is 22 cfm/ft^2. If the area of an ≈300 mm (11.81 in) opening is 0.79 ft^2, the area adjusted L rating is 2.5 cfm/ft^2. For this reason, ICT designers, installers, and regulators should favor systems that list actual leakage versus systems that report the area-adjusted leakage ratings.

W Ratings

The W rating criteria was established to address concerns where water stands on top of a firestop seal for a prolonged period of time. The test consists of subjecting the seal to ≈0.91 m (3 ft) of water for a period of 72 hours. The water in the test vessel is dyed with ink, and paper targets are laid beneath the assembly to provide evidence of any water leakage. At the conclusion of the test, a successful firestop system will earn a Class 1 W rating.

NOTE: W ratings are not a measure of early rain resistance. They are primarily intended for situations where a firestop seal has the potential to be subjected to pooled water, such as in an area where wash down will occur or near plumbing pipes that could potentially break or leak.

T Ratings

Temperature ratings, regardless of what the individual test method calls them (e.g., S rating, FT rating, FTH rating, I rating), will be referred to as T ratings. The T rating is sometimes the most misunderstood rating. T ratings (or variations of T ratings) are included in virtually all test standards. The T rating is a measure of thermal conductivity within a firestop system.

As part of a fire test, thermocouples are placed along the unexposed (non-fire) surface of the assembly to measure heat transmitted through the assembly, the firestop materials, and the penetrating item. Once a single thermocouple rises above the limiting temperature established, the T rating is reached. In certain test standards where the temperature rise is as equally important as flame passage, it can lead to test termination. Table 7.4 lists the limiting temperature for each test standard.

Ratings Derived from Firestop Testing, continued

Table 7.4
Limiting temperature for each test standard

Test Method	Limiting Temperature
ASTM E814 (UL 1479)	181 °C (358 °F) above initial starting temperature
CAN/ULC S115	181 °C (358 °F) above initial starting temperature
BS 476 Part 20	180 °C (356 °F) above initial starting temperature
EN 1366	180 °C (356 °F) above initial starting temperature
DIN 4102	180 °C (356 °F) above initial starting temperature

ASTM = ASTM International
BS = British Standard
CAN/ULC = Canadian/Underwriters Laboratories of Canada
DIN = Deutsches Institut für Normung
EN = European Norm

The T rating is expressed in minutes or hours. Since it is a measure of thermal conductivity, several things impact how a system will attain a T rating. The type and thickness of a barrier can contribute to better temperature resistance (i.e., thicker concrete floors or walls prevent more heat from being transferred). Additionally, the type of penetrating item can greatly affect the T rating. Most plastic conduits or innerducts have no trouble attaining higher T ratings (e.g., equal to the F rating) due to their nonconductive nature, while steel conduits and copper conductor cables may have weaker T ratings since metals are conductive. Simple physics dictates that certain items, like larger steel conduits or large bundles of copper conductor cables, are going to get hot. Additional steps may be necessary to achieve higher T ratings.

Local building and safety codes dictate whether or not T ratings are required. In certain countries or jurisdictions, there may be exceptions to requiring T ratings such as for penetrants contained in the cavity of walls or for penetrants not in direct contact with combustible material.

Systems and Tests

Most building and safety codes require firestop systems to be tested. In the U.S. and Canada, most firestop systems are tested at third-party listing and labeling laboratories or approval agencies. In Europe, there are many independent laboratories that may test assemblies and issue test reports or certifications.

The advantage to third-party listing and labeling laboratories or agencies is that most often products are required to comply with a quality assurance program informally referred to as follow-up services. With a follow-up service program, the laboratory verifies the ongoing quality of the products and conformance to the originally tested formulation or, in the case of firestop devices, the original construction.

The methodology for evaluating this over time is random unannounced inspections at the factory level. The idea is to prevent an entity from testing a particular configuration or formulation that meets the criteria and then substituting ingredients or elements into the product that have not been evaluated.

