FIRESTOPPING IN BUILDINGS

FIRESTOPPING IN BUILDINGS

Author(s) – Kamalika Kundu and Joanna Marie Gatus
Cover Design and Type Setting – Stephanie Castaneda

Web address : ask.hilti.com.sg

Correspondence address :
Hilti Philippines Inc.
9/F Robinsons Cyberscape Beta
(bet) Ruby and Topaz Road,
Ortigas Center
1605 Pasig City
Philippines

CIN: AS96004941
Toll Free : 1-800-10-87847100 customerservice.ph@hilti.com
www.hilti.com.ph

Registered Office : 9/F Robinsons Cyberscape Beta, Ortigas Center, Pasig City, Philippines

The information contained in this document is believed to be accurate; however, it is being provided for informational purpose only and is intended for use as a guide. The contents of this book are based on author's interpretation of international and national standards available on the subject. If such advice is required, it should be sought through the services of registered professional engineer, licensed attorney or other professional. All standards, product approvals whether given herein or cross-referred, are subject to revision. Please refer to the most recent editions for your design.

No responsibility is assumed for any injury and/or damage due to use of content in this book. Publication of this document by Hilti Philippines should not be construed as the publishers engaging in or rendering engineering, legal or other professional services. The authors and publishers have tried to trace the copyright holders of reproduced materials in this publication and apologize to copyright holders if consent to publish in this form has not been found. If any copyright material has not been recognized, then please write to us and let us know so that we may correct in any future reprint. The reference list is included towards end of the book.

Image Credits: Hilti and Internet Resources
Engineering Judgement: Hilti EPMO
ISBN: 978-621-8167-37-7
Published and Printed by:

REX PRINTING COMPANY, INC.
Typography & Creative Lithography
84 P. Florentino St., Quezon City
Tel. No. 8857-77-77

TABLE OF CONTENTS

FOREWORD

In Hilti, we believe that making construction better in terms of safety is not just a corporate responsibility but one of our main purposes for being part of the industry. We dedicate our resources not only to provide best-in-class solutions, but also to enable a society to strive in an environment where their safety is of the highest priority. Firestopping is one of the aspects of the Philippine construction industry where we can contribute with our global experience and expertise. Our goal is simply to help elevate how practicing professionals plan and execute firestopping solutions, which in turn contributes to saving lives, protecting assets, and improving building performance.

This “Firestopping in Buildings” book is the first in the country which focuses on the topic of Passive Fire Protection. In support of existing local codes, this book will provide in-depth information on the concept of firestopping – building applications, standards for performance assessment, and criteria for selection, installation, and inspection. This will serve as a very useful resource for firestopping professionals and enthusiasts as it will provide relevant materials on passive fire protection for the whole life cycle of a building (i.e., from planning and design to construction and maintenance).

We would like to thank our Hilti global organization, our industry partners, and our select government bodies for helping to make this book possible. This is an achievement born from our joint passion on making the buildings in the Philippines as safe as it can be.

Ann Lim
General Manager
Hilti Philippines, Inc.

PREFACE

Modern construction practices have enabled creation of beautiful, tall and functional buildings. Central heating and cooling are just one example of amenities that modern apartments, malls and hotels come equipped with. To stand out amongst the crowd, most buildings also make use of unique façade. These new features of the building have made the task of ensuring fire safety even more daunting.

The ever-increasing vertical landscape, need for mixed occupancy buildings, crowded roads, faulty water supply, lapse in alarm or active systems, etc. have only added to this problem. Just relying on one form of safety mechanism is no longer enough. The fire safety problem must be dealt holistically. Awareness, prevention strategy, planning & design, alarm & monitoring, active fire protection, passive fire protection as well as firefighting set up are all equally important.

This book focusses on firestopping, which is a type of passive fire protection. This book is aimed at practicing consultants, students, academicians, and others in the construction industry involved with selecting, designing, installing, maintaining and inspecting firestop with the purpose of introducing the fundamentals of firestopping. The book introduces the concept of firestopping, the applications, the available standards for performance assessment, selection criteria, installation and inspection criteria.

Republic of the Philippines
Department of the Interior and Local Government
BUREAU OF FIRE PROTECTION
NATIONAL HEADQUARTERS
Agham Road, Barangay Bagong Pag-asa, Quezon City

MESSAGE

The Bureau of Fire Protection is thankful for our partners in fire safety education and commends the effort of **HILTI Philippines** in putting together this **book "Firestopping in Buildings".** The agency is grateful for all the efforts to prevent and mitigate destructive fires especially amidst the rise of new buildings and modern facilities.

While the Republic Act 9514 otherwise known as the Fire Code of the Philippines and its Revised Implementing Rules and Regulations remain as the gold standard in fire safety, may this publication serve as additional guide for our practitioners and safety professionals in ensuring safer buildings for all.

DIRECTOR LOUIE S PURACAN, CEO VI
Chief, BFP

PHILIPPINE INTEGRATED FIRE PROTECTION ORGANIZATION
Block 17 Lot 17 Celina Homes 2 Brgy. 168 Deparo Road
Caloocan City, Philippines

MESSAGE

This handbook from HILTI Philippines is your quick guide to ensure that spread of fire and smoke is compartmentalized from source by ensuring fire stops are in place on the areas unseen in your building.

Improper material, installation and maintenance to your passive fire protection system will put your property at risk of damage and loss of life during fire incidents.

MAKE YOUR PASSIVE FIRE PROTECTION SYSTEM RISK FREE WITH PROPER FIRE STOPPING.

Archt. Roland James B. Arimado, UAP, LEED AP BD+C, NFPA, PIFPO
Philippine Integrated Fire Protection Organization
Member - National Board of Trustees
Passive Fire Protection Committee - Chairman

MESSAGE FROM UL SOLUTIONS

Model building, fire and life safety Codes have many requirements relating to firestop systems. Knowledge of and competency in these requirements are essential for building safety stakeholders, including design professionals, plan reviewers, contractors, code authorities, third-party inspectors, and building owners and managers.

Proactive approaches for code-compliant construction and building maintenance play an essential role in occupant safety. Best practices such as preconstruction meetings in which a design team, contractors, installers, building officials, and other stakeholders identify areas of concern and collaborate on potential solutions also play an important part. Utilizing qualified contractors to install firestop systems following the joints and penetrations made in fire-resistance-rated construction by electricians, plumbers or other construction trades is also paramount to a compliant final inspection that avoids unnecessary delays and costs.

Requiring firestop systems to be correctly specified and documented, installed by competent contractors and properly inspected to determine code compliance is essential for a building's passive fire protection to meet or exceed the required minimum level of safety for building occupants.

Using installers without specific firestop installation training or experience may lead to an increased failure rate of fire-stopped penetrations during the code compliance inspection, causing delays, cost overruns or, worse yet, failure during a fire event.

Although these programs and practices can prove challenging to implement, many municipalities have experienced the benefits. It may require some upfront time and effort to initiate these best practices, but once started, they are easy to maintain at a relatively low cost throughout the life of a building. These comprehensive programs and best practices provide confidence that the critical line of defense created by a balance of passive and active fire protection meets code requirements for installation, inspection and maintenance through the useful life of a building.

Underwriters Laboratories

Underwriters Laboratories

ABOUT THE AUTHORS

Engr. Kamalika Kundu is a technical expert on firestopping and post-installed fastenings. She is currently working as Regional Codes and Approval Manager at Hilti Asia Pacific Pvt. Ltd. located in Singapore and is responsible for markets like India, Australia, New Zealand, Malaysia, Singapore etc. in South Asia Pacific region. Prior to this, she has worked in various roles in Hilti in U.S.A and in India that involved product testing related to quality, development and approvals, product assessment, R&D collaboration with universities, collaboration with associations for awareness, supporting standardization initiatives and technical competence development of Engineering team.

She has been associated with this field for over a decade. She is a Civil Engineer with Bachelors degree from Malaviya National Institute of Technology (M.N.I.T.), Jaipur, India and Masters (specialization in seismic) from Virginia Tech, Blacksburg, USA.

She has served as committee member of Bureau of Indian Standards as well as ASTM committee. She is currently a part of Governing Council of Indian Concrete Institute (ICI) and also actively participates in activities of other engineering associations. She has published and presented in several international and national publications and forums. She has also delivered technical lectures in universities.

Engr. Joanna-Marie Solomon Gatus is a technical expert on firestopping and post-installed fastenings. She is currently working as Codes and Approval Manager at Hilti Philippines Inc. Prior to this, she has worked in various roles in Hilti related to design, product assessment and launch, collaboration with associations and government institutions for awareness, supporting standardization initiatives and technical competence development of both Sales and Engineering team.

She worked as Instructor in the Department of Civil Engineering, Faculty of Engineering at University of Santo Tomas (UST) and taught courses in Construction Materials, Testing of Materials, Matrix Theory of Structures, Concrete, and Steel Design. She worked as Site Engineer in Aldar Head Quarters, Abu Dhabi, and practiced construction management for various projects in the Philippines such as the University of Santo Tomas Hospital and Electronics Product Development Center of Department of Science and Technology Institute. She is a professional Civil Engineer with Bachelors degree from UST in Manila, Philippines and pursuing her Masters degree (specialization in Structural Engineering) from Technological University of the Philippines in Manila, Philippines.

She is a member of ACI Philippines Chapter (ACI PH) and Association of Structural Engineers of the Philippines (ASEP), and actively participates in activities of local code bodies and engineering associations such as ASEP, Integrated Institute of Electrical Engineers in the Phils. (IIEE), Philippine Integrated Fire Protection Organization (PIFPO), etc. She has published and presented in several international and national publications, forums, and delivered technical lectures in universities.

ACKNOWLEDGEMENT

Authors are grateful for the support from Hilti Philippines in bringing out this technical book. Firstly, authors would like to thank Ann Lim, GM of Hilti Philippines and Alim Hirani, Region Head, Hilti Asia Pacific Pte, for providing this opportunity. This publication would not have been possible without financial support from Hilti Philippines. Authors would like to thank Underwriter Laboratories (UL), Bureau of Fire Protection of the Philippines and Philippine Integrated Fire Protection Organization for their support and encouragement.

Authors are also grateful to their colleagues who provided them with many valuable suggestions concerning the topics covered in this book. Authors would like to thank Richmond Olaya, Pichaya Sa-Ardjit, Jonnie Cruz, Fitzgerald Padilla and Nicolas Roland. This publication would not have been possible without their support and contribution. Lastly, Authors would like to thank their publisher for designing and printing this book.

CHAPTER 1: IMPORTANCE OF FIRE SAFETY

1.1. INTRODUCTION TO FIRE SCIENCES

Before embarking on the journey to understand firestopping, it is important to first get acquainted with what is fire, what causes it and how it spreads. Fire is the visible effect of chemical reaction known as combustion.

Combustion is an exothermic redox reaction between a fuel and an oxidant. It is important to note that combustion does not always result in fire. This is because flame is only visible when the fuel or the substance undergoing combustion vaporizes. The heat from the flame, if provides enough energy, can make the reaction self-sustaining.

In summary, for fire to sustain and spread it needs fuel, oxygen, heat and chemical reaction. These four variables form the fire tetrahedron (see Figure 1.1). If the combustion process remains unchecked, even a small fire could spread and consume the whole building. Therefore, fire control and extinguishing measures rely on controlling one or all of the variable of the fire tetrahedron. Smoke is another visible effect

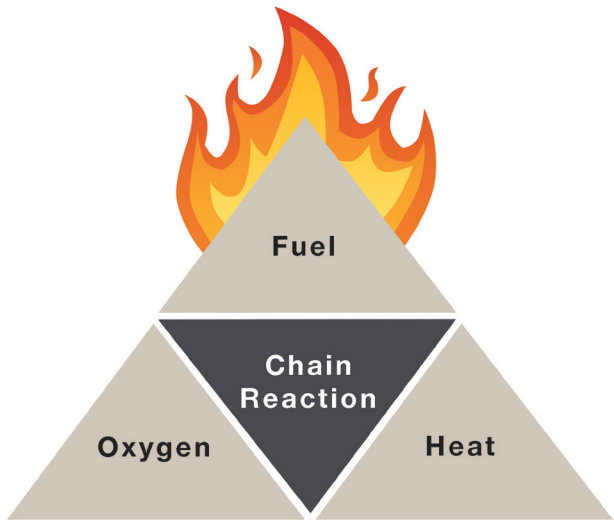


Figure 1.1 Fire tetrahedron

of combustion, which is produced due to incomplete combustion, i.e., when enough oxygen is not available to burn up all the substances or fuel. Smoke spreads much faster than fire if not contained. In fact, it is the leading cause of death in most fire accidents in buildings [1].

In the following section, we will look at some of the fire accidents in buildings that happened in Philippines and other parts of the world in the last few years.

1.2. FIRE ACCIDENTS AND THEIR CAUSES

According to CITF's (International Association of Fire and Rescue Service) World Fire Statistics report by Center of fire statistics, fire accidents kill on an average over 400 people every year in Philippines, earning it a spot in list of countries with more than 200 deaths per year due to fire [2]. In most developing countries around the world, this picture looks very grim. In addition to loss of life, it leads to huge financial losses and business interruptions. Below are some examples of devastating fire accidents that happened in Philippines and other parts of the world.

Fire at the Waterfront Manila Pavilion, Philippines – On 18th March 2018, a fire broke out in a hotel in Manila. The fire started on 21st floor of the hotel in early hours of morning and continued to rage for 9 hours. The fire soon spread to lower floors, leading to extensive damage. Figure 1.2 provides a glimpse of the havoc caused due to this fire. The meticulous efforts of the fire fighters helped to rescue over 300 hotel guests. Unfortunately, six people lost their lives and 23 people were injured. The cause of fire is still under investigation [3].

Fire at UP Dilman Campus, Metro Manila, Philippines – A fire broke out at University of Philippines Dilman Campus located in Quezon city on 1st April 2016 (see Figure 1.3). Fire started on the 3rd floor and then spread to the lower floors. Fortunately, the 20 fire trucks were rushed to the accident immediately, helped to control the fire. The fire still managed to destroy three buildings, reaching the eighth level alarm. No deaths were reported but a fireman was injured during the rescue operation. The structural damage cost was pegged

at approximately 3 million pesos. The cause of fire is still under investigation [5].

Figure 1.2 Fire at the Waterfront Manila Pavilion, Philippines [4]

Figure 1.3 Fire at University of Philippines Dilman Campus [5]

Figure 1.2 Photo taken by Ted Aljibe of Agence France-Presse
Figure 1.3 Photo taken by Yumi Lugod of CNN Philippines

Glasgow School of Art Fire, Scotland – In 2014, a fire outbreak in this beautiful historic building gutted its renowned library and caused extensive damage (see Figure 1.4). At that time, the building was not equipped with sprinklers to combat fire. Thus, the fire quickly spread unabated through flammable and antiquated ducting system. The fire was caused due to heat from a projector which ignited gases from a foam canister [6].

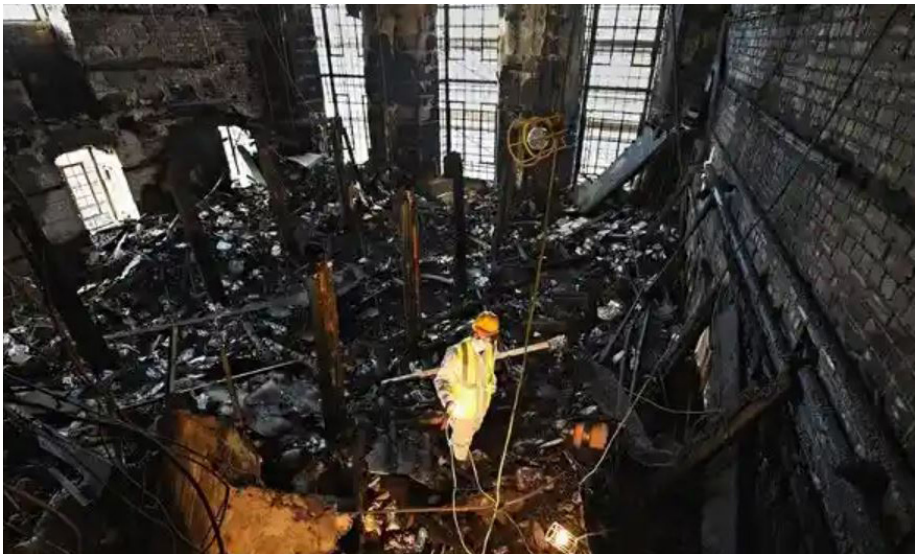


Figure 1.4 Fire at Glasgow School of Art in Scotland [7]

There is a common theme in all the above accidents. The fire started on one floor and quickly spread to the other floors. The rapid spread of smoke reduced visibility and trapped people. This rapid spread of smoke and fire also made it difficult for our fire fighters to carry out the rescue operations. If the buildings are properly compartmented along with right firestopping systems, the spread of fire and smoke can be controlled, providing more time for evacuation and rescue operations.

Figure 1.4 Photo taken by Jeff J Mitchell of Getty Images

1.3. FIRE PROTECTION IN BUILDINGS

There are several aspects that need to be considered when it comes to ensuring fire protection in buildings. The first and most important one is awareness. By educating the masses about the most common causes of fire and preparing them for an actual “fire accident”, we can not only reduce occurrence of such incidents but also reduce casualties in event of such incidents. The fire departments usually carry out mock fire drills as well as awareness drives to this effect. In fact, Bureau of Fire Protection (BFP) celebrates fire prevention month every year in March. During this month they organize programs on fire safety awareness which aims to reduce fire incidents in the country.

The next important piece to ensure fire protection is proper planning and design of the building. During this stage, aspects like the access to the building, egress system, building construction material, detection systems, monitoring systems, alerting systems, active as well as passive fire protection systems are considered. Figure 1.5 illustrates some of the key elements of fire protection.

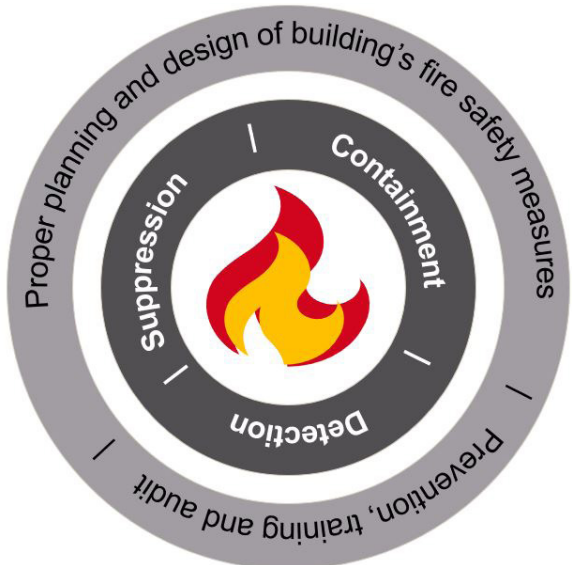
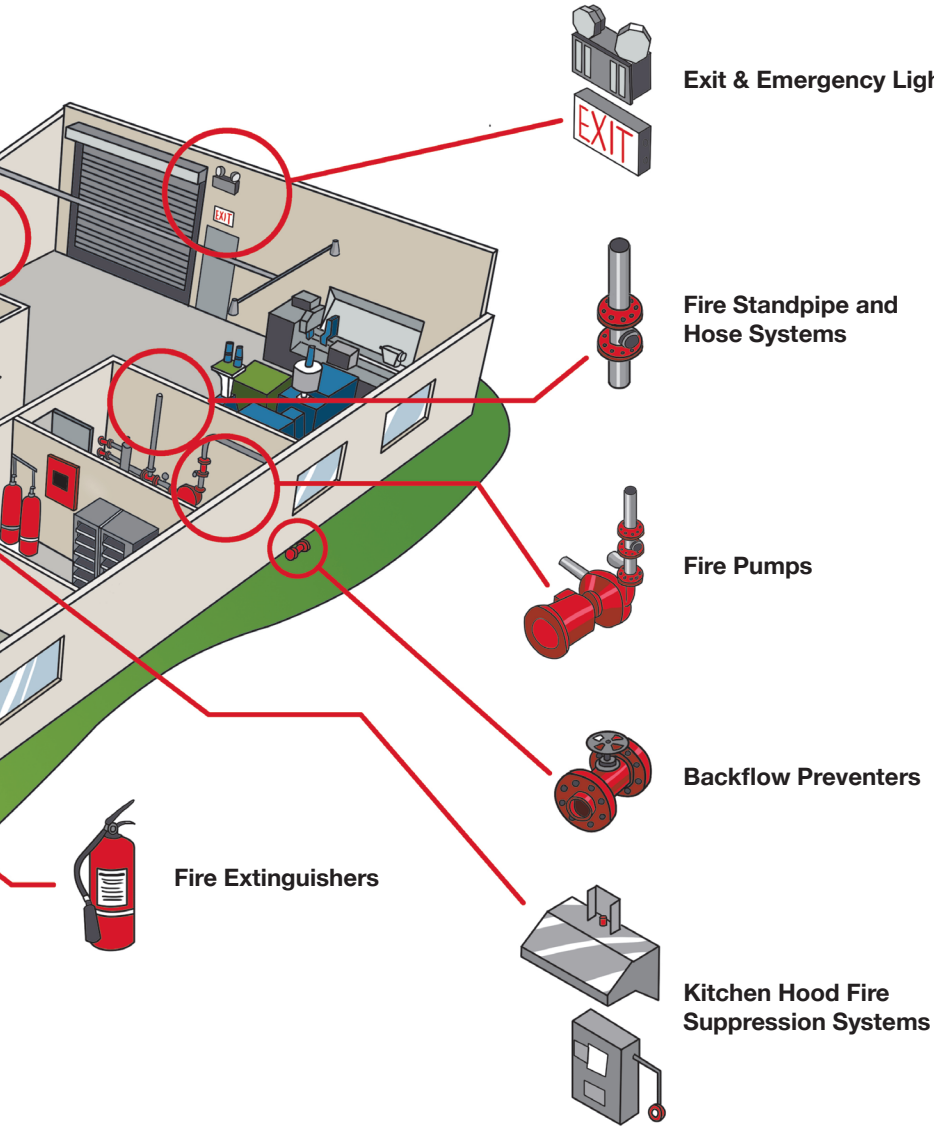


Figure 1.5 Elements of fire protection

Figure 1.6 Active fire protection systems


EXIT
Exit & Emergency Lights
Fire Standpipe and Hose Systems
Fire Pumps
Backflow Preventers
Fire Extinguishers
Kitchen Hood Fire Suppression Systems

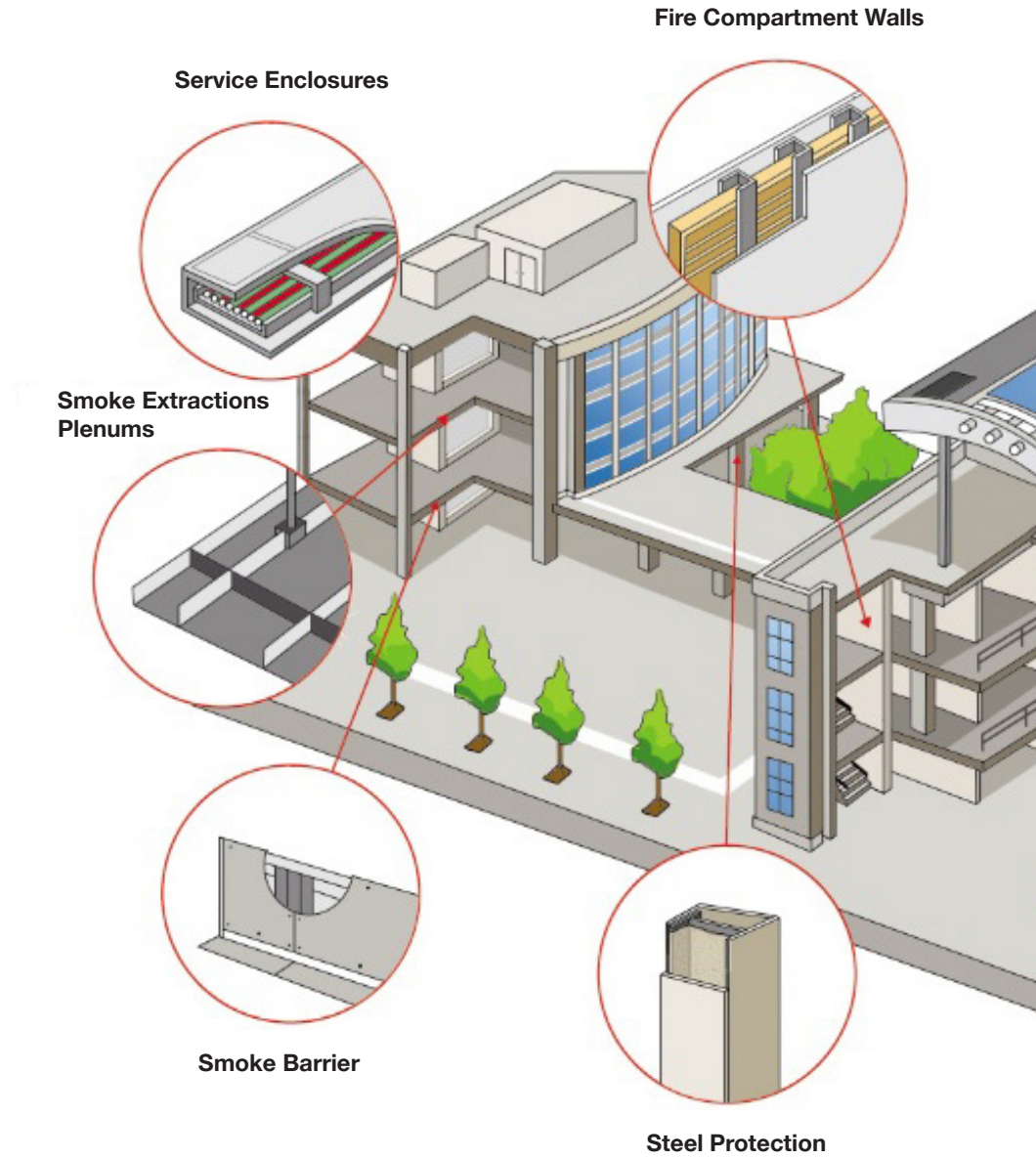
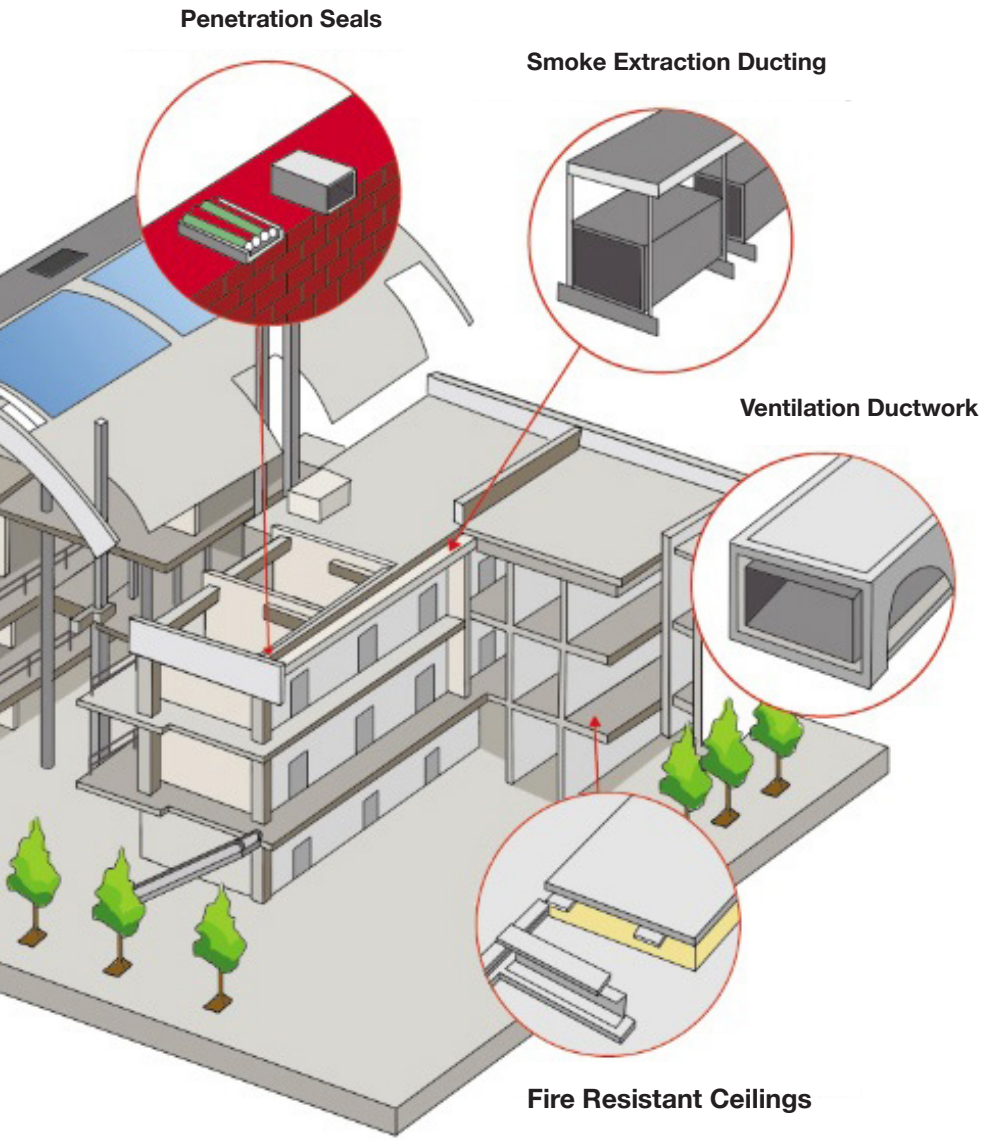


Figure 1.7 Passive fire protection systems


Penetration Seals
Smoke Extraction Ducting
Ventilation Ductwork
Fire Resistant Ceilings

Most people are familiar with active fire protection systems like sprinklers, fire extinguishers etc (see Figure 1.6). The term “Active” fire protection system implies that some type of “action” is taking place to prevent fire from spreading. It could be manual like “use of fire extinguisher by a person”, or automatic like “a sprinkler system”. These systems require activation.

