PRIEST & ASSOCIATES CONSULTING, LLC

ENGINEERING EVALUATION

Fortifiber Building Systems Group WRBs in NFPA 285-12 Assemblies

Project No. 10588, Revision 3

Prepared for:

Fortifiber Building Systems Group
300 Industrial Drive
Fernley, NV 89408

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4607 Verdi Road
Pleasanton, TX 78064
www.priestassociates.com

Solutions for the Building Materials Industry

1-877-505-7743 Office
210-410-8217 Mobile
deg.priest@priestassociates.com

Abstract

An engineering evaluation and NFPA 285 and cone calorimeter (ASTM E1354) data from Fortifiber were referenced to evaluate and create a matrix of constructions using Fortifiber WRB products that would meet NFPA 285 with specific limitations.

The conclusions reached by this evaluation are true and correct, within the bounds of sound engineering practice. All reasoning for our decisions is contained within this document.

Submitted by,

Javier Trevino
Associate Engineer
210-601-0655

May 4, 2022

Reviewed and Approved,

Deg Priest
President

May 4, 2022

INTRODUCTION

The purpose of this evaluation is to allow the use of various Fortifiber Building Systems Group WRB products in previously evaluated NFPA 285 assemblies (Ref. 4) that can meet the requirements of NFPA 285 (Ref. 1). Cone Calorimeter data (Ref. 3) was submitted to compare the flammability of various Fortifiber WRB products to various approved WRBs (Ref. 4).

REFERENCED DOCUMENTS

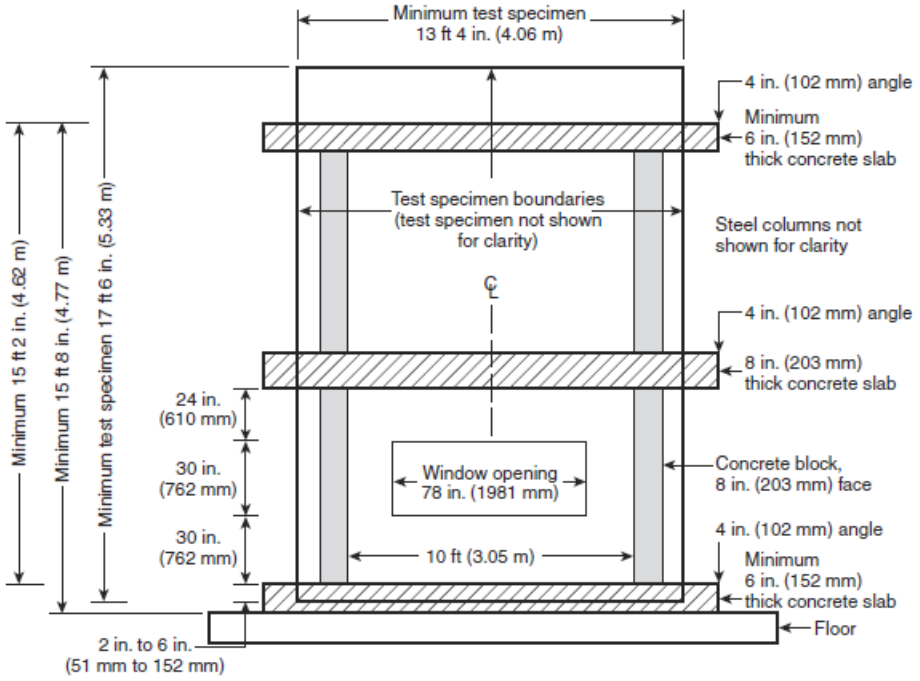
1) *NFPA 285-12 Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-loadbearing Wall Assemblies Containing Combustible Components*
2) *Babrauskas, V., Lucas, D., Eisenberg, D., Singla, V., Dedeo, M., & Blum, A. (2012). Flame retardants in building insulation: a case for re-evaluating building codes. Building Research & Information. doi:10.1080/09613218.2012.744533*
3) *Cone Calorimeter Data for Fortifiber – Data Confidential btw Fortifiber and Priest & Associates*
4) *Priest and Associates EEV 10123 Tables Only – Hunter NFPA 285 Evaluation with Fortifiber WRBs*
5) *DRJ Engineering TER 1402-01 and 02 Hunter Approved NFPA 285 Assemblies*
6) *Lindholm et al. Cone Calorimeter – a Tool for Measuring Heat Release* *http://www.ffrc.fi/FlameDays_2009/4B/LindholmPaper.pdf*
7) *Babrauskas et al., 10 Years of Heat Release Research NIST Publication* *http://fire.nist.gov/bfrlpubs/fire93/PDF/f93048.pdf*
8) *White, R.H., and Dietenberger, M.A., Wood Handbook Chapter 18 "Fire Safety of Wood Construction" Benichou, N., Sultan, M.A., Kodur, V.R., Fire resistance performance of light weight framed wall assemblies: effects of various parameters, key design considerations and numerical modelling. NRCC-45688, Institute of Research in Construction, National Research Council, Ottawa, Canada.* *http://nparc.cisti-icist.nrc-cnrc.gc.ca/eng/view/accepted/?id=10c2dafb-0fe9-4bd5-aac4-59d287e7188a*

This document provides an expert opinion on the properties of the materials, products, or assemblies identified in this report related to meeting a specific code or standard. Suitability to use is to be determined by the end-user.

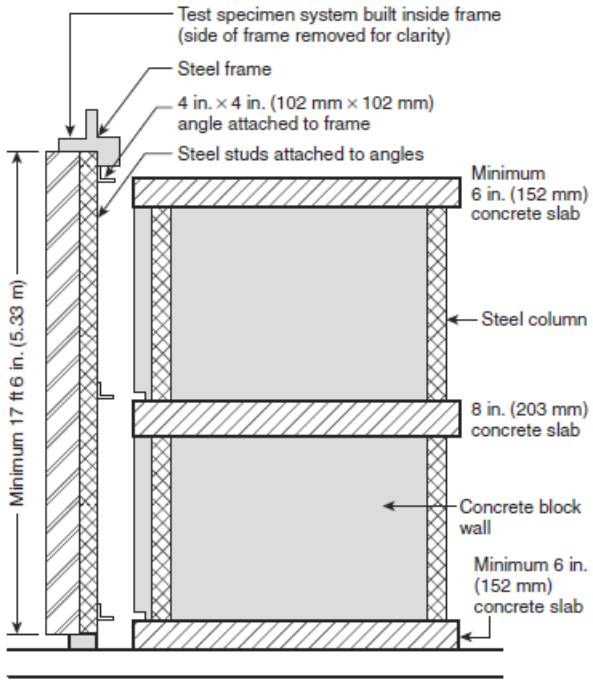
EVALUATION METHOD

NFPA 285 Criteria

The NFPA 285 fire test (see References section) is designed to test the flame spread properties of exterior walls containing combustible components. Two noncombustible rooms are stacked to simulate two stories of a multi-story building. The wall assembly is then attached to the outer face of the rooms.

