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Considerations for Detailing the Closure Penetration and Gypsum Fire Separation Wall Interface

BC Advisory Group on Advanced Wood Design Solutions

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STATUS see Appendix I for background

Last Revised November 20, 2015 (r)

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1. This guide is not a code and is not meant to replace any applicable codes.

2. This document is intended to be used by practitioners having experience with and knowledge of wood frame construction, fire protection engineering, and any other relevant and related disciplines.

3. Examples given in this guide are provided primarily to assist illustrating the concepts behind the solutions presented. The examples shown are not necessarily the appropriate or the only solution.

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ACKNOWLEDGEMENT

The financial contribution from Forestry Innovation Investment (FII) through its Wood First Program for the testing and the initial preparation of this guide is acknowledged. Additional support was provided by the Province of British Columbia, Ministry of Technology, Innovation and Citizens' Services; and BC Housing.

Diagrams and portions of these guidelines are provided courtesy of GHL Consultants Ltd.

SUMMARY

Vertical gypsum fire separation walls that have fire-resistive ratings evaluated in accordance with a recognized standard are permitted for use in building construction. When approved doors are inserted in such walls, the details must be presented for consideration as an "alternative solution".

This guide is based on observations of two CAN/ULC S101 (ULC, 2007) tests on gypsum fire separation walls with S104 (ULC, 2010) approved closure penetrations. The guidance is intended to direct the designer's attention to potential issues that might impact the performance of a closure penetration in a gypsum separation wall that use a thick wood-based sheathing (i.e. combustible) for carrying the weight of the fire door assembly. General guidance is provided on sizing the sheathing and the need for protecting the sheathing from fire, yet permitting the assembly to accommodate building movements in-service.

The purpose of this guide is to recommend considerations when **designing the interface between a fire door (closure penetration) in proprietary gypsum separation walls**. These considerations form only part of the alternative solution that will need to be presented to the AHJ for approval.

Although details are provided in Appendix VI to illustrate a possible solution, it is the responsibility of the designer to understand how the design is expected to perform. The guide discusses three scenarios to assist the designer in formulating an appropriate solution. These are performance under an extreme fire; performance under a limited fire; and performance under normal (non-fire) service conditions that may include high wind or high seismic event.

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1 GUIDE LAYOUT AND OVERVIEW

This document consists of three parts:

- **Part A** – describes the application, conditions, and motivation for developing these guidelines.
- **Part B** – outlines a how this application should be assessed and considerations for developing the design details. It contains recommended primary and secondary design considerations.
- **Part C** – are issues and other recommended design considerations indirectly related to the design application.

Part A should be carefully reviewed to determine if this guide is applicable. Additional information is provided in the Appendices that may be useful for developing the alternative solution.

PART A

2 MOTIVATION FOR AND PURPOSE OF THE GUIDE

Vertical gypsum fire separation walls that have fire-resistive ratings when evaluated in accordance with a recognized standard, such as CAN/ULC-S101, are permitted for use in building construction. These fire separation walls are strictly non-loadbearing (except for their self-weight) and have been developed to provide fire-resistive protection for common walls between, for example, wood frame townhouses.

Because they follow an erection sequence that is more compatible with wood frame platform construction, gypsum fire separation walls have been specified in multi-storey wood frame construction to enable large wood frame constructed buildings to meet the maximum area limits of the code. However, when used in larger multi-residential buildings, there is usually a need to allow for passage between the fire separated areas under normal service conditions.

Although use of these gypsum separation walls is within the scope of the product evaluation, what is not covered is the insertion of a closure penetration (e.g. a rated fire door). Even though the fire door has a fire-resistive rating, the gypsum fire separation wall with a fire door can only be accepted for use following the *alternatives solution* path.

To facilitate the acceptance of these *alternative solutions*, full-scale fire tests under the direction of the BC Advisory Group on Advanced Wood Design Solutions (AGW) were carried out to assess the performance and identify potential issues. Currently there are no consensus documents or industry standards directing the evaluation of a closure penetration in a gypsum separation wall. A hybrid of the CAN/ULC S101 and CAN/ULC S104 was consequently followed for the evaluation testing. The objective was to establish if there was evidence that the rating can be maintained, and if not, if areas for improvement can be identified.

Two closure penetration tests carried out by the AGW and FPInnovations suggest that it is possible to insert a closure penetration in a gypsum fire separation wall (see Appendix V for a summary describing the test, or GHL (2014)). These tests suggest that when combustibles are used in the vicinity of the

closure penetration to support the vertical and lateral loading from the door and door frame, additional protection should be provided to enhance the ability of the system to accommodate imperfections in the construction.

The purpose of this guide is to recommend considerations when **designing the interface between a fire door (closure penetration) in proprietary gypsum separation walls**. These considerations form only part of the *alternative solution* that will need to be presented to the AHJ for approval.

3 SCOPE

3.1 General

This guide is not intended to imply that proposed *alternative solutions* that are not developed as recommended in this guide are unacceptable. All *alternative solutions* should be technically justified by the proponent to the satisfaction of the Authority Having Jurisdiction (AHJ). The acceptance of any particular *alternative solution* is at the discretion of the AHJ.

This guide augments the standard practice for developing an *alternative solution*, and does provide a complete description of all the steps required to develop an *alternative solution*.[1] It is recognizing that there may be a number of possible design solutions. Consequently, this guide is a principles-based document and does not prescribe specific details. The design principles followed by this guide for developing recommended details are given in Appendix II.

3.2 Specific

This guide provides guidance in the design and detailing of the interface between the closure penetration and the gypsum fire separation wall. This guide has been prepared to assist with the development of an *alternative solution* under the following conditions:

- Applies only to UL listed fire separation walls, and UL listed doors and frames approved for use with wood or steel stud frame construction[2]
- The desired fire resistance rating for both the closure penetration and the separation wall are established elsewhere[3]. The designer must review and determine if the details need to be adjusted to accommodate higher fire resistance ratings.[4]

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[1] The standard practice includes, for example, reviewing the intent, objectives and functional statements of the applicable requirements. The documentation should also demonstrate that the firm involved understands these requirements and is qualified to develop and oversee the implementation (i.e. field reviews) of the *alternative solution*.

[2] Fire rated closure penetrations meeting CAN/ULC-S104 are evaluated in steel stud gypsum wall assemblies unless otherwise noted (CAN/ULC-S104 Clause 4.1.4). In general, doors frame specified specifically for use with masonry or reinforced concrete walls should not be used due to their potential reliance on the confining characteristics of these walls.

[3] See, for example, CAN/ULC-S101 for rated walls and CAN/ULC-S104 for rated doors.

[4] For purposes of this Guide, a 2-hr rated wall and 1.5-hr rated closure are assumed.

The examples provided in the appendices are primarily to aid in the presentation of the concepts provided in this guide.

PART B

4 APPLICABLE NBCC5 OBJECTIVES AND FUNCTIONAL REQUIREMENTS

The following table summarizes the NBCC clauses that were considered in the development of this guide. The engineer of record is responsible for ensuring these and all other applicable clauses are reviewed and addressed when developing the *alternative solution*.

The objectives and functional requirements for each are given in Appendix III.