Passive systems like fire doors, dampers, partition walls etc are also known to many as they are prominent and visible around us (see Figure 1.7). However, most people may not be familiar with firestopping, as they are usually hidden. We will focus on firestopping in this book. The term “Passive” fire protection system implies that passive or stationary materials are in place to contain the fire and prevent its spread. Fire retardant construction materials and fire-resistant coatings can also be categorized in this bucket. These systems, though known as passive, are always at work.

The last piece of fire protection in buildings is proper execution and maintenance. We all know that no matter how great our design is, if poorly executed at job site, it is useless. The building should be constructed as planned and equipped with various fire protection measures. Some of these systems may also require periodic inspection and repair.

In this book, we will focus on firestopping systems, which are a part of passive fire protection systems.

CHAPTER 2: FIRESTOPPING

2.1. CONCEPT

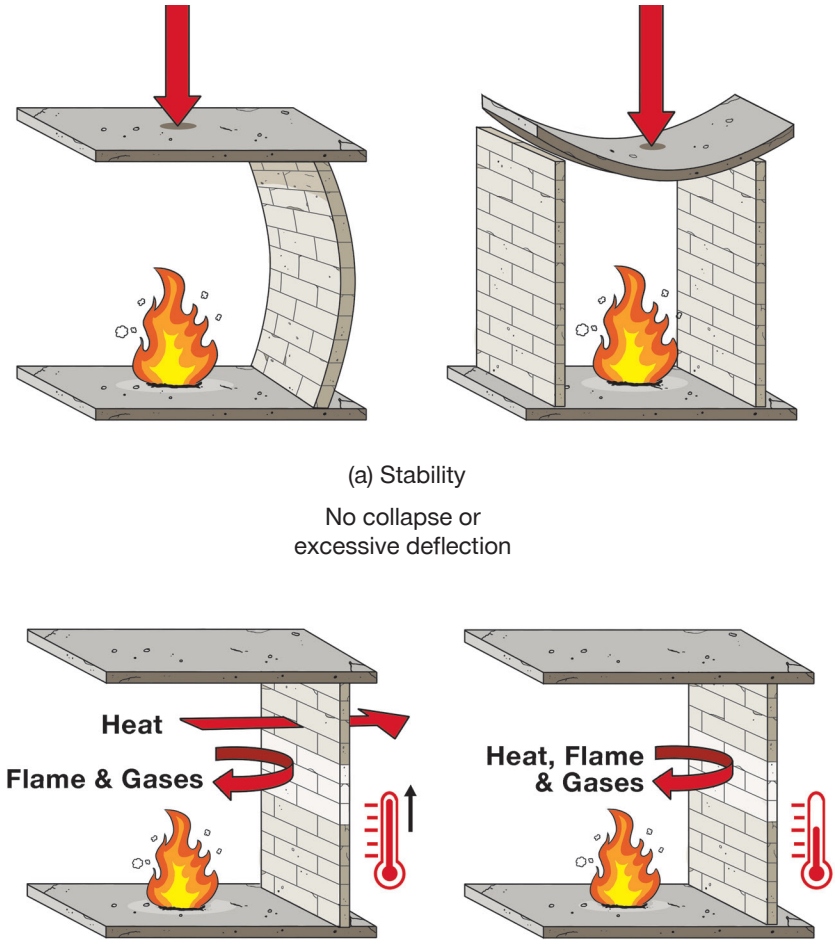
During any fire accident, time is of essence. From the time a fire is detected, to the time the authorities are alerted and activated, a small fire may turn into a catastrophic one.

As most of the cities are now plagued with overcrowded streets and traffic, it may take time for the fire fighters to reach the accident site, despite being alerted immediately. If the building is not equipped with passive fire protection measures and the active measures are unable to control the fire, then it can quickly spread and grow to an inferno by the time the rescue team reaches the site. Modern construction and interior finishing materials may add to this problem if flammable. A large fire is hard to control and makes the rescue operation riskier. The rising vertical nature of the city just adds another level of challenge to this problem. All these issues have helped passive fire protection gain prominence over the past decades.

Passive fire protection is based on the concept of impeding the spread of fire and/or smoke through compartmentation i.e., segmenting a large building or area into smaller compartments, as well other measures like retardants. The building can be compartmented vertically and/or horizontally. These compartments are equipped with fire-resistive boundaries and protected openings to contain fire for a specified period. This helps to slow down the spread of fire and “buy” time for evacuation of the occupants as well as to carry out rescue operations in a relatively safe environment. This system also provides an opportunity to control the fire before it turns into an inferno (by delaying its spread), thus helping to limit direct and indirect financial losses. It is important to note that passive fire protection systems are just one of the elements of fire protection and should be used in conjunction with other elements.

As mentioned earlier, these compartments are made of fire-resistive boundaries with protected openings. This is where firestopping systems come into picture. The fire-resistive boundaries that form the wall or floor of the compartment should be able to:

- **Maintain integrity**
- **Provided insulation to some degree,** and
- **Prevent collapse of the structure.**



(a) Stability

No collapse or
excessive deflection

(b) Integrity

No gaps

(c) Insulation

No excessive heat transfer

Figure 2.1 Illustration to explain integrity, insulation, and collapse prevention w.r.t fire-resistive boundaries

Often the openings in these fire-resistive boundaries are created to pass the utilities and services, resulting in loss of ability to fulfil the above three functions. Also, the joints between these boundaries need to be protected in order to achieve compartmentalization. Firestopping assemblies are used to protect these opening and joints to restore the rating of the boundary and/or compartment.

To better understand this concept let us first familiarize ourselves with the most commonly used terms associated with passive fire protection and firestopping.

- **Fire Compartment** – It is a space within a building that is enclosed by fire-resistant boundaries (walls or floors) on all sides. Division 6 of The Fire Code of The Philippines 2019 provides guidance on compartmentalization of buildings [8].

- **Fire Barriers** – Fire Barriers are interior fire-resistive partitions that are used to divide the space either horizontally or vertically for preventing the spread of fire. As per The Fire Code of The Philippines 2019, Fire Barriers are defined as follows:

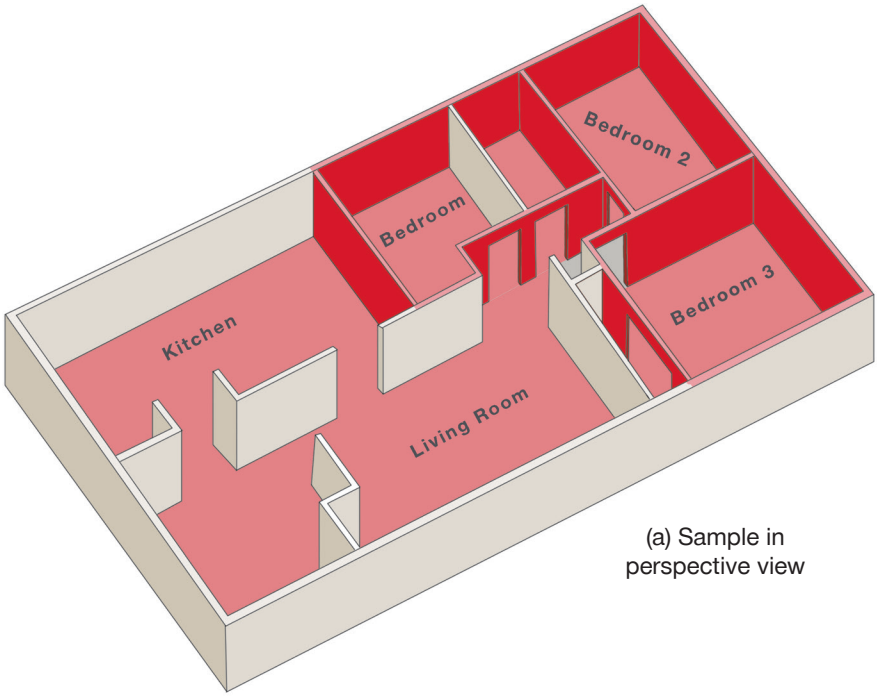
"A continuous membrane or a membrane with discontinuities created by protected openings with a specified fire protection rating, where such membrane is designed and constructed with a specified fire resistance rating to limit the spread of fire, that also restricts the movement of smoke [8]"

- **Fire-resistive rating** – As per Section 601 of National Building Code of Philippines 2005, fire-resistive rating is defined as follows:

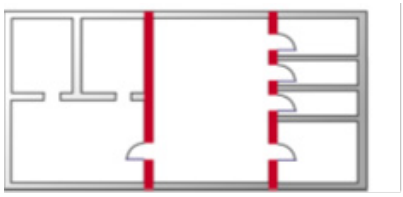
"Fire-resistive rating means the degree to which a material can withstand fire as determined by generally recognized and accepted testing methods [9]"

The Fire Code of the Philippines defines fire-resistive rating as follows:

"The duration that a material or construction can withstand the effect of a standard fire test [8]"



(a) Sample in perspective view



(b) Different floor plan sample in plan view

(c) Section view of Figure 2.2

Figure 2.2 Fire compartment and fire barriers

• **Firestop assembly** – These are tested systems which are used to restore the rating of fire barrier, and thereby the fire compartment, by sealing the breaches in the fire barriers as well as sealing linear and perimeter joints (see Figure 2.3). The Fire Code of The Philippines

Division 6 Section 10.2.6.5(F) provides guidance on firestopping. It is pertinent to note that firestop assembly is assigned a rating and not the firestop material; this is also recognized by the fire code. It defines Fire Protective Assembly as follows:

“An assembly incorporated in the structure designed to prevent the spread of fire, such as dampers, curtain boards, fire stoppers and the like [8]”

- **Annular space** – It is the gap between the penetrant and the surrounding base material of the fire barrier that it is breaching as illustrated in Figure 2.4.

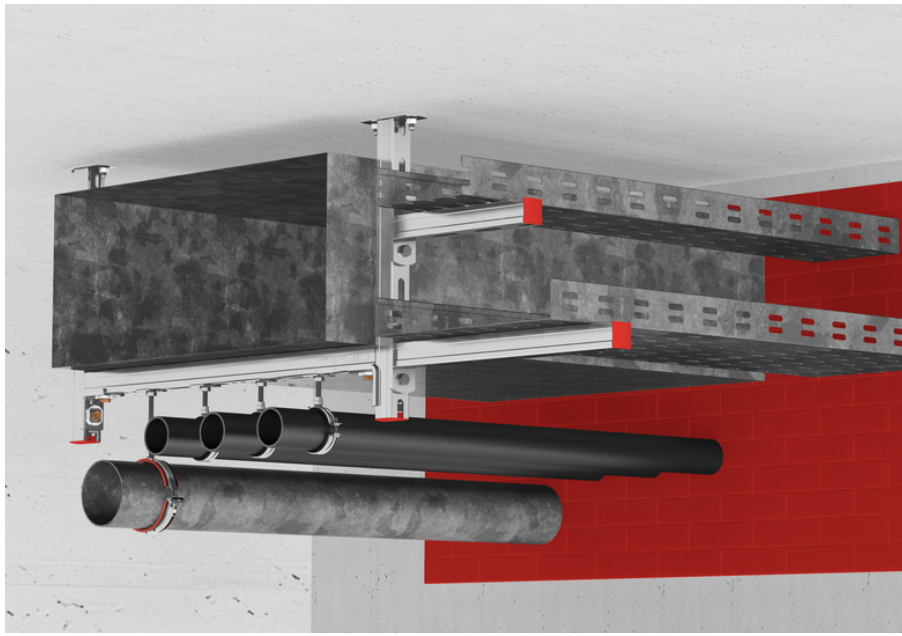
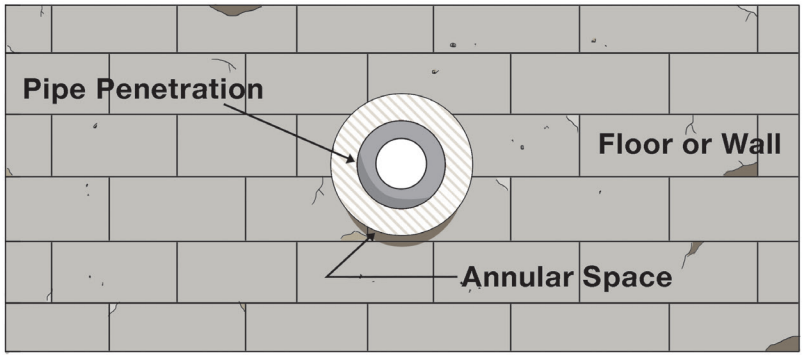
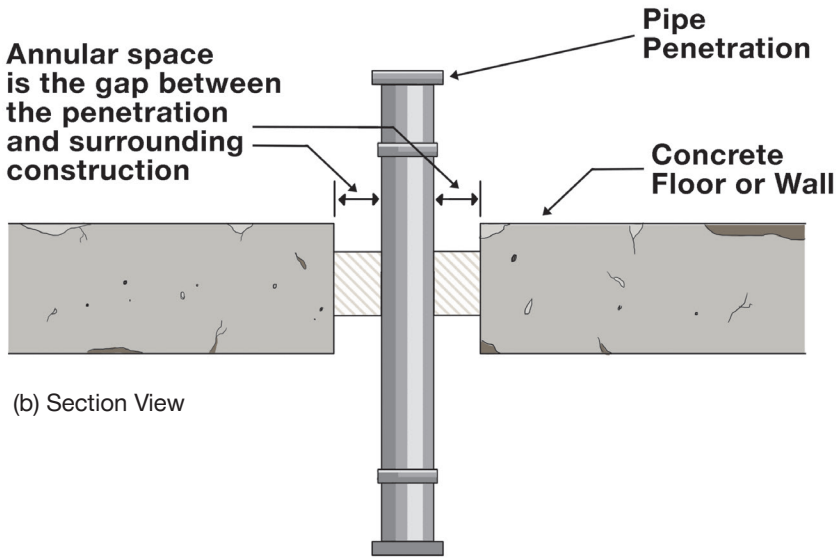


Figure 2.3 Illustration of firestop assembly



(a) Plan View



(b) Section View

Figure 2.4 Annular space

2.2. APPLICATIONS

Most modern buildings have a network of pipes, ducts, cables, and other utilities running through them. It becomes necessary to breach the compartment walls/floors to pave way for these utilities, thereby compromising the fire compartment. The gap between two adjacent fire barriers also renders the compartment ineffective.

As discussed in previous section, firestop assemblies are used to restore rating of these fire barrier/compartment by sealing the joints and the breaches in them. Their applications can be broadly classified into the following:

- Firestop assembly for penetrations (see Figure 2.5)
  - Membrane penetration firestop assembly
  - Through penetration firestop assembly
    - Mechanical – Pipes, ducts, etc.
    - Electrical – Cables, cable trays, etc.
  - Firestop for shaft sealing

- Firestop assembly for joints (see Figure 2.5)
  - Linear firestop joint
  - Perimeter firestop joint

Let us take a closer look at each of these applications to better understand them:

Firestop assembly for penetrations

- **Membrane penetration firestop assembly** – Membrane penetration is a breach made in only one side of a wall or a floor assembly. It is made typically to accommodate an item that is either installed into or is passing through the assembly. Membrane penetration firestop is the material, device or construction which is installed to protect the opening for this application. Whereas membrane penetration firestop assembly is the complete system that acts together to avoid the spread of fire from one side to the other. It includes the membrane penetration firestop, the penetrants and the fire-resistant wall or floor assembly that is being penetrated. An illustration of membrane penetration is shown in Figure 2.6.

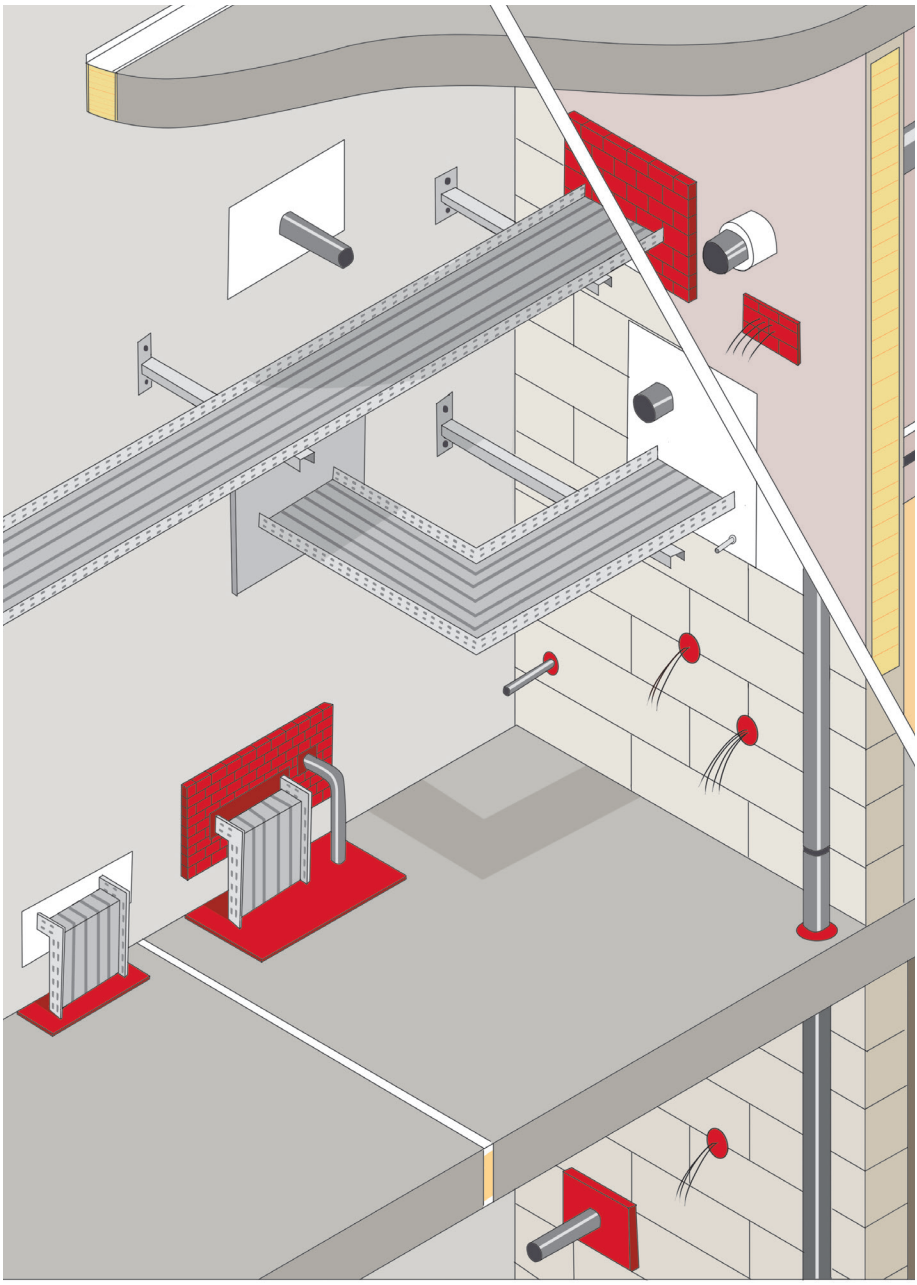


Figure 2.5 Different applications of firestop

• **Through penetration firestop assembly** – Through penetration is basically a breach made on both side of a wall or a floor assembly. It is made to accommodate an item that is completely passing through

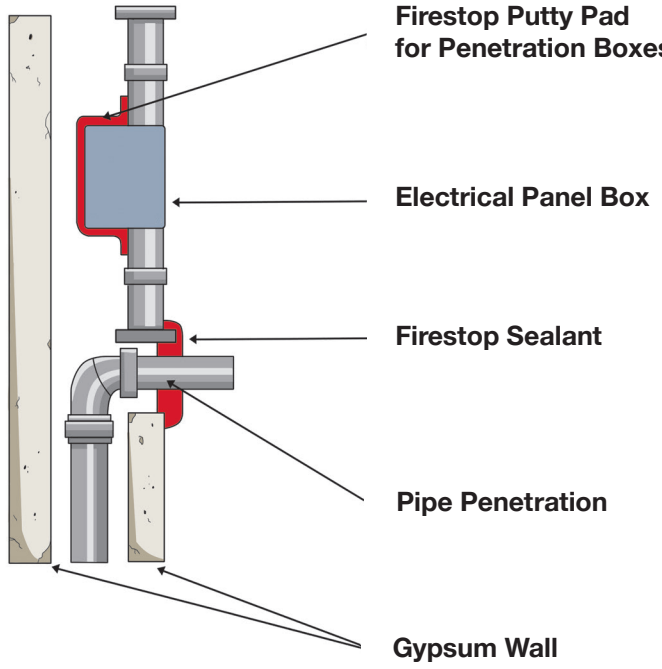


Figure 2.6 Membrane penetration firestop assembly

the assembly. Through penetration firestop is the material, device or construction which is installed to protect the opening for this application. Whereas through penetration firestop assembly is the complete system that acts together to avoid the spread of fire from one side to the other. It includes the through penetration firestop, the penetrants and the fire-resistant wall or floor assembly that is being penetrated. An illustration of through penetration is shown in Figure 2.7.

• **Firestop for shaft sealing** – The shafts in a building run through multiple floors. The shafts typically house pipes and various utility

Figure 2.7 Through penetration firestop assembly

services. Firestop systems are used to seal the shafts to delay the spread of fire. Figure 2.8 illustrates this application.

Firestop assembly for joints

- **Linear firestop joints** – Linear joint refers to the gap between two adjacent fire resistance rated barrier e.g., head of the wall joint. Firestop for linear joint refers to the material or the system used to seal the linear joint. Linear firestop joint refers to the complete system that acts together to avoid the spread of fire from one side to the other, and is installed within its tested design limits with respect to size of the joint, type of assembly, anticipated compression and extension of the joint, and so on.

- **Perimeter firestop joints** – Perimeter joint here refers to the gap between the exterior wall and adjacent floor assembly. Firestop for

Figure 2.8 Firestop for sealing shafts

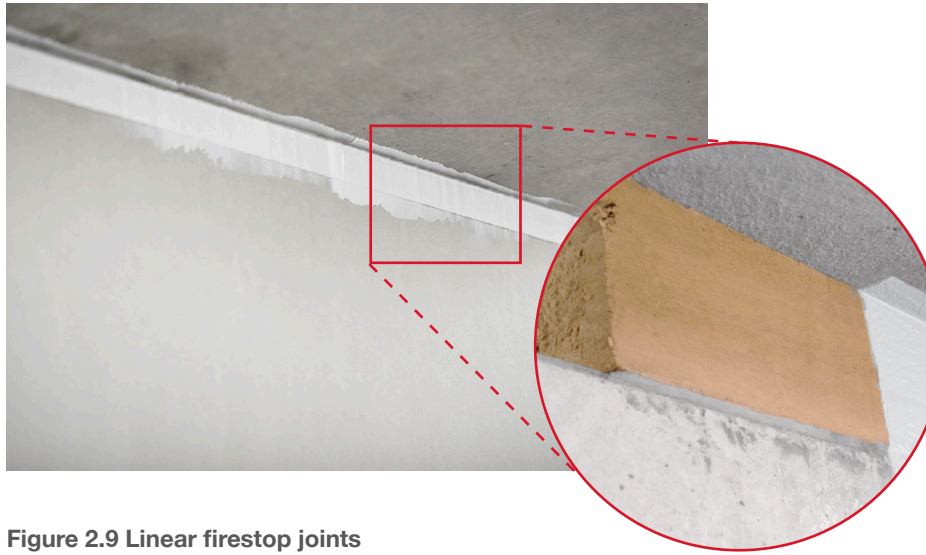


Figure 2.9 Linear firestop joints

perimeter joint refers to the material or the system used to seal the joint. Perimeter firestop joint refers to the complete system that acts together to avoid vertical spread of fire in the interior of the building and is installed within its tested design limits with respect to size of

the joint, type of construction/assembly, anticipated compression and extension of the joint, safing[1] material, and so on.

In this book, we will focus on through penetrations, linear joints, and perimeter joints. Membrane penetrations and shaft sealing applications will be briefly discussed in the chapter on through penetration firestops.

Figure 2.10 Perimeter firestop joints

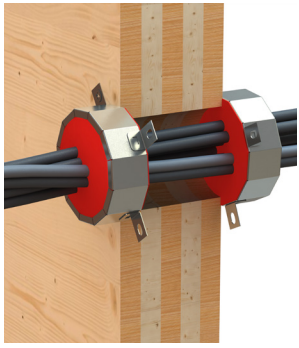
2.3. TYPES OF FIRESTOPS

Firestops can be broadly classified into basic type and preformed / factory assembled devices. Mortars, putties, foams, and sealants are some examples of basic type of firestops.

Composite boards, putty pads, sleeves, blocks, pillows, wraps, cable transit systems, track seal, quick seal and cast-in devices are some

[1] Materials used in the void of curtain wall are referred to as safing materials.

examples of preformed firestops. As the name suggests, they are "preformed" and require minimal effort to install at site, thereby reducing chances of error. They are also easier to visually inspect, without having to worry too much about uniform application of sealants and so on. Some variety of preformed firestop type also allow for passing more penetrants in future without having to redo the complete application.



(a) Cable collar

(b) Sleeve

(c) Cable transit system

Figure 2.11 Examples of preformed firestops

This makes maintenance easier. Irrespective of the type of firestop, its performance is dictated by the material used to make it and their fire resisting or firestopping properties. Most firestop products possess either one or more of the following properties – Intumescence, ablative reaction, endothermic reaction, and insulation [10].

Intumescence categorizes the ability of a material to expand i.e., increase in volume when exposed to heat. The threshold to kickstart this expansion process is typically around 150 to 180°C. As the intumescent firestop material swells it fills the open space around it, making it an ideal choice for applications where the penetrant leaves a gap after melting. Note that different intumescent formulations may result in different level of expansion and pressure.

Ablative reaction is the ability of a material to resist heat transfer by using the heat in the event of fire to erode itself. For example, silicon-based firestops make use of this property. Basically, in this case, the

material sacrifices itself to protect the unexposed side from rapid rise in temperature until it is spent.

Endothermic reaction is categorized by the ability of a material to decompose itself by absorbing the heat on the exposed side (e.g., gypsum), thereby retarding the heat transfer to the unexposed side.

Insulation property allows a material, like mineral wool with fibre, to resist heat transfer because of its low thermal conductivity. These materials must be stable at high temperatures.

2.4. FIRESTOP ASSEMBLY

As defined in previous section, Firestop assemblies are tested systems which are used to restore the rating of fire barrier, and thereby the fire compartment, by sealing the breaches in the fire barriers as well as sealing linear and perimeter joints. The fire-resistive rating is assigned to the firestop assembly and not the product.

But what do we mean by “assembly” here? The definition could differ based on the application in question. In case of through penetration, the firestop assembly comprises of the fire barrier that is being penetrated, the penetrating items such as pipes, cables etc., their layout within the opening, the firestop product or system as well as the support system. In case of perimeter joints, the firestop assembly comprises of the curtain wall system (comprising of backing material, transoms, mullions etc.), the floor that it is attached to and the firestop system.