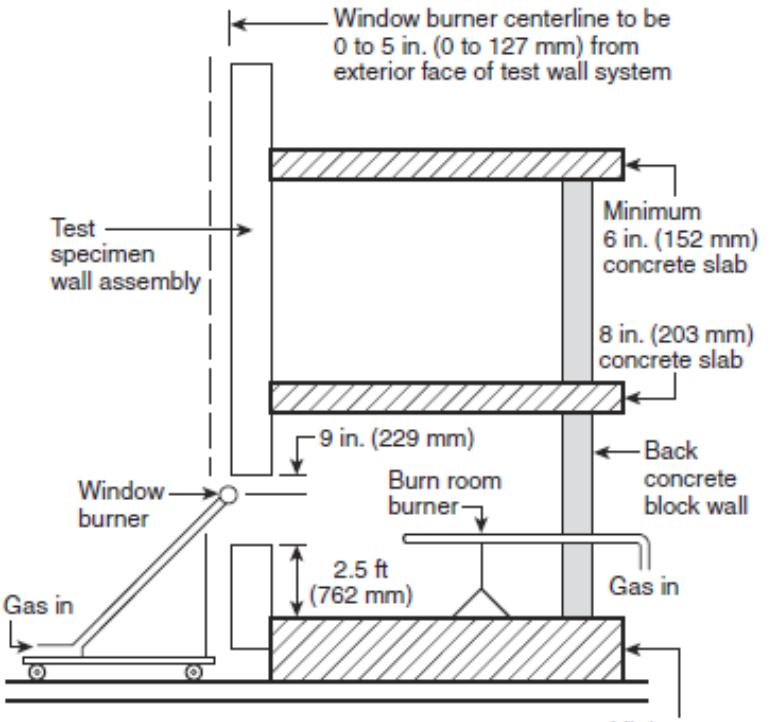


Front View of Test Specimen Superimposed over Test Apparatus (not to scale).



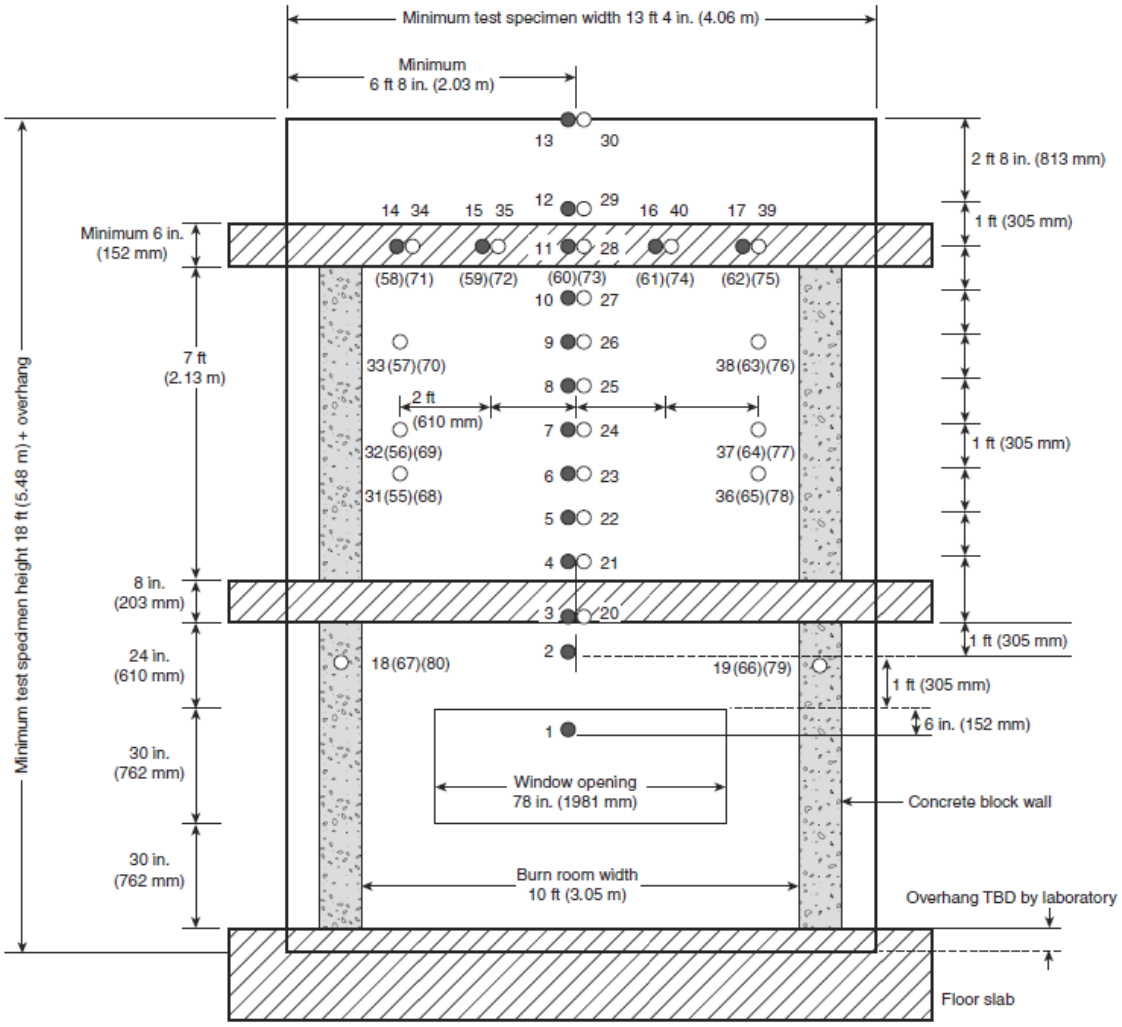
Side View of Test Apparatus with Test Specimen in Movable Test Frame (not to scale).

The two burners illustrated below are ignited to produce a specific time-temperature profile in the room and on the wall's exterior face.



Section View of Burner Placements for First-Story Test Room (not to scale).

A typical test wall measures 14 ft x 18 ft with a 30 in. tall x 78 in. wide window opening placed on the bottom floor. Thermocouples are placed at strategic locations to monitor temperature as an indicator of flame spread. In the depictions below, Thermocouples 1 - 10 and 20 - 27 are not used for compliance purposes. The remainders are used to monitor the spread of flame.