NBCC Clause	Principle
3.1.10.1. Prevention of Firewall Collapse	Human health and safety; progressive collapse and/or results in damage beyond immediate area.
3.1.10.2. Rating of Firewalls	Limit damage beyond original fire compartment.
3.1.10.3. Continuity of Firewalls	
3.1.10.5. Maximum Openings	
3.1.9.1. Fire Stops	

[5] National Building Code of Canada

5 PRIMARY DESIGN CONSIDERATIONS – FIRE SEPARATION STRUCTURAL INTEGRITY

The following are general design principles that are recommended to meet the NBCC objective and functional requirements when detailing a gypsum separation wall with a closure penetration. The intent is to maintain the integrity of the structural system supporting the closure.

Design Considerations	Rationale
1. Provide in-plane structural support to the fire door and a load path to the foundation equal or exceeding the fire-rating of the separation.	The in-plane support to the fire door should be provided by an engineered system down to the foundation and not by the gypsum separation wall or the supporting frame. • NBCC 3.1.10.1 • Assume firestopping compromised
2. Provide out-of-plane support to the fire door[6] equal or exceeding the fire-rating of the separation.	The out-of-plane support for loads applied to the fire door (inward or outward) should be provided by the adjacent structural walls, not the gypsum separation wall. • NBCC 3.1.10.1 • Assume firestopping compromised
3. Combustible components used to support the closure shall be sized and detailed to provide the load carrying resistance for the duration of the design fire.	In the event building movement compromises the firestopping (or if the firestopping is damaged or missing), the vertical load carrying elements should have sufficient residual capacity.

6 SECONDARY DESIGN CONSIDERATIONS – FIRE DAMAGE BEYOND POINT OF ORIGIN

In general, the interface between the fire separation wall and the closure penetration should be consistent with NBCC Clause 3.1.9.1.(1)(a) on Fire Stops. The intent is to develop a detail that effectively provides an F-rating that equals or exceeds the fire-protection rating required for the closure. Because the steel door jamb, two wood stud walls, and the steel stud/gypsum shaft liner meet at the interface, the firestop system will need to be designed using engineering judgement.

[6] The structural support of the separation wall away from the closure penetration is covered in a separate Guide, which is under development by the AGW.

Design Considerations	Rationale
1. Provide firestopping that will accommodate relative movement during the building's service life and during a fire	The details around closure penetrations should consider the potential movement that may occur during the normal service life. The appropriate materials and installation methods compatible with this movement should be selected. The amount of movement that can be tolerated should be communicated to the structural engineer.
2. Provide additional protection of combustibles in and around the fire door (e.g. wood sheathing used to transfer weight of door assemblies to the foundation)	Although combustibles used to provide vertical or horizontal load resistance may be sized to function even after exposure to fire, it is desirable to limit the extent of the fire damage to the compartment where the fire originated.
3. Allow for inspection and maintenance after major seismic or wind event, or for any physical damage in use.	Details that indicate that excessive building movement has taken place can be used to determine whether more invasive inspections can be specified to check for damage. Alternatively, access points can be provided to assist in inspections.

7 DESIGN BRIEF

Gypsum separation walls in wood frame construction will be covered by a stud wall (which may or may not be vertical load bearing, or a shear wall). The intent of the tests is to provide a realistic interface around the closure penetration. Although the effective resistance of the separation wall will include both the stud wall and the gypsum separation wall, the intent of the test is not to assess the wall away from the closure penetration[7]. Full scale testing undertaken prior to the development of this guide suggest that more attention to the detailing of the interface is required to ensure a more consist performance of the gypsum separation wall with a closure penetration.[8]

7.1 General Requirements

The assembly should resist the design load for the rated fire resistance (e.g. 2-hr as per S101), and the assembly should also be detailed to limit damage on the unexposed side (e.g. 1.5-hr as per S104). Fire damage to combustibles beyond the point of initiation (e.g. the plywood on the unexposed side) should be prevented by firestopping (e.g. between the framing and the door jamb). Where combustible

[7] Because of the potential for fire to pass from floor to floor between the building and the gypsum separation wall, this framed wall and the mineral wood between the building and the separation wall is also an extension of the horizontal separation.

[8] As noted earlier, the performance of the fire doors did not appear to meet the specifications. However, this was not judged to influence the ability of the test to assess of the fire performance of the interface.

on the unexposed side are ignited, flame spread should be contained and the loss of strength should not be such that the design load cannot be resisted. Because the time to ignite the plywood on the unexposed side may be unknown, it should be detailed to resist the load assuming the plywood is exposed to flame that may enter through any gap between the steel stud frame supporting the gypsum shaft liner and the door jamb.

These guidelines assume that wood structural sheathing (i.e. a combustible) is used to carry the weight of the closure penetrations to the foundation. The basic design guidance is as follows:

1. A stud wall must be placed in front of the firewall core and the sheathing support (see Figure 1 to Figure 3 in Appendix VI). These walls will typically be provided as part of the interior finish of the building. Although the wall may be counted in providing additional fire resistance to the overall fire separation, its main purpose under these guidelines is to limit or slow the charring of the wood support sheathing on the unexposed side (see next item). More importantly, these walls also provide physical protection to the gypsum shaft liner under normal use.[9]

2. This stud wall may be of combustible construction. The cavities of this wall must be filled with mineral wood (see Figure 8 in Appendix VI), primarily to protect the wide faces of the studs in the event there is a minor breach of the gypsum separation wall. The faces of the outer studs and plates around the opening will normally be protected by and finished with Type X gypsum wallboard. The exposed faces of the frame wall need not be sheathed with Type X gypsum wall board (see Figure 9 in Appendix VI); however, to avoid confusion with the Type X gypsum needed around opening, the outside face should also be sheathed with Type X gypsum.

3. To allow the shaft liner to move relative to the framed wall and the steel door frame, the void between the exposed edges of the shaft liner/plywood and the steel door frame should be filled with mineral wool (see Figure 1 and Figure 3 in Appendix VI).

4. The gap between the gypsum covering the outer stud and the steel door frame should be filled with fire caulking (see Figure 1 and Figure 3 in Appendix VI).

7.2 Performance – Severe Fire Events (leading to collapse)

The various details described above are intended to perform as follows during a severe fire event:

1. It is assumed that the stud wall on the exposed side has been burned away. Although there is mineral wood between the shaft liner and the doorframe, there is a possibility that the structural sheathing on the unexposed side will begin to char, starting from the edge nearest the closure. Although the structural sheathing is shielded on one side by the shaft liner and the other side

[9] The gypsum shaft liner and connections (i.e. slotted aluminum brackets) should be inspected whenever there is physical damage to the outer framed walls.

from the mineral wool or wood studs, these are not in close contact so partial exposure should be assumed.[10]

2. If plywood on the unexposed side begins to char on the edges closest to the closure penetration, it is important that the flat bar attached to the door frame has sufficient rigidity so that it does not buckle when the plywood under it chars. The flat bar and plywood also needs to be sufficiently long to continue to cantilever past the charred zone and continue to carry the weight of the closure. Sufficient structural sheathing also needs to remain to carry the vertical load of the closures above.

3. Mineral wool is back-up in the event the caulking is damaged in service or is lacking.

4. The wood shear walls are not intended to be part of the resistance of the fire separation. However, they do provide protection to the plywood support system, particularly on the unexposed side, thus allowing the plywood to be sized.

7.3 Performance – Limited Fire Events (confined to area and not leading to collapse)

The various details described above are intended to perform as follows during a fire event adjacent to the closure penetration[11]:

1. There may be damage to the exposed frame wall and possibly the structural sheathing on the exposed side.

2. The shaft liner and the mineral wood fill between the shaft liner and the steel door jamb should limit the fire damage to only the exposed side.