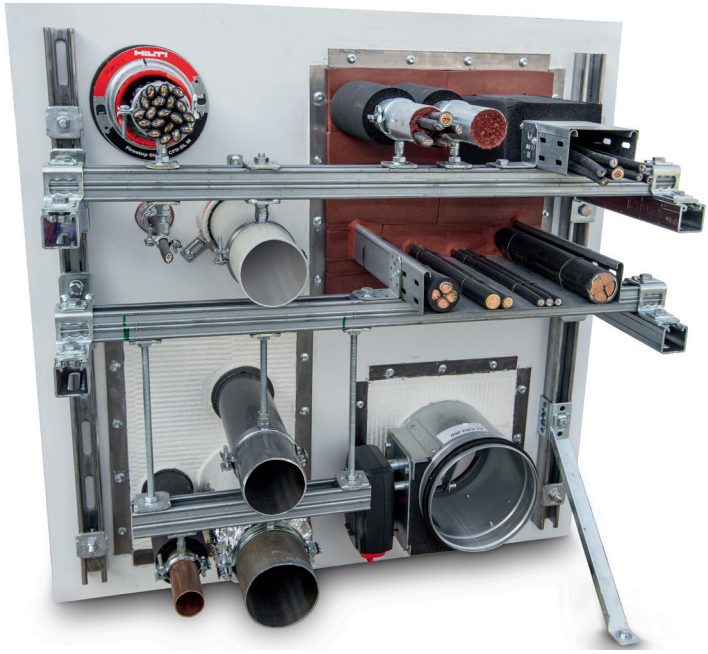
A firestop assembly is illustrated in Figure 2.3 as an example. We will discuss about firestop assemblies in more detail in the application specific chapters of this book.

2.5. RATING METHODOLOGY

The fire resistive rating and effectiveness of a firestop assembly is

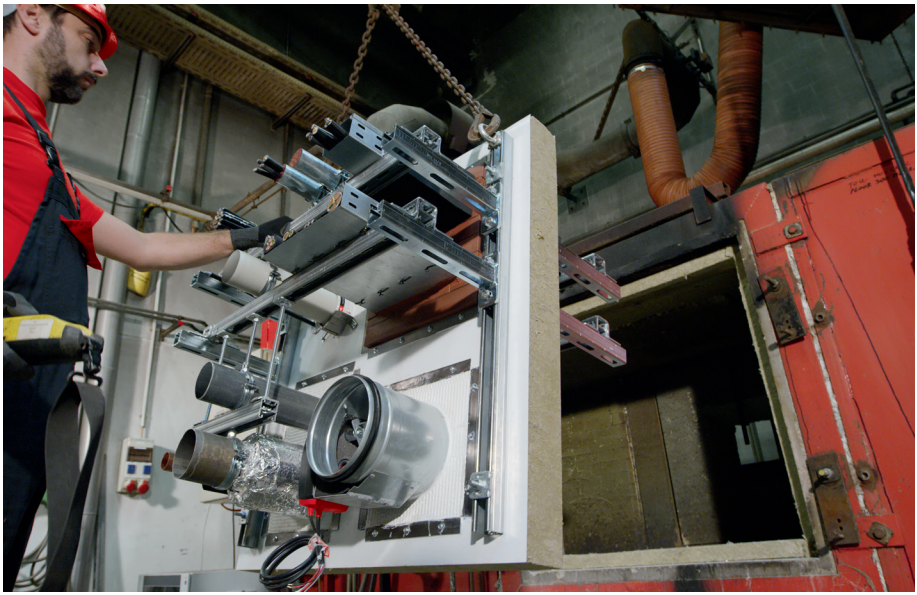
determined in a fire endurance test. Usually, the fire endurance test is accompanied by a hose stream test, which evaluates the ability of the assembly to resist disintegration under adverse conditions. The hose stream test is either performed upon termination of the fire endurance test on the same specimen, or on a duplicate specimen which has been exposed to standard fire for half the duration of the desired fire endurance classification.

These tests evaluate the ability of firestop assembly to resist the passage of flames or hot gases to the unexposed side (integrity), the ability of the firestop assembly to withstand impact, erosion and cooling effects when subjected to hose stream test (stability), and/or the ability of the firestop assembly to restrict the temperature rise on the unexposed side (insulation). Figure 2.12 showcases a fire endurance test and a hose stream test.



(a) Sandwich panel before fire endurance test

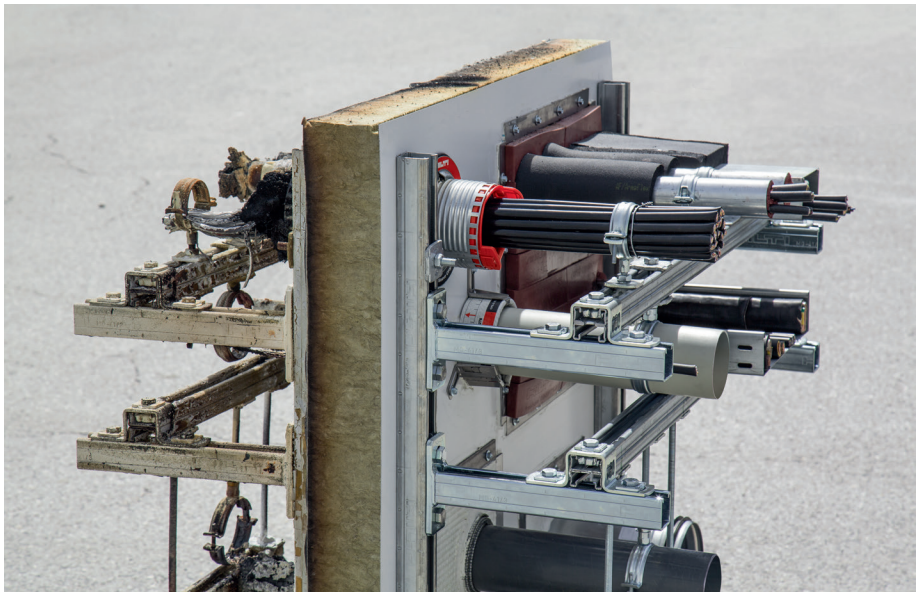
Figure 2.12 Fire endurance test and hose stream test



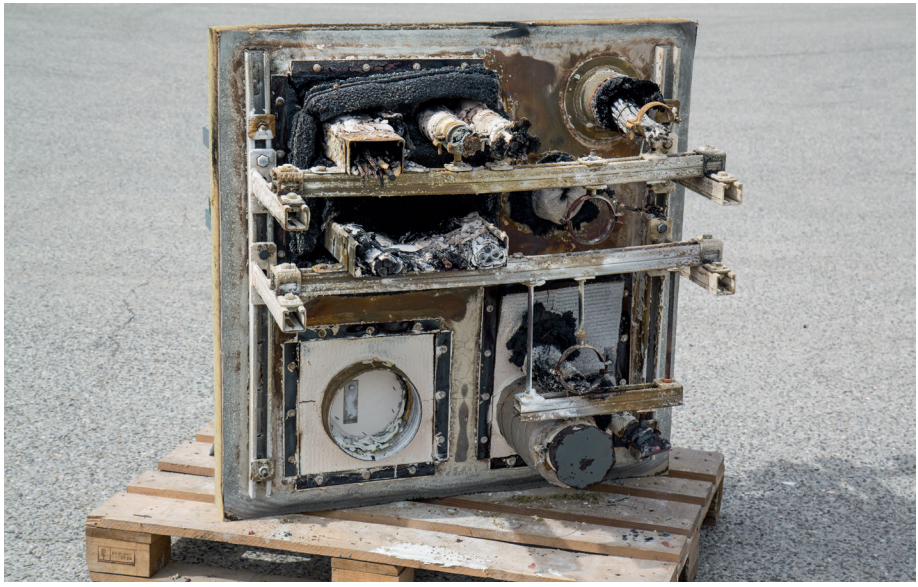
(b) Sandwich panel being placed in furnace

(c) Fire exposed side during the fire endurance test

Figure 2.12 Fire endurance test and hose stream test



(d) Burned and unburned side of sandwich panel



(e) Burned (fire exposed) side of sandwich panel after fire endurance test

Figure 2.12 Fire endurance test and hose stream test

(f) A typical hose stream test

Figure 2.12 Fire endurance test and hose stream test

There are some optional tests that the firestop assembly can be subjected to in order to determine air leakage, water leakage etc., to fulfill additional requirements for specific applications, though not mandated by the Codes.

As an outcome of the test, the firestop assemblies are assigned either one or more of the following ratings:

- **F Rating** – It is the time period for which the firestop assembly can limit the spread of flames to the unexposed side without compromising its structural integrity, when tested in accordance with specified test standards. A hose stream test is used to evaluate structural integrity after the fire endurance test. It is measured in minutes or hours. The concept of F rating is illustrated in Figure 2.13 [11].

- **T Rating** – It is the time period for which the firestop assembly can limit the spread of flames as well as limit the rise in temperature,

to a maximum of 180°C above its initial temperature, on the unexposed side (including the penetrant or within the joint void) without compromising its structural integrity [and, for joints with a maximum width greater than 6 inches limit the temperature rise on the unexposed side to an average of approx.140°C above its initial temperature], when tested in accordance with specified test standards. It is measured in minutes or hours. In summary, T rating is an indication of how long all the unexposed surfaces stay below the temperature rise limits, in addition to limiting flame spread. It is more difficult to obtain in comparison to F rating and is not required for all applications. The concept of T rating is illustrated in Figure 2.13 [11], [12].

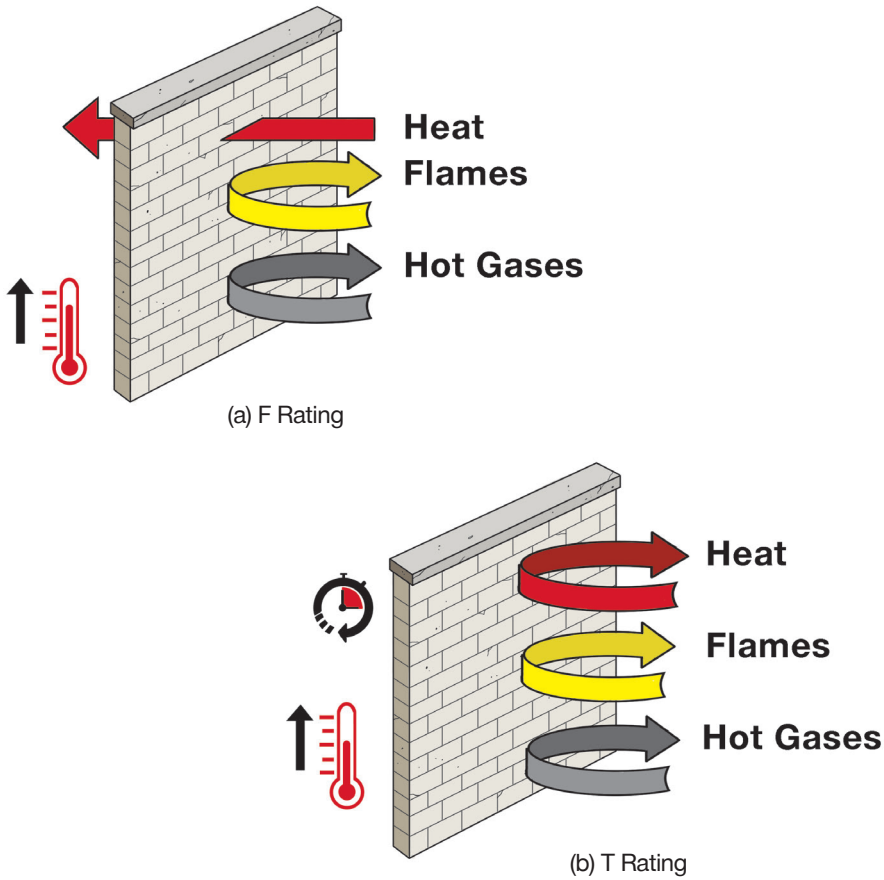


Figure 2.13 F rating and T rating

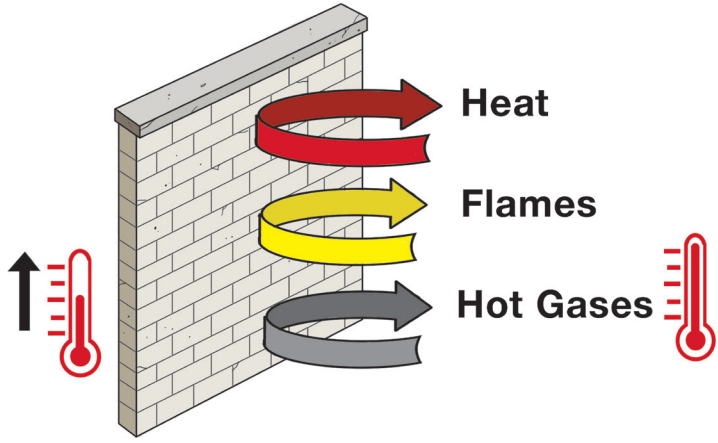
• **L Rating** – It indicates the ability of firestop assembly to limit air flow, and as an extension - limit smoke leakage (see Figure 2.14). It is also known as air leakage rating and is measured in in cfm/sq-ft [13]. As per International Building Code 2018, only firestop assemblies for use in smoke barriers are required to have an L rating to meet the code requirements. As per IBC 2018, the air leakage should not exceed 5.0 cubic feet per minute (cfm) per square foot of opening for each penetration, or a total leakage rate of 50 cfm for any 100 square feet of wall or floor area [14].

• **W Rating** – It indicates the ability of firestop assembly to prevent water from passing through it. It is also known as water leakage rating (see Figure 2.14). It is evaluated by subjecting the firestop assembly to a 3-foot water column pressure head for 72 hours. This rating ensures that the firestop assembly will be able to retain its fire performance even after incidental water exposure. W ratings are provided in classes [13]. This rating although not required by codes, provides an additional level of safety depending on the application need.

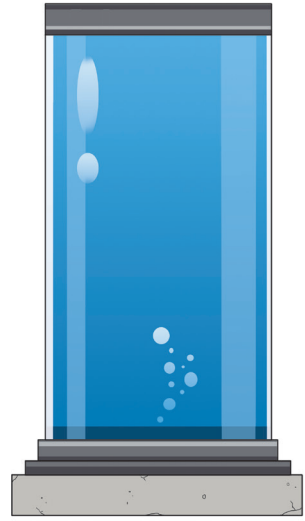
In addition to the above ratings, a firestop assembly can be checked for additional performance attributes like movement, acoustic, resistance to mold/mildew growth and so on. The penetrations and joints in most buildings may move due to internal or external factors and hence movement is an important consideration while selecting the assembly. Sound transmission through walls and floors in buildings in increasingly becoming an important consideration during design to accommodate the needs of the occupants and hence acoustic is another importance consideration.

The test procedures are prescribed in international standards like ASTM, most of which are cross-referred in national standards. Table 1 lists some of the relevant test standards. We will discuss these standards and the requirements in detail in application specific chapters of this book.

The tests are carried out by independent 3rd party testing agencies like Underwriter Laboratories, Intertek etc. These labs test and list or issue approval certificates to document the approved firestop assembly for a specific application along with its rating. Some sample listings are included in Annex – Sample Listing for reference.



(a) L Rating



(b) W Rating

Figure 2.14 L Rating and W Rating

Table 2.1 List of test standards for firestop applications

Application	Rating for	Relevant test standard
Penetration firestopping	F and T Rating	ASTM E814 “Standard Test Method for Fire Tests of Penetration Firestop Systems”
	F, T, L and W Rating	UL 1479 “Fire tests of Penetration firestops”
	Movement capability	ASTM E3037-16 “Standard Test Method of Measuring Relative Movement Capabilities of Through Penetration Firestop Systems”
Linear firestop joints	Fire endurance Rating; Movement capability	ASTM E1966 “Standard Test Method for Fire-Resistive Joint Systems”
	Fire endurance, L and W Rating; Movement capability	UL 2079 standard for safety "Tests for Fire Resistance of Building Joint Systems"
Perimeter firestop joints	F and T Rating; Movement capability	ASTM E2307 “Standard Test Method for Determining Fire resistance of Perimeter Fire Barriers Using Intermediate-Scale, Multistory Test Apparatus”

2.6. SYSTEM SELECTION

Each application has its own unique requirements. When it comes to firestop, it is not possible to go for “one size fits all” approach. The choice of the firestop assembly may be influenced by several parameters such as:

- The type and rating of the fire-resistive assembly

- The opening size and its configuration
- The type of penetrant, its size and material
- The annular space between the penetrant and the periphery of the opening
- The type, property and thickness of insulation used on the penetrant (if any)
- The material and thickness of the sleeve used (if any)
- Covering on the penetrant (if any)
- Joint width
- Anticipated joint movement
- The type of firestopping material or system used, etc.
- Needed additional attributes e.g. acoustics

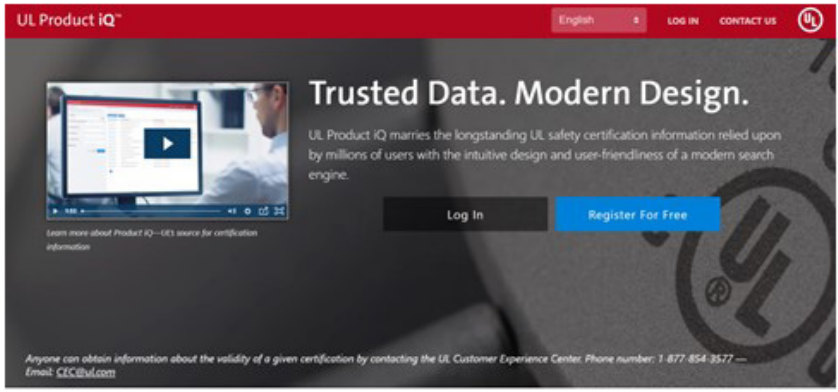
Different manufacturers offer a variety of solutions for the same application. In fact, one manufacturer may have 2-3 firestop assembly listings for same application, some may be basic, and others may be using preformed firestops. The architects and/or consultants would have to choose based on their application need. In the end, the ultimate objective is to restore the fire resistance rating of the construction to its original condition.

There are hundreds of listed firestop assemblies available in the market. It is not possible to review these listings one-by-one to determine the most suitable system. Therefore, the accredited labs or listing agencies like Underwriter Laboratories maintain a database of tested firestop assemblies that can be easily accessed through their website. By entering the desired performance requirement, the Architect, Engineer or Consultant can narrow down the list of suitable tested and approved firestop systems, and eventually select the one that is most suitable. Similar databases are also maintained by the manufacturers.

Figure 2.15 and Figure 2.16 illustrate the steps to select the suitable tested firestop assemblies from listing agency and manufacturer database, respectively.

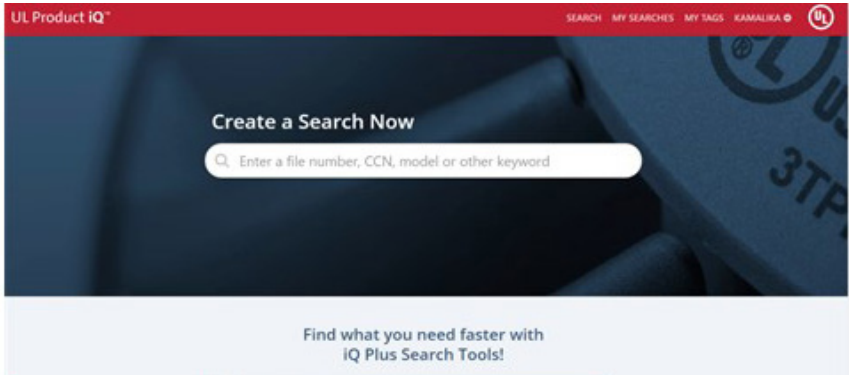
But it is not enough to just select the correct firestop assembly, it also needs to be clearly specified to ensure proper execution. A detailed schedule of firestop systems should be prepared.

1.



Go to www.iq.ulprospector.com to register for free access to “UL Product iQ”

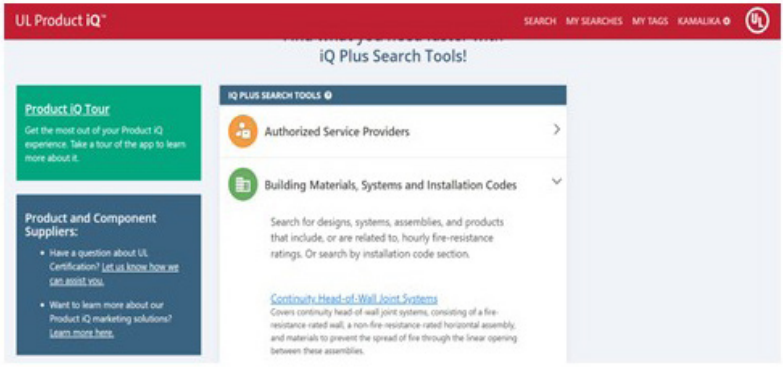
2.



You can directly search for listing if you have the listing system number

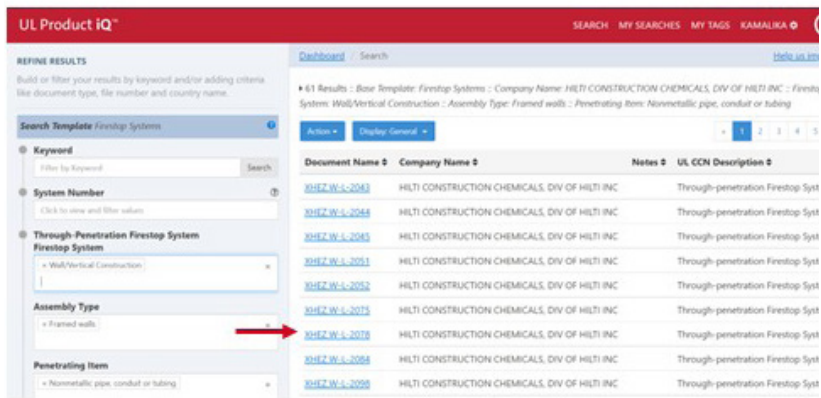
Figure 2.15 Steps to select tested firestop assemblies from UL website (Source: https://iq.ulprospector.com) [15]

3.



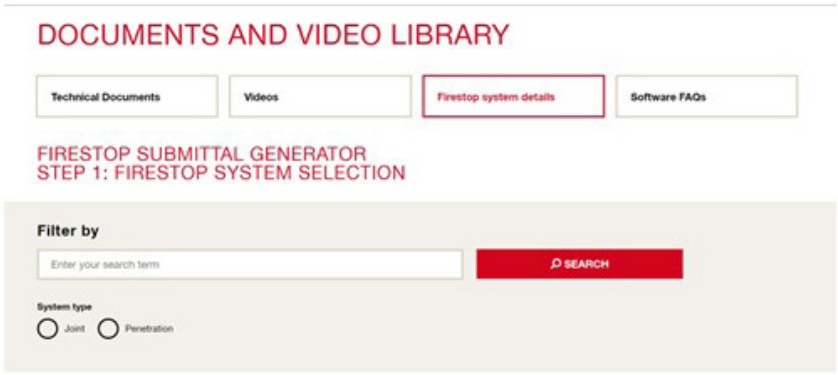
Enter parameters to refine search. For example → wall with 2 hr rating and non-metallic penetrant. Click on listing to view details.

4.



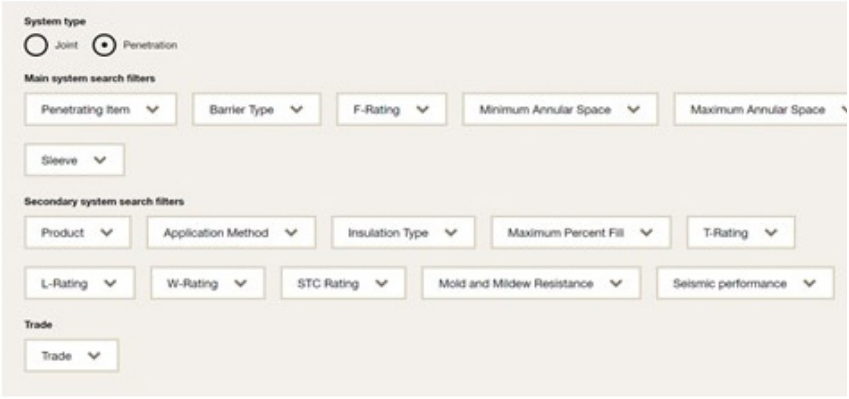
Or, you can go to “Building Materials, Systems and Installation” Codes tab → “Firestop Systems”

1.



Go to www.hilti.com/firestops to access firestop listings

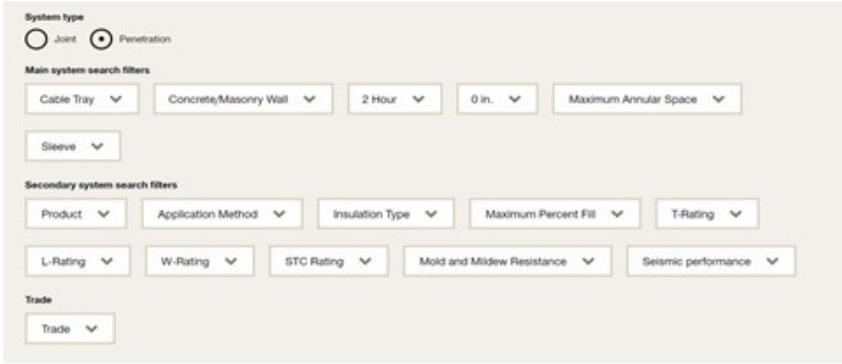
2.



Select the system type – “Joints” or “Penetrations”

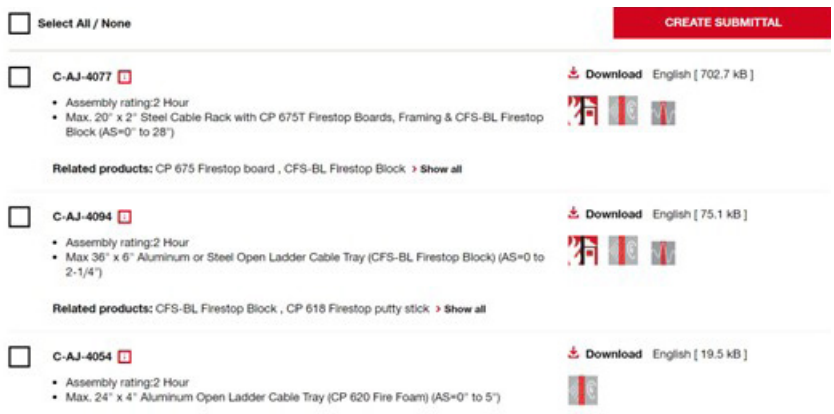
Figure 2.16 Steps to select tested firestop assemblies using a manufacturer database [16]

3.



Choose the system that best matches the application

4.



Select the desired parameters to filter the listings

2.7. ENGINEERING JUDGEMENT

Though there are large number of tested firestop assemblies available, they may not be exhaustive enough to cover every unique application and design requirements that we encounter in jobsites. We may also encounter unanticipated construction hindrances that cannot be easily redesigned using available tested assemblies. Even after going through the exhaustive database of third party listing body or manufacturer, we may not be able to find an assembly that matches our requirement.

Under such circumstances, when tested configurations that exactly match the jobsite conditions are not available, firestop design recommendations prepared by trained and authorized person may be used as an alternative solution to ensure that the performance of the firestop assembly is not compromised. Such recommendations are known as 'Engineering Judgments or EJs' (see Figure 2.17 to Figure 2.21). EJs should be prepared based on site conditions by a trained and authorized person of the firestop manufacturer, or a fire protection engineer, or a third-party lab.

Below are some examples of situations when an EJ may be required:

- Oversized openings
- Annular space is larger or smaller than tested
- Opening shape is different than tested
- Perimeter joint construction is not identical to the tested configuration
- Intersections of fire rated assembly with non-rated assembly

International Building Code 2018 Section 104.11 permits use of "alternative materials, design and methods of construction and equipment" provided they have been approved [14]. Please refer to the code for more details.

International Firestop Council (IFC) has a guideline that provides guidance on how to prepare Engineering Judgements [17]. Below is the list of documents available on Engineering Judgements on IFC website [18]:

- IFC Guidelines for Evaluating Engineering Judgements
- IFC Guidelines for Evaluating Engineering Judgements – Perimeter Fire Barrier Systems
- IFC Guidelines for Evaluating Engineering Judgements – Air Ducts
- IFC Guidelines for Evaluating Engineering Judgements – Grease Ducts

These guidelines issued by International Firestop Council may be considered by professionals, building officials, fire authorities, and other stakeholders, when evaluating whether firestop EJ meets minimal requirements.