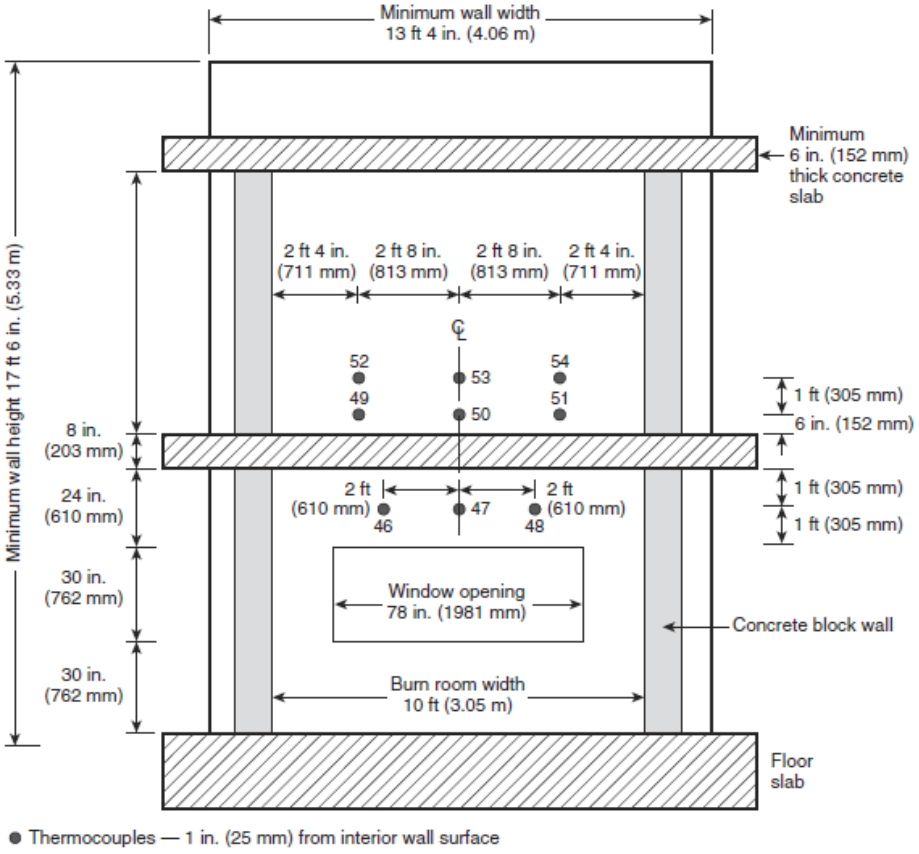


● Thermocouples — 1 in. (25 mm) from exterior wall surface

○ Thermocouples — In the wall cavity air space or the insulation, or both, as shown in Figure 6.1(b) Details A through I.

( ) Thermocouples — Additional thermocouples in the insulation or the stud cavity, or both, where required for the test specimen construction being tested, as shown in Figure 6.1(b) Details C through I.

Figure not to scale



Interior View of the Test Specimen. Instrumentation arrangement.

During a test, a calibrated fire starts in the bottom room. After 5 minutes, the exterior (window) burner is ignited to produce a specific heat flux/temperature pattern on the exterior of the wall. Both burners remain ignited during the remainder of the 30-minute test, with the gas flow to each increasing every five minutes. During calibration, the temperatures at various locations throughout the 30 minutes must reach those indicated below.

Calibration Average Values for Time Periods Indicated

Thermocouple Location and Numbers	Temperature											
	0–5 min		5–10 min		10–15 min		15–20 min		20–25 min		25–30 min	
	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
Test room ceiling: Nos. 18–22	1151	622	1346	730	1482	806	1600	871	1597	869	1648	898
Interior wall surface of test room: Nos. 15–17	1065	574	1298	703	1433	778	1578	859	1576	858	1655	902
1 ft (305 mm) above top of window opening: No. 2	602	317	870	466	952	511	992	533	1046	563	1078	581
2 ft (610 mm) above top of window opening: No. 3	679	359	1015	546	1121	605	1183	639	1245	674	1296	702
3 ft (914 mm) above top of window opening: No. 4	646	341	971	521	1096	591	1174	634	1245	674	1314	712
4 ft (1219 mm) above top of window opening: No. 5	577	302	858	459	982	528	1063	573	1135	613	1224	662
5 ft (1524 mm) above top of window opening: No. 6	521	272	765	407	875	469	949	509	1007	542	1106	597
6 ft (1829 mm) above top of window opening: No. 7	472	244	690	366	787	419	856	458	913	489	1010	543

Also, during the calibration procedure, the radiant flux at the identified locations and times must reach those indicated in the table below.

Calorimeter Locations and Numbers	Heat Flux (W/cm²)					
	0–5 min	5–10 min	10–15 min	15–20 min	20–25 min	25–30 min
2 ft (610 mm) above top of window opening: Letter C–2ft	0.9 ± 0.2	1.9 ± 0.4	2.5 ± 0.5	2.9 ± 0.6	3.4 ± 0.7	3.8 ± 0.8
3 ft (914 mm) above top of window opening: Letter C–3ft	1.0 ± 0.2	2.0 ± 0.4	2.6 ± 0.5	3.2 ± 0.6	3.7 ± 0.7	4.0 ± 0.8
4 ft (1219 mm) above top of window opening: Letter C–4ft	0.8 ± 0.2	1.5 ± 0.3	2.0 ± 0.4	2.5 ± 0.5	3.0 ± 0.6	3.4 ± 0.7

Both the room and window burners are under programmed PID control, so once they are calibrated to meet the above requirements, they repeat the same exposure for each test wall.

Personnel monitor flame spread visually during the test; a computer data acquisition system monitors and records the thermocouple temperatures. The criteria for passing are as follows (reworded in more straightforward terms for this analysis):

1) Flames shall not spread vertically 10 ft or more above the window opening as determined visually or by thermocouples located at the 10 ft level. Failure occurs when Thermocouples 11 or 14 - 17 exceed 1000 °F.
2) Flames shall not spread (visually) horizontally 5 ft or more on either side of the window opening centerline.
3) Flames shall not spread inside the wall cavity as determined by thermocouples placed within the wall cavity insulation and air gaps if present. Failure occurs when Thermocouples 28, 31 - 40, or 55 - 65 and 68 - 79 exceed 750 °F above ambient.
4) Flames shall not spread horizontally within the wall cavity past the interior room dimension as determined by wall cavity thermocouples. Failure occurs when Thermocouples 18 - 19, 66 - 67, or 79 - 80 exceed 750 °F above ambient.
5) Flames shall not spread to the second-story room as determined by interior wall surface thermocouples. Failure occurs when Thermocouples 49 - 54 exceed 500 °F above ambient.
6) Flames shall not occur in the second story (visually).
7) Flames shall not escape (visually) from the interior to the exterior at the bottom story room wall/wall intersection.

Constructions Tested or Approved Assemblies

This evaluation is based on Hunter EEV 10123 Tables (Ref. 4) and reference to a UL listing for XPS insulation when used with stucco. The referenced EEV was based on several NFPA 285 tests deemed worst-case assemblies, allowing various component options based on the testing. Each report describes a specific construction tested per NFPA 285. The specific constructions are confidential but include multiple combinations of wall components. These include cavity insulation, exterior sheathing, water-resistive barrier (WRB), exterior insulation, exterior WRB, air gap, claddings, and window details. Additionally, cone calorimeter data for Fortifiber WRBs was used for this analysis.

Allowed Base Wall Options.
The following base wall options are allowed in Ref. 4 (with specific limitations listed in the conclusion table).