7.4 Performance – During Normal Use

The various details described above are intended to perform as following during service (non-fire events):

1. Moderate building movement – As the building shrinks or moves in response to moderate seismic or wind events, the shaft liner will move relative to the wood frame system (walls, and floors). The door frame and thresholds will move with the wood frame system. The plywood will be attached to the shaft liner but is permitted to move in the plane of the shaft liner. This is so that the plywood can transfer the mass of the closures and frame to the foundation.

2. Severe building movement – Under severe lateral loading such as in an earthquake, the framed wall will move a sufficient amount to likely cause damage to the fire caulk joint. The edges of

[10] Annex B.10 in CSA O86-14 provides some guidance on the char rate to assume for partial exposure. This can be considered when deciding on an appropriate apparent char rate. For example, the assumption used for nail laminated mass timber may be a reasonable assumption.

[11] It is generally assumed that fire doors are not designed to be used where large amounts of combustibles are stored up against them (NFPA, 2013). Consequently, their ratings are 90-minutes, versus 2 hours for the walls in which they are installed.

the shaft line may also bear against the steel door jamb and may crush the gypsum. The fasteners (e.g. threaded rod) attached to the structural sheathing and passing through the shaft liner may also cause bearing against and damage the shaft liner.

PART C

8 EXECUTION / IMPLEMENTATION

The installation of a closure penetration in a gypsum fire separation wall contains many steps that need to be done in a particular sequence. Builders may need to develop familiarity with the steps involved in installing a closure penetration in a gypsum separation wall. Because details of the *alternative solution* may vary from project to project, a mock-up along with field inspections is recommended.

9 FINAL REMARKS

Recent full scale testing described in this report has demonstrated that a closure penetration can be installed in a gypsum separation wall[12]. To ensure consistency in performance under normal service and during a fire event, this guide references a number of details that should be addressed in the *alternative solution*. To further facilitate the use of gypsum separation walls, particularly in multi-storey wood frame construction, it is recommended that additional fire testing be undertaken to develop ULC/UL listed separation walls that include ULC/UL listed doors and frames.

Guidance is provided on detailing the interface of a closure penetration in gypsum separation walls so that the performance is consistent with that established for walls in CAN/ULC-S101 and for doors in CAN/ULC-S104.

Although meeting the performance objectives of this guide is not mandatory, it is recommended that they be considered along with the NBCC objective and functional requirements.

[12] However, it should be noted that in both case, the listed door assembly did not appear to meet its stated fire-performance rating as per CAN/ULC-S104 when tested as part of the gypsum firewall assembly. Although this was not judged to influence the results of the test on the interface, the performance of the fire doors should be further investigated as an integral part of gypsum firewall assemblies.

References and Other Sources

10 REFERENCE PUBLICATIONS

Canadian Standards Association (CSA). 2014. O86-14 - Engineering design in wood.

National Fire Protection Association (NFPA). 2013. *NFPA 80: Standard for Fire Doors and Other Opening Protectives*. Retrieved from www.nfpa.org/codes-and-standards

Underwriters Laboratories of Canada (ULC). 2007. *CAN/ULC-S101: Standard Method of Fire Endurance Test of Building and Construction Materials*.

_____. 2010. *CAN/ULC-S104: Standard Method for Fire Tests of Door Assemblies*.

_____. 2011. *CAN/ULC-S115: Standard Method for Fire Tests of Firestop Systems*.

11 KEYWORDS FOR WEB SEARCHES

- gypsum wall
  - area separation
  - fire-rated
  - shaft liner
- cold-formed steel
  - framing members
    - H-stud
    - C-channel
- wood structural sheathing
  - plywood; OSB
- mineral wool; rock wool
  - fire batts

Appendix I Guideline Review Ranking System[1]

The following ranking system has been developed to monitor the status of the wood building design guidelines[2] maintained by the BC Advisory Group on Advanced Wood Design Solutions (AGW):

RANK	DEFINITION
#	This is a draft document this is being circulated for review and comments.
A	This guideline is new and represents the best available evidence at this time. It will be periodically reviewed to determine if it remains current.
B	This guideline was last reviewed on the date indicated and there have been new studies published since the guideline was developed. However, the AGW determined that these studies are not sufficient to warrant changing the guideline. The information contained in this guideline provides the user with the best evidence available at the time the guideline was published. Readers are encouraged to search the current literature as a supplement to using this guideline.
C	This guideline was last reviewed on the date indicated. As a result of that review, the AGW determined that new studies have been published that warrant an update of the chapter/section of this practice guideline. The AGW also determined that the remainder of the chapters/sections does not require updating and these recommendations remain current.
D	This guideline was last reviewed on the date indicated. As a result of that review, the AGW determined that new data are available that are sufficient to potentially change guideline recommend and a full revision is warranted.
E	This guideline was last reviewed on the date indicated. As a result of that review, the AGW decided it is outdated; however, it has been retained for historical and/or educational purposes. These guidelines should be used with caution for design purposes.

[1] This list was adapted from the Canadian Thoracic Society Policy and Evidence-Based Medicine, and the American College of Chest Physicians (ACCP) Guidelines Ranking System.
[2] Check fpinnovations.ca for the latest edition.

Appendix II Principles for Developing Guidelines

Below are basic principles that have been established for purposes of developing these recommended guidelines. Although it may not always be possible to follow these basic principles, having these will assist in identifying appropriate content and areas for improvements or further study.

A. The objective is to establish redundant parallel systems to mitigate the following during a hazardous/damaging event:

   1. Disproportionate collapse / harm (safety)
   2. Disproportionate damage (cost)
   3. Local damage / local failure (element)

B. To ensure a level of robustness, the following is assumed to be the norm when developing recommendations:

   1. Incomplete knowledge of rare extreme events
   2. Risk mitigation systems are potentially variable and not perfect
   3. Errors do occur – but not intentional / sabotage

Appendix III NBCC Objectives and Functional Requirements

The relevant NBCC objectives and functional requirements for the gypsum separation wall is summarized below:

3.1.10.1. Prevention of Firewall Collapse

Function	Link	Persons/Building Not Harmed
F04 To retard failure or collapse due to the effects of fire.	so that	**OS1.2** a person in or adjacent to the building will not be exposed to an unacceptable risk of injury due to fire or explosion impacting areas beyond its point of origin.
		OP1.2 the building will not be exposed to an unacceptable risk of damage due to fire or explosion impacting areas beyond its point of origin.
		OP3.1 the adjacent buildings will not be exposed to an unacceptable risk of damage due to fire or explosion impacting areas beyond the building of origin.

Intent 1:

To limit the probability that the collapse of a structural framing member attached to or supported on the firewall will lead to failure of the firewall, which could lead to the spread of fire from an adjacent building to the building, which could lead to damage to the building.

Intent 2:

To limit the probability that the collapse of a structural framing member attached to or supported on the firewall will lead to failure of the firewall, which could lead to the spread of fire from the building to an adjacent building, which could lead to harm to persons in the adjacent building.

3.1.10.2. Rating of Firewalls

Function	Link	Persons/Building Not Harmed
F03 To retard the effects of fire on areas beyond its point of origin	so that	**OS1.2** a person in or adjacent to the building will not be exposed to an unacceptable risk of injury due to fire or explosion impacting areas beyond its point of origin.
		OP1.2 the building will not be exposed to an unacceptable risk of damage due to fire or explosion impacting areas beyond its point of origin.
		OP3.1 the adjacent buildings will not be exposed to an unacceptable risk of damage due to fire or explosion impacting areas beyond the building of origin.