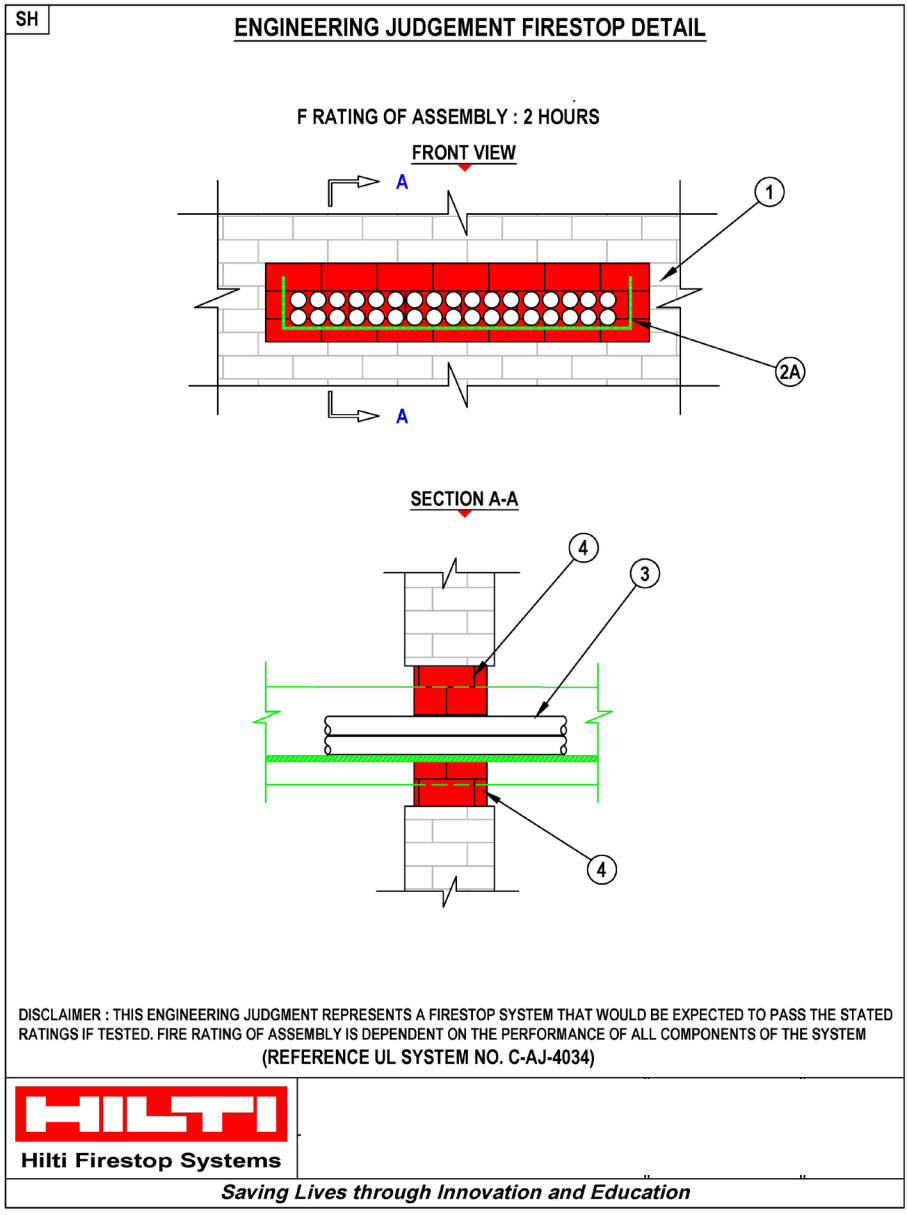
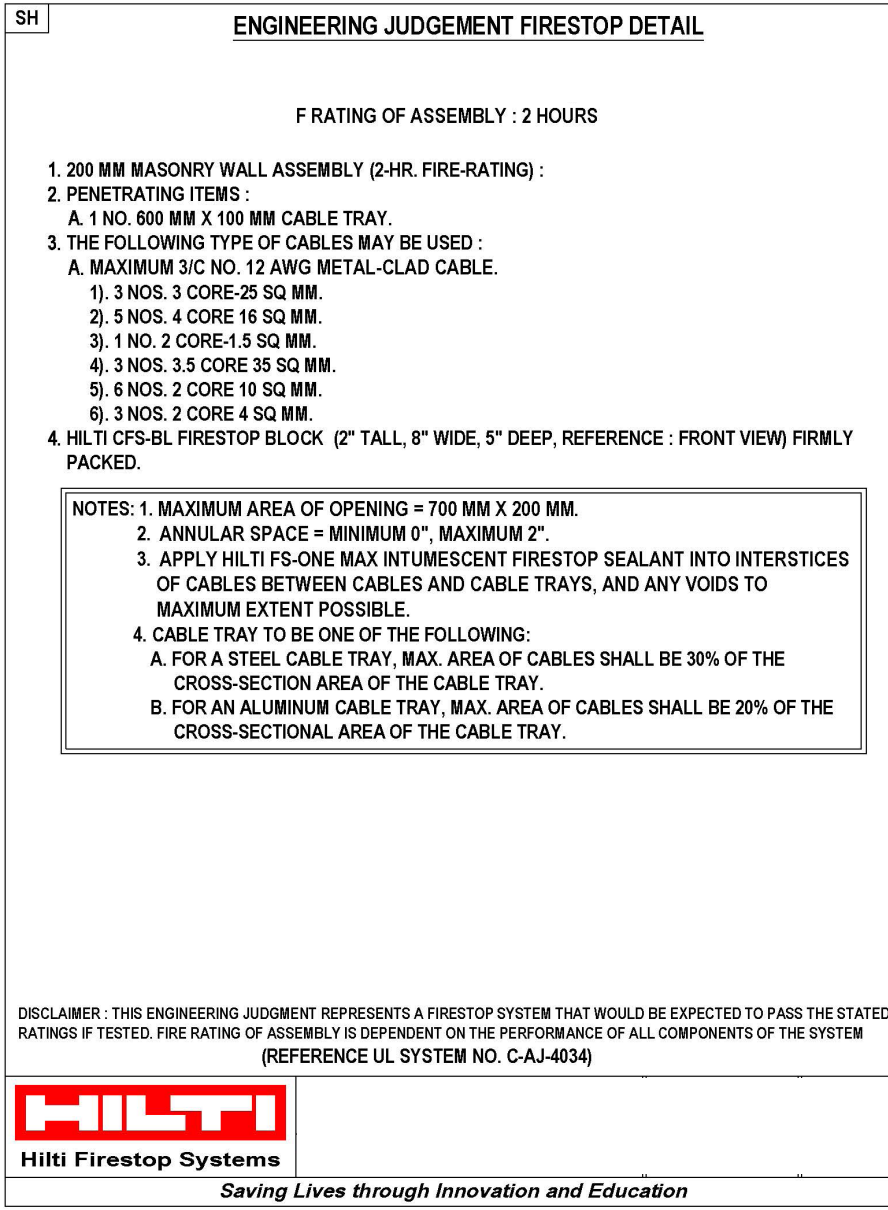


Figure 2.17 Example of an Engineering Judgement for Cable Tray Application



SH

ENGINEERING JUDGEMENT FIRESTOP DETAIL

F RATING OF ASSEMBLY : 2 HOURS

1. 200 MM MASONRY WALL ASSEMBLY (2-HR. FIRE-RATING) :
2. PENETRATING ITEMS :
   A. 1 NO. 600 MM X 100 MM CABLE TRAY.
3. THE FOLLOWING TYPE OF CABLES MAY BE USED :
   A. MAXIMUM 3/C NO. 12 AWG METAL-CLAD CABLE.
      1). 3 NOS. 3 CORE-25 SQ MM.
      2). 5 NOS. 4 CORE 16 SQ MM.
      3). 1 NO. 2 CORE-1.5 SQ MM.
      4). 3 NOS. 3.5 CORE 35 SQ MM.
      5). 6 NOS. 2 CORE 10 SQ MM.
      6). 3 NOS. 2 CORE 4 SQ MM.
4. HILTI CFS-BL FIRESTOP BLOCK (2" TALL, 8" WIDE, 5" DEEP, REFERENCE : FRONT VIEW) FIRMLY PACKED.

NOTES: 1. MAXIMUM AREA OF OPENING = 700 MM X 200 MM.
2. ANNULAR SPACE = MINIMUM 0", MAXIMUM 2".
3. APPLY HILTI FS-ONE MAX INTUMESCENT FIRESTOP SEALANT INTO INTERSTICES OF CABLES BETWEEN CABLES AND CABLE TRAYS, AND ANY VOIDS TO MAXIMUM EXTENT POSSIBLE.
4. CABLE TRAY TO BE ONE OF THE FOLLOWING:
   A. FOR A STEEL CABLE TRAY, MAX. AREA OF CABLES SHALL BE 30% OF THE CROSS-SECTION AREA OF THE CABLE TRAY.
   B. FOR AN ALUMINUM CABLE TRAY, MAX. AREA OF CABLES SHALL BE 20% OF THE CROSS-SECTIONAL AREA OF THE CABLE TRAY.

DISCLAIMER : THIS ENGINEERING JUDGMENT REPRESENTS A FIRESTOP SYSTEM THAT WOULD BE EXPECTED TO PASS THE STATED RATINGS IF TESTED. FIRE RATING OF ASSEMBLY IS DEPENDENT ON THE PERFORMANCE OF ALL COMPONENTS OF THE SYSTEM

(REFERENCE UL SYSTEM NO. C-AJ-4034)

HILTI

Hilti Firestop Systems

Saving Lives through Innovation and Education

Figure 2.17 Example of an Engineering Judgement for Cable Tray Application

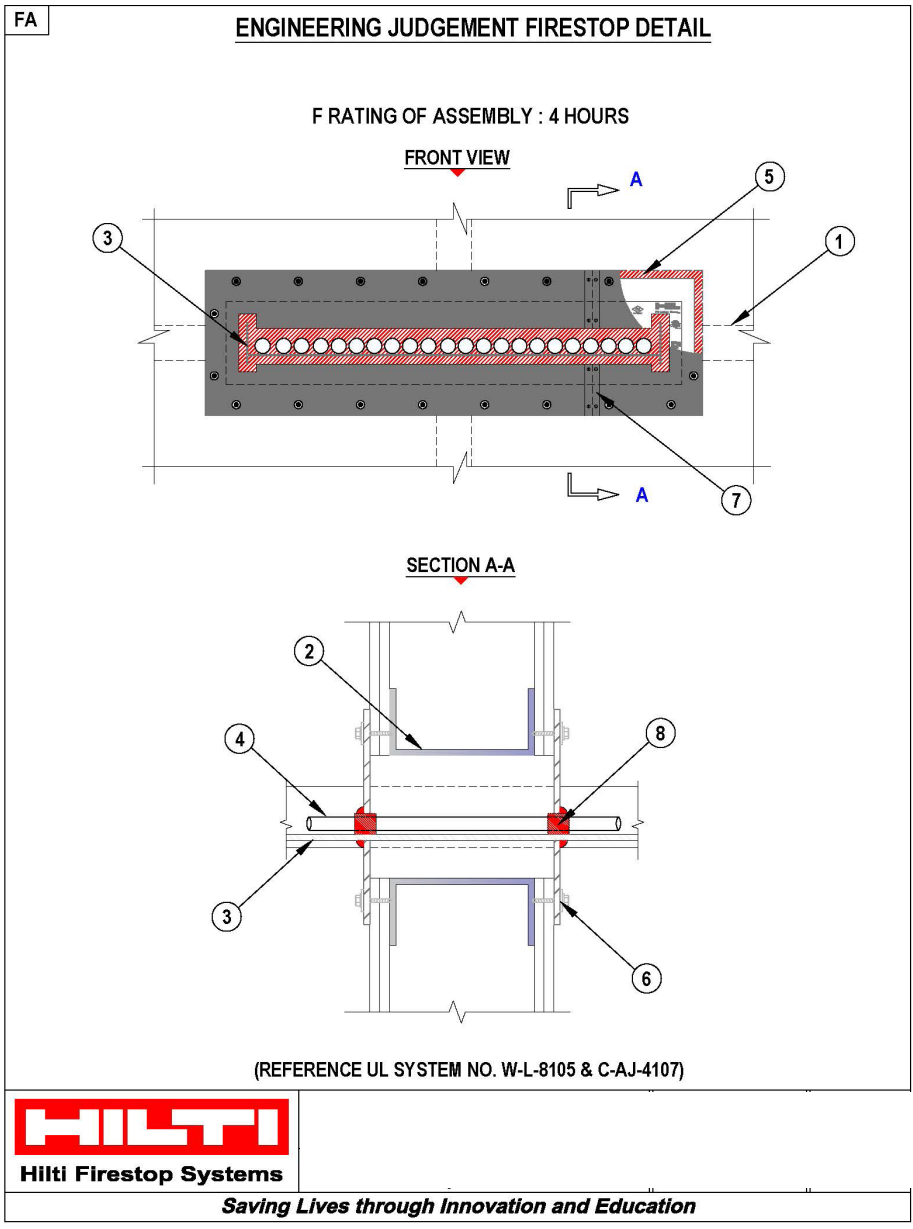


Figure 2.18 Example of an Engineering Judgement for Multiple Penetration in Large Openings

FA

ENGINEERING JUDGEMENT FIRESTOP DETAIL

F RATING OF ASSEMBLY : 4 HOURS

1. 300 MM GYPSUM WALL ASSEMBLY (4-HRS. FIRE-RATING).
2. OPENING TO BE FRAMED OUT WITH ADDITIONAL STUD MATERIAL.
3. 1 NO. 1000 MM X 100 MM FIBREGLASS, STEEL OR ALUMINUM OPEN LADDER CABLE TRAY.
4. CABLES TO BE A COMBINATION OF ANY OF THE FOLLOWING:
   A. MAXIMUM 750 MCM POWER CABLES, THHN OR THWN JACKETED.
   B. MAXIMUM 8/C NO. 12 AWG MULTICONDUCTOR POWER AND CONTROL CABLE.
   C. MAXIMUM 300 PAIR NO. 24 AWG COPPER CONDUCTOR COMMUNICATION CABLE WITH PVC JACKET.
   D. MULTIPLE FIBER OPTIC COMMUNICATION CABLE WITH PVC JACKET.
   E. MAXIMUM 25 PAIR NO. 24 AWG TELEPHONE CABLE WITH PVC JACKET.
5. MINIMUM 13 MM BEAD HILTI FS-ONE MAX INTUMESCENT FIRESTOP SEALANT APPLIED UNDER COMPOSITE SHEET AROUND PERIMETER OF OPENING AND OVER BUTTED SEAM OR SLIT MADE IN COMPOSITE SHEET.
6. HILTI CFS-COS FIRESTOP COMPOSITE SHEET CUT TO OVERLAP WALL A MINIMUM OF 50 MM. COMPOSITE SHEET INSTALLED WITH THE ALUMINUM FOIL FACING AGAINST THE WALL AND SECURED WITH MINIMUM 5 MM DIAMETER BY 32 MM LONG DRYWALL SCREWS WITH 25 MM DIAMETER STEEL FENDER WASHERS AT MAXIMUM 50 MM FROM ENDS AND MAXIMUM 150 MM C/C. COMPOSITE SHEET CUT TO TIGHTLY FOLLOW THE CONTOUR OF THE PENETRANTS.
7. MINIMUM 50 MM WIDE STAINLESS STEEL STRIP (MIN. 24 GA.) CENTERED OVER ENTIRE LENGTH OF BUTT SEAM OR SLIT MADE IN THE COMPOSITE SHEET. COVER STRIP SECURED TO COMPOSITE SHEET WITH STEEL SHEET METAL SCREWS OR STEEL RIVETS SPACED MAXIMUM 75 MM C/C ON EACH SIDE OF SEAM OR SLIT.
8. WHEN F-RATING 4-HRS. HILTI FS ONE MAX INTUMESCENT FIRESTOP SEALANT TO BE INSTALLED TO TIGHTLY FOLLOW THE CONTOUR OF THE CABLE TRAY AND CABLE FILL AROUND ITS ENTIRE PERIMETER. 50 MM WIDE LAYER OF SEALANT REQUIRED ON BOTH SIDES OF THE WALL ASSEMBLY AND SHOULD PROJECT 25 MM BEYOND EACH FACE OF THE COMPOSITE SHEET.

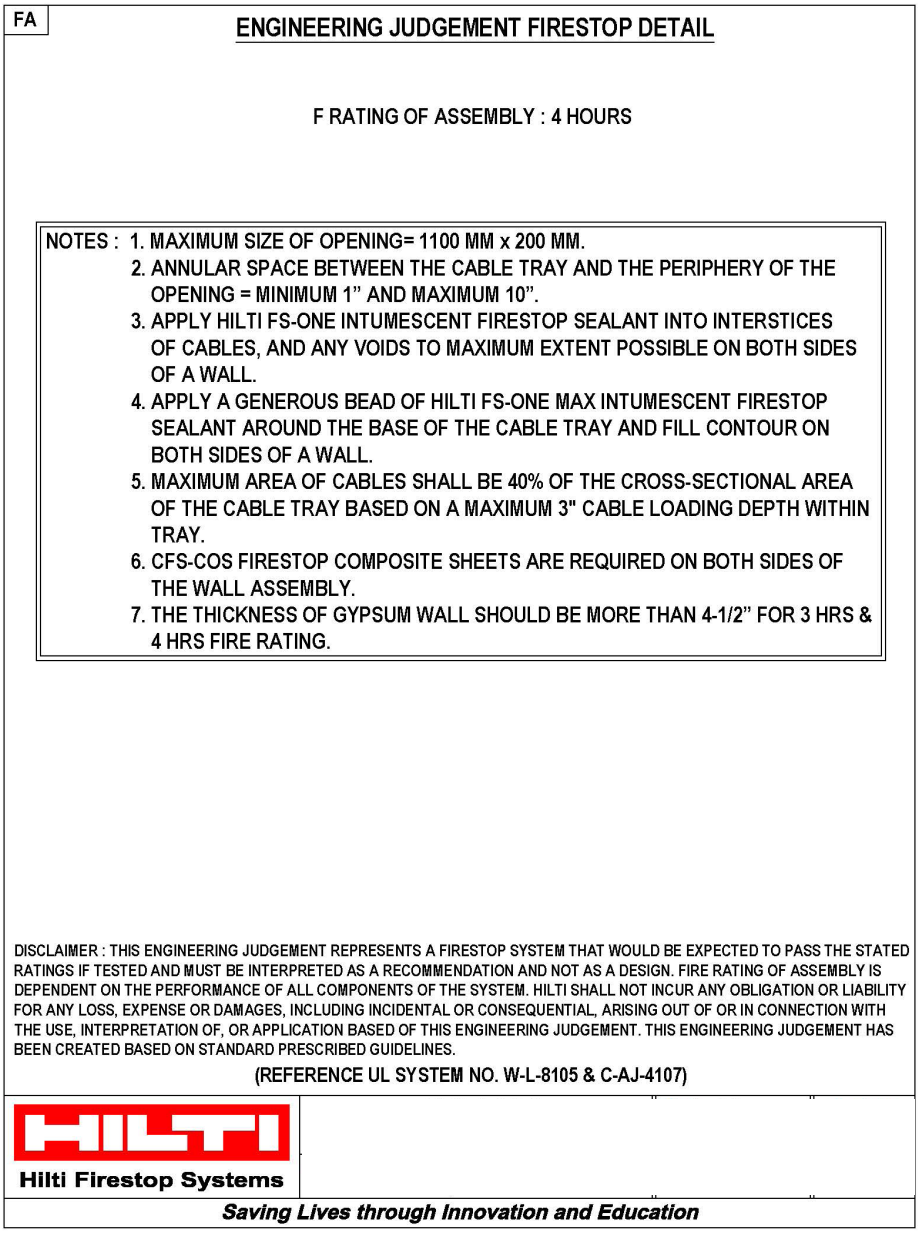
(REFERENCE UL SYSTEM NO. W-L-8105 & C-AJ-4107)

HILTI

Hilti Firestop Systems

Saving Lives through Innovation and Education

Figure 2.18 Example of an Engineering Judgement for Multiple Penetration in Large Openings



FA

ENGINEERING JUDGEMENT FIRESTOP DETAIL

F RATING OF ASSEMBLY : 4 HOURS

NOTES :
1. MAXIMUM SIZE OF OPENING= 1100 MM x 200 MM.
2. ANNULAR SPACE BETWEEN THE CABLE TRAY AND THE PERIPHERY OF THE OPENING = MINIMUM 1" AND MAXIMUM 10".
3. APPLY HILTI FS-ONE INTUMESCENT FIRESTOP SEALANT INTO INTERSTICES OF CABLES, AND ANY VOIDS TO MAXIMUM EXTENT POSSIBLE ON BOTH SIDES OF A WALL.
4. APPLY A GENEROUS BEAD OF HILTI FS-ONE MAX INTUMESCENT FIRESTOP SEALANT AROUND THE BASE OF THE CABLE TRAY AND FILL CONTOUR ON BOTH SIDES OF A WALL.
5. MAXIMUM AREA OF CABLES SHALL BE 40% OF THE CROSS-SECTIONAL AREA OF THE CABLE TRAY BASED ON A MAXIMUM 3" CABLE LOADING DEPTH WITHIN TRAY.
6. CFS-COS FIRESTOP COMPOSITE SHEETS ARE REQUIRED ON BOTH SIDES OF THE WALL ASSEMBLY.
7. THE THICKNESS OF GYPSUM WALL SHOULD BE MORE THAN 4-1/2" FOR 3 HRS & 4 HRS FIRE RATING.

DISCLAIMER : THIS ENGINEERING JUDGEMENT REPRESENTS A FIRESTOP SYSTEM THAT WOULD BE EXPECTED TO PASS THE STATED RATINGS IF TESTED AND MUST BE INTERPRETED AS A RECOMMENDATION AND NOT AS A DESIGN. FIRE RATING OF ASSEMBLY IS DEPENDENT ON THE PERFORMANCE OF ALL COMPONENTS OF THE SYSTEM. HILTI SHALL NOT INCUR ANY OBLIGATION OR LIABILITY FOR ANY LOSS, EXPENSE OR DAMAGES, INCLUDING INCIDENTAL OR CONSEQUENTIAL, ARISING OUT OF OR IN CONNECTION WITH THE USE, INTERPRETATION OF, OR APPLICATION BASED OF THIS ENGINEERING JUDGEMENT. THIS ENGINEERING JUDGEMENT HAS BEEN CREATED BASED ON STANDARD PRESCRIBED GUIDELINES.

(REFERENCE UL SYSTEM NO. W-L-8105 & C-AJ-4107)

HILTI

Hilti Firestop Systems

Saving Lives through Innovation and Education

Figure 2.18 Example of an Engineering Judgement (See Appendix I for document sample with details)

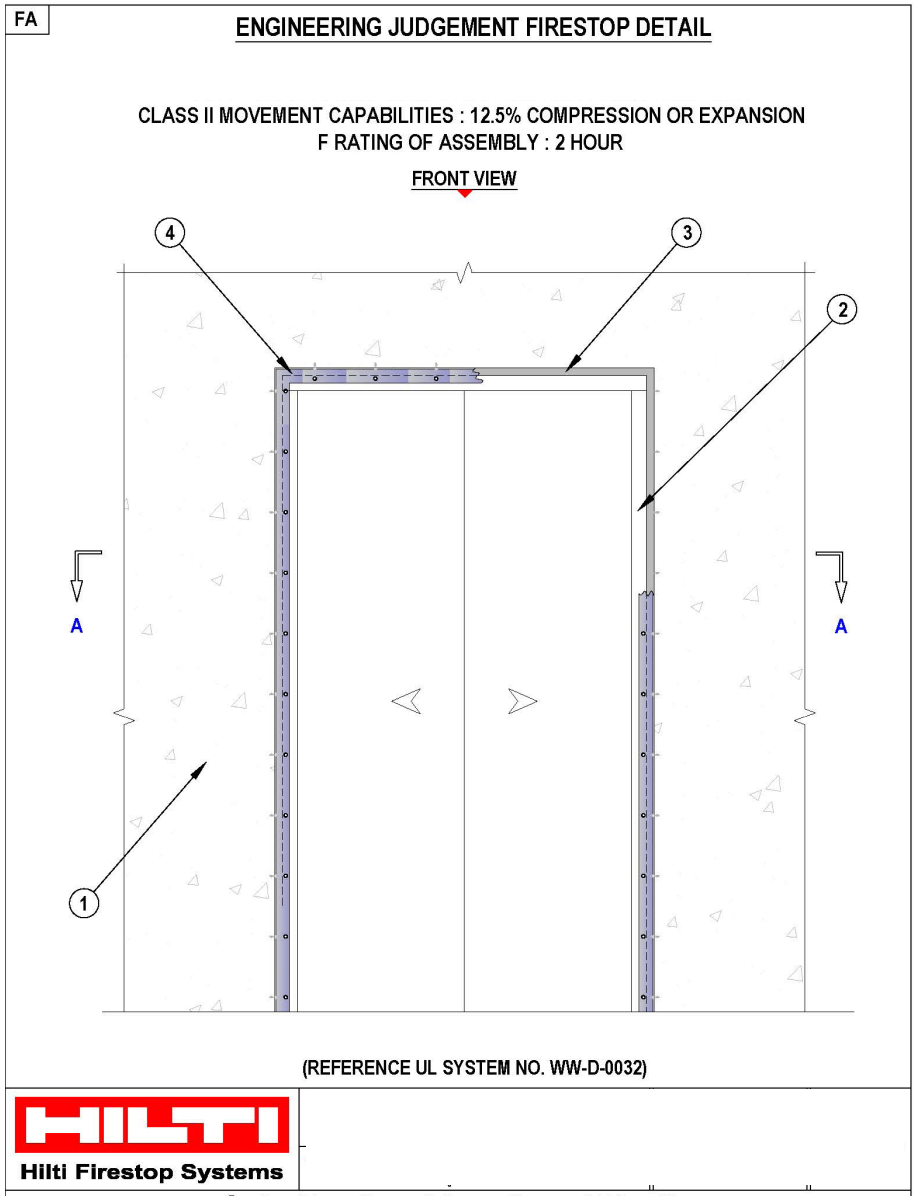


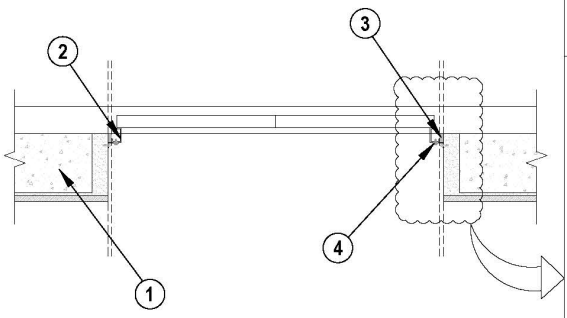
Figure 2.19 Example of an Engineering Judgement for Joint Application

FA

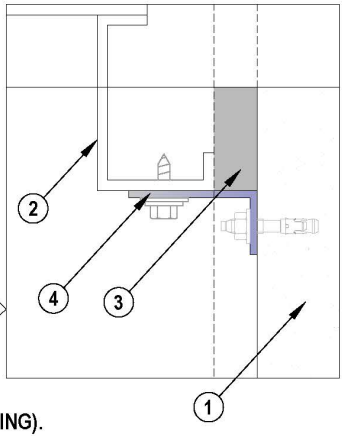
ENGINEERING JUDGEMENT FIRESTOP DETAIL

CLASS II MOVEMENT CAPABILITIES : 12.5% COMPRESSION OR EXPANSION
F RATING OF ASSEMBLY : 2 HOUR

SECTION A-A



ZOOM VIEW



1. 200 MM CONCRETE WALL ASSEMBLY (1-HR. FIRE-RATING).
2. STEEL DOOR JAMBS (1-HR. FIRE-RATING).
3. MINIMUM 25 MM DEPTH HILTI CP 606 FLEXIBLE FIRESTOP SEALANT.
4. SHEET METAL COVER PLATE (MIN. 18 GA.) ATTACHED WITH THE APPROPRIATE HILTI ANCHORS.

NOTES :
1. MAXIMUM WIDTH OF JOINT = 15 MM.
2. FIRE-RATING OF ASSEMBLY IS DEPENDENT UPON THE PERFORMANCE OF STEEL DOOR FRAME UNDER FIRE CONDITIONS.
3. SYSTEM IS DESIGNED TO EXTEND RATING OF WALL ASSEMBLY OUT TO STEEL DOOR FRAME IN ACCORDANCE WITH UL-2079.

DISCLAIMER : THIS ENGINEERING JUDGEMENT REPRESENTS A FIRESTOP SYSTEM THAT WOULD BE EXPECTED TO PASS THE STATED RATINGS IF TESTED AND MUST BE INTERPRETED AS A RECOMMENDATION AND NOT AS A DESIGN. FIRE RATING OF ASSEMBLY IS DEPENDENT ON THE PERFORMANCE OF ALL COMPONENTS OF THE SYSTEM. HILTI SHALL NOT INCUR ANY OBLIGATION OR LIABILITY FOR ANY LOSS, EXPENSE OR DAMAGES, INCLUDING INCIDENTAL OR CONSEQUENTIAL, ARISING OUT OF OR IN CONNECTION WITH THE USE, INTERPRETATION OF, OR APPLICATION BASED OF THIS ENGINEERING JUDGEMENT. THIS ENGINEERING JUDGEMENT HAS BEEN CREATED BASED ON STANDARD PRESCRIBED GUIDELINES.

