CLOSING THE GAP: THE CRITICAL ROLE OF BOTTOM-OF-WALL JOINT PROTECTION IN FIRE AND SMOKE CONTAINMENT

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EXECUTIVE SUMMARY

This report responds to the question of why bottom-of-wall joint protection is such an important component of passive fire protection. It will demonstrate why the omission of bottom-of-wall fire-resistant joint systems will severely impact the overall prescribed fire performance of a wall, reduce passive fire protection requirements in buildings and allow an unprotected path of fire and smoke spread between compartments.

The research included post-flashover fire conditions, fire spread through the bottom of wall, fire testing, static joint conditions, gap sizes, smoke migration, vertical shaft continuity, and impact of construction practices.

Five separate research and testing laboratories conducted a series of nineteen bottom of wall configurations using the prescribed standard test methods for fire-resistive joint systems, UL2079 and ASTM E1966. The test configurations included both unprotected and protected bottom-of-wall joints, varying features such as gap sizes, wall stud type, and use of baseboards. Some configurations included a discontinuous track to replicate observed field conditions. Observation and testing to assess the ability of the bottom-of-wall joint to resist smoke leakage was also conducted.

The results illustrate that protected joint systems consistently outperformed unprotected bottom of wall joints by a wide margin.

The results illustrate that protected joint systems consistently outperformed unprotected bottom-of-wall joints by a wide margin. Testing showed that protected joints provide the level of safety required by codes whereas unprotected bottom-of-wall joints do not. Variables such as gap sizes, metal or wood studs, and discontinuous tracks all contribute to premature failure when unprotected. The testing also confirmed static bottom-of-wall conditions require a protected joint.

This research illustrates how inadequate protection of bottom-of-wall joints severely impacts the intended fire performance of a compartment, reducing passive fire protection and allowing an unprotected path of fire and smoke spread between compartments.

The full fire testing report and further information about bottom-of-wall joint systems can be found at the following link located on the International Firestop Council website, http://firestop.org/bow.

INTRODUCTION

The role of fire-resistant joint systems in providing continuity at the bottom of a fire resistance rated wall assembly is widely underestimated. Continuity refers to the requirement for building elements such as fire walls, fire barriers, fire partitions, smoke barriers, and other types of fire separations to form an uninterrupted continuous barrier that performs an important fire safety function. Without proper protection at the intersection of these assemblies, fire can spread easily between adjacent separated spaces in a building. Model building codes rely on fire resistance rated assemblies being continuous to minimize spread of fire. Fire resistant joint systems are designed to maintain continuity between two fire resistance rated assemblies such as a floor and wall.

This paper intends to answer the question of why bottom-of-wall joint protection is such an important component of passive fire protection. It will demonstrate why the omission of bottom-of-wall fire-resistant joint systems will severely impact the overall prescribed fire performance, reduce passive fire protection requirements and allow an unprotected path of fire and smoke spread between compartments.

Key topics to be discussed will include post-flashover fire conditions, fire spread through the bottom of wall, fire testing and results, static joint conditions, gap sizes, smoke migration, vertical shaft continuity, and impact of construction practices. These topics are critical in understanding the role of adequate bottom-of-wall protection.

To illustrate what can happen when bottom-of-wall joints are inadequately protected, five separate research and testing laboratories conducted a series of nineteen bottom of wall configurations using the prescribed fire test standards UL2079 and ASTM E1966 Fire-Resistant Joint Systems.

Throughout this paper, reference is made to “protected” and “unprotected” joints. A “protected” joint refers to one in which a Listed, static, bottom-of-wall joint has been installed in the gap between a wall assembly and the fire resistance rated floor that it rests upon. Conversely, the term “unprotected” refers to a joint in which no Listed joint system has been installed. In some instances, unprotected joints may also include other elements, such as baseboards.

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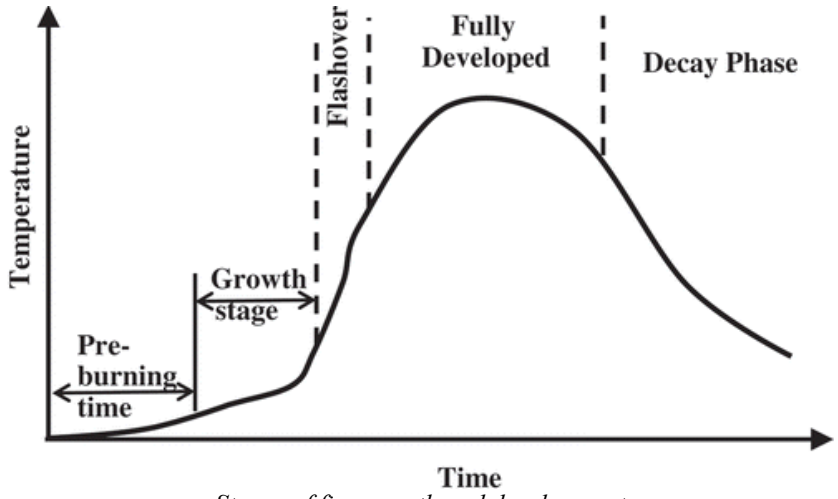
THE SPREAD OF FIRE AND SMOKE AT BOTTOM-OF-WALL