Intent 1:

To limit the probability that a firewall will have insufficient fire-resistance, which could lead to the spread of fire from one building to another, which could lead to harm to persons in the building not originally involved in the fire.

Intent 2:

To limit the probability that fire will spread from one building to another during the time needed for emergency responders to carry out their duties, which could lead to harm to persons in the building not originally involved in the fire.

3.1.10.3. Continuity of Firewalls

Function	Link	Persons/Building Not Harmed
F03 To retard the effects of fire on areas beyond its point of origin	so that	**OS1.2** a person in or adjacent to the building will not be exposed to an unacceptable risk of injury due to fire or explosion impacting areas beyond its point of origin.
		OP1.2 the building will not be exposed to an unacceptable risk of damage due to fire or explosion impacting areas beyond its point of origin.
		OP3.1 the adjacent buildings will not be exposed to an unacceptable risk of damage due to fire or explosion impacting areas beyond the building of origin.

Intent 1:

To limit the probability of a firewall not being continuous, which could lead to gaps or openings in the firewall during a fire, which could lead to the spread of fire from one building to another, which could lead to harm to persons in the building not originally involved in the fire.

3.1.10.5. Maximum Openings

Function	Link	Persons/Building Not Harmed
F03 To retard the effects of fire on areas beyond its point of origin	so that	**OS1.2** a person in or adjacent to the building will not be exposed to an unacceptable risk of injury due to fire or explosion impacting areas beyond its point of origin.
		OP1.2 the building will not be exposed to an unacceptable risk of damage due to fire or explosion impacting areas beyond its point of origin.
		OP3.1 the adjacent buildings will not be exposed to an unacceptable risk of damage due to fire or explosion impacting areas beyond the building of origin.

Intent 1:

To limit the probability of a large number of openings in a firewall, which could lead to the failure of the integrity of the firewall and its protective closures for these openings during a fire, which could lead to the spread of fire from one building to another, which could lead to:

damage to the building or to the adjacent building, and

harm to persons in the building not originally involved in the fire.

Appendix IV Commentary

The CAN/ULC-S101-07 has the following requirements that may be relevant for the design:

Item	Passing Criteria
1	The average temperature measured by stationary thermocouples on the unexposed side should not exceed 140°C above the initial average temperature, and the temperature measured at an individual point should not exceed 180°C above the initial average temperature.
2	The test specimen should sustain applied load throughout the fire test without the passage of flame or gases hot enough to ignite cotton pads.
3	The test specimen should sustain applied load throughout the test and the hose stream test, without passage of flame or gases hot enough to ignite cotton pads and passage of the hose stream. The assembly is considered to have failed the hose stream test if an opening develops that permits a projection of water from the stream beyond the unexposed face.

The CAN/ULC-S104-M10 has the following requirements that may be relevant for the design:

Item	General Passing Criteria
1	The test specimen should withstand the fire test and hose stream without developing openings anywhere in the assembly (with exceptions).
2	No flaming should occur on the unexposed surface of the assembly during the first 30 minutes of the rating period.
3	After 30 minutes, some intermittent flames approximately 150-mm long may occur along the edges of the doors. No intermittent flames may occur, for periods exceeding 5-minute intervals.
4	Light flaming may occur during the last 15 minutes of test. Flaming should be contained within 40 mm from a vertical door edge and within 75 mm from the top edge of the door, and within 75 mm from the top edge of the frame of a visual panel.
5	When hardware is to be evaluated, it shall hold the door closed for the duration of the test and the latch bolt shall remain engaged and intact for the duration of the test.

Item	Passing Criteria for Swinging Doors
1	Movement of the door should not result in any portion of the edges adjacent the door flame moving from the original position in a direction perpendicular to the plane of the door: more than the thickness of the door during the first half of the test more than 73 mm during the fire test or hose stream test
2	Movement of a pair of swinging doors should not result in any portion of the meeting edges moving more than the thickness of the door away from the adjacent door edge in a direction perpendicular to the plane of the doors during the fire test or the hose stream test.
3	An assembly consisting of a pair of swinging doors with an astragal may not separate in the direction parallel to the plane of the doors more than 19 mm along the meeting edges.
4	Door frames evaluated with doors should remain securely fastened to the wall on all sides and not permit through openings between the frame and the doors, or between the frame and the adjacent wall.

Although it is not clear as to how to resolve the discrepancy in requirements, for purposes of this guide the longer fire-resistive rating for the wall is interpreted the requirement for the interface. There are suggestions that this may not be necessary:

- The longer resistance is more appropriate for a separation given that the single test is one sample of a larger wall that will serve as the fire separation. It would be appropriate to demonstrate a higher level of performance in a single test in order to capture the potential variability in between single tests, which might be more representative of the variation across a larger but more realistic sized wall. On the other hand, the fire door tested is a sample of the actual door to be used.
- NFPA suggests that combustible are not likely to be stacked against a fire door. Therefore, its expected performance need not be as high as for a separation wall.

Appendix V Summary of 2013/14 Closure Penetration Tests

Common Details of Test Specimens

- Wall (2h listed GWB Firewall (CAN/ULC-S101))
  - Overall size: 12 ft. wide by 9 ft. high
  - Core framing: 2 in. 25 Ga. H-stud and C-runner
  - Core: 2 layers of 1in. thick CGC SheetRock Glass-Mag Liner Panel
  - Exterior wall framing: nominal 2x4 wood studs @ 16-in. on center on either side of the core
  - Exterior wall insulation: 3.5-in thick Roxul R14 ComfortBatt insulation with 3.5-in screws and washers to hold the insulation in place
  - Exterior wall sheathing: 5/8-in thick FireCode Type X CGC SheetRock Gypsum panel
- Door (1.5h listed door assembly (CAN/ULC-S104))
  - Type: Steel double egress
  - Hardware: Four point latching surface mounted panic hardware
  - Hinges: Three 4x4.5 in. steel ball bearing butt hinges per door
  - Frame: 16 Ga. fully welded steel frame
- Applied load (dead load equivalent to 5 door assemblies attached to the plywood sheathing with pairs of steel flat bars – see notes in Figure 6 of Appendix VI)
  - Total load of 4732 pounds distributed to the plywood on either side of the door
  - Load maintained on the test assembly for the duration of the test

Test #1 (Target: 90 minute duration under load):

Specific Details of Test Specimen (in addition to Common Details) and Laboratory Test Report

- Core sheathing: Each face was sheathed with 1 in. thick plywood to the edge of the specimen
- Door type: Steel double egress with astragals on both doors
- Frame anchor: Six 1.5 in. by 35-in steel straps on each side screwed into the 1-inch plywood
- Laboratory test report: QAI (2014a).

GHL Observations

- Tested for 92 minutes controlled by the time-temperature curve.
- Door ‘failed’ at approx. 37min; however, door frame attachment remained intact for the duration of the test.
- With the exception of the door failure, the test specimen met all passing criteria of ULC-S101 and ULC-S104 test standards.
- Test specimen sustained applied load throughout the test and hose stream test.

Test #2 (Target: 120 minute duration under load):

Specific Details of Test Specimen (in addition to Common Details) and Laboratory Test Report

- Core sheathing: Each face was sheathed with 1 in. thick plywood excluding the outermost 12 in. of each side.
- Door type: Steel double egress with slotted astragals on both doors
- Frame anchor: Six 2 in. by 24-in steel straps on each side screwed into the 1-inch plywood
- Laboratory test report: QAI (2014b).