(REFERENCE UL SYSTEM NO. WW-D-0032)

HILTI
Hilti Firestop Systems

Saving Lives through Innovation and Education

Figure 2.19 Example of an Engineering Judgement for Joint Application

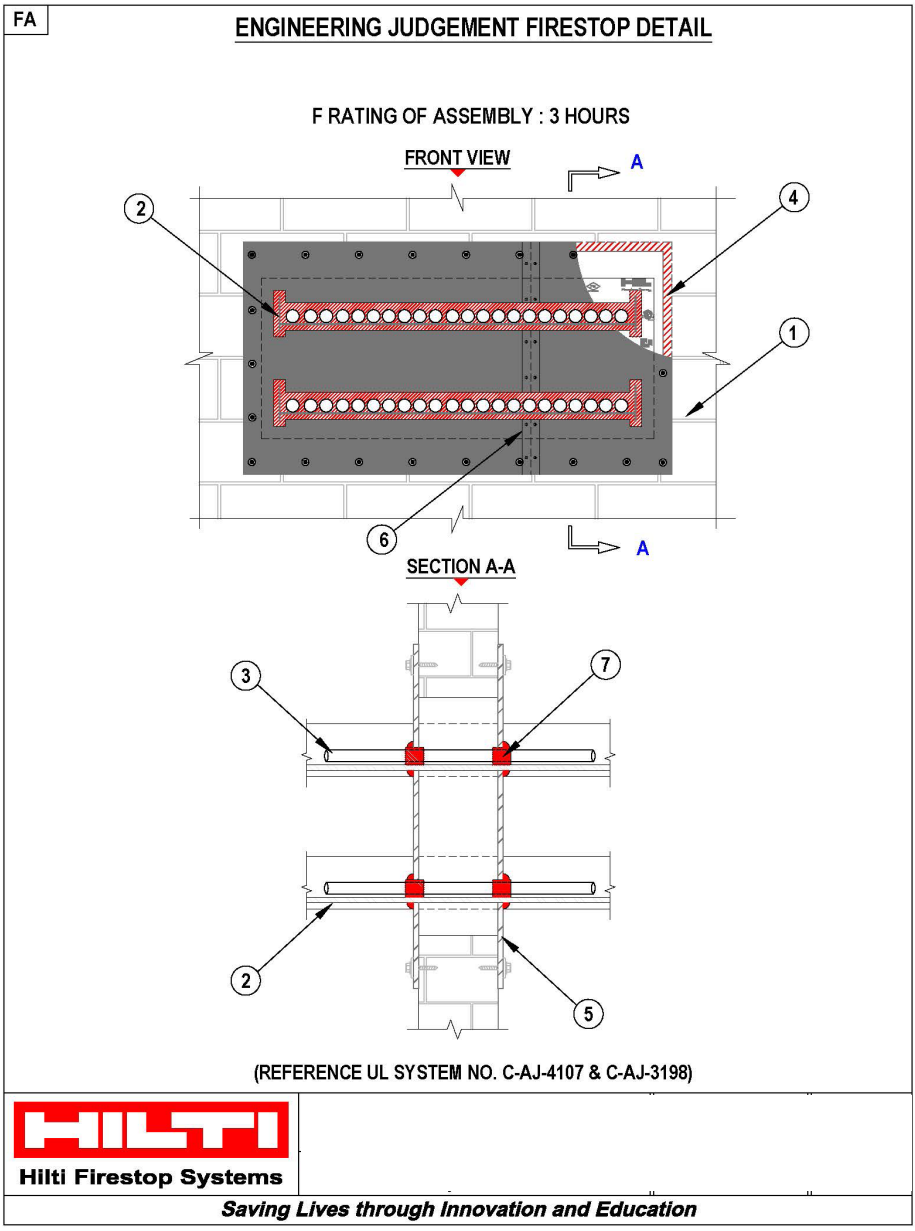
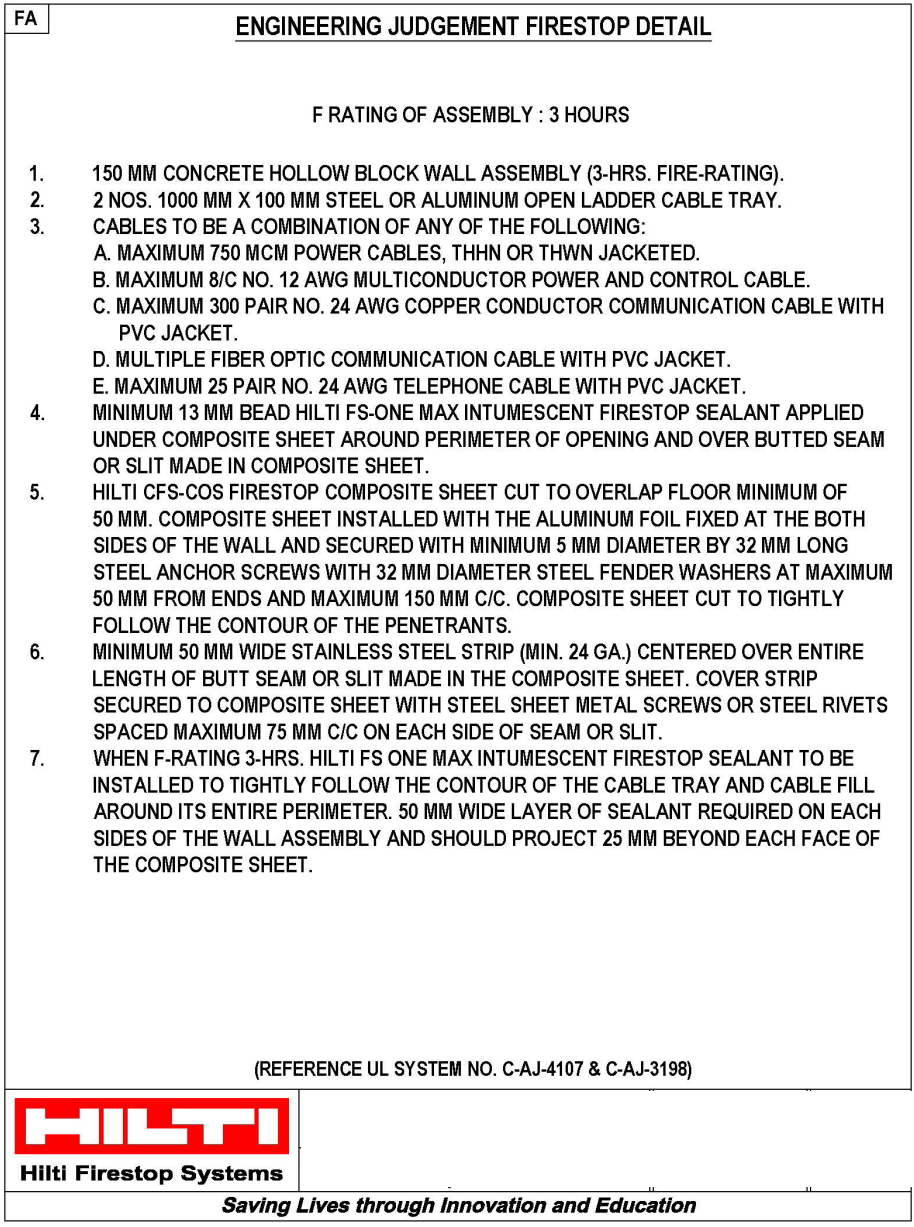


Figure 2.20 Example of an Engineering Judgement for Multiple Penetration in Mid-Large Openings



FA

ENGINEERING JUDGEMENT FIRESTOP DETAIL

F RATING OF ASSEMBLY : 3 HOURS

1. 150 MM CONCRETE HOLLOW BLOCK WALL ASSEMBLY (3-HRS. FIRE-RATING).
2. 2 NOS. 1000 MM X 100 MM STEEL OR ALUMINUM OPEN LADDER CABLE TRAY.
3. CABLES TO BE A COMBINATION OF ANY OF THE FOLLOWING:
   A. MAXIMUM 750 MCM POWER CABLES, THHN OR THWN JACKETED.
   B. MAXIMUM 8/C NO. 12 AWG MULTICONDUCTOR POWER AND CONTROL CABLE.
   C. MAXIMUM 300 PAIR NO. 24 AWG COPPER CONDUCTOR COMMUNICATION CABLE WITH PVC JACKET.
   D. MULTIPLE FIBER OPTIC COMMUNICATION CABLE WITH PVC JACKET.
   E. MAXIMUM 25 PAIR NO. 24 AWG TELEPHONE CABLE WITH PVC JACKET.
4. MINIMUM 13 MM BEAD HILTI FS-ONE MAX INTUMESCENT FIRESTOP SEALANT APPLIED UNDER COMPOSITE SHEET AROUND PERIMETER OF OPENING AND OVER BUTTED SEAM OR SLIT MADE IN COMPOSITE SHEET.
5. HILTI CFS-COS FIRESTOP COMPOSITE SHEET CUT TO OVERLAP FLOOR MINIMUM OF 50 MM. COMPOSITE SHEET INSTALLED WITH THE ALUMINUM FOIL FIXED AT THE BOTH SIDES OF THE WALL AND SECURED WITH MINIMUM 5 MM DIAMETER BY 32 MM LONG STEEL ANCHOR SCREWS WITH 32 MM DIAMETER STEEL FENDER WASHERS AT MAXIMUM 50 MM FROM ENDS AND MAXIMUM 150 MM C/C. COMPOSITE SHEET CUT TO TIGHTLY FOLLOW THE CONTOUR OF THE PENETRANTS.
6. MINIMUM 50 MM WIDE STAINLESS STEEL STRIP (MIN. 24 GA.) CENTERED OVER ENTIRE LENGTH OF BUTT SEAM OR SLIT MADE IN THE COMPOSITE SHEET. COVER STRIP SECURED TO COMPOSITE SHEET WITH STEEL SHEET METAL SCREWS OR STEEL RIVETS SPACED MAXIMUM 75 MM C/C ON EACH SIDE OF SEAM OR SLIT.
7. WHEN F-RATING 3-HRS. HILTI FS ONE MAX INTUMESCENT FIRESTOP SEALANT TO BE INSTALLED TO TIGHTLY FOLLOW THE CONTOUR OF THE CABLE TRAY AND CABLE FILL AROUND ITS ENTIRE PERIMETER. 50 MM WIDE LAYER OF SEALANT REQUIRED ON EACH SIDES OF THE WALL ASSEMBLY AND SHOULD PROJECT 25 MM BEYOND EACH FACE OF THE COMPOSITE SHEET.

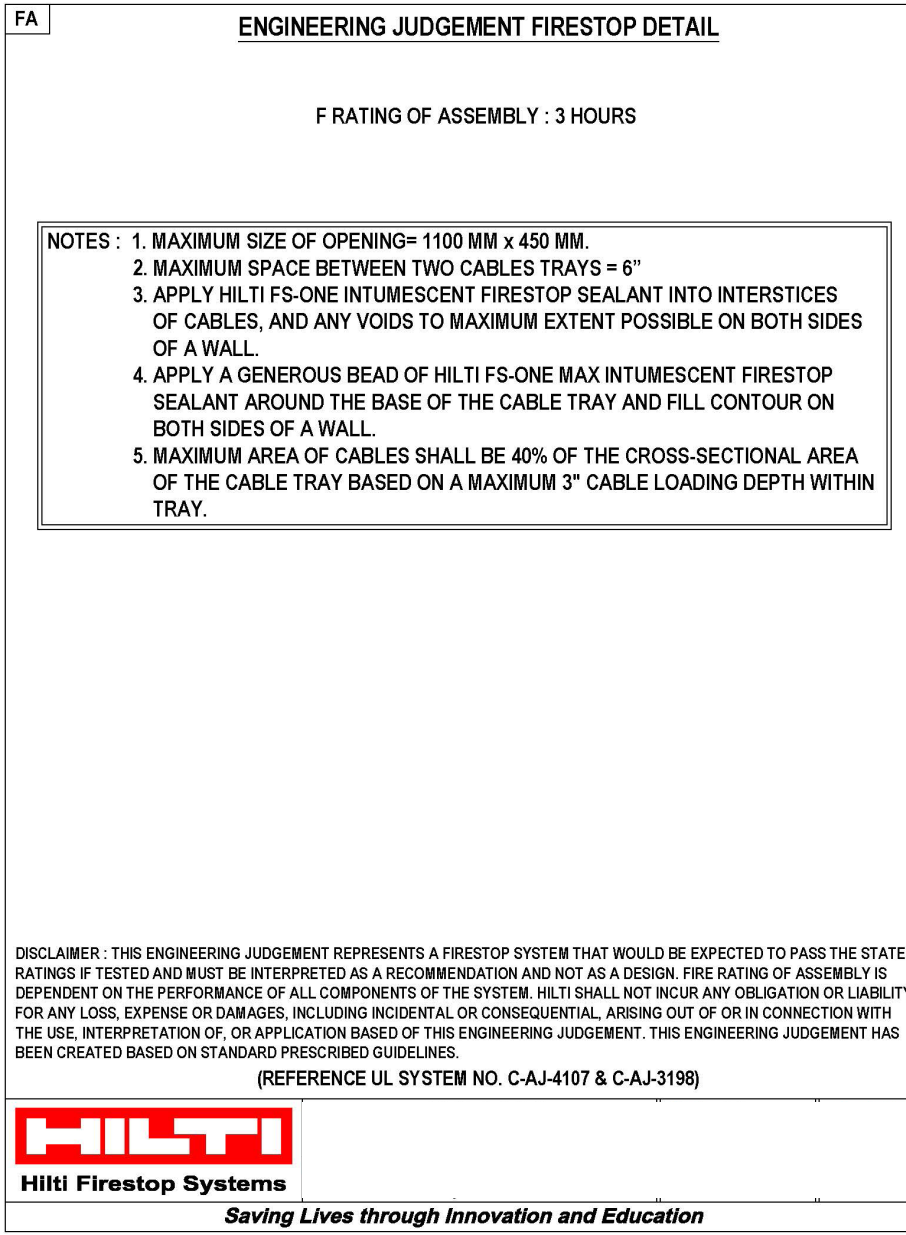
(REFERENCE UL SYSTEM NO. C-AJ-4107 & C-AJ-3198)

HILTI

Hilti Firestop Systems

Saving Lives through Innovation and Education

Figure 2.20 Example of an Engineering Judgement for Multiple Penetration in Mid-Large Openings



FA

ENGINEERING JUDGEMENT FIRESTOP DETAIL

F RATING OF ASSEMBLY : 3 HOURS

NOTES :
1. MAXIMUM SIZE OF OPENING= 1100 MM x 450 MM.
2. MAXIMUM SPACE BETWEEN TWO CABLES TRAYS = 6”
3. APPLY HILTI FS-ONE INTUMESCENT FIRESTOP SEALANT INTO INTERSTICES OF CABLES, AND ANY VOIDS TO MAXIMUM EXTENT POSSIBLE ON BOTH SIDES OF A WALL.
4. APPLY A GENEROUS BEAD OF HILTI FS-ONE MAX INTUMESCENT FIRESTOP SEALANT AROUND THE BASE OF THE CABLE TRAY AND FILL CONTOUR ON BOTH SIDES OF A WALL.
5. MAXIMUM AREA OF CABLES SHALL BE 40% OF THE CROSS-SECTIONAL AREA OF THE CABLE TRAY BASED ON A MAXIMUM 3" CABLE LOADING DEPTH WITHIN TRAY.

DISCLAIMER : THIS ENGINEERING JUDGEMENT REPRESENTS A FIRESTOP SYSTEM THAT WOULD BE EXPECTED TO PASS THE STATED RATINGS IF TESTED AND MUST BE INTERPRETED AS A RECOMMENDATION AND NOT AS A DESIGN. FIRE RATING OF ASSEMBLY IS DEPENDENT ON THE PERFORMANCE OF ALL COMPONENTS OF THE SYSTEM. HILTI SHALL NOT INCUR ANY OBLIGATION OR LIABILITY FOR ANY LOSS, EXPENSE OR DAMAGES, INCLUDING INCIDENTAL OR CONSEQUENTIAL, ARISING OUT OF OR IN CONNECTION WITH THE USE, INTERPRETATION OF, OR APPLICATION BASED OF THIS ENGINEERING JUDGEMENT. THIS ENGINEERING JUDGEMENT HAS BEEN CREATED BASED ON STANDARD PRESCRIBED GUIDELINES.

(REFERENCE UL SYSTEM NO. C-AJ-4107 & C-AJ-3198)

HILTI

Hilti Firestop Systems

Saving Lives through Innovation and Education

Figure 2.20 Example of an Engineering Judgement for Multiple Penetration in Mid-Large Openings

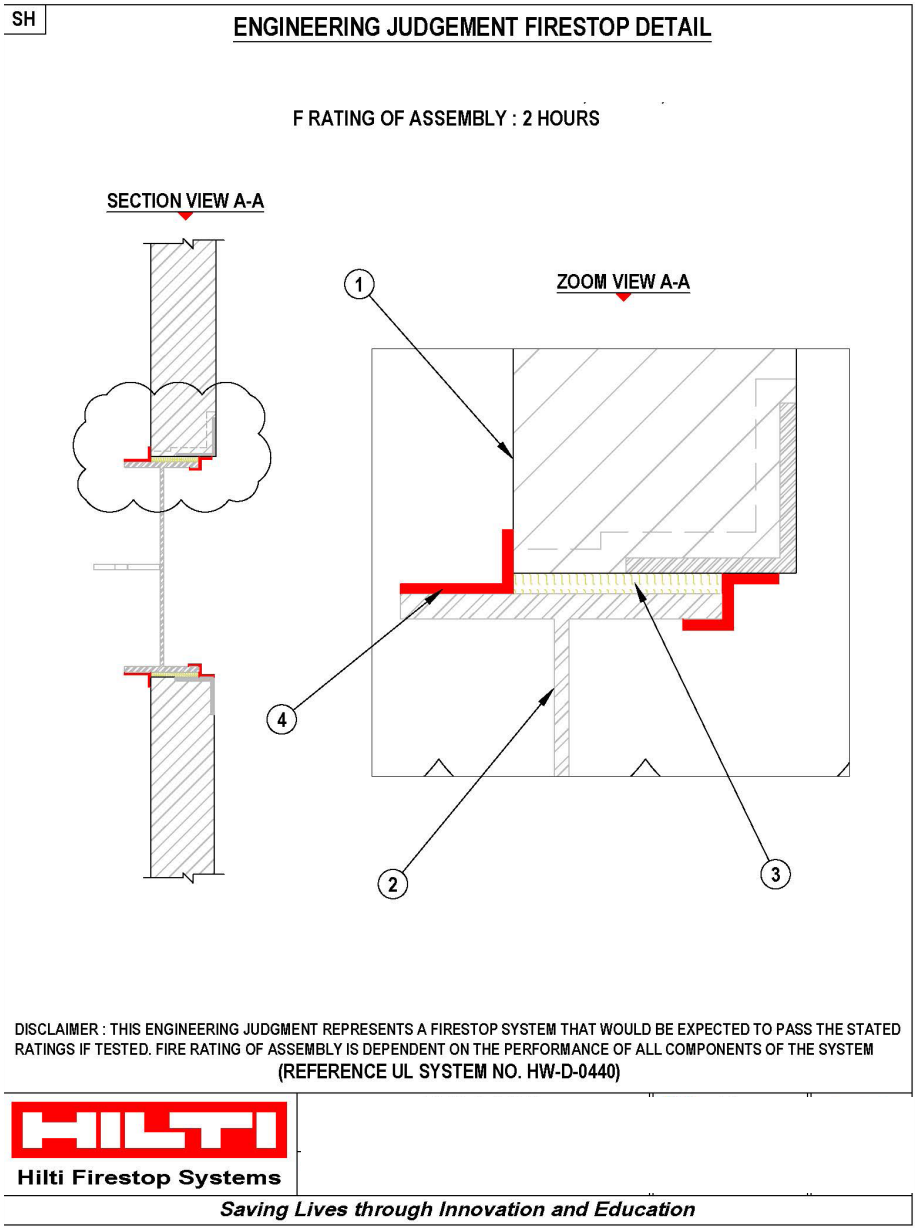


Figure 2.21 Example of an Engineering Judgement for Edge of Slab or Perimeter Joint Application

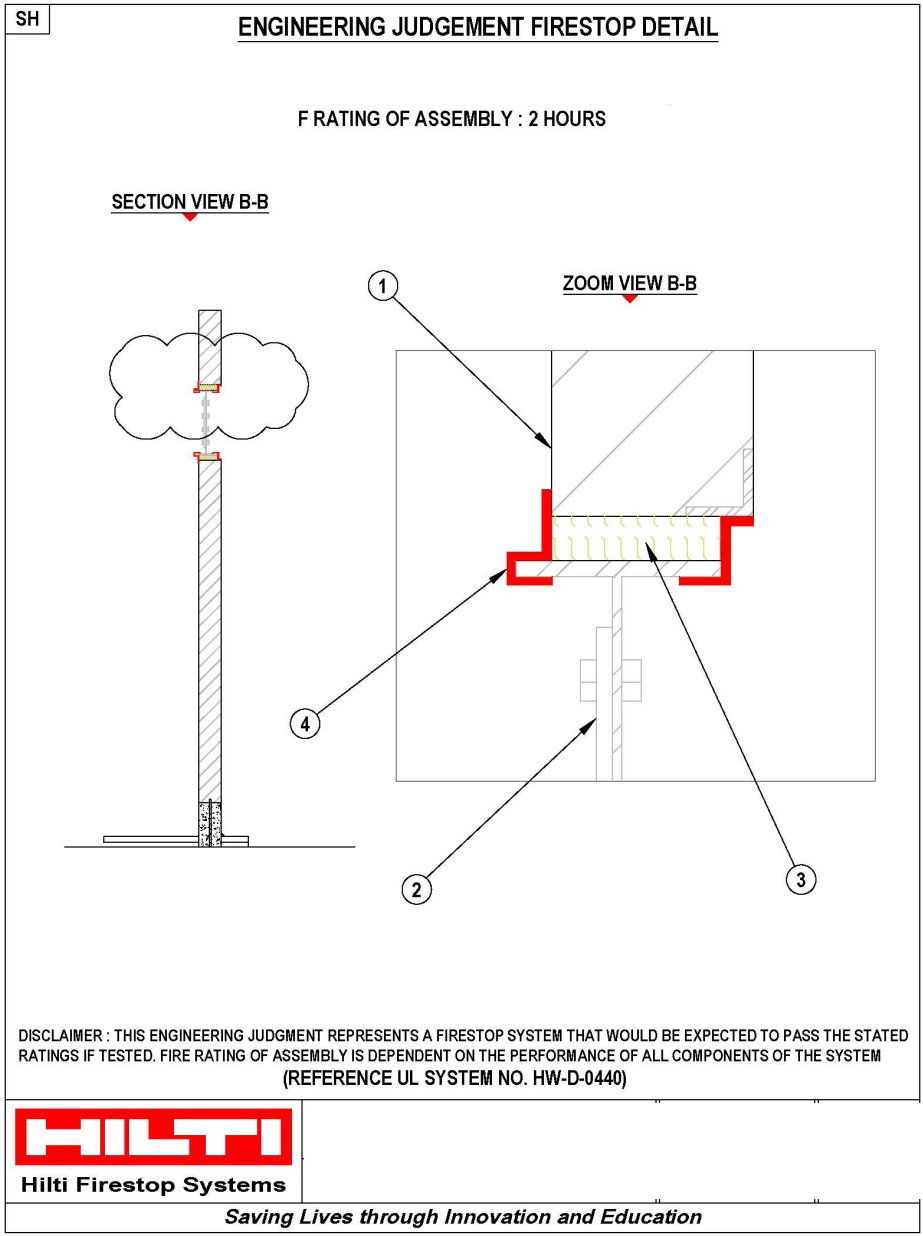


Figure 2.21 Example of an Engineering Judgement for Edge of Slab or Perimeter Joint Application

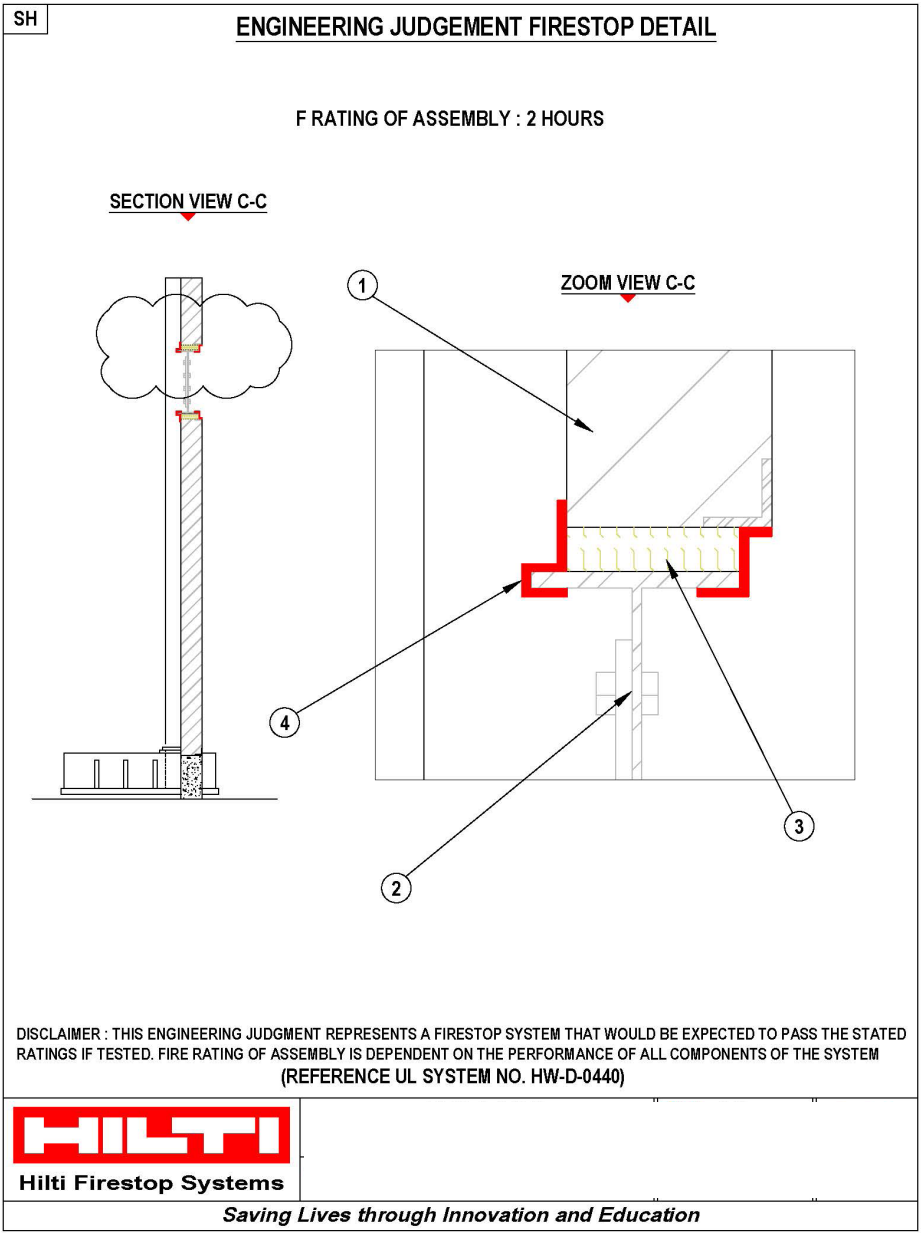


Figure 2.21 Example of an Engineering Judgement for Edge of Slab or Perimeter Joint Application

SH

ENGINEERING JUDGEMENT FIRESTOP DETAIL

F RATING OF ASSEMBLY : 2 HOURS

1. WALL PANEL (2 HOUR / 3-HR. FIRE-RATING).
2. STRUCTURAL STEEL BEAM FIREPROOFED BY UL CLASSIFIED FIREPROOFING (2 HOUR FIRE RATED).
3. MINIMUM 200 MM THICKNESS MINERAL WOOL (MIN. 64 KG/M3 DENSITY) COMPRESSED 50%, FLUSH WITH WALL ASSEMBLY.
4. MINIMUM 3.2 MM (WET) THICKNESS HILTI CFS-SP WB FIRESTOP JOINT SPRAY TO COMPLETELY COVER MINERAL WOOL WITHIN JOINT. HILTI FIRESTOP SPRAY TO OVERLAP MINIMUM 1/2" ONTO WALL ASSEMBLY AND MINIMUM 2" ONTO FIREPROOFING ON BOTH SIDES OF WALL ASSEMBLY.

NOTES:
1. MAXIMUM WIDTH OF JOINT= 10 MM.
2. FIRE-RATING OF ASSEMBLY IS DEPENDENT ON THE PERFORMANCE OF FIREPROOFED STRUCTURAL STEEL AND WALL PANEL ASSEMBLY UNDER FIRE CONDITIONS.