- Interior gyp board – ⅝" type X (minimum thickness)
- Cavity Insulation (SPF only with exterior gypsum sheathing):
  - 1½" (min) of Covestro EcoBay CC SPF (up to full cavity thickness)
  - 1½" (min) of BASF Walltite SPF (up to full cavity thickness)
  - Any noncombustible insulation per ASTM E136
  - Any mineral fiber (Board type Class A ASTM E84 faced or unfaced)
  - Any fiberglass (batt type Class A ASTM E84 faced or unfaced)

  - Any foam plastic insulation (SPF or board) which has been tested per ASTM E 1354 (at a minimum of 20 kW/m^2 heat flux) and shown by analysis to be less flammable (improved T_{ign}, Pk. HRR) than Covestro EcoBay CC or BASF Walltite
  - NCFI InsulBloc SPF (up to full cavity thickness)
  - Icynene MD-C-200v3 (Proseal) up to 5½ inches (only with ½ in. (min.) exterior gypsum sheathing)
  - SWD Urethane Quik-Shield 112 up to 6 inches in 6 inch (max.) stud cavities with an air gap not exceeding 2½ inches
  - 1½" (min.) ThermoSeal 2000 (up to full cavity thickness)
- Steel or FRT studs.
- ½" FRT wood sheathing as needed for shear in Type III construction with FRT wood studs
- ½" or thicker exterior gypsum sheathing

Base Wall Analysis

SPF Insulation

The exterior sheathing of the base wall acts as a thermal break between the exterior insulation/cladding (wall region 1) and the cavity insulation/interior sheathing (wall region 2). The two wall regions behave independently when separated by gypsum sheathing, which allows tested or approved SPF products in stud cavities as long as the two regions are separated by gypsum sheathing. The fire response of Region 1 has very little to do with the fire behavior of Region 2 when separated by gypsum sheathing.

FRT Plywood Exterior Sheathing

In Ref. 4, FRT plywood is used over foam insulation (Xci-Ply) under ACM cladding, which is a worst-case allowance for FRT plywood in NFPA 285 walls because the ACM cladding can easily melt, ignite and spread flames exposing the FRT to direct flaming. In this report, we can allow $^7/_{16}$" (min.) FRT plywood as an exterior sheathing based on the allowance of Xci-Ply in Ref. 4. Gypsum sheathing may be added over the FRT plywood if needed since this reduces the overall flammability of the system.

Base Wall Framing – FRT Wood Lumber Studs

Most NFPA 285 approvals list 3⅝" (min.) 20 GA. (min.) 24 or 16 in. OC (max.) steel studs, which typically represents the tested design. This allowance is based on the premise that deeper studs of thicker material with lesser spacing are more structurally robust. Our experience shows that the stud spacing does not affect flame spread. This analysis proposes that the studs may be FRT wood lumber and spaced up to 24 in. OC. These can be allowed based on the following:

1) In many ESR or ER reports, the headings list Type I - IV, including Type III. Type III allows FRT wood framing to be substituted for steel. In Dryvit ESR 1543, the EIFS system is allowed to use FRT wood studs as allowed by Ch. 6 of the IBC (see highlighted item below).

TABLE 3—ASSEMBLIES FOR USE WITH TYPE I, II, III AND IV CONSTRUCTION[2]

Framing Members			Interior Sheathing			Exterior Sheathing			Insulation Board
Min. Depth (inch)	Min. Gage	Max. spacing (inch)	Type and Min. Thickness (inch)	Fastener Type	Max. Fastener Spacing (inches o.c.)	Type and Min. Thickness (inch)	Fastener Type	Max. Fastener Spacing (inches o.c.)	Thickness Maximum[1] (inch)
Steel Framing									
3 5/8	20 (0.033 inch)	16" o.c.	Min. 5/8" Type X gypsum wallboard complying with ASTM C36 or ASTM C1396	Minimum No. 6, 1 1/4-inch-long buglehead, self-drilling Type S screws	8" at board joints, 12" at intermediate framing	Min. 1/2" Water-resistant core gypsum sheathing complying with ASTM C1396	Minimum No. 8, 1 1/4-inch-long, self-drilling Type S screws	8" o.c. along all studs	13
Fire-retardant-treated Wood Studs[3]									
2x4	N/A	24" o.c.	Min. 5/8" Type X gypsum wallboard complying with ASTM C36 or ASTM C1396	Minimum No. 8, corrosion-resistant steel, Type W, bugle-head drywall screws	8" at board joints, 12" at intermediate framing	Min. 1/2" Glass mat gypsum sheathing complying with ASTM C1177	Minimum No. 8, 1 5/8-inch-long, corrosion-resistant steel, Type W, bugle-head drywall screws	8" at board joints, 12" at intermediate framing	4

For **SI:** 1 inch = 25.4 mm.

[1]Combustible content of the foam plastic must not exceed an average potential heat content of 6,000 Btu/ft^2 (68.2 MJ/m^2) in every 20-square-foot wall area.
[2]Floor levels must be blocked with 4-inch-thick (102 mm), 4 pcf (64.1 kg/m^3) mineral-fiber insulation.
[3] Fire-retardant treated wood studs must comply with IBC Section 2303.2. Fire-retardant-treated wood framing is acceptable in Types I, II, III or IV construction as permitted by Chapter 6 of the IBC.

2) The use of fire-retardant-treated wood (FRTW) framing and sheathing covered under IBC Section 2303.2 is allowed in Type III construction within bearing and nonbearing exterior walls with required fire ratings of two hours or less. The use of FRT wood framing in the exterior walls is not expected to detract from the NFPA 285 performance of the approved wall systems for the following reasons:
   a) In ASTM E1354 Cone calorimeter testing, the initial Peak Heat Release Rate (Pk. HRR) for FRT plywood is comparable to gypsum sheathing (Ref. 8 and see Appendix A). It is expected that FRT studs have lower heat release due to the higher density of wood vs. plywood, and plywood has binders (adhesives) holding it together.
   b) The literature (Ref. 8) established that steel stud walls exhibit fire resistance behavior similar to wood stud walls.
   c) The building code allowance for FRT framing instead of noncombustible materials is predicated on its Class A flame spread rating. It does not support progressive combustion during the ASTM E84 30-minute fire test.
   d) Many NFPA 285 approved spray foams (SPF) allow the SPF to fully insulate the stud cavities of base walls (see Appendix B). Since most SPF products are more flammable than FRT studs (see note below), we contend that the stud cavity can be framed with FRT studs, thus providing a less flammable base wall design than a wall filled with SPF insulation.

      Note. SPF foams typically have Class A E84 ratings (some flame spread is allowed to obtain FSI ≤ 25), while FRT lumber as Class A rating (actual flame spread less than SPF) are also compliant with 30-minute extended E84 testing (now a separate standard: ASTM E2768). It is unlikely SPF can meet the same criteria. Also, there are NFPA 285 approvals (DrJ TER 1402-02) with FRT plywood exterior sheathing directly under ACM building panels. The approval is under DrJ Engineering for Hunter Xci-Ply insulated panels. There are no NFPA 285 approvals for SPF directly behind ACM building panels – it is unlikely this combination can pass the test. This information essentially shows that FRT lumber is less flammable than SPF foam.
   e) Most important, we have experience with NFPA 285 tests that used **non-FRT** wood studs. Our observations indicate that the studs were minimally damaged (slight charring but no uncontrolled flame spread). The thermal barrier (⅝" type X gypsum board) provides enough protection to keep the untreated wood from igniting. Based on this information, FRT studs are expected to perform better.
   f) Some NFPA 285 approvals list 16 in. OC (max.) stud spacing. For FRT framing, increasing the stud spacing to 24 in. OC reduces the fuel load of the system. In our experience, wider spacing does not affect flame spread.