GHL Observations

- Tested for 120 minutes controlled by the time-temperature curve.
- Door 'failed' again; however, similar to the first test, the door remained latched.
- Smoke and gases observed through to the unexposed side around the door frame soon after the start of the test. This was not apparent in the first test.
- Significant flaming from the plywood on the unexposed side around the door frame was apparent towards the end of the test. This was not apparent in the first test.
- Although flaming on the unexposed side was apparent, visual observation confirmed that the wall assembly successfully sustained the applied load for 2h duration.

GHL Conclusions and Recommendations

- Tests did show some issues and there are details to be resolved.
- Tests concluded that enhanced level of review and detail is required.
- Although no perfect test was achieved, data from the two available fire tests specifically demonstrates that 90min listed fire protection rated doors can be installed in 2h fire rated gypsum firewalls without compromising the expected performance of either doors or firewall.

- Further test would be useful to confirm final recommendations; however, it may be more appropriate that additional tests be funded by gypsum and door manufactures.

References

GHL Consultants Ltd. 2014. FPI Gypsum Fire Wall Test Program (GHL File FPI-4971.00). April 4, 2014. 43pp

QAI Laboratories. 2014a. Test Report # T895-1. Prepared for FPInnovations. April 8, 2014. 8 pages and Appendices A1 to A19.

_____. 2014b. Test Report # T895.2. Prepared for FPInnovations. May 21, 2014. 9 pages and Appendices A1 to A20.

Appendix VI Example Configurations and Details

NOTE: This example is provided to assist to illustrate the concepts. The example is not necessarily the appropriate or the only solution.

The following is a description of a closure penetration in a 2-hr gypsum fire separation wall that highlights the subcomponents specified to address the considerations presented in this guide. It should be noted that:

- The details shown to tie the gypsum core to the wood frame structure (i.e. slotted aluminium clips) are discussed in the AGW Guide, *Structural Performance of Frame Supported Gypsum Area Separation Walls*.
- Although fire resistance rated framed loadbearing shear wall on both sides are shown on both sides, they should not be included in the calculation of the fire resistance rating of the wall.
- There may be other firestopping details around the enclosure that are not shown.

	Comments
Figure 1	Sample door header detail. Detail to permit movement under moderate events and building component shrinkage. Fill gap with mineral wall and firestopping caulking. Inspect as required if large building moment has occurred.
Figure 2	Sample threshold detail. Detail to permit movement under moderate events and building component shrinkage.
Figure 3	Sample door jamb for a flat bar option. Detail to permit movement under moderate events and building component shrinkage.
Figure 4	Shaft liner and light-gage steel H-studs and C-Runners form the core of the fire separation wall. Consult manufacturer's literature.
Figure 5	Structural wood sheathing (typically plywood) is place over the wall on both sides with 4-inch screw through the shaft liner, alternating from each side.
Figure 6	Fire door mounted on steel door frame that is attached to the wood structural sheathing on both faces with flat bar.
Figure 7	Stud wall is framed on both sides and attached to the wood structural sheathing with aluminium slotted clips.
Figure 8	Mineral wood batts are inserted between the studs of the framed wall and pinned to the wood structural sheathing. This is required to limit flame spread on the wood sheathing on the unexposed side of the closure penetration during a severe fire event on the opposite side.
Figure 9	Type X gypsum wallboard is installed over the framed wall with allowance around the perimeter of the opening. This wall is not included in the computed fire resistance rating but must be maintained to provide protection to the gypsum shaft liner and the wood sheathing on the unexposed side of the closure penetration during a severe fire event on the opposite side.