Fire compartmentation is a design principle where buildings are divided into separate areas by fire resistance rated assemblies to contain fires and minimize fire and smoke spread throughout the building. The stages of a compartment fire include:

1. Incipient
2. Growth
3. Fully developed
4. Decay



Stages of fire growth and development

The fully developed stage of a fire includes post-flashover conditions. This is characterized by extremely high temperatures, rapid fire spread, simultaneous ignition of available combustibles and positive pressure at the bottom of walls. All fire resistance rating test methods using the standard time-temperature curve are designed to evaluate performance during the post flashover conditions. During post-flashover conditions fire, smoke and superheated gases can migrate from the room of origin into adjacent spaces through unprotected gaps at the bottom-of-wall. In addition, combustible loading at the floor level from burning molten material could flow through unprotected gaps at bottom-of-wall.

Construction practices and building codes require the bottom of fire resistance rated walls to be continuous starting from the top of the foundation or floor/ceiling assembly below. The language in codes regarding “from the top of the foundation or floor/ceiling assembly” clearly is intended to include the bottom of a wall. The fire resistance rating of the wall is dependent on where the wall board terminates. The gap between the wallboard and the floor creates an unprotected area at that location even with a bottom track or plate and/or baseboard.

Testing of wall assemblies, horizontal assemblies, and fire-resistant joint systems is designed to simulate post-flashover fire conditions. In the United States, tests for fire resistance of building joint systems are conducted in accordance with either UL 2079 or ASTM E1966. All joint

systems are exposed to a positive furnace pressure differential of 0.01 inch of water at a distance of 12 inches below the exposed horizontal surface of the floor assembly. These positive pressure fire tests expose the bottom-of-wall joint to super-heated gases and flames. Certified fire-resistant rated bottom-of-wall joint systems are published in the directories of the certification bodies such as UL and Intertek.

Typical bottom of wall UL 2079 or ASTM E1966 fire test arrangement

RESULTS OF FIRE TESTING

To illustrate the importance of bottom-of-wall joint systems, the International Firestop Council undertook a research program to compare various bottom-of-wall fire-resistant joint systems to unprotected bottom of wall conditions. A total of nineteen different bottom of wall configurations were fire tested at five different research and testing laboratories. Seven of the configurations were tested at Intertek accredited facilities in San Antonio. The remaining twelve assemblies were tested at four manufacturer testing laboratories that are participants in UL's Client Test Data Program (CTDP)[1].

Seventeen assemblies tested were comprised of gypsum board on metal studs and track installed on a 4½ inch thick concrete slab. Two assemblies tested were comprised of gypsum board on wood studs installed on a 4½ inch thick slab. The configurations tested were not designed to accommodate movement (i.e. static joint systems). All configurations were tested using the prescribed standard test methods for fire-resistive joint systems, UL 2079 and ASTM E1966. The configurations are shown in Table 1.

[1] The CTDP program provides a means for UL to accept externally generated test data in support of UL Mark certification by utilizing their own or third-party facilities for product testing. Participating test facilities are required to have the appropriate physical resources, equipment and qualified personnel needed to conduct testing, equivalent to what would be used in their own laboratories for the same testing. UL conducts a thorough review and audit of all data submitted before they are used for certification and reassess a test laboratory annually. For more information visit, www.ul.com/dap.

Assembly No.	Joint System Protection	Wall Assembly Rating (hr)	Stud Type	Track Type	Bottom gap width (inches)	Baseboards	Pass/Fail
1	Protected	1	Steel	Continuous	1	No	Pass
2	Protected	1	Steel	Continuous	1	No	Pass
3	Protected	1	Steel	Continuous	1	No	Pass
4	Protected	1	Steel	Continuous	1	No	Pass
5	Protected	2	Steel	Continuous	1	No	Pass
6	Protected	2	Wood	Discontinuous	1	No	Pass
7	Unprotected	1	Steel	Continuous	1/4	No	Fail
8	Unprotected	1	Steel	Continuous	1/4	No	Fail
9	Unprotected	1	Steel	Continuous	1/4	No	Fail
10	Unprotected	1	Steel	Continuous	1	No	Fail
11	Unprotected	1	Steel	Continuous	1	No	Fail
12	Unprotected	1	Steel	Continuous	1	No	Fail
13	Unprotected	2	Steel	Continuous	1	No	Fail
14	Unprotected	2	Steel	Continuous	1	PVC	Fail
15	Unprotected	2	Steel	Continuous	1	PVC	Fail
16	Unprotected	2	Steel	Continuous	1	MDF	Fail
17	Unprotected	2	Steel	Continuous	1	Wood	Fail
18	Unprotected	2	Steel	Discontinuous	1	No	Fail
19	Unprotected	2	Wood	Discontinuous	1	No	Fail

Table 1. Fire Test Configurations

The following charts present a series of direct performance comparisons, including pass/fail outcomes and temperature measurements across both 1-hour and 2-hour fire-resistance assemblies, including baseboards and discontinuous track conditions.