WRB Analysis
WRBs are the main focus of this report. If an alternate WRB is less flammable than the NFPA 285 tested WRB, it is allowed as an alternate component. Cone calorimeter data (Ref. 3) was submitted to evaluate substitutions of the WRB products. Based on this analysis, some of the Fortifiber WRBs are allowed to be used over the foam insulation in Ref. 4, which allows "None" to be an option for exterior insulation for these WRB products since removing the foam reduces the fuel load of the wall. See Ref.4 when Hunter foam will be used as exterior insulation with Fortifiber WRB products.

The list of WRB products that may be used over the exterior insulation is given below in Ref. 4. As stated above, these will be allowed to be used without exterior insulation.

- Fortifiber Building Systems Group WeatherSmart Housewrap, WeatherSmart Drainable, WeatherSmart Commercial, or WeatherSmart D.

As a special case, Super Jumbo Tex 60 and WeatherSmart Rainscreen will be analyzed for use over the other Fortifiber WRBs (or as a doubled layer of Super Jumbo Tex 60) in stucco or related assemblies.

Special Case – Analysis of combining WRBs with Stucco Assemblies
Only two claddings will be listed for cases where combined WRBs are needed at the client's request. The claddings are listed below.

1) ¾" minimum exterior cement plaster and lath (stucco)
2) Adhered masonry veneer over ⅞" lath and mortar installed per 2015 IBC Section 1405.10.1.4.

Cladding #1is listed as allowed in Ref. 4. Cladding #2 is deemed superior to cladding #1 from a fire and thermal transmission point of view since the cladding base is ⅞ inch stucco, and the veneer is adhered with cement plaster. The combined layers are noncombustible and add thermal mass, reducing the heat transferred to combustibles under the cladding.

There are various NFPA 285 listings on the UL website for 4-inch Owens Corning 1.55 pcf FOAMULAR 250 for use with ¾ inch stucco. We use UL Design EWS 0027 for this evaluation. The maximum foam thickness is two layers of 2 inch. From the FOAMULAR 250 product data sheet, the insulation is Type IV. According to ICC-ES ESR 1061, FOAMULAR 250 is Type IV and has a potential heat of 2271 Btu/ft^2 (25.8 MJ/m^2) per inch.

From this, 2271 Btu/ft^2 (25.8 MJ/m^2) per inch x 4 inches = 9084 Btu/ft^2 (103.2 MJ/m^2) is the maximum allowed potential heat for use with ¾ inch stucco. If the potential heat of the Fortifiber WRBS (single or double-layered or two different WRBs combined) is less than the maximum allowed, then these WRBs may be used with ¾ inch stucco or similar claddings. The potential heat of the Fortifiber WRBs is as follows (Ref. 3):

- Super Jumbo Tex 60 THR = 5.2 MJ/m^2 single layer
- WeatherSmart HouseWrap THR = 3.7 MJ/m^2 single layer
- WeatherSmart Commercial THR 6.7 MJ/m^2 single layer
- WeatherSmart Drainable THR = 5.0 MJ/m^2 single layer
- WeatherSmart D THR = 4.98 MJ/m^2 single layer

Worst Case
All WRBs have a potential heat less than the maximum allowed as a single layer. Any combination of two WRBs is also less than the maximum allowed. The worst-case combination of two WRBs is a double layer of WeatherSmart Commercial with a total potential heat of 13.4 MJ/m2. A double layer of any WRBs is less than the maximum allowed. It is permissible to combine any two WRBs when used with ¾ inch stucco or similar claddings.

WeatherSmart Rainscreen with a potential heat of 15.33 MJ/m2 may be allowed over the 5 WRBs listed above with ¾ inch stucco or similar claddings for a worst-case potential heat of 22.03 MJ/m^2, which is less than the potential heat of 103.2 MJ/m^2 listed above as a baseline.

Claddings

The list of claddings allowed with three Fortifiber WRBs used a single layer (WeatherSmart Housewrap, WeatherSmart Drainable, or WeatherSmart Commercial.) over the foam is shown below (Ref. 4.). In this case, these WRBs may be used without exterior insulation since the fuel load of the wall is reduced. For a complete list of allowed Cladding/WRB/Insulation combinations, see Ref. 4. The allowed claddings are:

1) Brick – Nominal 4" clay or concrete brick or veneer with a maximum 2" air gap behind the brick. Brick Ties/Anchors 24" OC (max.)
2) Stucco – minimum ¾" thick exterior cement plaster and lath
3) Limestone – minimum 2" thick using any standard non-open joint installation technique such as shiplap
4) Natural Stone Veneer – minimum 2" thick using any standard non-open joint installation technique such as grouted/mortared stone
5) Cast Artificial Stone – minimum 1½" thick complying with ICC-ES AC 51 using any standard non-open joint installation technique such as shiplap
6) Terracotta Cladding – minimum 1¼" thick (solid or equivalent by weight) using any standard non-open joint installation technique such as shiplap
7) Any MCM that has successfully passed NFPA 285
8) Uninsulated sheet metal building panels including steel, copper, aluminum, or zinc
9) ¼" (min.) uninsulated fiber-cement siding, or porcelain or ceramic tile mechanically attached
10) Stone, porcelain, ceramic/aluminum honeycomb composite building panels that have successfully passed NFPA 285 criteria
11) Autoclaved-aerated-concrete (AAC) panels that have successfully passed NFPA 285 criteria
12) Terracotta Cladding – Any Rain-screen Terra Cotta (min. ½" thick) with ventilated shiplap
13) ½" Stucco – Any one coat stucco (½" min.) which meets AC11 acceptance criteria or is approved for use in Type I - IV construction or has been tested per NFPA 285 or stays in place when tested per ASTM E119 (stucco exposed to fire) for at least 30 minutes
14) Thin brick/cultured stone set in thin-set adhesive and metal lath tested to ASTM E119 (brick exposed to furnace) and remains in place for a minimum of 30 minutes or has passed an NFPA 285 test. Minimum ¾"
15) Glen Gery Thin Tech Elite Series Masonry Veneer or TABS II Panel System with ½" thick bricks using TABS Wall Adhesive
16) Natural Stone Veneer – minimum 1¼" thick using any standard installation technique
17) FunderMax M.Look Grey Core – minimum ¼ inch thick using any traditional installation technique

CONCLUSIONS

The following Table of NFPA 285 Assemblies is allowed based on the discussion above. When Hunter exterior insulation is used, see Reference 4.