To assure that a product and firestop system is listed and labeled for firestop purposes, look for a mark or marking on the product or product packaging. The official mark will be prominently displayed and should indicate that it is listed as a firestop product or firestop device. There are several third-party agencies in the U.S. and Canada that offer such services (e.g., UL, Intertek Testing Services, Factory Mutual Approvals, UL of Canada). All of the agencies offer searchable online databases of listed firestop systems. Most of these databases are offered free of charge and represent the most up-to-date information, since the websites are continually updated as new certifications are established.

Guidelines for Membrane Penetration Firestops

A membrane penetration is made when a pipe, conduit, cable, or other service element breeches a single side or membrane of a fire-resistive barrier (e.g., single side of a framed wall/stud wall assembly, ceiling component of a floor/ceiling assembly). Many building and safety codes provide guidelines relating to membrane penetrations.

Some AHJs require the membrane penetration to be treated as one-half of a through-penetration firestop system. Other AHJs may require additional build-up of the wall opposite the membrane penetration. It is important to consult with the local AHJ to determine the sealing requirements.

Evaluation of Firestop Systems

Firestops are:

- Specific combinations of materials installed and (possibly) supported or anchored in a certain way.
- Qualified by independent agencies based on the material's performance when tested in a particular configuration.

NOTE: The characteristics of a noncombustible material do not qualify that material as a firestop. Only the products that have been tested to applicable fire test standards for through-penetration firestops and met the conditions of compliance may be qualified as a firestop.

Evaluation of Firestop Systems, continued

It is not possible to test every firestop arrangement. Many test assemblies are based on testing the worst case in a number of variables. This worst-case configuration may extend to less severe configurations. Therefore, engineering judgment should be exercised in selecting a suitable firestop system for a particular application.

Qualification Testing for Field Conditions

Qualification testing of firestop systems provides evidence of the system's performance across the range of conditions known or expected to exist for any sealing situation.

A firestop system shall:

- Be tested in:
  - Sleeve systems (e.g., if sleeve systems are used to form the opening).
  - Construction that is representative of the barrier into which the firestop system is installed (e.g., two-hour rated framed wall construction, three-hour rated poured concrete construction).
- Demonstrate the ability to perform despite the mass of:
  - Thermal-conducting elements expected to penetrate openings.
  - Combustible or degradable material likely to penetrate openings (e.g., heavily loaded cable tray containing PVC-jacketed cable bundles).

Qualification Testing for Openings

Qualification testing of firestop systems provides evidence of performance across the full range of opening configurations.

A firestop system shall be qualified for use in walls and floors according to its intended use to include the type of penetrating items. Roof penetrations must be weatherproof, and floor penetrations should be installed to prevent down flooding.

Other Qualification Information

Additional testing may be required to confirm that the firestop can perform other functions, including:

- Accommodating the pipe movement without violating the integrity of the seal.
- Providing protection against pressure or flooding.
- Providing environmental protection.
- Special requirements (e.g., EMI/EMP barrier).
- Reducing sound transmission between compartments.
- Resisting the effects of explosion.

Types of Firestop Systems

Overview

Firestop systems can be divided into two broad categories:

- Mechanical
- Non-mechanical

A mechanical firestop system is described as a product that is furnished in its final form to the project site. A non-mechanical firestop is generally a product that is assembled or installed in a precise manner to achieve a particular fire rating. Some products can be classified as mechanical but may in fact integrate a product that is traditionally considered non-mechanical.

Mechanical Firestop Systems

Several types of mechanical systems have been developed and marketed. Common categories include:

- Cable transit systems.
- Fire-rated pathway devices.
- Factory-fabricated sleeve systems.

Cable Transit Systems

Cable transit systems consist of pre-manufactured elastomeric components shaped to fit around standard cables, tubes, conduits, and waveguides (e.g., elliptical, rectangular).

The elastomeric modules are:

- Fitted around penetrating elements.
- Arrayed within a frame (see Figure 7.2).