Statement from UL Solutions: "The static bottom-of-wall joints are currently contained within our XHBN category. The published systems in this category are specifically intended for the fire protection of joints as defined in the IBC".

- March 12, 2025, letter to IFC confirming UL Solutions official position on static bottom-of-wall joints

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[2] Read the full letter and statement from UL Solutions at www.firestop.org/bow

Chart 1. Test performance results for protected joints versus unprotected joints. Neither, the ¼ inch or 1-inch unprotected joint achieved the 1-hour rating.

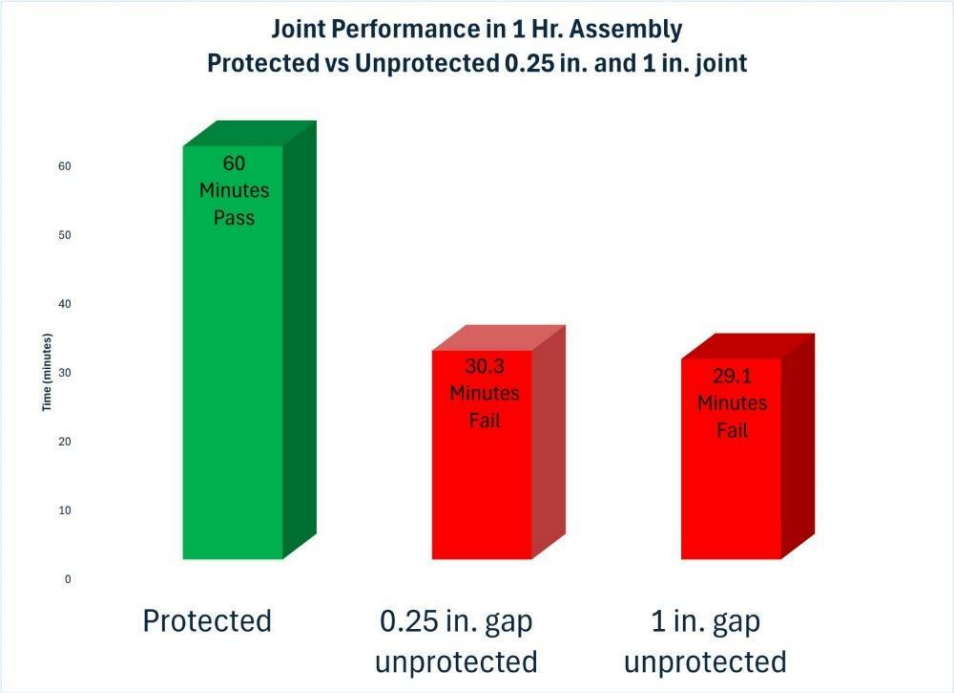


Chart 2. Test performance results for maximum temperature comparison for protected joints versus unprotected joints. The maximum temperatures for unprotected joints far exceed the failure point during the 60-minute test. The failure point criteria are established by UL 2079 / ASTM E1966.

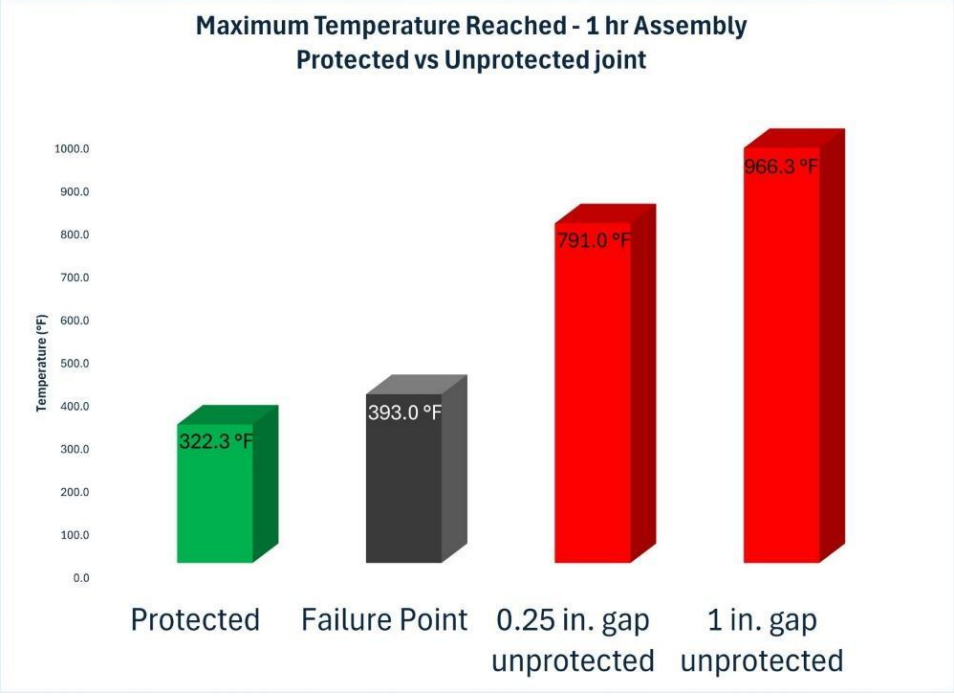


Chart 3. Test performance results for maximum temperature comparison for protected joints versus unprotected joints with baseboards – 2 hour assembly. The baseboard temperatures significantly exceeded the protected joint temperatures.