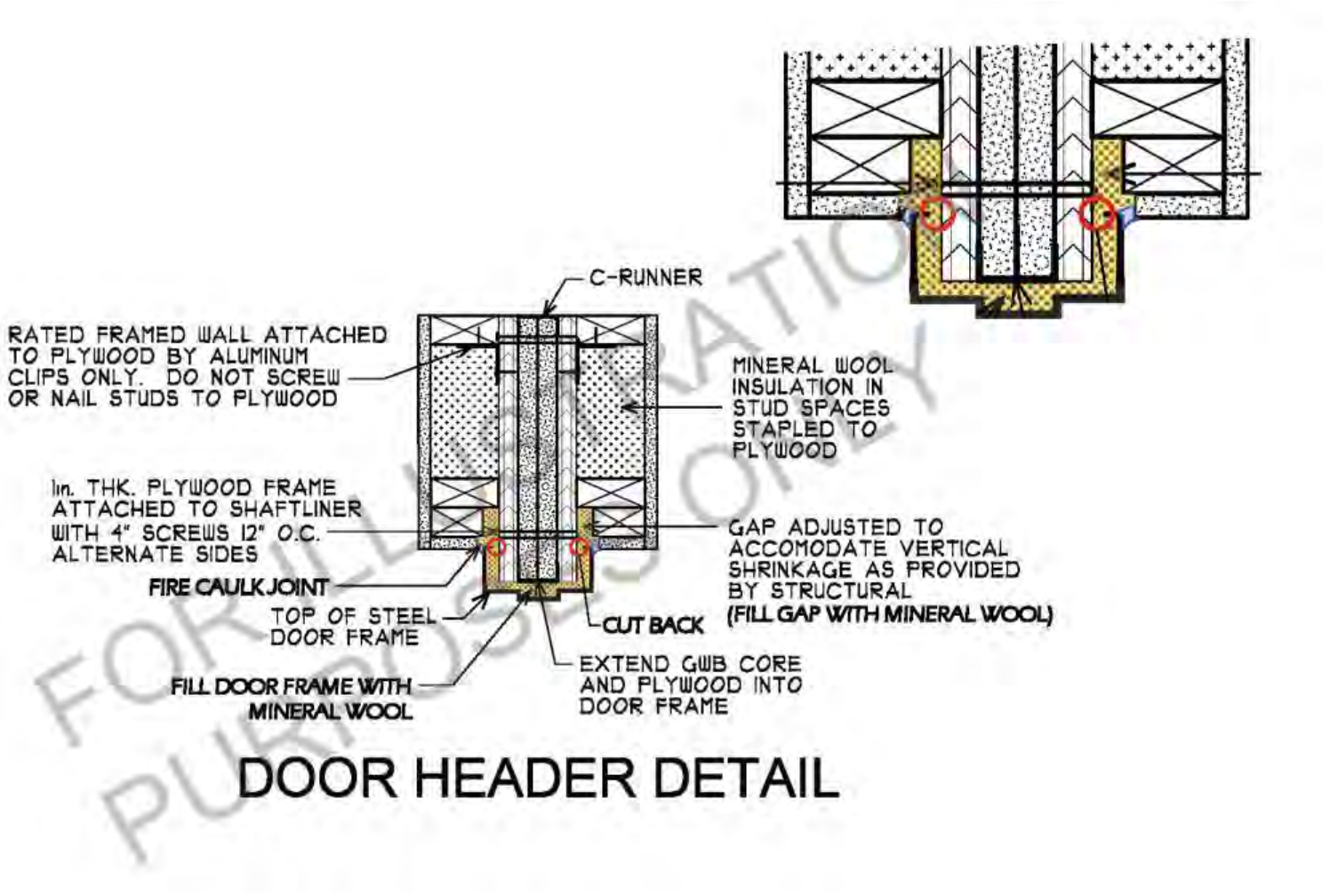

Figure 1 – Sample door header detail

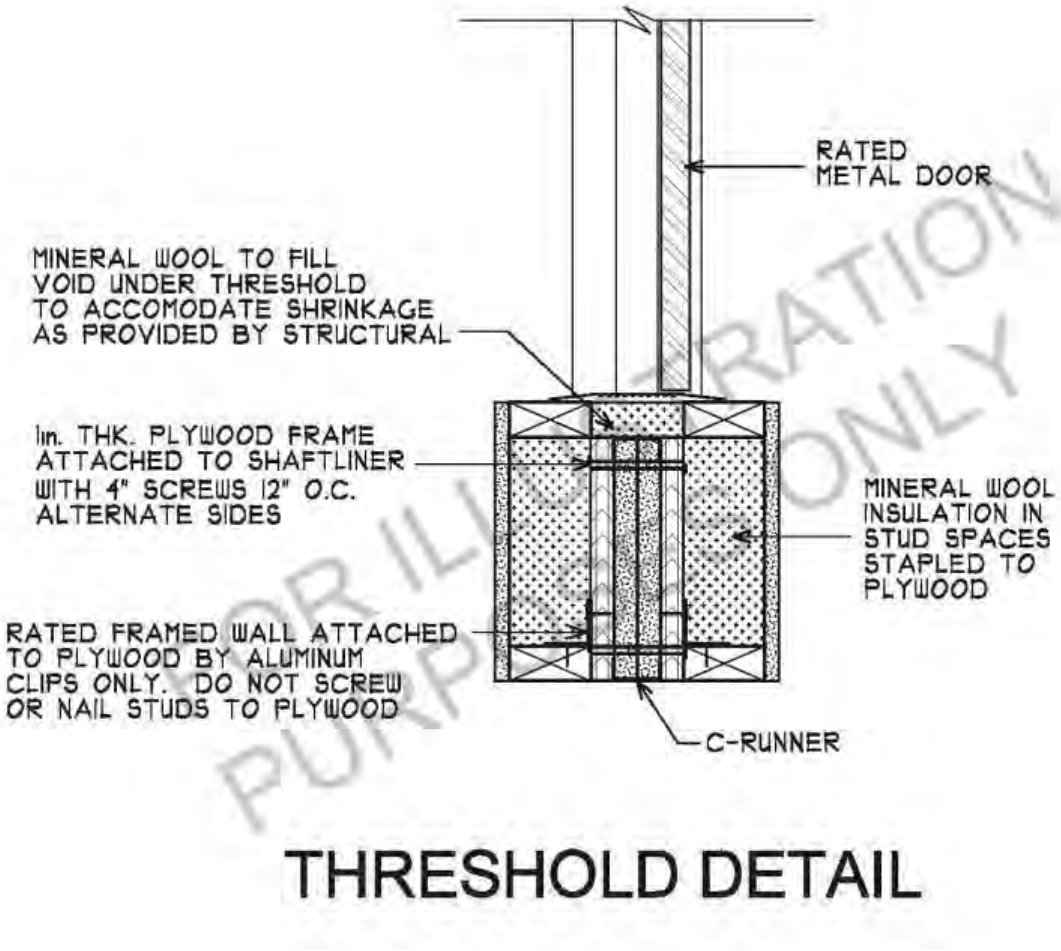

Figure 2 – Sample threshold detail

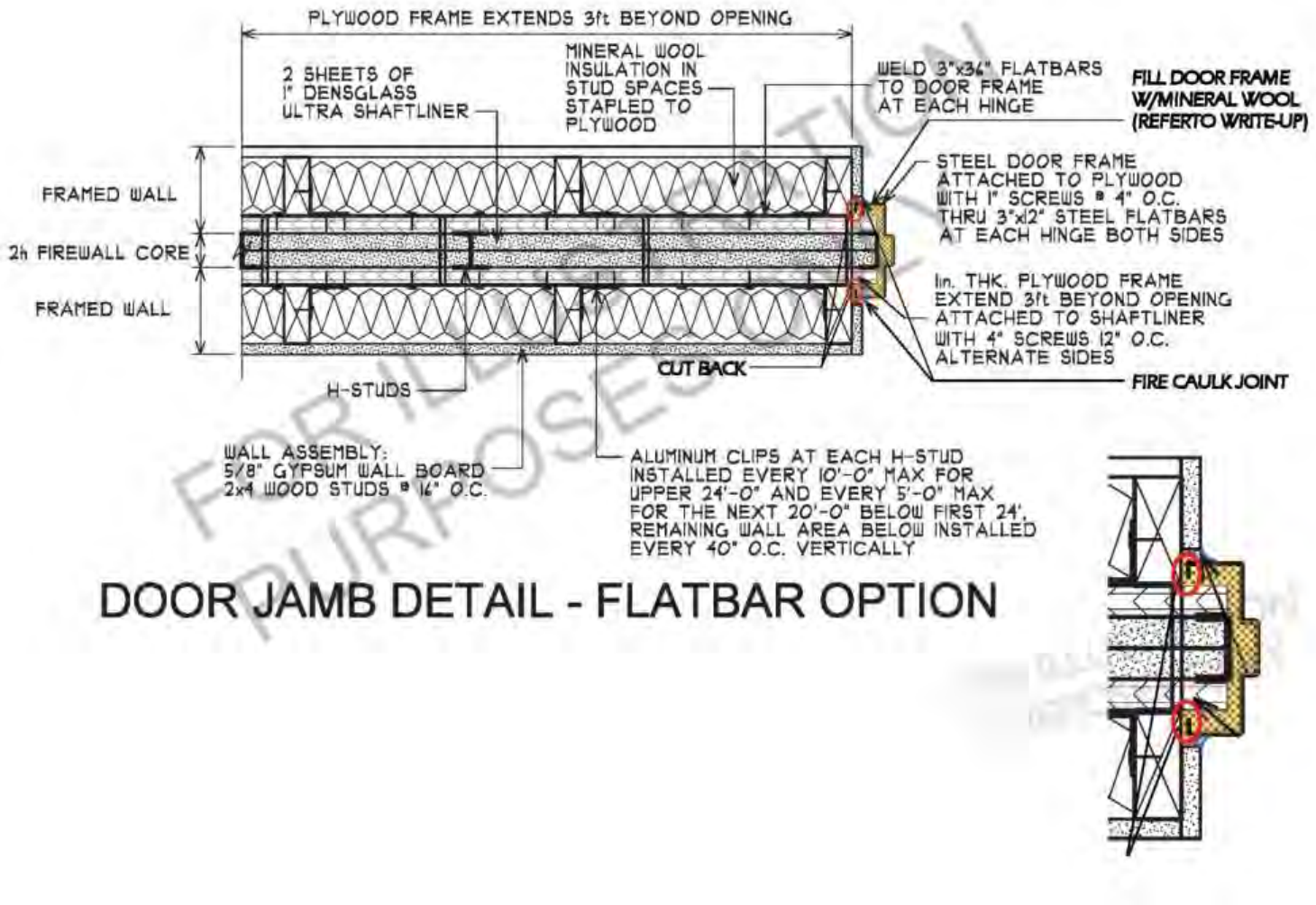

Figure 3 – Sample door jamb detail for the flat bar option

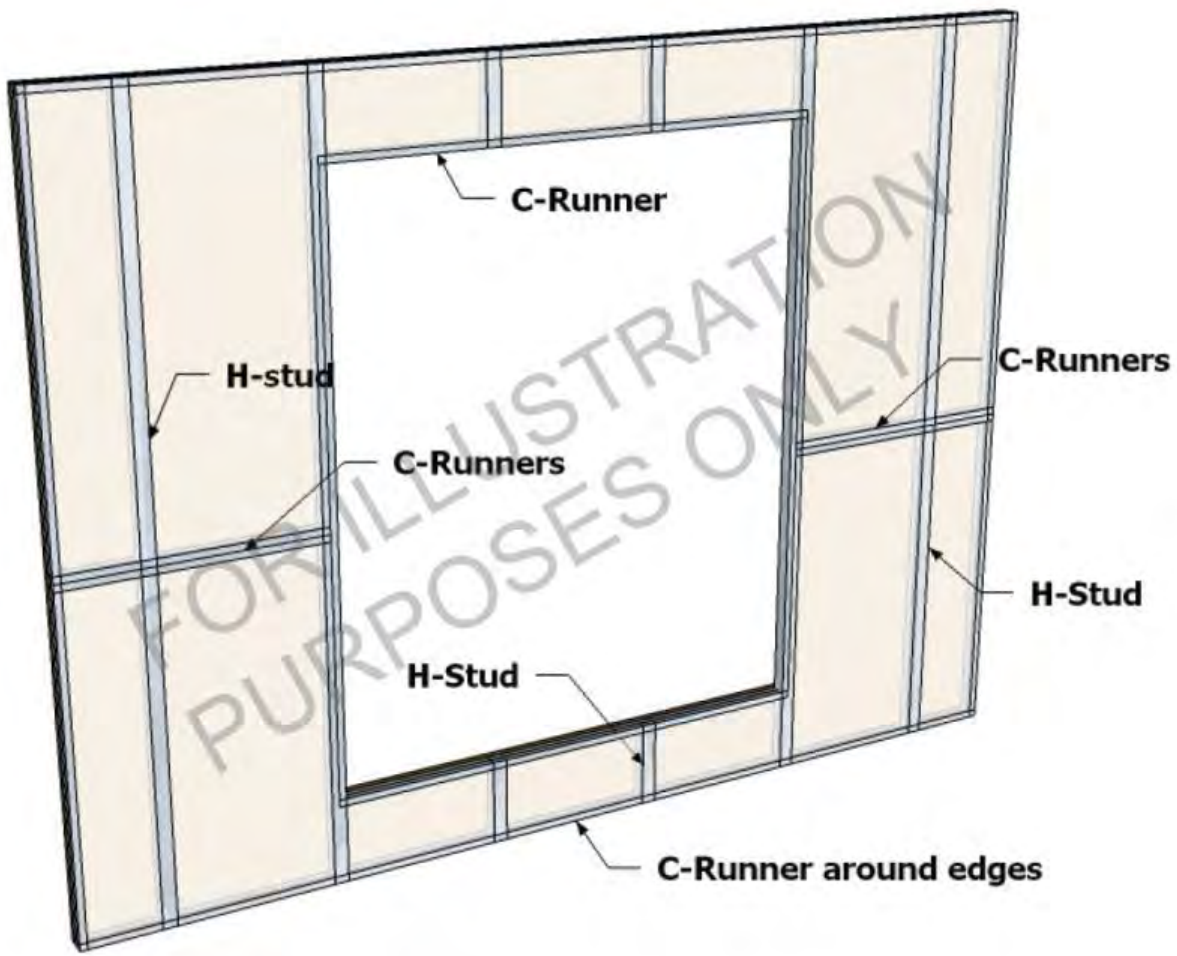

Figure 4 – Shaft liner and light-gauge steel H-studs and C-Runners