Table 1: NFPA 285 Table of allowed components

Wall Component	Options
Base Wall Use Item 1, 2, 3 or 4	1) Cast Concrete Walls 2) CMU Concrete Walls 3) 25 GA. min. 3⅝" (min.) steel studs spaced 24" OC (max.) a. ⅝" type X Gypsum Wallboard Interior b. Lateral Bracing every 4 ft 4) FRTW studs: min. nominal 2 x 4 dimension, spaced 24" OC (max.) ⅝" type X Gypsum Wallboard Interior w/ Bracing as required by building code
Fire-Stopping at Floor Lines	1) Any approved mineral fiber-based safing insulation in each stud cavity at the floor line. Safing thickness must match stud cavity depth 2) Solid FRTW fire blocking at floor line per building code requirements for Type III construction
Cavity Insulation Use any Item 1 - 11	1) None 2) 1½" (min.) of Covestro EcoBay CC SPF (up to full cavity thickness) 3) 1½" (min.) of BASF Walltite SPF (up to full cavity thickness) 4) Any noncombustible insulation per ASTM E136

Wall Component	Options
Items 2, 3, 8, 9, 10, and 11 may only be used with exterior sheathing 1.	5) Any Mineral Fiber (Board type Class A ASTM E84 faced or unfaced) 6) Any Fiberglass (Batt Type Class A ASTM E84 faced or unfaced) 7) Any foam plastic insulation (SPF or board type) which has been tested per ASTM E1354 (at a minimum of 20 kW/m^2 heat flux) and shown by analysis to be less flammable (improved T_{ign}, Pk. HRR) than Covestro EcoBay CC or BASF Walltite 8) NCFI InsulBloc SPF (up to full cavity thickness) 9) Icynene MD-C-200v3 (Proseal) up to 5½ inches (only with ½ in. (min.) exterior gypsum sheathing) 10) SWD Urethane Quik-Shield 112 up to 6 inches in 6-inch (max.) stud cavities with an air gap not exceeding 2½ inches. 11) 1½" (min.) ThermoSeal 2000 (up to full cavity thickness)
Exterior Sheathing Use any Item 1 - 4	1) ½" or thicker exterior gypsum sheathing 2) ½" or thicker exterior gypsum sheathing over $^7/_{16}$" (min.) FRTW structural panels in Type III construction 3) $^7/_{16}$" (min.) FRTW structural panels in Type III construction 4) None (for base wall 1 or 2)
WRB over Base Wall Surface	See Table 2
Exterior Insulation –	None
Exterior Cladding - Use any Item 1 - 17 Item 18 - 19 are special cases using double WRB Item 7 may use any tested/approved installation technique. Items 8, 9, or 12 may use any standard installation technique.	1) Brick – Nominal 4" clay or concrete brick or veneer with a maximum 2" air gap behind the brick. Brick Ties/Anchors 24" OC (max.) 2) Stucco – minimum ¾" thick exterior cement plaster and lath 3) Limestone – minimum 2" thick using any standard non-open joint installation technique such as shiplap 4) Natural Stone Veneer – minimum 2" thick using any standard non-open joint installation technique such as grouted/mortared stone 5) Cast Artificial Stone – minimum 1½" thick complying with ICC-ES AC 51 using any standard non-open joint installation technique such as shiplap 6) Terra Cotta Cladding – minimum 1¼" thick (solid or equivalent by weight) using any standard non-open joint installation technique such as shiplap 7) Any MCM that has successfully passed NFPA 285 8) Uninsulated sheet metal building panels including steel, copper, aluminum, or zinc 9) ¼" (min.) uninsulated fiber-cement siding, or porcelain or ceramic tile mechanically attached 10) Stone, porcelain, ceramic/aluminum honeycomb composite building panels that have successfully passed NFPA 285 criteria 11) Autoclaved-aerated-concrete (AAC) panels that have successfully passed NFPA 285 criteria 12) Terra Cotta Cladding – Any Rain-screen Terra Cotta (min. ½" thick) with ventilated shiplap 13) ½" Stucco – Any one coat stucco (½" min.) which meets AC11 acceptance criteria or is approved for use in Type I-IV construction or has been tested per NFPA 285 or stays in place when tested per ASTM E119 (stucco exposed to fire) for at least 30 minutes 14) Thin brick/cultured stone set in thin-set adhesive and metal lath tested to ASTM E119 (brick exposed to furnace) and remains in place for a minimum of 30 minutes or has passed an NFPA 285 test. Minimum ¾" 15) Glen Gery Thin Tech Elite Series Masonry Veneer or TABS II Panel System with ½" thick bricks using TABS Wall Adhesive 16) Natural Stone Veneer – minimum 1¼" thick using any standard installation technique

Wall Component	Options
	17) FunderMax M.Look Grey Core – minimum ¼ inch thick using any traditional installation technique 18) ¾" minimum exterior cement plaster and lath (stucco) (same as Cladding #2 but for use with double layer WRB Option 2 in Table 2) 19) Adhered masonry veneer over ⅞" lath and mortar installed per 2015 IBC Section 1405.10.1.4. (for use with double layer WRB Option 2 in Table 2)

Table 2. Allowable WRBs for Table 1

WRB over Base Wall Surface Use Item1, a, b, c, or d single layer with Claddings 1 - 17 Use Item 2 with Claddings 18 - 19. It is permissible to combine any two WRBs when used with Claddings 18 or 19. Use Item 3 with Claddings 18 - 19 over the WRBs listed in Item 2 a), b), c), d), or e)	1) Fortifiber Building Systems Group (with Claddings 1 - 17) a) WeatherSmart Housewrap b) WeatherSmart Drainable c) WeatherSmart Commercial d) WeatherSmart D 2) Fortifiber Building Systems Group (with Claddings 18 - 19 – combine any item a), b), c), d), or e) a) WeatherSmart Housewrap b) WeatherSmart Drainable c) WeatherSmart Commercial d) Super Jumbo Tex 60 e) WeatherSmart D 3) WeatherSmart Rainscreen over any WRB listed above in Item 2

See Appendices on the following pages.

Appendix A

Flammability of Gypsum Wallboard vs. FRT Plywood

Gypsum wallboard is a product that is considered to be an effective thermal and ignition barrier for foam plastics. Gypsum wallboard ignites and produces measurable heat due to the ignition of the paper facer. In the graph below, gypsum wallboard was tested bare and with several coats of paint (Ref. http://fire.nist.gov/bfrlpubs/fire99/PDF/f99168.pdf)

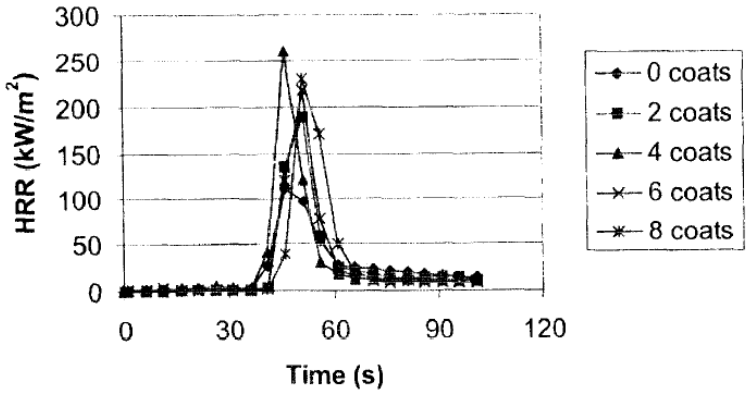


FIGURE 1(a). Representative heat release rate histories at 50 kW/m² exposure.