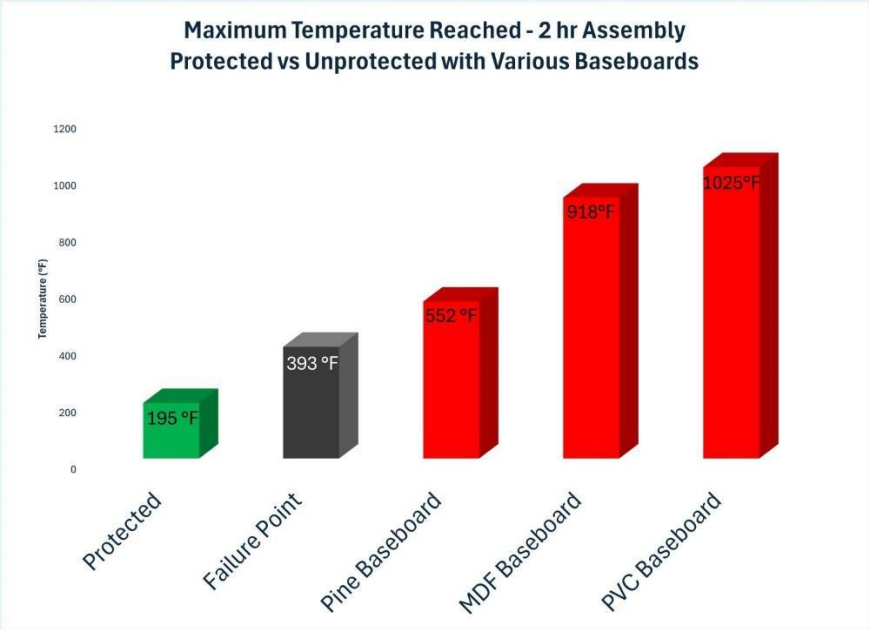


Chart 4. Average maximum temperature for all 1- hour tests combined – Protected versus Unprotected. The graph shows that only the protected joints remained below the pass / fail criteria during the 60-minute duration.

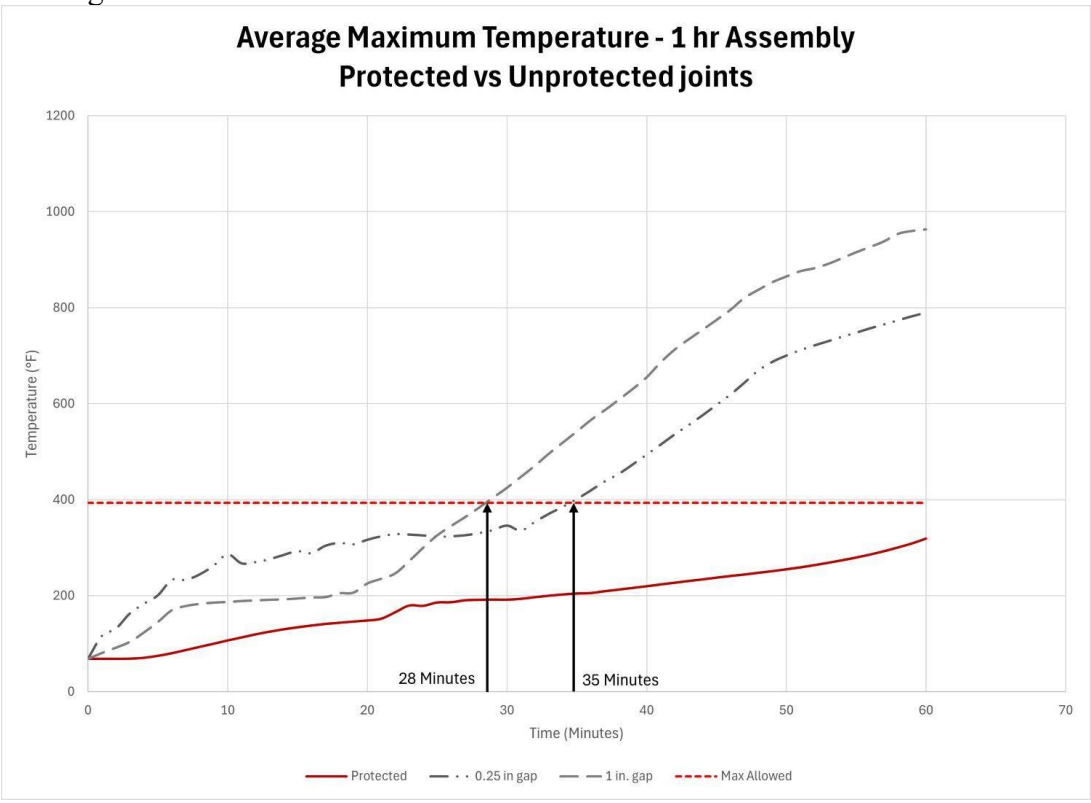


Chart 5. Test performance results for protected joints versus unprotected joints with discontinuous track.