DISCLAIMER : THIS ENGINEERING JUDGMENT REPRESENTS A FIRESTOP SYSTEM THAT WOULD BE EXPECTED TO PASS THE STATED RATINGS IF TESTED. FIRE RATING OF ASSEMBLY IS DEPENDENT ON THE PERFORMANCE OF ALL COMPONENTS OF THE SYSTEM

(REFERENCE UL SYSTEM NO. HW-D-0440)

HILTI

Hilti Firestop Systems

Saving Lives through Innovation and Education

Figure 2.21 Example of an Engineering Judgement for Edge of Slab or Perimeter Joint Application

CHAPTER 3: PENETRATION FIRESTOPPING

3.1. ABOUT THE APPLICATION

The labyrinth of utilities such as pipes, ducts, cables etc. is a common sight in modern buildings, especially high-rise buildings, commercial buildings, data centres and so on. They are essential for building services to perform their intended function.

Examples of such services are – central air conditioning, heating, drainage pipes, electrical supply etc. These services run either horizontally and/or vertically through the building, penetrating the floor and wall in their path, and are usually concealed.

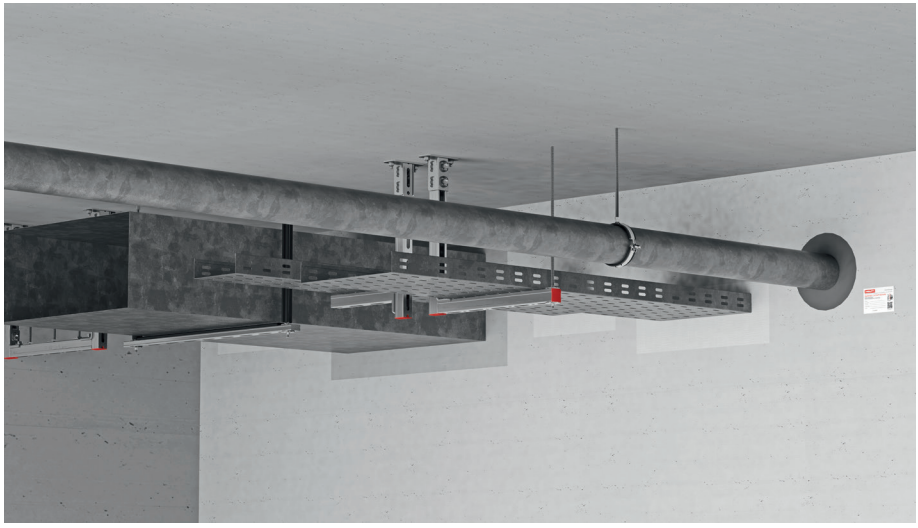


Figure 3.1 Illustration of typical utilities in a building

Some of these floors and walls may be a part of the fire compartment. When these services penetrate the walls or floors of the fire compartment completely or partially, the fire barrier loses its fire-resistant rating as the opening in the fire barrier allows the flame and smoke to easily spread to other areas. In short, the fire compartment loses its effectiveness in containing spread of fire.

It is necessary to seal these breaches using tested firestop assemblies to restore the rating of the fire barrier, and thereby

reinstating the fire compartment. Merely sealing the opening with a filler material like concrete or grout may not be sufficient.

Let's take example of a 4 cm plastic pipe passing through a concrete wall. In the event of fire, this plastic pipe will melt and leave an opening. Even if the surrounding area is sealed with grout, the flame and smoke can easily spread through the gap created due to the melted pipe. When multiple penetrant types pass through the barrier, the complexity only increases.

Therefore, it is important to use tested firestop assemblies, that match the application requirement in jobsite, to restore the rating of the compromised fire barrier.

As discussed in previous chapter, firestops assemblies for penetrations can be classified into the following types (see Figure 3.2):

- Membrane penetration firestop assembly
- Through penetration firestop assembly
  - Mechanical – Pipes, ducts, etc.
  - Electrical – Cables, cable trays, etc.
- Firestop for shaft sealing

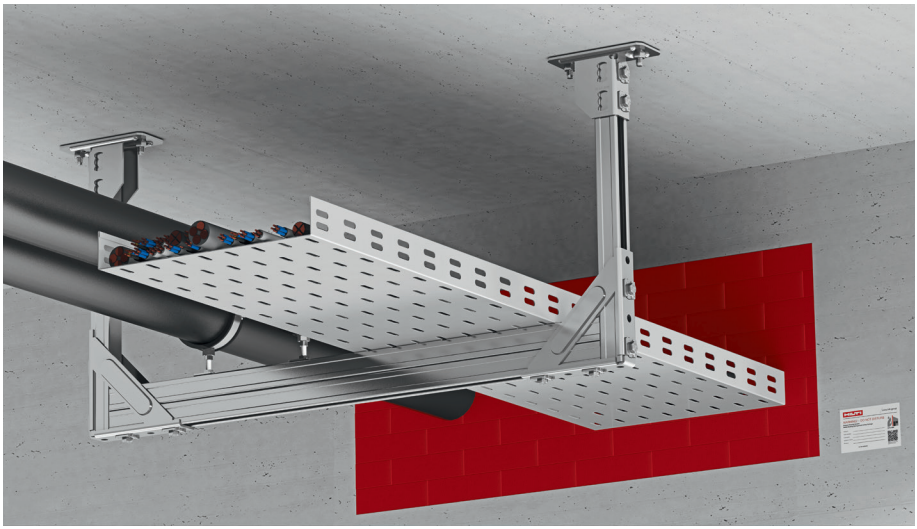


Figure 3.2 Illustration of firestop assembly for penetrations

The penetrant passes through only one side of the fire barrier in case of membrane penetration application. Some examples of this application are junction boxes, outlet boxes and so on.

Whereas the penetrant passes completely through the fire barrier in case of through penetration application. Some examples of this application are pipes, cables etc. passing through the wall.

Firestop for shaft sealing application, as the name suggests, refers to sealing the opening in the shafts.

3.2. CODES AND STANDARDS

National Building Code of Philippines 2005 (PD No. 1096) recognizes the need for protecting such openings [9].

Section 1301 and 1303 of National Building Code of Philippines 2005 direct users to refer to “Philippine Electrical Code” and “Philippine Mechanical Engineering Code” for electrical and mechanical applications, respectively.

2012 Philippine Mechanical Engineering Code Chapter 9(B) provides guidance on “Firestop Protection”. It applies to:

“All piping penetrations of required fire resistance rated walls, partitions, floors, floor/ceiling assemblies, roof/ceiling assemblies, or shaft enclosures” [19]

It defines “Penetration firestop system” as:

“A specific assemblage of field assembled material, or a factory-made device, which has been tested to a standard test method and, when installed properly on penetrating piping materials, is capable of maintaining the fire resistance rating of assemblies penetrated” [19]

2012 Philippine Mechanical Engineering Code Chapter 9(B) talks about requirements for combustible and non-combustible piping

installations. It recognizes the need for restoring the rating of the assembly to its original rating by using approved firestop assemblies tested in accordance with ASTM E119 “Standard Test Methods for Fire Tests of Building Construction and Materials” or ASTM E814 “Standard Test Method for Fire Tests of Penetration Firestop Systems”. It also specifies the positive pressure differential requirement [19]. Out of the two, ASTM E814 is exclusively for penetration firestop systems.

As 2012 Philippine Mechanical Engineering Code does not provide guidance on which standard is more suitable for a given application, International Building Code 2012 may be referred.

International Building Code 2012 Section 714.4.1 on “Through penetrations” recommends using assemblies tested as per ASTM E814 or UL 1479[2] . It allows for an exception wherein the annular gap around non-combustible penetrants like steel pipes, copper pipes, etc. could be sealed using material tested according to ASTM E119 or UL 263[3] , to prevent passage of flame and hot gasses [14]. Refer to the International Building Code 2018 to better understand this exception and when it is permitted. A similar exception is also recommended for non-combustible piping in Section 9.1.2 of 2012 Philippine Mechanical Engineering Code [19]. The Fire Code of The Philippines also allows for some exceptions if the area is protected using sprinklers. Such exceptions are not discussed in this book.

Though the 2012 Philippine Mechanical Engineering Code does not explicitly state any movement requirement, it could be considered in selection process if the penetrant is expected to move during the life of the building to prevent damage to the system. Also, firestopping openings even in a non-fire resistance rated assembly can add another layer of protection and reduce the likelihood of a fire spreading to other levels.

The firestopping requirement for other mechanical installations, like ducts, is covered in various chapters of 2012 Philippine Mechanical

---

[2] UL 1479 – Fire Tests of Penetration Firestops
[3] UL 263 – Fire Tests of Building Construction and Materials

Engineering Code. For example, Section 507.2.5 and Section 507.2.6 in Chapter 5 of this Code talks about firestopping grease duct enclosures using assemblies tested in accordance with ASTM E814 [19].

Philippine Electrical Code 2017 Section 3.0.1.21 recommends to firestop openings around electrical installations using “approved methods” to maintain the fire resistance rating but does not explicitly state what these methods are [20].

International Building Code 2018 Section 713 and 714 may be referred to for more guidance.

3.3. PERFORMANCE RATING

ASTM E119 “Standard Test Methods for Fire Tests of Building Construction and Materials” provides guidance on how to measure fire endurance of wall and floor/ceiling assemblies, roof structures, columns and beams. ASTM E814 “Standard Test Method for Fire Tests of Penetration Firestop Systems” or UL 1479 “Fire Tests of Penetration Firestops” are the standards for testing and measure fire endurance of penetration firestops. Based on the tests, firestop assemblies are given one or more of the following ratings [11], [13]:

- **F rating** – to rate ability to limit spread of flame for a specific duration
- **T rating** – to rate ability to limit spread of flame and rise in temperature (to max 180°C) on unexposed side for a specific duration
- **L rating** – to rate the ability to limit air flow, and as an extension - limit smoke leakage.
- **W rating** – to rate ability to prevent water from passing through it

2012 Philippine Mechanical Engineering Code talks about the F rating and T rating requirement for some of the applications. As an example, for combustible piping installations for floor penetrations the Code recommends a F rating as well as a T rating of at least 1 hour each, but it should not less than the rating of fire barrier being

penetrated. Refer Code for exceptions. However, no requirement for L rating and W rating are explicitly stated in the code [19].

ASTM E3037-16 “Standard Test Method of Measuring Relative Movement Capabilities of Through Penetration Firestop Systems” is used to evaluated movement capability of through penetration firestops. Though this test is not required by code, a system with movement capability could be selected for applications where the penetrant movement is anticipated.

Penetration Firestop assemblies are tested according to the above-mentioned standards and listed by third-party accredited independent testing agencies such as Underwriters Laboratories (UL), Intertek and so on. All design and installation requirements are clearly stated in the listing. Some sample listings are included in Annex – Sample Listing.

3.4. SELECTION AND SPECIFICATION

Each tested firestop assembly has a unique combination of penetrant layout, penetrant types, firestop system, fire barrier type and so on. While identifying the most suitable firestop assembly for your application, you would have to compare your application details to the firestop assembly that best matches it. It may be cumbersome to manually sieve though each listing to find the best match. Therefore, independent testing agencies as well as manufacturers maintain a list of tested assemblies that can be narrowed down based on your application requirement (Refer Section 2.6). Table 3-1 lists the numbering format followed by Underwriter Laboratories Inc for penetration firestop systems for ease of navigation and identification. As an example, UL system no. C-AJ-3095 refers to a “Floor or wall” assembly with minimum thickness of 3 inch for electrical cable penetration. Refer UL’s “XHEZ.GuideInfo” available on their website for more information.

Table 3-1 Numbering system followed by UL for penetration firestop systems

First alpha component		Second alpha component		Numeric component	
F	Floor	A	Concrete floor ≤ 5 in.	0000 -0999	No penetrating items
W	Wall	B	Concrete floor > 5 in.	1000 -1999	Metallic pipe, conduit or tubing
C	Floor or Wall	C	Framed floors	2000 -2999	Nonmetallic pipe, conduit or tubing
		D	Steel decks in marine vessels	3000 -3999	Electrical cable
		E	Floor-ceiling assemblies with concrete with membrane protection	4000 -4999	Cable trays with electrical cable
		F-I P-Z	For future use	5000 -5999	Insulated pipe
		J	Concrete or masonry walls ≤ 8 in.	6000 -6999	Miscellaneous electrical penetrants
		K	Concrete or masonry walls > 8 in.	7000 -7999	Miscellaneous mechanical penetrants
		L	Framed walls	8000 -8999	Grouping of penetrations
		M	Bulkhead in marine vessels	9000 -9999	For future use
		N	Composite panel walls		
		O	Cross laminated timber wall assembly		

Below are some of the parameters that one should consider for selection of the system:

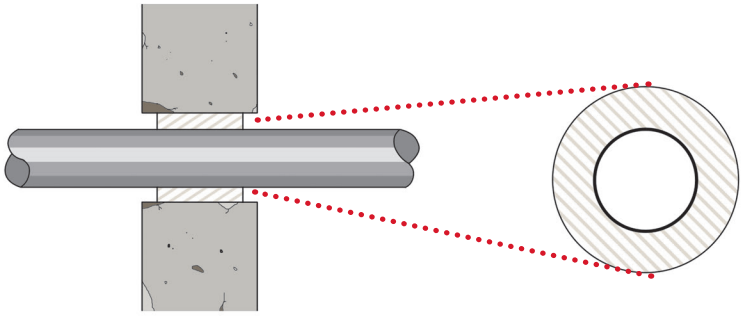
- Rating of the fire resistance assembly being penetrated
- Material and construction of the fire barrier
- Opening size and configuration
- Type and variety of penetrants (e.g., pipes, cables)
- Material and size of the penetrant
- Annular gap between penetrants as well as distance from the periphery of the opening
- Penetrant insulation details (if any)
- Material and type of firestopping system (e.g., sleeve) used
- Additional attributes like resistance to mold and mildew

Let us take the example of annular gap. Some of the firestop listings provide details on how the penetrant must be placed within the opening, which also has an impact on the annular gap (see Figure 3.3). The listing may also specify the minimum and maximum permissible annular gap. Your application layout should either match or be within these limits.

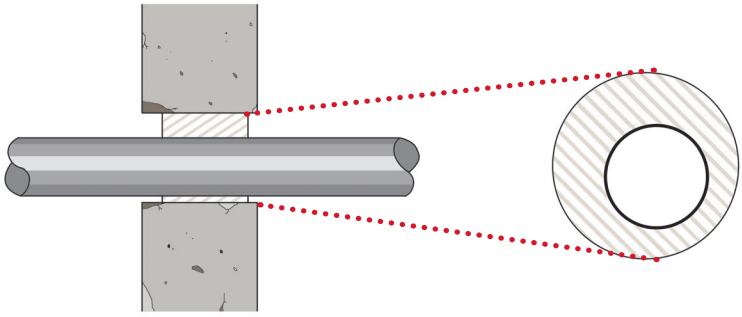
If your application deviates from the tested firestop listing available on independent testing agency website or manufacturer database, then EJ could be requested (Refer Section 2.7).

After selecting the most suitable firestop assembly for your application, it should be correctly specified in the drawings and tender documents to ensure correct execution at jobsite. A sample specification drawing is shown in Figure 3.4.

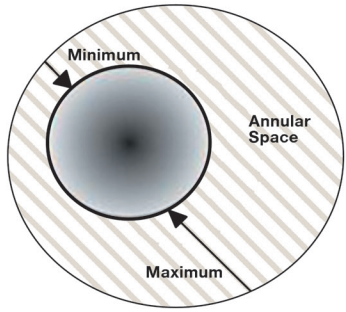
The schedule could include text like “Manufacturer system XYZ listing to be used for plastic pipe penetrant with diameter less than x cm and annular space less than xx cm for use in gypsum drywall. This kind of schedule helps contractor to plan their opening and layout, and hence avoiding the need for engineering judgment later. It is important to prepare such schedules during the planning phase, keeping in mind that the actual suitable listing would have to be selected at a later stage when more details about penetrants, hole size, and so on is available, as these details may not be available during the design phase.



(a) Centered



(b) Off-centered



(c) Minimum and Maximum Permissible Annular Gap

Figure 3.3 Annular Gap

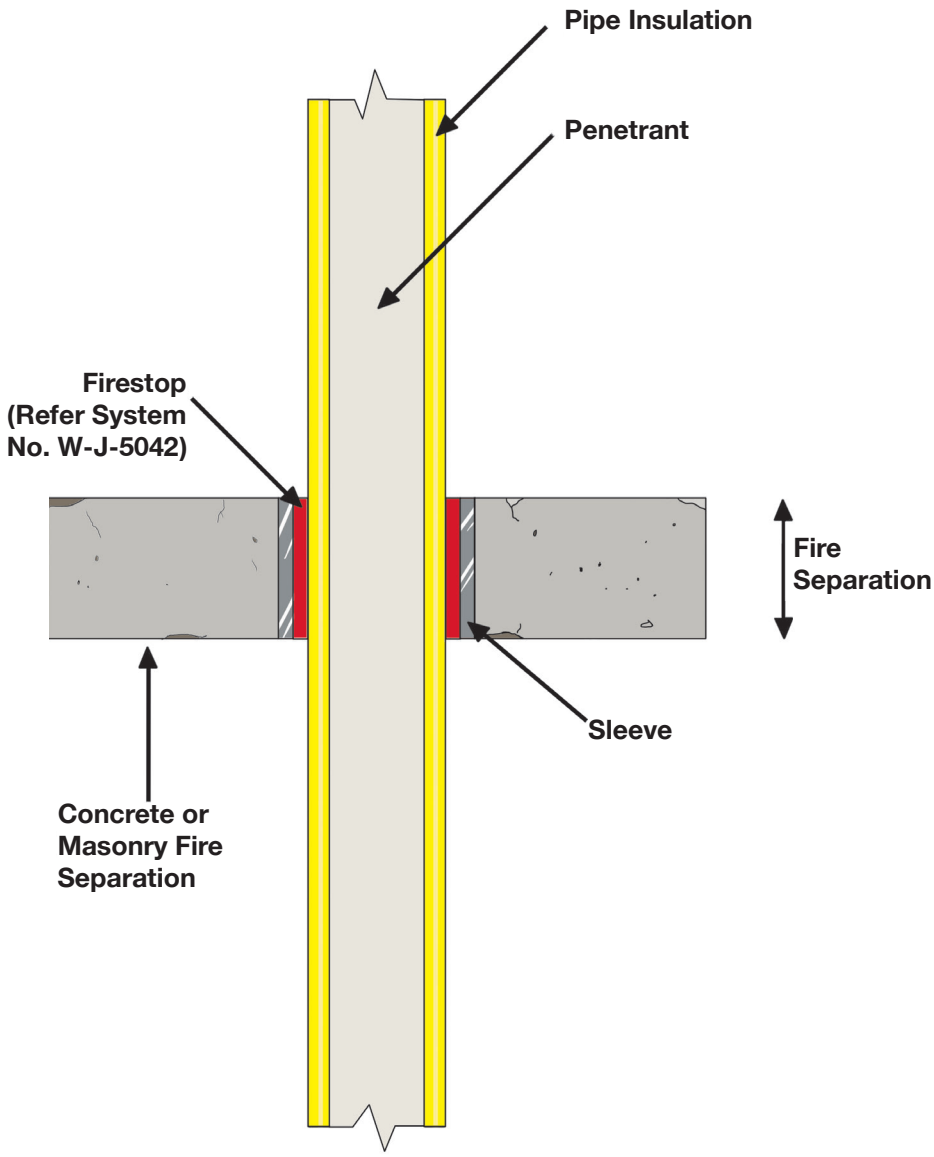


Figure 3.4 Sample specification of firestop assembly for penetrations

CHAPTER 4: JOINT FIRESTOPPING

4.1. ABOUT THE APPLICATION

In the context of this chapter, the gap between two adjacent barriers is referred to as joint. With increase in use of barriers like precast concrete panels, drywall panels, concrete metal deck etc. and façade systems like curtain wall, such joints have become very common in buildings.

Though the different barrier types used may have a fire resistance rating, the gaps between these barriers need to be protected to ensure complete compartmentation, to limit or delay the spread of flame and smoke inside the building. Firestop assembly for joints are used to seal such gaps. They may be broadly classified into two types:

- Linear joints, and
- Perimeter joints

Figure 4.1 Perimeter firestop joints

Linear joints are the ones that are between the interior barriers of the building. Example of such joints are:

- Gap between adjacent precast concrete wall panel
- Expansion joints between floors
- Top-of-the-wall or Head-of-the-wall joints between the wall and floor/roof

Figure 4.2 Example of linear firestop joints

Perimeter joints are the ones that are between the floor assembly and the façade. Most modern high-rise buildings are usually enveloped in curtain wall[4]. There is a gap between the floor slab and the façade which needs to be protected. This application is known as “edge of slab” or “perimeter” joint. The intended function of the perimeter joint protection is to accommodate movements, such as those induced by live loads, thermal differentials, seismicity, wind loads, and so on, and impede the interior vertical spread of fire at perimeter joint. The snorkel height limitation and large evacuation distance in high-rise buildings, make this a very critical application from perspective of fire protection. The connection detail between the exterior curtain wall and the floor assembly will dictate the fire risk. Example of such curtain wall systems are:

- Stick systems
- Unitized systems

In stick systems, the façade is assembled component by component

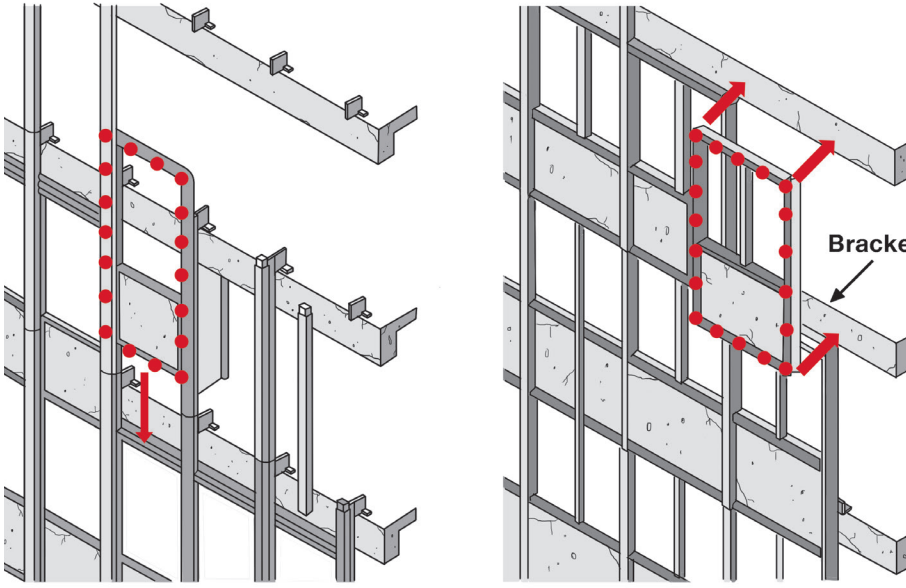
[4]A curtain wall refers to a thin metal frame system, usually aluminum, containing in-fills of glass, metal, or thin stone panels. These systems are typically factory made and then assembled in job site.

at the jobsite. This system is common in case of low to mid-rise buildings. In such systems, the panels are usually combustible and are directly attached to the wall exterior. NFPA 285 “Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components” provides guidance on how to measure propagation of fire in stick systems. In unitized systems, the panels are partially preassembled as large

Figure 4.3 Example of perimeter firestop joints

units and then erected at jobsite. This system is common in case of high-rise buildings. In such systems, the preassembled façade is fixed to a bracket protruding from the floor slab, resulting in a perimeter gap of about 50 to 250 mm between them. Firestop assemblies are used to protect this joint. ASTM E2307 “Standard Test Method for Determining Fire resistance of Perimeter Fire Barriers Using Intermediate-Scale, Multistory Test Apparatus” provides guidance on how to measure the integrity of the compartment when unitized curtain wall configurations are used.

In summary, out of the two curtain wall systems, firestop assemblies are applicable to unitized systems and will be discussed further in this chapter.



(a) Stick (b) Unitized

Figure 4.4 Stick system vs. unitized curtain wall system

4.2. CODES AND STANDARDS

The Fire Code of Philippines 2019 Section 10.2.6.5 (F) recognizes the need to protect joints. It states that:

"(a) Every exterior and interior wall and partition shall be fire-stopped at each level, at the top storey ceiling level, and at the level of support for roofs." [8]

The Fire Code of the Philippines 2019 Division 6 Section 10.2.6.1(D) explicitly refer to the need to inspect firestop protected joints:

"In high rise buildings and healthcare occupancy buildings, a quality assurance program for devices and systems installed to protect penetration and joints shall be conducted by an approved inspection agency in accordance with American Society for Testing and Materials (ASTM) E2393, Standard Practice for On-Site Inspection of Installed Fire Resistive Joint Systems and Perimeter Fire Barriers." [8]

The Fire Code of the Philippines 2019 does not provide further guidance on this application. For further clarity on this application, International Building Code 2018 may be referred to.

International Building Code 2018 Section 715 deals with "fire-resistant joint systems". International Building Code 2018 Section 715.1 recommends protecting the joints installed "in or between" fire resistance rated barriers such as floor/ceiling assemblies using an approved joint system that has been tested according to specified standards and is capable of resisting passage of fire for a period of time not less that the rating of the barrier. International Building Code 2018 Section 715.1.1 talks about perimeter joint (i.e., curtain wall) application [14].

International Building Code 2018 Section 715.1 provides a list of ten applications where this requirement of protecting joints using fire-resistive joint assemblies does not apply. For example, mezzanine floors, walls with unprotected openings and so on [14]. The reason for permitting this exception is due to the fact that fire can bypass the joint system through another route due to the nature of application or is already protected as in case of shaft enclosure, thereby rendering the joint protection mute. Some of these examples are shown in Figure 4.5.

Although the code allows for these exceptions, it should be evaluated based on need, keeping in mind that the code does not permit unprotected openings that could jeopardize integrity of the fire-resistive rated assembly.

International Building Code 2018 Section 715 also lists some exceptions where an approved material may be used instead of an assembly. Irrespective of whether a system or material is used, it should be able to:

- Accommodate building movements
  - Both expansion and contraction should be considered.
  - When opening size expands, it could rip open the joint if not within limit.
  - When the opening size reduces, it could displace the joint material if not within limit
- Restrict spread of flame and hot gases sufficient to ignite cotton waste on the unexposed side
- Stay securely in place even upon impact of hose stream test

International Building Code 2018 also provides guidance on fire-resistive joints in smoke barriers in Section 715.6. It recommends using assemblies having L rating when tested according to UL 2079 for air leakage [14]. This test is carried out at two temperatures – ambient and elevated [21]. Note that all assemblies tested as per UL 2079 will not have a L rating as it is an optional test.

(a) Atrium Floors [26]

(b) Mezzanine Floor [27]

Figure 4.5 Illustration of some applications which are exempted from protecting linear joints as per IBC 2018 Section 715.1

4.3. PERFORMANCE RATING

As stated in previous chapter, firestop assemblies are tested as per specified standards and listed by independent testing agencies such as Underwriters Laboratories (UL), Intertek and so on.

Before looking at the test standards, lets first understand how the flame and hot gases spread through joints. In case of linear joint, the spread mechanism is simple and like that of penetration openings. Basically, the flame and hot gases pass to the unexposed side through the gap between two fire resistance rated barriers (see Figure 4.6).

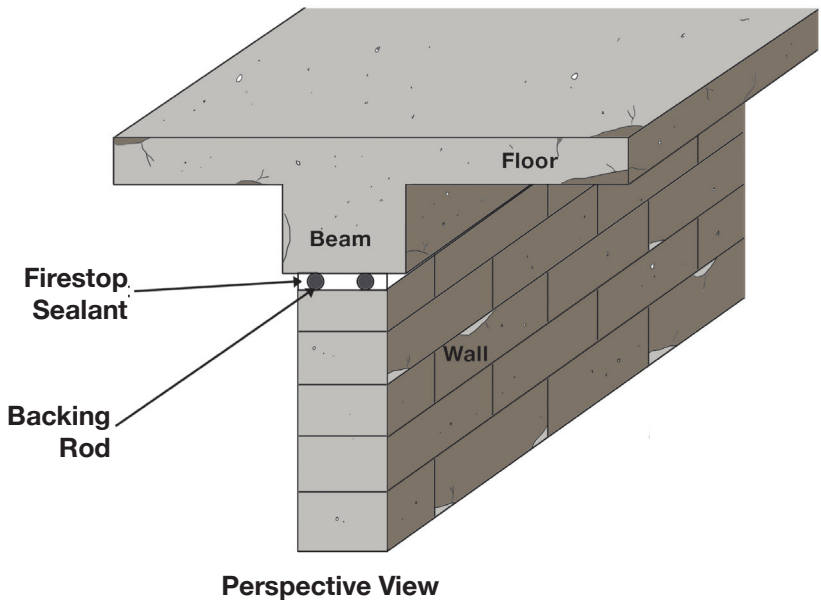


Figure 4.6 Illustration of Top of Wall Linear Joint

As per International Building Code 2018 Section 715.3, the linear firestop joints assemblies should be tested as per ASTM E1966 “Standard Test Method for Fire-Resistive Joint Systems” or UL 2079 “Tests for Fire Resistance of building Joint Systems” [14], which are very similar. In terms of requirements, it’s like ASTM E119 “Standard

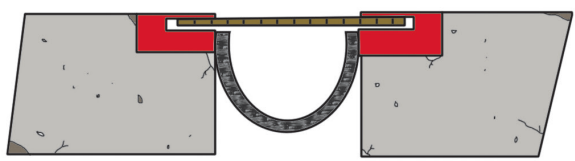
Test Methods for Fire Tests of Building Construction and Materials" or UL 263 "Fire Tests of Building Construction and Materials" and evaluates fire endurance rating of the assembly.