The peak HRR of bare gypsum wallboard is approximately 110 kW/m^2

In another publication (Ref. http://www.fpl.fs.fed.us/documnts/fplrp/fpl_rp670.pdf), similar results are shown at various heat fluxes.

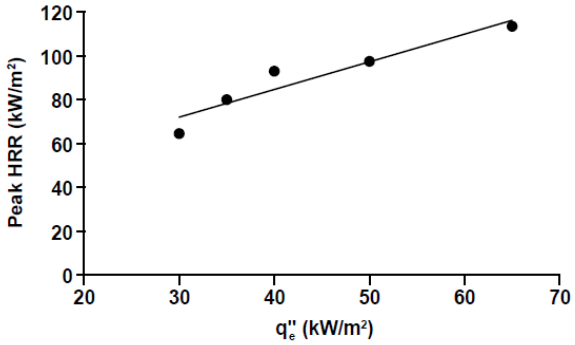


Figure 8. Peak heat release rate (HRR) as a function of external irradiance for Type X gypsum board (test no. 1).

In Reference 8, the results for FRT treated plywood indicate that the initial peak HRR is approximately 55 kW/m^2. The secondary peak HRR is in the 75 kW/m^2 range. The first and second peaks are used in this comparison since flame spread is a primary event occurring on the surface. The 3rd peak is due to deep burning of the plywood layers, but this 140 kW/m^2 HRR is slightly higher than gypsum wallboard.

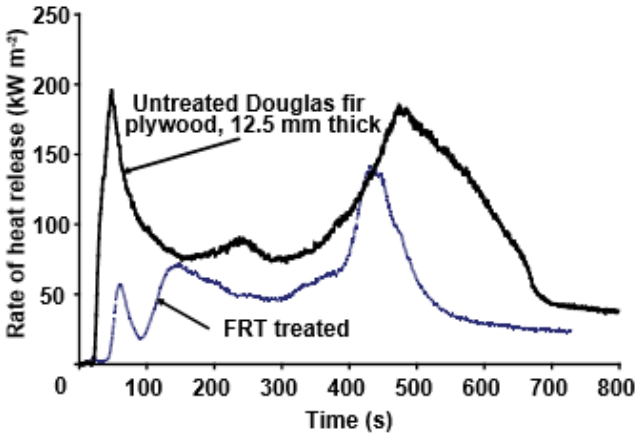


Figure 18–4. Heat release curves for untreated and fire-retardant-treated (FRT) Douglas-fir plywood, 12.5 mm thick.

From this data, the relative flammability of gypsum wallboard is worse than FRT plywood during initial flame spread events.

APPENDIX B – ESR Approved SPF Constructions

The following depicts the approvals for SPF. These approvals are third-party ICC-ES ESR reports based on testing and possibly engineering judgments.

4.6.1 Nonload-bearing NFPA 285-tested Wall Assembly:

4.6.1.1 Interior Face: One layer of $^{5}/_{8}$-inch-thick (16 mm), Type X gypsum wallboard complying with ASTM C36 or ASTM C1396 is installed with the long dimension perpendicular to $3^{5}/_{8}$-inch-deep (92 mm), 20 gage steel studs spaced a maximum of 24 inches (609 mm) on center. The wallboard is attached with $1^{1}/_{4}$-inch-long (31.8 mm), bugle head screws located 8 inches (203 mm) on center along the perimeter and 12 inches on center (305 mm) in the field of the wallboard. Wallboard joints must be taped and treated with joint compound in accordance with ASTM C840 or GA-216. Fastener heads must also be treated with joint compound in accordance with ASTM C840 or GA-216.

4.6.1.2 Stud Cavity: *SEAL*ECTION® 500 foam insulation, in a maximum thickness of $3^{5}/_{8}$ inches (92 mm), is spray-applied in all stud cavities.

4.6.1.3 Exterior Face: One layer of $^{5}/_{8}$-inch-thick (16 mm) GP DensGlass® sheathing attached to steel studs using $1^{1}/_{4}$-inch-long (31.8 mm), self-tapping screws spaced 8 inches (203 mm) on center along the perimeter and 12 inches on center (305 mm) in the field of the sheathing. Details of the exterior wall covering must be provided by the report holder, designer or specifier to the code official, with a fire engineering analysis demonstrating that the addition of the wall covering will not negatively affect conformance of the assembly with the requirements of IBC Section 2603.5.

Demilec ESR 1172

4.7 Exterior Walls of Type I, II, III and IV Construction:

4.7.1 General: When used on exterior walls of Type I, II, III, and IV construction, the HEATLOK SOY® 200 PLUS insulation must comply with Section 2603.5 of the IBC and this section (Section 4.7), and the insulation must be installed at a maximum thickness of 3.4 inches (86 mm). The potential heat of Demilec HEATLOK SOY® 200 PLUS insulation is 1930 Btu/ft^2 (21.8 Mj/m^2) per inch of thickness when tested in accordance with NFPA 259.

4.7.2 Interior Face: One layer of $^{5}/_{8}$-inch-thick (15.9 mm), Type X gypsum wallboard complying with ASTM C36 or ASTM C1396 is installed with the long dimension perpendicular to $3^{5}/_{8}$-inch-deep (92 mm), No. 20 gage steel studs spaced a maximum of 24 inches (610 mm) on center. The wallboard is attached with No. 6, $1^{1}/_{4}$-inch-long (32 mm), self-tapping screws located

8 inches (203 mm) on center along the perimeter and in the field of the wallboard. Wallboard joints must be taped and treated with joint compound in accordance with ASTM C840 or GA-216. Fastener heads must also be treated with joint compound in accordance with ASTM C840 or GA-216.

4.7.3 Exterior Face: One layer of $^{5}/_{8}$-inch-thick (15.9 mm) GP DensGlass® sheathing is attached to steel studs using $1^{1}/_{4}$-inch-long (32 mm), self-tapping screws spaced 8 inches (203 mm) on center along the perimeter and in the field of the sheathing. HEATLOK SOY® 200 PLUS spray-applied polyurethane foam insulation, at a maximum thickness of 3.4 inches (86 mm), is spray-applied onto the exterior of GP DensGlass® sheathing. Brick ties, $3^{1}/_{2}$ inches long (89 mm), must be installed at a nominal 24 inches on center to each vertical steel stud, using two No. 14 by 5-inch-long (127 mm) hex head screws. Exterior veneer must be 4-inch-thick (102 mm) standard brick with a nominally 2-inch air gap between brick and the foam plastic insulation.

Demilec ESR 3210

4.6 Exterior Walls in Type I, II, III and IV Construction:

4.6.1 General: When used on exterior walls of Types I, II, III or IV construction, the assembly must comply with IBC Section 2603.5 and this section, and the Classic, Classic Max and Classic Eco insulations must be installed at a maximum thickness of 6 inches (152 mm). The potential heat of Icynene insulations tested in accordance with NFPA 259 is as follows:

- **Classic and Classic Max:** 494 Btu/ft^2 (5.6 MJ/m^2) per

inch of thickness

- **Classic Eco:** 168 Btu/ft^2 (1.9 MJ/m^2) per inch of thickness.