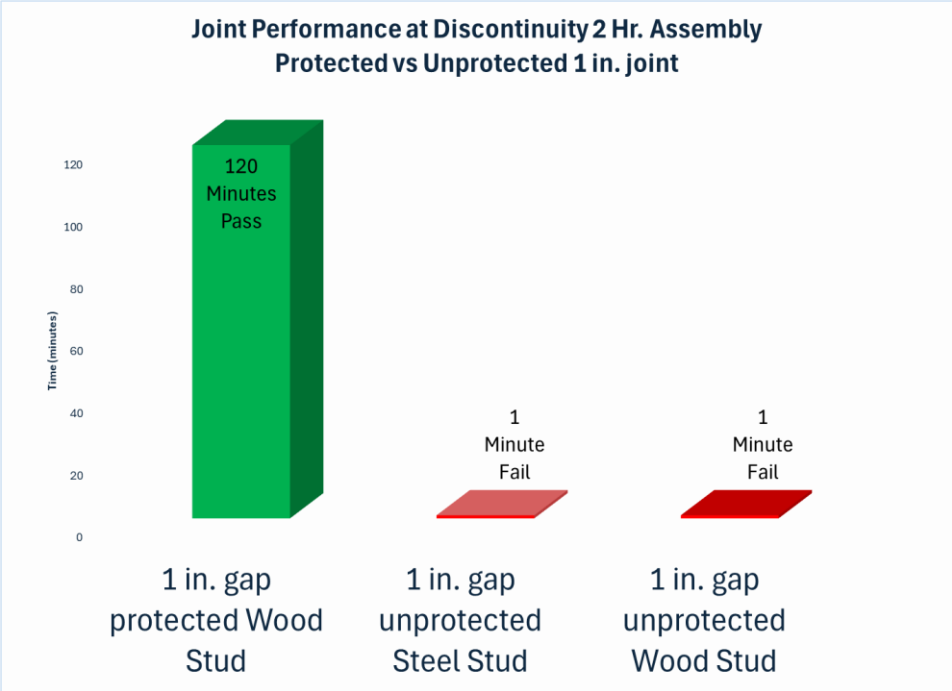
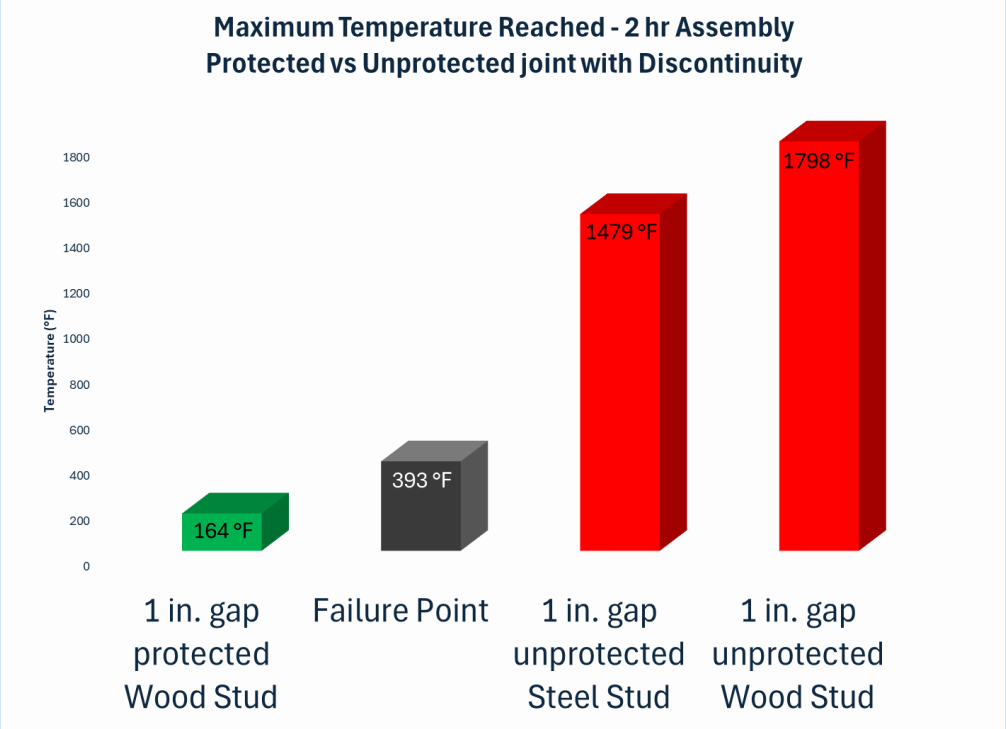


Chart 6. Test performance results for maximum temperature comparison for 2-hour protected joints versus unprotected joints with discontinuous track. The failure point criteria are established by UL 2079 / ASTM E1966.