However, ASTM E1966 or UL 2079 focuses on the joint, which is not is scope of ASTM E119 or UL 263. These standards also evaluate the joints' ability to perform its intended function when subjected to movement cycles [22], [21]. UL 2079 also offers guidance on some additional requirements like L rating for evaluating air leakage and W rating for evaluating water leakage [21].

International Building Code 2018 Section 715.3 also highlights the need for testing both faces of non-symmetrical fire joints i.e., each face exposed to furnace and tested. The rating is based on the shortest duration obtained out of the two tests. It is permitted to test only one face of non-symmetrical linear fire joint under the following two conditions [14]:

- When the least fire-resistant side can be established then only that side needs to be tested
- When the dire separation distance is greater than 3.048 m for exterior walls, only interior side needs to be tested.

(a) Symmetrical Joint



(b) Non-symmetrical Joint

Figure 4.7 Symmetrical and non-symmetrical fire resistive joints

In case of perimeter firestop joint, the flame and hot gases spread mechanism is complicated and can be described as follows:

Through leapfrogging

- In interior of the building, the perimeter firestop joint and curtain wall is exposed to the flames and hot gases generated due to fire inside the building.
- When the glazing is shattered due to heat exposure, the flame and hot gases project outward and then upwards, reaching for the curtain wall on the above level from outside the building.
- The flame and hot gases then reach from exterior to the interior of the building and damage contents of above level after having shattered the glazing.

Through void

- In this case the flame and hot gases spread in interior of the building through the void between the exterior curtain wall and the floor/ceiling assembly.

Through cavity

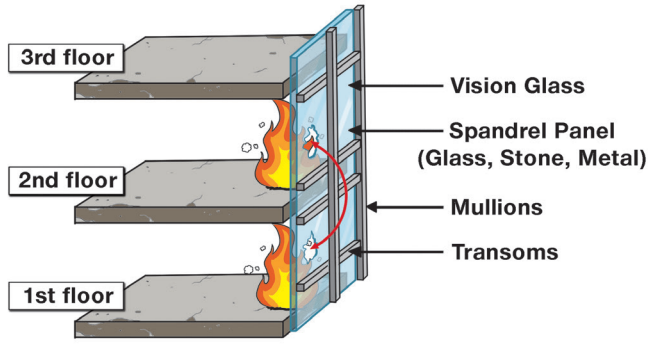
- The flame and hot gases spread through the cavity or concealed space within the exterior curtain wall. This is not covered in this book. International Building Code 2018 Section 718 may be referred to.

These three spread mechanisms based on different exterior wall and floor intersection arrangements are illustrated in Figure 4.8.

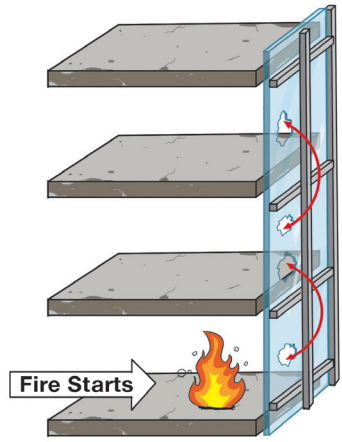
International Building Code 2018 Section 715.1.1 explicitly talks about perimeter firestop application. It states that

“The void created at the intersection of a floor/ceiling assembly and an exterior curtain wall assembly shall be protected in accordance with Section 715.4” [14]

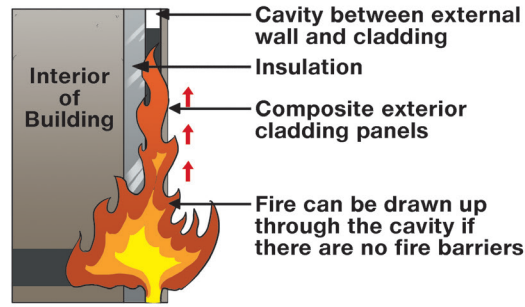
The reason the code defines this application in a separate sub-section is because it does not distinguish between fire rated and non-fire rated assemblies. This implies that the void between the exterior curtain wall and floor/ceiling assembly needs to be protected regardless of whether the curtain wall is fire rated. The reason for



(a) Spread through leapfrogging



(b) Spread through void

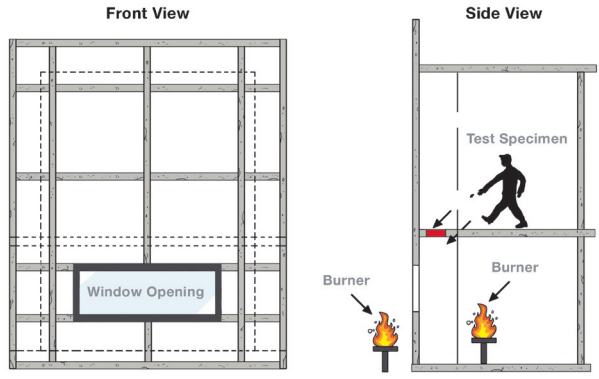


(c) Spread through cavity

Figure 4.8 Illustration of how flame and hot gases spread in case of perimeter joint

doing so is to ensure continuity of horizontal assembly, thereby eliminating spread of flame and hot gasses through the void. The void would act as a flute or chimney if left unprotected.

As per International Building Code 2018 Section 715.4, the perimeter firestop joints assemblies for protecting void at intersection of fire rated floor/ceiling assembly and exterior curtain wall should be tested and rated as per ASTM E2307 “Standard Test Method for Determining Fire resistance of Perimeter Fire Barriers Using Intermediate-Scale, Multistory Test Apparatus” [14]. ASTM E2307 replicates a situation that mimics non-fire rated unitized curtain wall with a fire rated floor assembly on a test furnace [12] as shown in Figure 4.9.



(a) Test Set Up

(b) Actual Test Set Up

Figure 4.9 ASTM E2307 test set up

Such assemblies should provide a F rating equal to or greater than that of the floor assembly [14]. This requirement is linked to "through void" spread mechanism. This requirement in conjunction with International Building Code 2018 Section 715.5 and 705.8 may be linked to "through leapfrogging" mechanism, by defining spandrel requirement to avoid the said effect. In case where the vision glass extends to the finished floor level, the code permits to seal the void with an "approved" material to prevent interior spread of fire, provided it can prevent the passage of flame and hot gases as explained in International Building Code 2018 Section 715.4 [14]. The code allows this exception as this application cannot pass the requirements of ASTM E2307.

International Building Code 2018 Section 715.4 has two sub-clauses 715.4.1 and 715.4.2 that deal with curtain wall-to-non fire rated floor and non-fire rated curtain wall-to-vertical fire barrier intersections, respectively. As per International Building Code 2018 Section 715.4.1, Code allows use of "approved" material for this application because the floor is without a rating. Note that it does not restrict use of tested system for this application, it's just that it would be not as per firestop assembly listing which is usually for use with fire rated floor assembly. International Building Code 2018 Section 715.4.2 recognizes the need to seal the gap between the curtain wall and the adjacent vertical fire barrier, which is different than application covered in scope of ASTM E1966 or UL 2079.

As stated earlier, the code requires approved systems tested as per ASTM E2307 to seal voids between exterior curtain wall and adjacent fire rate floor/ceiling, to prevent interior spread of fire. The test method in ASTM E2307 evaluates the ability of the joint assembly to restrict passage of flame and hot gases through the void that it is used to seal [12]. The test method in ASTM E2307 is not intended to evaluate leapfrogging or spread within cavity of the curtain wall assembly. By itself, ASTM E2307 does not provide the same level of protection as desired by the code. Spandrel requirements are spelled out in IBC 2018 Section 705.8.5 and 715.5, which help to address leapfrogging. These requirements are based on presence of windows in the exterior wall and are not based on fire rating of the exterior wall. Perimeter joints are typically concealed by some type of an interior wall such as a knee or pony wall (see Figure 4.10), these wall

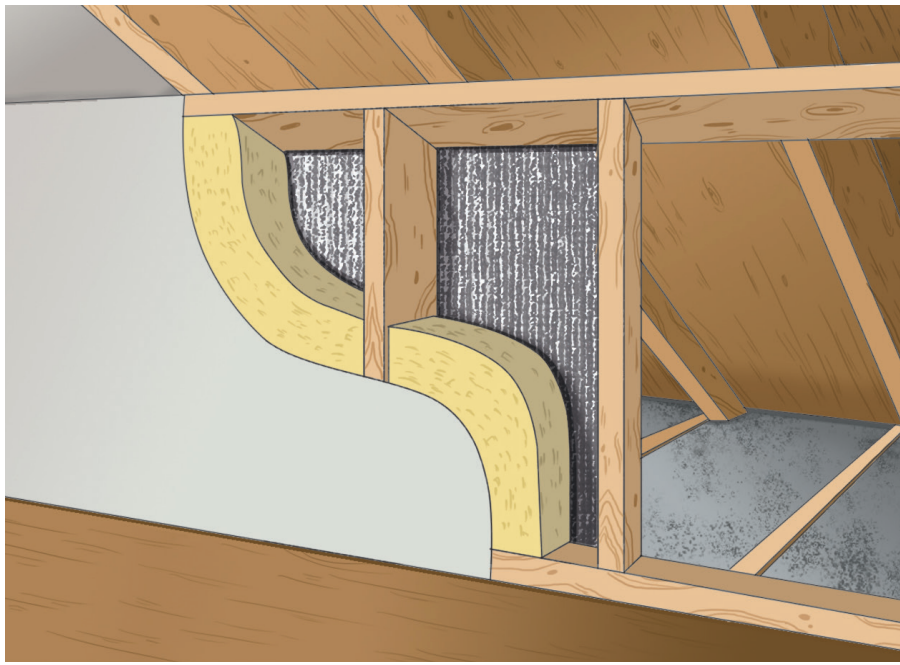


Figure 4.10 Knee or pony wall

systems are not a part of the tested assembly and are not discussed.

The listings based on ASTM E2307 have details about spandrel insulation, which is to ensure that the safing material remains in place, without which the perimeter firestop joint assembly will fail. This is not to be confused with spandrel requirement of International Building Code 2018.

ASTM E2307 allows the joint to be static or dynamic. In the latter case, a cyclic test is conducted before the fire endurance test. The standard also requires the effect of a splice within the joint to be evaluated as its presence and orientation can affect fire performance. The tests are carried out at maximum joint width. In case of static

---

[5]For dynamic joints, the effective compression and the effective density of the insulation decrease at maximum joint width which increases heat transfer through it and is the worst-case scenario for the test

joint, maximum width is same as the nominal width i.e., the width at time of installation whereas for dynamic joints maximum width[5] is higher than nominal. For dynamic joints, expansion/ contraction and shear movements are cyclic tested. Based on the testing, an assembly (F and/or T) rating and/or a movement rating is issued [12].

Though ASTM E2307 allows both static and dynamic joints, the latter one is better representative of the application needs and is also worst-case scenario, due to reduced density at maximum width.

4.4. SELECTION AND SPECIFICATION

It is important to find a perimeter firestop joint system that has been evaluated using the same conditions as those in the actual jobsite. Each tested firestop joint assembly has a unique combination of barrier type, joint width, firestop system, movement requirement and so on. Parameters like curtain wall attachment method, safing materials and insulation details are very critical for perimeter firestop joint assembly.

In addition to the firestopping requirement, movement is another performance criteria that needs to be considered during the design and selection process. Joint movement may occur due to internal factors such as creep/shrinkage, thermal response, or due to external factors such as wind, seismic forces, live load and environmental effect such as humidity, temperature changes, and so on.

While identifying the most suitable linear or perimeter firestop joint assembly for your application, you would have to compare your application details to the firestop assembly that best matches it.

It is difficult to manually sieve through each listing to find the best match. Therefore, independent testing agencies as well as manufacturers maintain a list of tested assemblies that can be narrowed down based on your application requirement (Refer Section 2.6). Table 4-1 lists the numbering format followed by Underwriter Laboratories Inc for firestop joint systems for ease of navigation and identification. As an example, UL system no. WW-D-0270 refers to a “wall-to-wall” dynamic

Table 4-1 Numbering system followed by UL for firestop joint systems

First 2 alpha component		Third alpha component		Numeric component (for identifying nominal joint width)	
FF	Floor-to-floor	S	Static	0000 -0999	Width ≤ 2 in.
W W	Wall-to-wall	D	Dynamic	1000 -1999	2 in. < Width ≤ 6 in.
FW	Floor-to-wall			2000 -2999	6 in. < Width ≤ 12 in.
HW	Head-of-wall			3000 -3999	12 in. < Width ≤ 24 in.
BW	Bottom-of-wall			4000 -4999	Width > 24 in.
CG	Wall-to-wall joints as corner guards			4000 -4999	Width > 24 in.

joint assembly with 2 inch nominal joint width. Refer UL's "XHBN. GuideInfo" available on their website for more information.

Below are some of the parameters that one should consider:

- Type and rating of the fire resistance assembly being connected, e.g., floor-to-wall with 2 hr rating
- Any special requirements like L rating
- Material and construction of the assembly e.g., Gypsum drywall-to-bottom of concrete over metal deck floor, Glass curtain wall with aluminum mullions-to-concrete floor

- Joint width
  - For perimeter joint application, joint width is the distance from edge of slab to closest point of curtain wall assembly
- Movement requirement e.g., % of the joint size
- Curtain wall assembly insulation details (if applicable)
- Preferred material and type of firestopping system
- Special considerations like exposure conditions, site restrictions and so on.

Let's take the example of joint width and movement. Some of the firestop listings that have been tested as per ASTM E2307, are marked as static or dynamic. If the joint is expected to move, a dynamic joint assembly should be selected. Structural Engineer should be consulted to determine the anticipated joint movement and the assembly should be selected such that it is able to accommodate this movement and joint width is within the tested limits.

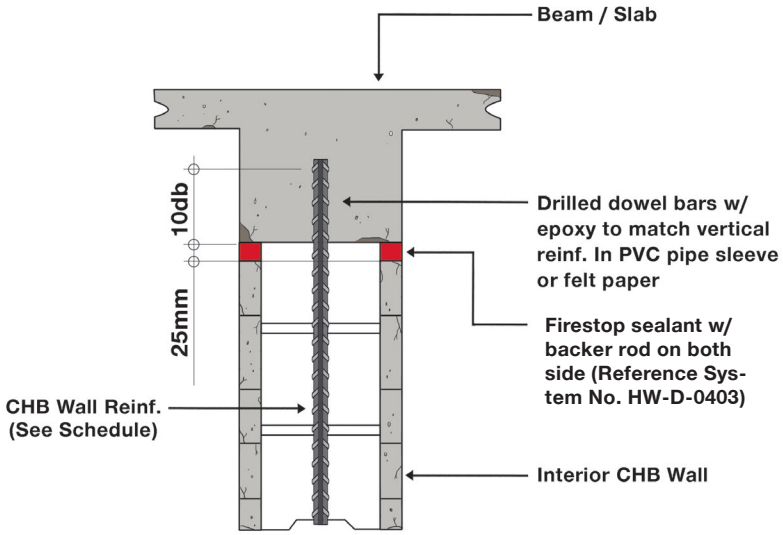


Figure 4.11 Sample specification drawing of firestop assembly for linear joints

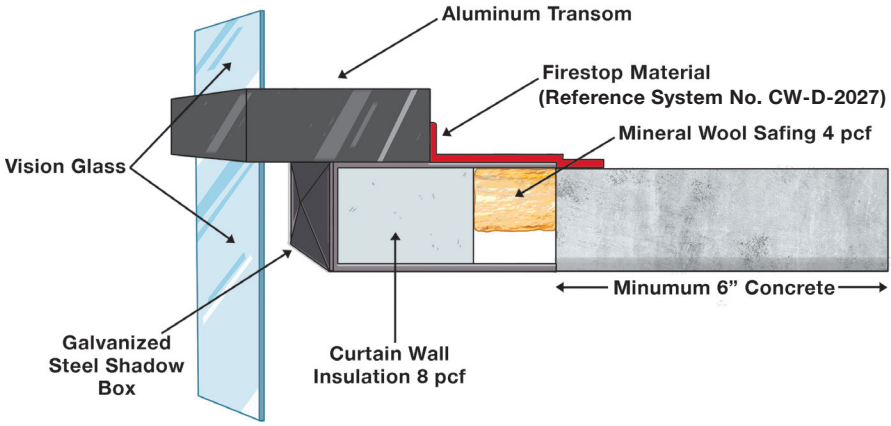


Figure 4.12 Sample specification drawing of firestop assembly for perimeter joints

If your application deviates from the tested firestop listing available on independent testing agency website or manufacturer database, then EJ could be requested (Refer Section 2.7).

After selecting the most suitable firestop assembly for your application, it should be correctly specified in the drawings and tender documents to ensure correct execution at jobsite. Some sample specifications are shown in Figure 4.11 and Figure 4.12.

The schedule could include text like “Manufacturer system XYZ listing to be used for joint width with % movement capability and xx curtain wall detail”. This kind of schedule helps contractor to plan their joint width, and hence avoiding the need for engineering judgement later. It is important to prepare such schedules during the planning phase, keeping in mind the actual suitable listing would have to be selected at a later stage when more details about actual joint width, backing material and so on is available, as these details may not be available during the design phase.

CHAPTER 5: INSTALLATION, INSPECTION AND MAINTENANCE

5.1. INSTALLATION

For the firestop system to perform as intended it should be installed correctly as per the details provided in its third-party certification/ listing and manufacturer's installation instruction. If you select the right firestop assembly but it is installed incorrectly then the whole purpose of the design and selection process is defeated, as incorrectly installed systems may not be able to restore the rating of the fire compartment.

As discussed in previous chapters, each firestop assembly is unique. It is important to ensure that the selected tested and listed firestop assembly is suitable for the application design conditions and are installed within the limits defined in the listing, to be able to deliver the required performance in the jobsite.

International Building Code 2018 emphasizes on the importance of correct installation of firestop assembly by repeatedly using phrases like "installed in accordance with the manufacturer's installation instructions and the listing criteria", "installed as tested", and so on in sections relevant for firestops. However, it does not explicitly state "who is responsible" to do so nor does it talk about "the qualification requirement" to ensure it is "installed as tested". It basically states the intent without specifying exact means to do so.

It is the responsibility of the Project Owner, Consultant or Architects to engage a sub-contractor or specialty contractor who is trained and experienced in understanding/interpreting the listing limits and then correctly installing the firestop assembly within the defined limits as per the construction details provided in its third-party listing and manufacturer's installation instruction. If this responsibility is pawned off to individual tradesperson with the intent to hold them accountable for protecting the openings they create, it would be difficult to coordinate and execute. Some examples of incorrect installation are shown in Figure 5.1.

(a) Lack of firestop sealant to enclose firestopping of multiple penetration, i.e. cable tray and cable bundles, and barrier

(b) Improper application of firestop sealant for cable bundle

Figure 5.1 Examples of incorrect installation

5.2. INSPECTION

National Building Code of The Philippines 2005 has several clauses that talk about the building owners engaging certified agencies to carry out inspection. It also talks about submission of various works to the building officials for issue of permit and occupancy certificate [9]. Firestop forms a small but essential part of such submissions. Various sections of The Fire Code of The Philippines 2019 talk about the need to inspect firestop assemblies. Below are some examples of the same from the code.

The Fire Code of the Philippines 2019 Division 6 Section 10.2.6.1(H) states:

"The person responsible for the conduct of inspection shall demonstrate appropriate technical knowledge and experience in fire resistance rated design and construction acceptable to the Chief BFP or his/her duly authorized representative..." [8]

Standards like ASTM E2174 "Standard Practice for On-Site Inspection of Installed Fire Stops" [23] and ASTM E2393-20a "Standard Practice for On-site Inspection of Installed Fire Resistive Joint Systems and Perimeter Fire Barriers" [24] provide guidance on how to inspect firestop assemblies for joints and penetrations. One example of visual inspection is illustrated in Figure 5.2. The latter is also explicitly referred in The Fire Code of The Philippines 2019. International Building Code 2018 Section 1705.17 also recommends use of these two standards for inspection in high-rise and certain types of buildings. The inspector should check the documents to make sure that the firestop systems being used are certified for use in that specific application and are properly installed.

Below are some of the aspects that inspector should consider while carrying out inspection:

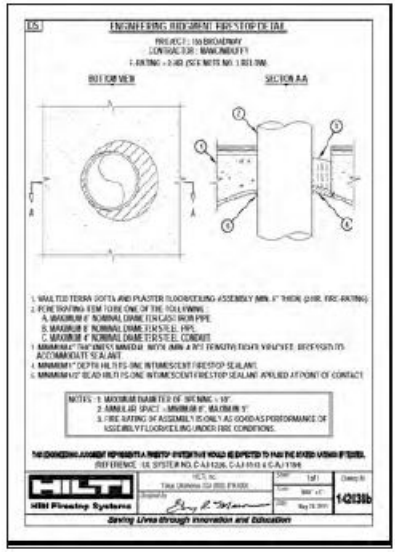
- Is the firestop system listed?
- Does it match the application it is being used for?
- Has the firestop assembly been installed as per listing?

- How is the quality of workmanship?
- In case an Engineering judgement has been used, has it been prepared by trained personnel?

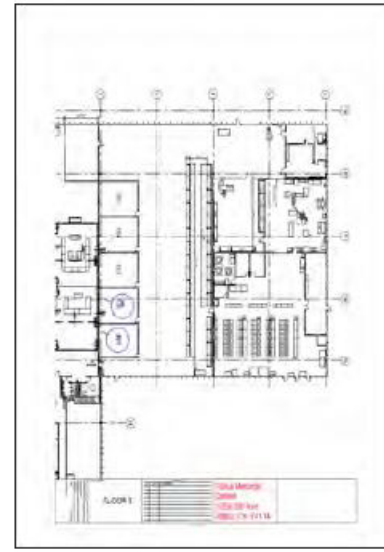
Refer to International Firestop Council's inspection guideline available at https://www.firestop.org/inspection-guidelines, for a more comprehensive checklist.

Figure 5.2 Example of visual inspection

As per The Fire Code of the Philippines 2019 Division 6 Section 10.2.6.1, a written report documenting the result of visual inspection prepared by the inspector should be submitted to the C/MFM having jurisdiction. Thought not explicitly stated in this clause, it is implied that these systems should be accessible (i.e., not concealed from view) for the inspector to be able to carry out inspection. In addition, a certification of firestopping in accordance with standards like PD 1096, NFPA 251, UL 263, ASTM E119, and so on, if available should be submitted to the C/MFM having jurisdiction [8]. A sample documentation is shown in Figure 5.3.



(a) Engineering Judgement



(b) 2D Plan

(c) Technical documents (Work orders, Certificates, Approval letters)

Figure 5.3 Sample documentation

The Fire Code of the Philippines 2019 Division 6 Section 10.2.6.1 emphasises on the criticality of fire protection in high-rises by recommending inspection of fire resistance rated assemblies in high rise buildings at least once every three (3) years, provided they are accessible [8]. In addition, The Fire Code of the Philippines 2019 Division 6 Section 10.2.6.1(D) states:

"In high rise buildings and healthcare occupancy building, a quality assurance program for devices and systems installed to protect penetration and joints shall be conducted by an approved inspection agency in accordance with American Society for Testing and Materials (ASTM) E2393, Standard Practice for On-Site Inspection of Installed Fire Resistive Joint Systems and Perimeter Fire Barriers." [8]

International Building Code 2018 Section 703.7 talks about marking and identifying protected openings in concealed fire or smoke barriers if they are accessible [14]. Though The Fire Code of Philippines 2019 does not talk about such identification (see Figure 5.4), this is a useful feature that could help to inspect and maintain in future.

Figure 5.4 Marking and identification of firestop assemblies

In summary, it is not enough to check if the opening has been sealed or the firestop material is a certain colour or type. A thorough inspection is required to ensure that the systems have been “installed as tested” and are suitable for use in that application. For a firestop system to be able to perform as tested, it has to be correctly installed as per listing and manufacturer’s installation instruction.

5.3. MAINTENANCE

During the service life of the building, new utilities and penetrations may have to be added, floor layout may have to be changed and so on. This may lead to dismantling of, or damage to firestop assembly, resulting in loss of its ability to restrict passage of flame and smoke. Therefore, it becomes necessary to periodically inspect and maintain protected openings and joints.

The Fire Code of Philippines 2019 identifies the need for repair and maintenance of fire resistive construction in Section 10.2.6.1(E). It states:

“Required fire resistive construction, including fire barriers, fire wall, exterior walls due to location on property, fire resistive requirements based on type of construction, draft-stop partition, and roof coverings shall be maintained and shall be immediately repaired, restored or replaced where damaged, altered, breached, penetrated, removed or improperly installed” [8]

In addition, International Fire Code 2021 Section 703.1 and 704.1 exclusively talk about “maintaining protection” for penetration and Joints/Voids, respectively. International Fire Code 2021 Section 703.2 and 704.2 talks about repair [25].

If the document and design details of original listing are maintained and are accessible by the personnel responsible for maintenance, it becomes easier to carry our repair and maintenance activities.

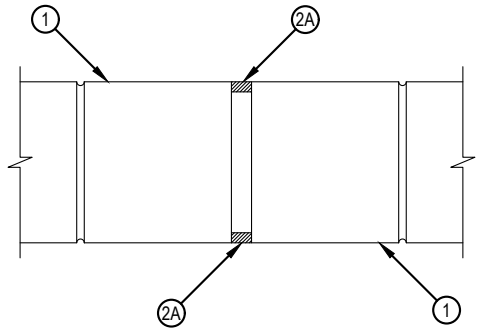
ANNEX – SAMPLE LISTING

Classified by Underwriters Laboratories, Inc. to UL 2079 and CAN/ULC-S115

System No. WW-D-0032

WWD 0032

ANSI/UL2079	CAN/ULC S115
Assembly Rating — 1 and 3 Hr (See Item 2)	F Rating — 1 and 3 Hr (See Item 2)
Nominal Joint Width - 1 In.	FT Rating — 1 and 3 Hr (See Item 2)
Class II or III Movement Capabilities — 12.5% Compression or Extension	FH Rating — 1 and 3 Hr (See Item 2)
L Rating At Ambient — Less Than 1 CFM/ft	FTH Rating — 1 and 3 Hr (See Item 2)
L Rating At 400 F — Less Than 1 CFM/ft	Nominal Joint Width - 25 mm
	Class II or III Movement Capabilities — 12.5% Compression or Extension
	L Rating At Ambient — Less Than 1.5 L/s/m
	L Rating At 204 C — Less Than 1.5 L/s/m



1. Wall Assembly — Min 8 in. (203 mm) thick steel reinforced lightweight or normal weight (100-150 pcf or 1600-2400 kg/m3) structural concrete. Wall may also be constructed of any UL Classified Concrete Blocks*.
   See Concrete Blocks (CAZT) category in the Fire Resistance Directory for names of manufacturers.
2. Joint System — Max width of joint (at time of installation) is 1 in. (25 mm). The joint system is designed to accommodate a max 12.5 percent compression or extension from its installed width. The joint system shall consists of the following:
   A. Fill, Void or Cavity Material* - Sealant — A min 1/4 in. (6 mm) or min 1/2 in. (13 mm) thickness of fill material installed within the joint, flush with each surface of the wall. When min 1/4 in. (6 mm) thickness is used, the hourly ratings of the system are 1 hr.
   HILTI CONSTRUCTION CHEMICALS, DIV OF HILTI INC — CP606 Flexible Firestop Sealant
   B. Forming Material — (Optional, Not Shown) - Mineral wool insulation or polyurethane foam backer rod. Forming material to be recessed from both surfaces of the wall as required to accommodate the required thickness of fill material.

* Indicates such products shall bear the UL or cUL Certification Mark for jurisdictions employing the UL or cUL Certification (such as Canada), respectively.