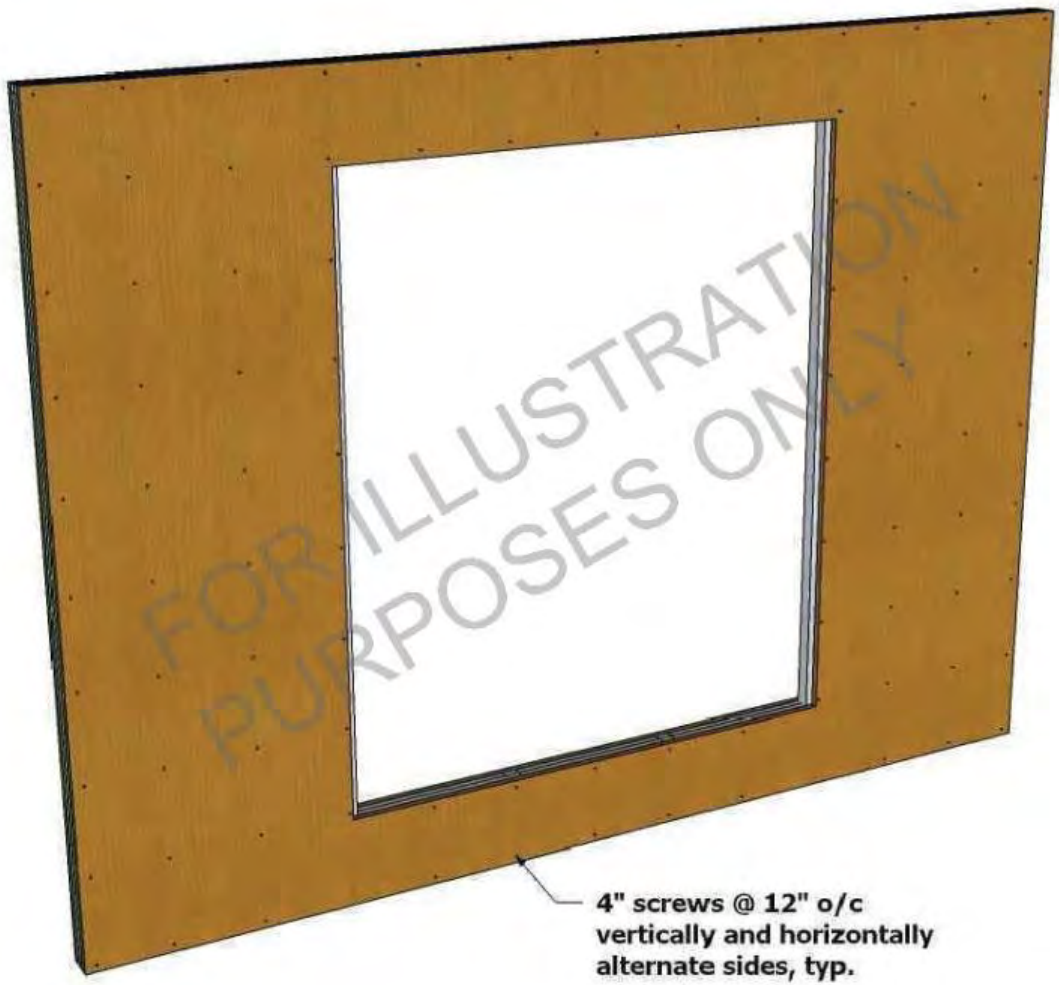

Figure 5 – Structural wood sheathing attached with 4-inch screws through shaft liner to opposite wood sheathing layer

Figure 6 – Door mounted on steel door frame with steel flat bars attached to the structural wood sheathing

Figure 7 – Wood framing wall attached to structural sheathing using aluminum slotted clips