As demonstrated by the test results, protected joints significantly outperform the unprotected joints. In all cases the listed fire-resistant joint systems complied with the requirements of UL2079 and ASTM E1966 for the 1 hour or 2-hour duration targeted. The same is not true for the unprotected joints and the differences are stark. The results of the fire testing demonstrate the following:

1. In all cases the unprotected bottom-of-wall joints failed to achieve the required fire rating.
2. In all cases the listed fire-resistant joint systems complied with the requirements of UL2079 and ASTM E1966 for the 1 hour or 2-hour duration targeted.
3. Unprotected joints were up to 5 times hotter than protected joints.
4. The use of baseboards without a protected joint provides no appreciable fire resistance.
5. Unprotected joints led to severe premature deterioration of the gypsum board and studs.
6. Unprotected joints with a discontinuous bottom track led to flaming on the unexposed side of the assembly and extremely high temperatures.
7. Protected joints performed well even with a discontinuous bottom track.

In summary, the fire test data clearly demonstrates unprotected, static, bottom-of-wall joints will allow migration of superheated gases, fire and smoke to spread between compartments.

As demonstrated by the test results, protected joints significantly outperform the unprotected joints.

JOINT MOVEMENT

Model building codes such as the International Building Code (IBC) define a Joint as "the opening in or between adjacent assemblies that is created due to building tolerances or designed to allow independent movement of the building in any plane caused by thermal, seismic, wind or any other loading". The IBC also defines a fire-resistant joint system as "a tested system that resists the passage of fire through *joints* made in or between fire-resistance-rated assemblies".

Joint systems that are designed for movement are classified as dynamic, while joints that are designed without movement are classified as static. Dynamic joint systems are required to undergo movement cycling prior to fire testing. Static systems are not cycle tested.

A common misunderstanding is that a joint only exists to accommodate movement. While accommodating movement is one purpose of a joint, they can also be created due to building tolerances. For example, the fire-resistance rating of a gypsum wall assembly at the bottom of the wall is highly dependent on where the wall board terminates. Fire testing has demonstrated that regardless of whether movement is anticipated or not, joint protection is necessary to maintain continuity and achieve the required rating. UL Solutions and Intertek conduct fire tests and certify both static and dynamic joint conditions.

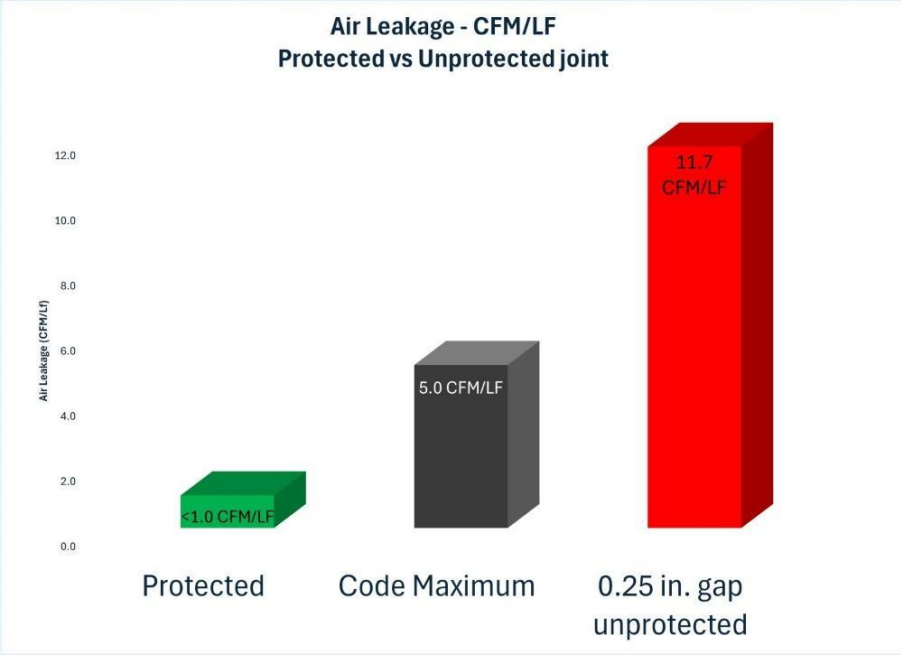
MINIMIZING SMOKE LEAKAGE IN HIGH-RISK OCCUPANCIES

Certain types of occupancies are more susceptible to the impact of smoke leakage than others. In defend-in-place occupancies, such as hospitals or prisons where some occupants cannot evacuate, smoke-resistant compartments are essential. Smoke barriers within these facilities are required to undergo leakage testing (L-ratings)[3], in accordance with UL 2079.

Leakage testing has shown unprotected systems will not meet the code prescribed leakage requirement. It also demonstrates that unprotected bottom of wall joints can lead to significant migration of smoke between compartments. Visual observation from the fire testing described in this paper demonstrated that unprotected joints allow significantly more smoke through the assembly as compared to protected joints.

The photograph shows a side-by-side comparison of smoke through multiple assemblies during a fire test. The assembly on the right is a protected joint; all others are unprotected with baseboard only. Notice the visible smoke for unprotected baseboards versus protected in this 2-hour assembly.