Hilti Firestop Systems

Reproduced by HILTI, Inc. Courtesy of Underwriters Laboratories, Inc.
March 19, 2020

Reprinted from the Online Certifications Directory with permission from UL

cUL SYSTEM NO. W-J-0024

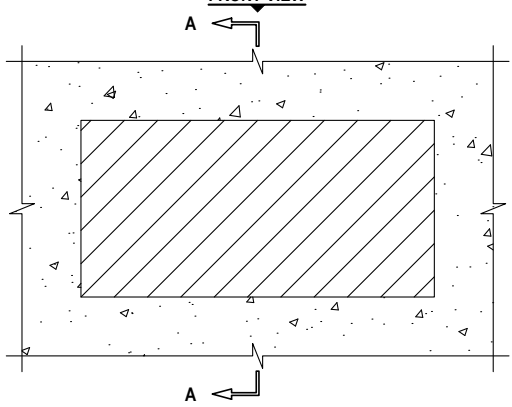
CANADA ONLY

BLANK OPENING THROUGH CONCRETE WALL OR BLOCK WALL ASSEMBLY

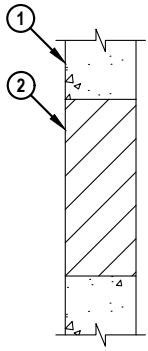
F-RATING = 1-HR. OR 2-HR.
FT-RATING = 1-HR. OR 2-HR.
FH-RATING = 0-HR.
FTH-RATING = 0-HR.

cUL WJ0024b.010417

FRONT VIEW



SECTION A-A



1. CONCRETE WALL ASSEMBLY (1-HR. OR 2-HR. FIRE-RATING) :
   A. LIGHTWEIGHT OR NORMAL WEIGHT CONCRETE WALL (MIN. 4-3/4" THICK, FOR A 1-HR. FIRE-RATING).
   B. LIGHTWEIGHT OR NORMAL WEIGHT CONCRETE WALL (MIN. 6" THICK, FOR A 2-HR. FIRE-RATING).
   C. ANY UL/cUL CLASSIFIED SOLID OR FILLED CONCRETE BLOCK WALL.
2. HILTI CP 660 FIRESTOP FOAM INSTALLED FLUSH WITH BOTH SURFACES OF THE WALL :
   A. MINIMUM 4-3/4" THICKNESS, FOR A 1-HR. FIRE-RATING.
   B. MINIMUM 6" THICKNESS, FOR A 2-HR. FIRE-RATING.

NOTE : MAXIMUM SIZE OF OPENING = 30" x 15".

Hilti Firestop Systems	HILTI, Inc. Plano, Texas USA (800) 879-8000	Sheet 1 of 1 Scale 7/64" = 1" Date Jan. 04, 2017	Drawing No. cUL WJ0024b

Saving Lives through Innovation and Education

Reprinted from the Online Certifications Directory with permission from UL

cUL SYSTEM NO. W-L-0048

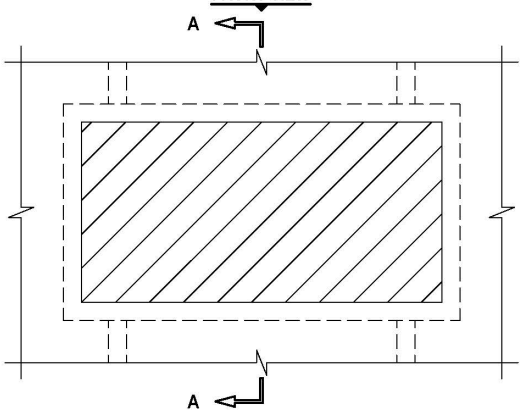
BLANK OPENING THROUGH GYPSUM WALL ASSEMBLY

CANADA ONLY

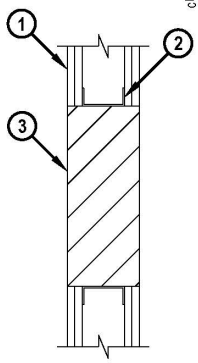
cUL WL0048b 011217

F-RATING = 1-HR. OR 2-HR.
FT-RATING = 1-HR. OR 2-HR.
FH-RATING = 0-HR.
FTH-RATING = 0-HR.

FRONT VIEW



SECTION A-A



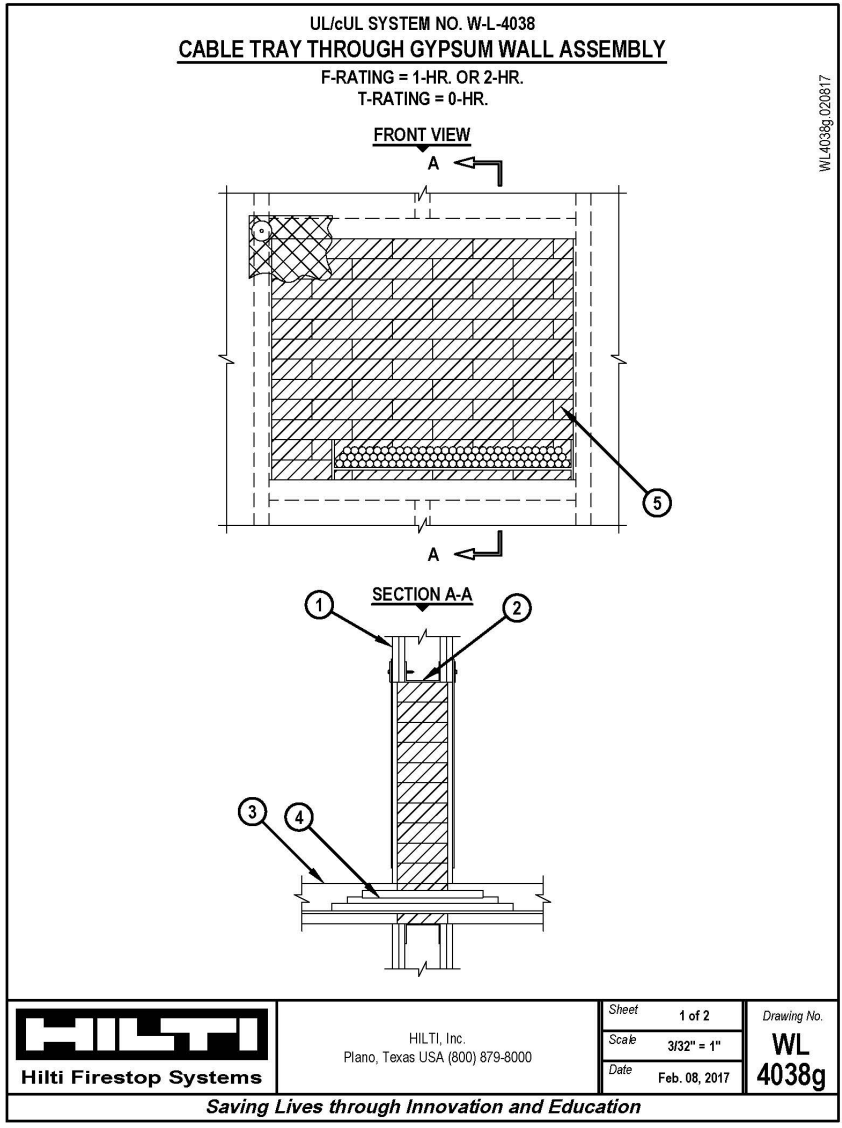
1. GYPSUM WALL ASSEMBLY (UL/cUL CLASSIFIED U400 SERIES) (1-HR. OR 2-HR. FIRE-RATING) (2-HR. SHOWN).
2. OPENING TO BE "FRAMED-OUT" WITH LIGHTGAGE STEEL STUDS (MIN. 3-1/2" WIDE).
3. HILTI CP 660 FIRESTOP FOAM INSTALLED FLUSH WITH BOTH SURFACES OF THE WALL :
   A. MINIMUM 4-3/4" THICKNESS, FOR A 1-HR. FIRE-RATING.
   B. MINIMUM 6" THICKNESS, FOR A 2-HR. FIRE-RATING.

NOTE : MAXIMUM SIZE OF OPENING = 30" x 15".

Hilti Firestop Systems	HILTI, Inc. Plano, Texas USA (800) 879-8000	Sheet 1 of 1 Scale 7/64" = 1" Date Jan. 12, 2017	Drawing No. cUL WL0048b

Saving Lives through Innovation and Education

Reprinted from the Online Certifications Directory with permission from UL



Reprinted from the Online Certifications Directory with permission from UL

UL/cUL SYSTEM NO. W-L-4038

CABLE TRAY THROUGH GYPSUM WALL ASSEMBLY

F-RATING = 1-HR. OR 2-HR.
T-RATING = 0-HR.

WL4038g 020817

1. GYPSUM WALL ASSEMBLY (UL/cUL CLASSIFIED U300, U400, V400, OR W400 SERIES) (1-HR. OR 2-HR. FIRE-RATING) (2-HR. SHOWN).
2. WOOD STUDS TO CONSIST OF NOMINAL 2" x 4" LUMBER. STEEL STUDS TO BE MINIMUM 2-1/2" WIDE. OPENING TO BE COMPLETELY "FRAMED-OUT".
3. MAXIMUM 24" WIDE x 4" DEEP, ALUMINUM OR STEEL, OPEN LADDER OR SOLID BACK, CABLE TRAY.
4. CABLES TO BE ANY COMBINATION OF THE FOLLOWING :
   A. MAXIMUM 300 PAIR NO. 24 AWG TELEPHONE CABLE.
   B. MAXIMUM 750 KCMIL SINGLE CONDUCTOR POWER CABLE.
   C. MAXIMUM 1/2" DIAMETER FIBER-OPTIC CABLE (24 FIBER).
   D. MAXIMUM 3/C NO. 12 AWG METAL-CLAD CABLE.
5. HILTI CFS-BL FIRESTOP BLOCK (2" THICK x 8" WIDE x 5" DEEP, REFERENCE : FRONT VIEW) FIRMLY PACKED AND CENTERED WITHIN OPENING.

NOTES : 1. MAXIMUM AREA OF OPENING = 900 SQ. IN., WITH A MAXIMUM DIMENSION OF 30".
2. ANNULAR SPACE = MINIMUM 0", MAXIMUM 26" (FOR STEEL STUD WALLS) OR MINIMUM 1", MAXIMUM 26" (FOR WOOD STUD WALLS).
3. CABLES TO FILL MAXIMUM 45% OF CROSS-SECTIONAL AREA OF CABLE TRAY BASED ON A MAXIMUM 3" CABLE LOADING DEPTH.
4. APPLY HILTI FS-ONE MAX INTUMESCENT FIRESTOP SEALANT, HILTI CP 618 FIRESTOP PUTTY STICK, HILTI CP 620 FIRE FOAM, OR HILTI CP 660 FIRESTOP FOAM IN ANY VOID THAT MAY EXIST (INTO INTERSTICES OF CABLES, BETWEEN CABLES AND CABLE TRAY, OR BETWEEN FIRESTOP BLOCKS), TO MAXIMUM EXTENT POSSIBLE.
5. FOR WALLS CONSTRUCTED OF STEEL STUDS LARGER THAN 3-5/8", FIRESTOP BLOCKS SHOULD BE INSTALLED 8" DEEP, RECESSED UP TO A MAXIMUM 1/2" FROM OUTER WALL SURFACES.
6. WHEN ANNULAR SPACE EXCEEDS 4", A NOMINAL 2" x 2" STEEL WIRE MESH (16 GA.) SHALL BE ATTACHED TO BOTH SIDES OF THE WALL BY MEANS OF 1/4" HILTI TOGGLER BOLTS WITH 1-1/2" DIAMETER FENDER WASHERS (SPACED MAX. 8" C/C) OR ATTACHED TO STEEL STUDS WITH STEEL SCREWS AND 1-7/16" DIAMETER FENDER WASHERS (SPACED MAX. 6" C/C).
7. [NOT SHOWN] AS AN ALTERNATE TO WIRE MESH, STEEL PLATE (MIN. 22 GA.) MAY BE USED. STEEL PLATE SHALL BE SECURED TO BOTH SURFACES OF THE WALL ASSEMBLY WITH 1/4" DIAMETER LONG STEEL HOLLOW WALL ANCHORS OR ATTACHED TO STEEL STUDS WITH STEEL SCREWS (SPACED MAX. 12" C/C).
8. STEEL WIRE MESH/STEEL PLATE SHALL BEGIN MAXIMUM 2-1/2" FROM THE PENETRANT AND OVERLAP MINIMUM 3" BEYOND THE PERIPHERY OF THE OPENING.

Hilti Firestop Systems	HILTI, Inc. Plano, Texas USA (800) 879-8000	Sheet 2 of 2 Scale - Date Feb. 08, 2017	Drawing No. WL 4038g

Saving Lives through Innovation and Education

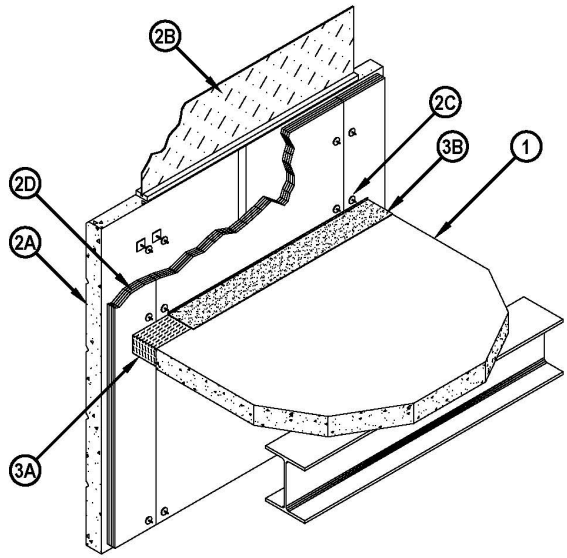
Reprinted from the Online Certifications Directory with permission from UL

CWD 2025

Classified by
Underwriters Laboratories, Inc.
to ASTM E2307

System No. CW-D-2025

F Rating — 2 Hr
T Rating — 1/4 Hr
Linear Opening Width - 8 In. Max
Class II Movement Capabilities - 5% Vertical Shear (See Item 3)



1. Floor Assembly — Min 4-1/2 in. (114 mm) thick steel-reinforced lightweight or normal weight (100-150 pcf or 1600-2400 kg/m3) structural concrete. Floor assembly to be supported at perimeter edges by spandrel beams having a Restrained or Unrestrained Beam Rating of 2 hr. Edge of concrete floor to be max 8 in. from interior surface of spandrel panel (Item 2A).
2. Curtain Wall Assembly — The curtain wall assembly shall incorporate the following construction features:
   A. Spandrel Panels — Min 36 in. (914 mm) high by min 4 in. (102 mm) thick steel-reinforced lightweight or normal weight (100-150 pcf or 1600-2400 kg/m3) structural concrete spandrel panels. Wall may also consist of min 4 in. (102 mm) thick steel-reinforced lightweight or normal weight concrete tilt-up panels with a min 36 in. (914 mm) vertical separation between window openings. Panels provided with steel dead load anchors welded to steel reinforcing bars embedded in the concrete for attachment to the steel columns and spandrel beams. Panels also provided with steel lateral anchors or braces. The dead load anchors, which are located in the linear gap between the concrete floor slab and the spandrel panel or tilt-up panel, are to be spaced max 72 in. (1829 mm) OC. The top of the dead load anchor is to be recessed min 1/2 in. (13 mm) from top surface of floor.
   B. Framed Window — Metal framed window with nom 1 in. thick (double pane) transparent heat-strengthened glass panels. Sill of window to be min 6 in. above top of floor.
   C. Impaling Pins — No. 12 gauge steel pins, min 1/2 in. (13 mm) longer than thickness of insulation boards (Item 2D), swaged to nom 2 by 2 in. (51 by 51 mm) galv steel base plate. Steel base plates secured to concrete spandrel panel with steel concrete screws or powder-driven steel fasteners. Impaling pins to be spaced 3 in. (76 mm) from edges of insulation boards (Item 2D) on each side of seams and spaced max 24 in. (610 mm) OC both vertically and horizontally. A min of two horizontal arrays of impaling pins are required to be located on spandrel panel above top surface of floor.

Hilti Firestop Systems

System No. CW-D-2025

C1. Clutch Clips — (Optional, Not Shown) - Nom 2 by 2 in. (51 by 51 mm) wide by 1-1/4 in. (32 mm) high V-shaped steel clutch clips used in conjunction with impaling pins (Item 2C) to offset curtain wall insulation (Item 2D) from spandrel panel (Item 2A). Clutch clips to be used on all impaling pins. When clutch clips are used, a row of impaling pins shall be located max 3 in. (76 mm) from top and bottom surfaces of floor assembly and spaced max 18 in. (457 mm) OC.

D. Curtain Wall Insulation* — Min 2 in. (51 mm) thick mineral wool board insulation, faced on one side with aluminum foil/scrim vapor retarder, supplied in min 24 by 48 in. (610 by 1219 mm) boards. Insulation boards installed vertically with tightly-butted seams to cover interior surface of concrete spandrel panel. Horizontal seams of insulation boards (if necessary) to be located min 24 in. (610 mm) above and min 6 in. (152 mm) below planes of floor. Insulation boards secured to spandrel panel with impaling pins in conjunction with min 1-1/2 in. (38 mm) diameter galv steel clinch shields. Butted seams to be covered with aluminum foil tape.
ROCKWOOL MALAYSIA SDN BHD — CurtainRock 80
ROXUL INC — CurtainRock 80

3. Safing System — Max separation between edge of floor assembly and curtain wall insulation is 8 in. The safing system is designed to accommodate vertical shear movement of up to 5% of its installed width. The safing system shall incorporate the following construction features:

A. Forming Material* — Mineral wool batt safing material to be cut into min 4-1/2 in. (114 mm) wide pieces and stacked to a thickness which is at least 25 percent greater than the width of the linear gap between the curtain wall insulation (Item 2D) and the edge of the concrete floor slab. The stacked safing material is compressed and inserted cut-edge-first into the linear gap such that its top surface is flush with the top surface of the floor assembly. A max of one tightly butted seam is permitted between spandrel panel attachment plates or tubes. An additional min 1/2 in. (13 mm) thick piece of mineral wool batt safing material is to be installed to cover top surface of each dead load anchor.
ROCKWOOL MALAYSIA SDN BHD — SAFE
ROXUL INC — SAFE

B. Fill, Void or Cavity Material* — Min 1/8 in. (3.2 mm) wet thickness (1/16 in. or 1.6 mm dry) of fill material spray-applied over top of forming material and lapping min 1 in. (25 mm) onto the top surface of the concrete floor and onto the curtain wall insulation. When CFS-SP SIL is used, min wet (and dry) thickness of spray is 2 mm.
HILTI CONSTRUCTION CHEMICALS, DIV OF HILTI INC — CP 672 FC Firestop Joint Spray, CFS-SP SIL Firestop Silicone Joint Spray or CFS-SP WB Firestop Joint Spray

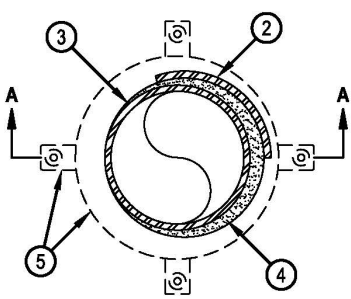
*Bearing the UL Classification Mark

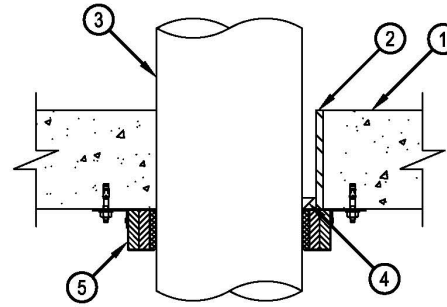
CAJ 2109

Classified by Underwriters Laboratories, Inc. to UL 1479

System No. C-AJ-2109

F Ratings — 2 and 3 Hr (See Item 3)
T Ratings — 0, 2 and 3 Hr (See Items 2 and 3)
W Rating - Class 1 (See Items 2, 3 and 4)
L Rating at Ambient — Less Than 1 CFM/sq ft (See Item 4)
L Rating at 400 F — Less Than 1 CFM/sq ft (See Item 4)





SECTION A-A

1. Floor or Wall Assembly — Min 4-1/2 in. (114 mm) thick reinforced lightweight or normal weight (100-150 pcf or 1600-2400 kg/m3) concrete. Wall may also be constructed of any UL Classified Concrete Blocks*. Max diam of opening is 12 in. (305 mm).
   See Concrete Blocks (CAZT) category in the Fire Resistance Directory for names of manufactures.
2. Steel Sleeve — (Optional) - Nom 12 in. (305 mm) diam (or smaller) Schedule 40 (or heavier) steel pipe cast or grouted into floor or wall assembly, flush with floor or wall surfaces a max of 3 in. (76 mm) above the floor. If the steel sleeve extends above the floor, the T Rating of the firestop system is 0 Hr and a min 1/2 in. (13 mm) annular space is required between the through penetrant (Item 3) and the periphery of the opening. The W Rating does not apply when the steel sleeve is used.
3. Through Penetrants — One nonmetallic pipe to be installed either concentrically or eccentrically within the firestop system. For max 6 in. (152 mm) diam pipes, the annular space between the pipe and the periphery of opening shall be min 0 in. (0 mm, point contact) to max 1/2 in. (13 mm). For nom 8 in. (203 mm) and 10 in. (254 mm) diam pipes, the annular space between the pipe and the periphery of opening shall be min 0 in. (0 mm, point contact) to max 1-1/4 in. (32 mm). If the steel sleeve extends above the floor (Item 2), a min 1/2 in. (13 mm) annular space is required between the through penetrant (Item 3) and the periphery of the opening. Pipe to be rigidly supported on both sides of floor or wall assembly. For systems with a W Rating, the max annular space is 1/2 in. (13 mm). The T Ratings are dependent on the size and/or type of pipe as shown in the table below. The following types and sizes of nonmetallic pipes may be used:
   A. Polyvinyl Chloride (PVC) Pipe — Nom 10 in. (254 mm) diam (or smaller) Schedule 40 solid core or cellular core PVC pipe for use in closed (process or supply) or vented (drain, waste or vent) piping systems. For systems with a W Rating, the nom diam of pipe shall not exceed 6 in. (152 mm).
   B. Chlorinated Polyvinyl Chloride (CPVC) Pipe — Nom 10 in. (254 mm) diam (or smaller) SDR13.5 CPVC pipe for use in closed (process or supply) piping systems. For systems with a W Rating, the nom diam of pipe shall not exceed 6 in. (152 mm).
   C. Acrylonitrile Butadiene Styrene (ABS) Pipe — Nom 6 in. (152 mm) diam (or smaller) Schedule 40 solid-core or cellular core ABS pipe for use in closed (process or supply) or vented (drain, waste or vent) piping system.
   D. Flame Retardant Polypropylene (FRPP) Pipe — Nom 6 in. (152 mm) diam (or smaller) Schedule 40 FRPP pipe for use in closed (process or supply) or vented (drain, waste or vent) piping systems.

HILTI
Hilti Firestop Systems

Reproduced by HILTI, Inc. Courtesy of Underwriters Laboratories, Inc.
January 27, 2015

Page: 1 of 2

REFERENCES

[01] J. John R. Hall, "Burns, toxic gases and other hazards," Fire Analysis and Research Division, NFPA, Quicy, MA, USA, 2004.

[02] N. N. Brushlinsky, M. Arhens, S. V. Sokolov and P. Wagner, "World Fire Statistics," Center of fire statistics, CITF, 2021.

[03] Wikipedia, [Online]. Available: https://en.wikipedia.org/wiki/2018_Manila_Pavilion_Hotel_fire.

[04] The Straits times, [Online]. Available: https://www.straitstimes.com/asia/3-die-23-hurt-as-manila-hotel-fire-rages-over-9-hours.

[05] CNN, [Online]. Available: https://www.cnnphilippines.com/metro/2016/04/01/up-diliman-faculty-center-fire.html.

[06] BBC, [Online]. Available: https://www.bbc.com/news/uk-scotland-glasgow-west-60112316.

[07] The Guardian, [Online]. Available: https://www.theguardian.com/education/2014/nov/26/glasgow-school-of-art-fire-foam-canister-report.

[08] The Fire Code of The Philippines, Manila: Bureau of Fire Protection, 2019.

[09] Task force for National Building Code, National Building Code of The Philippines (P.D. 1096), Manila: Dept. of Public Works, Transportation and Communications, 2018.

[10] J. K. Richardson, J. Q. D and R. Haldy, Best practice guide on firestops and fire blocks and their Impact on sound transmission, Canada: National Research Council Canada - Construction Research Center, 2007.

[11] ASTM E814-13a "Standard Test Method for Fire Tests of Penetration Firestop Systems", Pennsylvania: ASTM, 2017 .

[12] ASTM E2307—10 “Standard Test Method for Determining Fire resistance of Perimeter Fire Barriers Using Intermediate-Scale, Multistory Test Apparatus”", Pennsylvania: ASTM, 2020.

[13] UL 1479 “Fire tests of Penetration firestops”, Underwriters laboratories Inc., 2015.

[14] International Code Council, International Building Code 2018, U.S.A: International Code Council, 2017.

[15] "UL," [Online]. Available: https://iq.ulprospector.com.

[16] "Hilti," [Online]. Available: https://www.hilti.com/firestops.

[17] Recommended IFC Guidelines for Evaluating Firestop System Engineering Judgements, U.S.A: International Firestop Council, 2018.

[18] "International Firestop Council," [Online]. Available: (https://www.firestop.org/engineering-judgement-guidelines).

[19] 2012 Philippine Mechanical Engineering Code, Manila: Professional Regulatory Body of Mechanical Engineering, 2012.

[20] Philippine Electrical Code, Manila: Institute of Integrated Electrical Engineers of The Philippines, Inc, 2017.

[21] UL 2079 Standard for Safety “Tests for Fire Resistance of building Joint Systems”, Underwriters Laboratories Inc., 2015.

[22] ASTM E1966 “Standard Test Method for Fire-Resistive Joint Systems”, Pennsylvania: ASTM, 2019.

[23] ASTM E2174 “Standard Practice for On-Site Inspection of Installed Fire Stops”, Pennsylvania: ASTM, 2020.

[24] ASTM E2393-20a “Standard Practice for On-site Inspection of Installed Fire Resistive Joint Systems and Perimeter Fire Barriers”, Pennsylvania: ASTM, 2010.

[25] International Fire Code, International Code Council, 2021.

[26] Promega, [Online]. Available: https://www.ctpprojects.com/demo/promega/html/IMG_20201221489 69.html

[27] Panel Built Incorporated, [Online]. Available: https://www.panelbuilt.com/products/structural-steel-mezzanines

INDEX

DOCUMENTATION MANAGER

The authors have made use of some examples of documentation using Hilti Documentation Manager to illustrate the concept. Documentation Manager is a state-of-the art software that does documentation – through a cloud-based tool.

Advantages of Documentation Manager software are:

1. Improve transparency – Get visibility about how the application has been installed in a job site.
2. Reference document – It serves as a document for record keeping and for reference purpose.

ASK HILTI

Questions related to firestop and its applications can be posted on Ask Hilti community. Ask Hilti is an online community platform for Engineering and Construction professionals. It offers opportunities for gaining knowledge on topics such as fastening and passive fire protection systems through Q&A, Webinars and Articles with the end goal of improving safety across the construction industry. The platform contains 3 sections for Ask Hilti members to use:

1. **Expert Advice** – ask questions for fast, expert advice from Hilti Engineers on some of the most challenging and innovative applications/concepts like seismic, retrofitting, concrete to concrete post-installed connection(s), fire safety etc.
2. **Education** – engage with Hilti on-demand and/or live webinars on innovative topics and be awarded with participation certificates.
3. **Articles** – regularly added to the platform, read up on recent projects, expand users' knowledge on the topic and be educated on the latest standards and ask questions on articles.

Finally, a handy search function allows users to easily delve into the archive of webinars, articles, and questions.

FIRESTOPPING IN BUILDINGS

This book is a one stop reference guide for firestopping in buildings. Architects, Consultants as well as inspectors can make use of this book to better understand firestopping applications. In this book, the firestopping concept is explained and then each application is explained in detail along with code requirement. This book also contains some design and selection examples. Lastly, this book also includes basic information on how to inspect firestopping applications.

ABOUT THE AUTHORS

Kamalika Kundu

Engr. Kamalika Kundu is a technical expert on firestopping and post-installed fastenings. She is currently working as Regional Codes and Approval Manager at Hilti Asia Pacific Pvt. Ltd. in Singapore. Prior to this, she has worked in U.S.A. and in India. She is a Civil Engineer with a Bachelors's degree from M.N.I.T., Jaipur, India and Masters (specialization in seismic) from Virginia Tech, Blacksburg, USA.

Joanna Marie Gatus

Engr. Joanna-Marie Gatus is a technical expert on firestopping and post-installed fastenings. She is currently working as Codes and Approval Manager at Hilti Philippines Inc. She is a Civil Engineer with a Bachelors degree from UST Manila, Philippines and pursuing her Masters degree (specialization in Structural Engineering) at TUP in Manila, Philippines