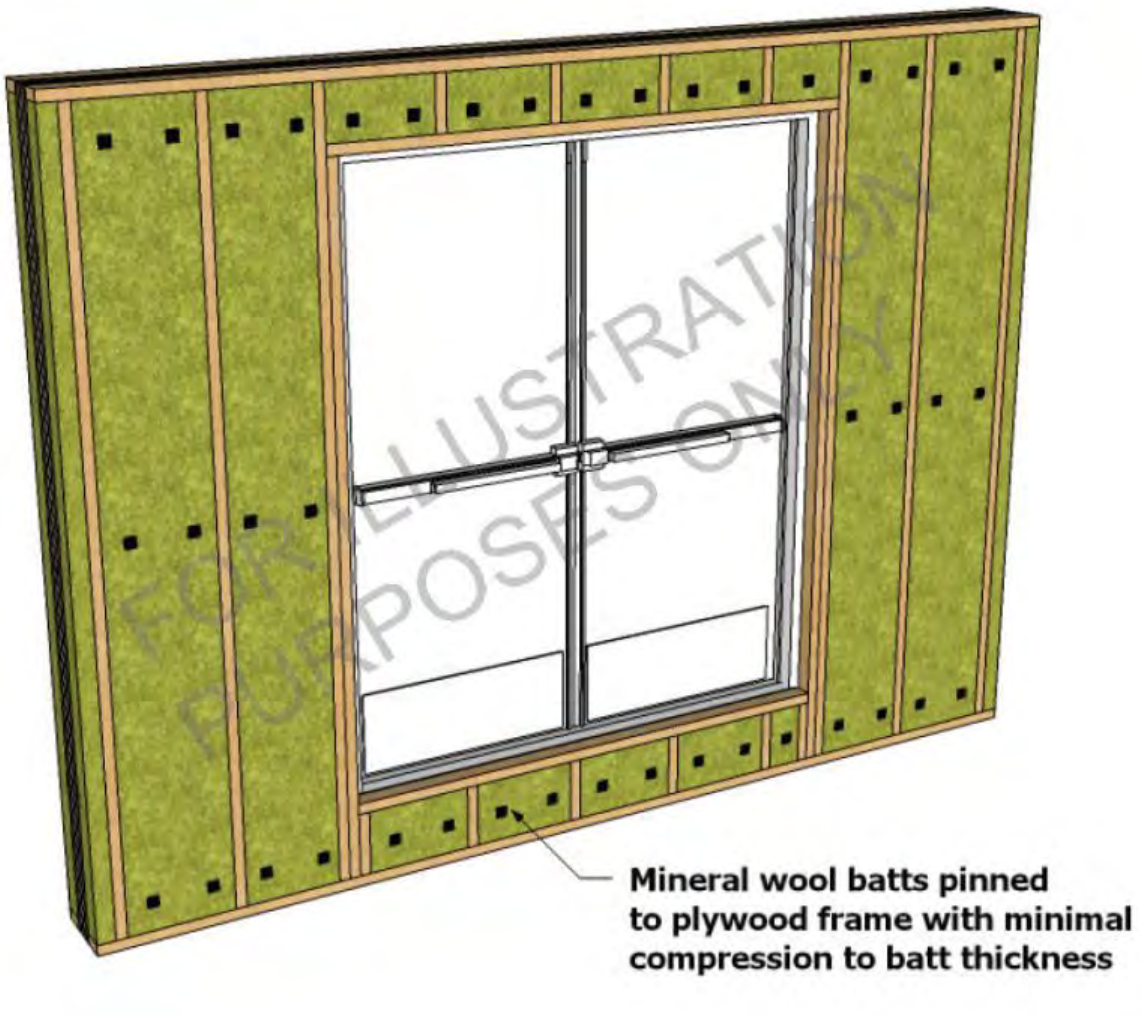

Figure 8 – Mineral wood batts between studs of the framed wall and pinned to the wood structural sheathing

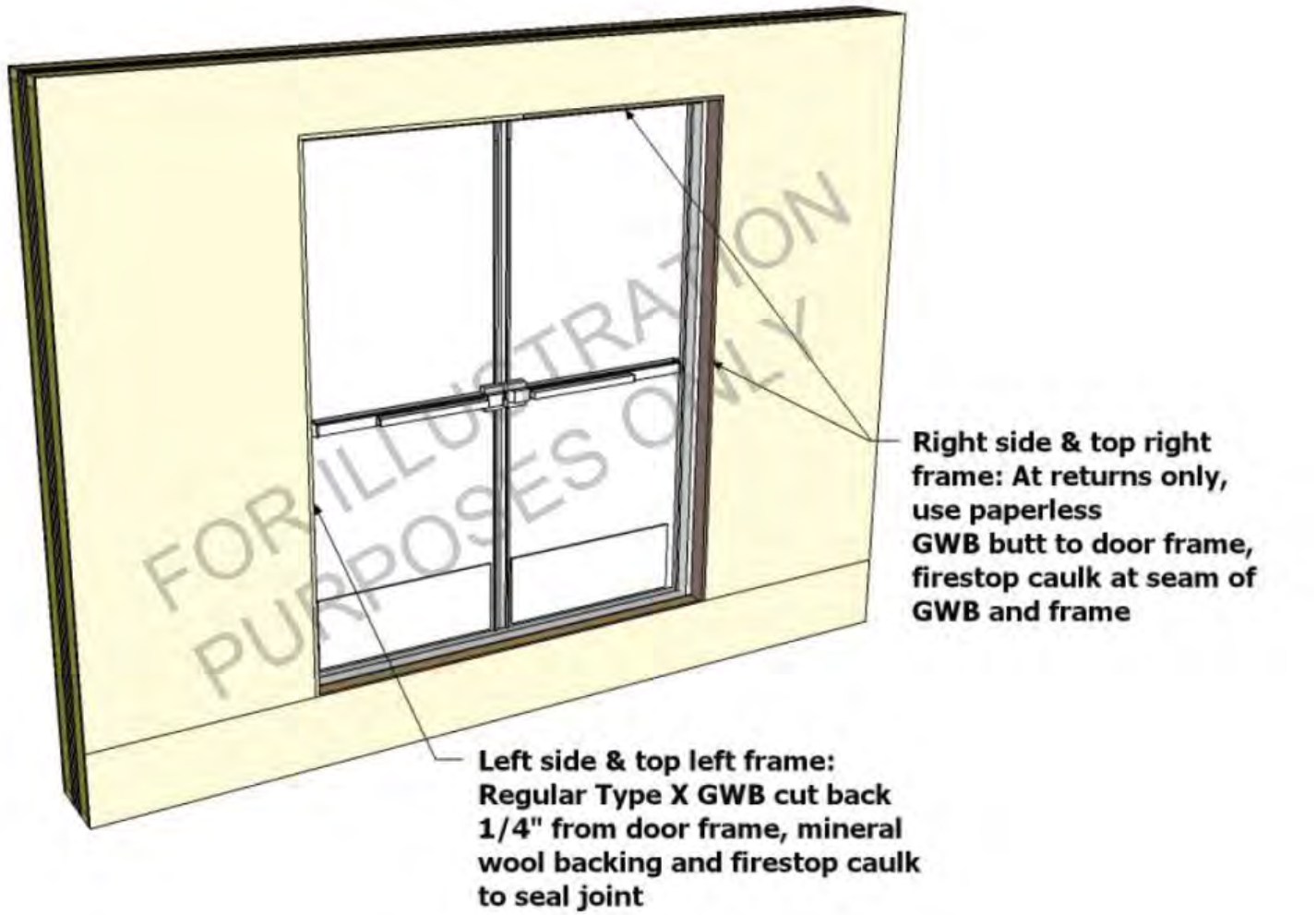

Figure 9 – Type X gypsum wallboard over framed wall and with allowance around perimeter of opening for fire caulking

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