This chart demonstrates the test performance results for the leakage rate comparison for protected versus unprotected joints. The unprotected joint far exceeds the maximum allowable leakage rate for Smoke Barriers in accordance with the IBC.



Even with a small ¼ inch gap, unprotected joints provide minimal resistance to smoke migration and would not comply with the prescribed IBC leakage rating requirements for joints in smoke barriers.

[3] *International Building Code,* Section 715.9 Joints and voids in smoke barriers. Fire-resistant joint systems protecting joints in smoke barriers, and perimeter fire containment systems protecting voids at the intersection of a horizontal smoke barrier and an exterior curtain wall, shall be tested in accordance with the requirements of UL 2079 for air leakage. The L-rating of the joint system shall not exceed 5 cubic feet per minute per linear foot (0.00775 m3/s m) of joint at 0.30 inch of water (74.7 Pa) for both the ambient temperature and elevated temperature tests.

IMPACT OF CONSTRUCTION PRACTICES

Varying Joint Gap Size

The size of the gap between the fire-resistance rated wall assembly and floor assembly can vary depending on the type of construction and specific application. For gypsum wall assemblies the continuity of the fire-resistance ratings ends at the bottom of the wall board. While it is not uncommon to see larger gaps due to building tolerances, the Gypsum Association Document GA-216[4] recommends that the gypsum board terminate a minimum ¼ inch above the floor. Typical construction practice using standard bottom track sizes include ⅝ inch or 1inch gaps. In some cases, these gaps can be as large as 4 inches. The results of the fire testing verified that, even with a minimal ¼ inch gap the wall assembly will not maintain the required continuity without the installation of a fire-resistant joint system.

Some examples of typical construction practices are noted in the following photos.

wide protected joint

unprotected joint

Discontinuous Bottom Track

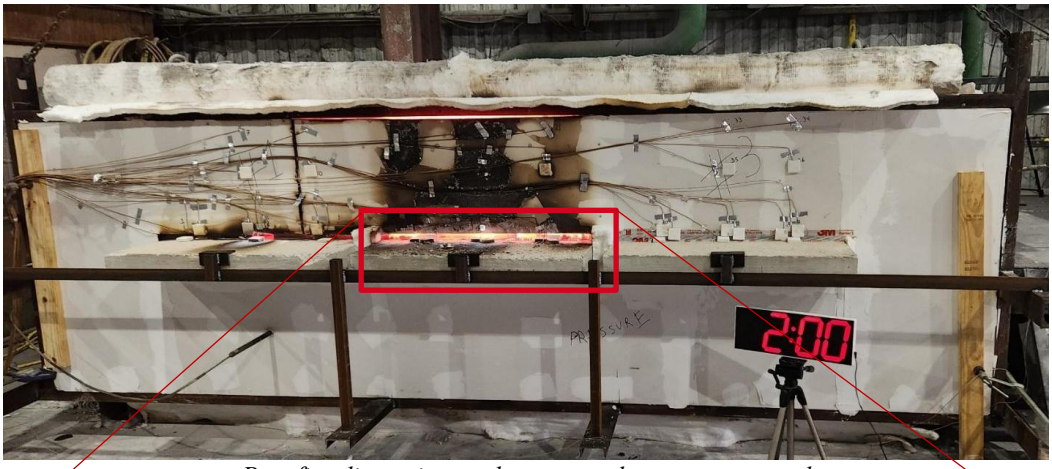
Another common site condition observed is where building services or structural elements are installed within the cavity of the wall resulting in a discontinuous bottom track. At these locations within the assembly there is an unimpeded path for fire and smoke to spread between compartments. As part of the test series conducted, the effect of a discontinuous bottom track was evaluated. The performance of a wall assembly with a discontinuous track in a wood stud and steel stud wall was compared to the performance of a discontinuous track with a protected joint in a wood stud wall. The graphs showing the results are provided in the Results of Fire Testing section in Chart 5 and Chart 6.

The unprotected joints exceeded the temperature limits in the criteria of the test standards within the first five minutes, and flame was visible on the non-fire side of the wall. Post test observations also showed the wood studs within the wall cavity were entirely consumed at the bottom of the wall and the metal studs were severely damaged.

In comparison, the temperature recorded on the protected joint was well below the temperature limits in the criteria of the test standards, no flaming occurred through the joint, and post-test observations showed the wood studs were still largely unaffected.

[4] Gypsum Association Document GA-216-2024, *Application and Finishing of Gypsum Panel Products*

Site condition with discontinuous bottom track in multiple locations



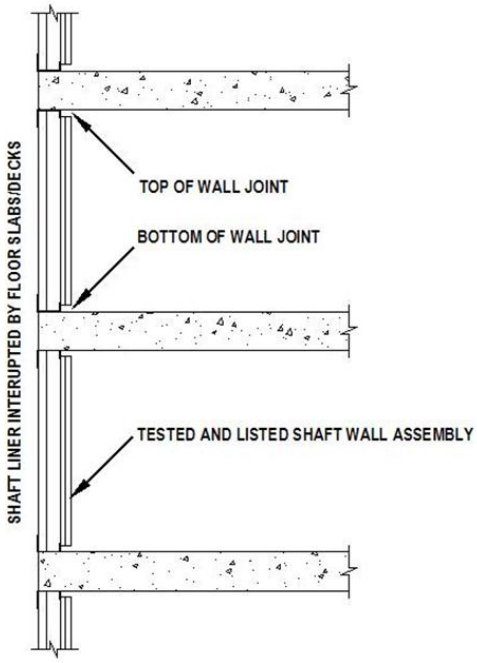
Post fire discontinuous bottom track versus protected

Close-up of above image

VERTICAL SHAFTS

The purpose of a vertical shaft enclosure is to minimize fire and smoke spread between floors. Shafts are protected spaces that can be used to install building services and combustible materials that are distributed throughout the building. The SFPE *Handbook of Fire Protection Engineering* explains that a shaft or other wall that abuts two or more interconnected levels may experience leakage through the gap at the bottom of wall sufficient to allow migration of fire, smoke, or superheated gases.

One sample configuration is noted in the figure below.



In areas where the bottom of the shaft walls are stacked on the floor slabs, fire and smoke can spread into or out of the shaft. When bottom-of-wall joints are not properly protected, fire and smoke can spread to multiple stories throughout the building which will significantly impact the overall building fire and life safety.

In contrast, unprotected bottom of wall joints do not provide the necessary protection against the hazards of fire and smoke needed to provide effective compartmentation.

CONCLUSION

Fire-resistant joint systems are used to maintain continuity at the intersection between the bottom of a wall and a floor assembly. The importance of providing adequate protection at this bottom-of-wall intersection has been reviewed. Understanding key topics such as post-flashover fire conditions, fire spread through the bottom-of-wall, fire testing, static joint conditions, gap sizes, smoke migration, vertical shaft continuity, and impact of construction practices are all critical in understanding the role of bottom-of-wall protection.

When prescribing performance related to fire resistance, the IBC requires ASTM E119 or UL 263 fire exposures. The time-temperature curves in these tests are designed around post-flashover conditions. Similarly, when testing the bottom-of-wall joints, the code relies on these same post-flashover test conditions used by UL 2079 and ASTM E1966 to provide systems that can achieve the level of safety intended and required. During post-flashover conditions fire, smoke and superheated gases can migrate from the room of origin into adjacent spaces through unprotected joints at the bottom of the wall.

The function of fire separation is to prevent the passage of excessive temperature, flames, or smoke and hot gases. This study reviewed the results from nineteen different bottom of wall configurations fire tested in accordance with joint system test standards UL2079 and ASTM E1966. The results illustrate the stark difference in performance between a protected versus unprotected bottom-of-wall joint. Testing consistently showed that protected joints performed this function very effectively. In contrast, unprotected bottom-of-wall joints do not provide the necessary protection against the hazards of fire and smoke needed to provide effective compartmentation.

The information gathered from this research study concludes the following:

1. Test standards UL 2079 and ASTM E1966 allow for the evaluation of static bottom-of-wall joints to post-flashover fire conditions.

2. Variables such as gap sizes, metal or wood studs, and discontinuous tracks all contribute to premature failure when unprotected. In contrast these variables do not inhibit the ability of a protected joint to achieve the required performance. These fire tests demonstrated that unprotected joints were typically five times hotter than protected joints. In some cases, temperatures exceeded 1700°F and visible flaming was observed on the unexposed side. Additionally, the use of baseboards provides no appreciable increase in fire resistance. It should also be noted that metal and wood stud wall assemblies with unprotected joints were more susceptible to premature deterioration of the gypsum board and studs.

3. The model codes address joints designed for movement and joints created due to building tolerances. UL and Intertek have been testing and certifying the performance of these static and dynamic joints for more than three decades. The test results from this study illustrate that unprotected static bottom-of-wall joints will not provide the level of

protection required by the code. The study also demonstrates that protected static bottom-of-wall joints are needed to achieve the code prescribed level of performance.

4. While not quantifiable during the fire test, it is evident from visual observation that unprotected joints allow significantly more smoke through the assembly as compared to protected joints. Standardized air leakage testing confirms what was observed during the fire tests. Leakage test results were more than 10 times higher for unprotected ¼ inch gap than for a protected joint.

This research illustrates how static bottom-of-wall joint protection contributes to the passive fire protection features of buildings and maintains continuity between the floor and wall assembly. Inadequate protection of bottom-of-wall joints severely impacts the overall fire performance reducing passive fire protection and allowing an unprotected path of fire and smoke spread between compartments.

About the Authors

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Tony Crimi, P.Eng., Masc. - Tony is a fire protection expert with more than 30 years of experience in building and fire-related codes, standards, research, and product development. His work includes extensive involvement in UL, ICC, NFPA, and ASTM standards development and authorship of numerous technical papers on fire protection and façade fire safety.

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The IFC promotes the technology of fire and smoke containment in building construction through research, education, development of safety standards, testing, and code provision.