4.6.2 Exterior Face: Nominally 6-inch-deep (152 mm), No. 18 gage, galvanized steel studs spaced 16 inches (406 mm) on center, are fastened to No. 18 gage, galvanized steel floor and ceiling track using No. 8, $^7/_8$-inch-long (22.2 mm), self-tapping pan head framing screws. GP DensGlass® Exterior Sheathing, $^1/_2$ inch (12.7 mm) thick, is installed over the exterior side of steel studs with the long end perpendicular to the steel studs, using No. 6, Type S, $1^1/_4$-inch (31.7 mm) long, self-tapping bugle head screws spaced 8 inches (203 mm) on center around the perimeter and in the field. The stud cavity is filled with Icynene Classic, Classic Max or Classic Eco insulation to a nominal thickness of 6 inches (152 mm).

4.6.3 Interior Face: Type X gypsum board, $^5/_8$ inches (15.9 mm) thick, is installed with the long dimension perpendicular to steel studs with No. 6, Type S, $1^1/_4$ inch-long (31.7 mm), self-tapping, bugle head screws spaced 8 inches (203 mm) on center around the perimeter and in the field. The gypsum board joints must be treated with vinyl or casein, dry or premixed joint compound applied in two coats to cover all exposed screw heads and gypsum board butt joints, and a minimum 2-inch-wide (51 mm) paper, plastic, or fiberglass tape embedded in the first layer of compound over butt joints of the gypsum board.

4.6.4 Exterior Wall Covering: Details of the exterior wall covering must be provided to the code official by the report holder, designer or specifier, with an engineering analysis demonstrating that (1) the exterior wall covering conforms to ASTM E136 and (2) the addition of the wall covering to the assembly described in this section does not negatively affect conformance of the assembly with the requirements of IBC Section 2603.5.

Icynene ESR 1826

4.6 Exterior Walls in Types I, II, III and IV Construction:

When used on walls of Type I, II, III and IV construction, the assembly in which the Bayseal™ Closed Cell spray-applied polyurethane insulation is used must comply with Section 2603.5 of the IBC and must be installed at a maximum thickness of 3.25 inches (82.6 mm) in accordance with the manufacturer's published installation instructions and this report. The potential heat of the Bayseal™ Closed Cell spray-applied polyurethane insulation is 1838 Btu/ft^2 (20.9 MJ/m^2) per inch of thickness when tested in accordance with NFPA 259. Wall assemblies complying with this section must be as described in Table 2.

TABLE 2—NFPA 285 COMPLYING EXTERIOR WALL ASSEMBLIES

WALL COMPONENT	MATERIALS
Base Wall System – Use either 1, 2 or 3	1 – Concrete wall 2 – Concrete masonry wall 3 – 1 layer $^{5}/_{8}$-inch-thick Type X gypsum wallboard complying with ASTM C36 or C1396 on the interior, installed over minimum $3^{5}/_{8}$-inch-deep, No. 20 gage, C-shaped steel studs, spaced a maximum of 24 inches on center with lateral bracing every 4 feet vertically. Gypsum wallboard must be attached with No. 6, $1^{1}/_{4}$-inch-long self-tapping screws located 8 inches on center along the perimeter and in the field of wallboard. Gypsum wallboard joints must be taped and treated with joint compound in accordance with ASTM C840 or GA-216
Floorline Firestopping	4 pcf mineral wool (e.g., Thermafiber) in each stud cavity at each floorline, attached with Z-clips
Cavity Insulation – Use either 1, 2 or 3	1 – None 2 – Fiberglass batt insulation (faced or unfaced) 3 – Bayseal closed cell or open cell insulation
Exterior Sheathing – Use either 1 or 2	1 – $^{1}/_{2}$-inch-thick, exterior-type gypsum sheathing 2 – $^{5}/_{8}$-inch-thick, exterior-type gypsum sheathing
Exterior Insulation	Bayseal™ closed cell SPF, up to a maximum nominal thickness of 3 inches
Exterior Wall Covering – Use either 1, 2 or 3	1 – Brick - standard nominally 4-inch-thick clay brick; brick veneer anchors – standard types installed a maximum of 24 inches OC vertically on each stud – Maximum 2-inch air gap between exterior insulation and brick 2 – Stucco - minimum $^{3}/_{4}$-inch-thick, exterior cement plaster and lath. A secondary water-resistive barrier may be installed between the exterior insulation and the lath. The secondary water-resistive barrier must not be full-coverage asphalt or butyl- based self-adhered membranes 3 – Minimum 2-inch-thick limestone. Any standard non-open-jointed installation technique such as ship-lap, etc., may be used

For **SI:** 1 inch = 25.4 mm; 1 pcf = 16.018 kg/m^3.

Bayer ESR 2072

4.5 Exterior Walls in Types I, II, III and IV Construction:

Foam-Lok FL2000 spray foam insulation may be installed on exterior walls of buildings of Types I, II, III and IV construction complying with IBC Section 2603.5 and as described in this section. The maximum thickness of the foam plastic is 3 inches (76 mm) when installed on the exterior of the sheathing. The wall assembly must be as described in Table 2. The potential heat of Foam-Lok FL2000 spray foam insulation is 1,885 Btu/ft^2 (21.4 MJ/m^2) per inch of thickness.

TABLE 2—NFPA 285 COMPLYING WALL

Steel Studs	$3^5/_8$ inch deep, No. 20 GA galvanized steel studs, 24 inches on center, secured with #8-by-$^1/_2$ inch-long, pan head framing screws to No. 20 GA top and bottom track; No. 16 GA CRC lateral bracing installed 4 feet o.c.
Interior Cladding	4-foot–by–10-foot-by-$^5/_8$ inch USG SheetRock® Firecode Core Type X™ gypsum board installed with the long dimension perpendicular to the studs, fastened to the framing with #6-by-$1^1/_4$ inch self-drilling, zinc-plated bugle head screws spaced 8 inches on center around the perimeter and 12 inches on center in the field; joints and fasteners receive a Level 2 finish in accordance with GA-216 and ASTM C840.
Exterior Sheathing	4-foot–by–8-foot-by-$^1/_2$ inch DensGlass® Gold Exterior Sheathing installed over exterior side, with the long edge perpendicular to the studs; secured with #6-by-$1^1/_4$ inch self-drilling, zinc plated screws, spaced 8 inches at the joints and around the perimeter and 12 inches in the field. A water resistive barrier must be installed over the exterior sheathing in accordance with the manufacturer's installation instructions and Section 1404.2 of the IBC or Section 703.2 of the IRC, as applicable.
Insulation	Nominal 3-inch Foam-LOK FL2000 spray foam insulation, spray-applied over DensGlass® Sheathing.
Anchors	Hohmann & Barnard $3^1/_2$-inch X-Seal Anchors and $^3/_{16}$-inch-by-3-inch-by-3-inch VeeBee ties installed 24 inches on center vertically to each stud using #14-by-5-inch screws with washers, creating a nominal 2 inch air gap between the insulation and the exterior facing.
Exterior Wall Covering	4-inch standard clay brick (nominal $3^1/_2$-inch-by-$7^3/_4$-inch-by-$2^1/_4$-inch) in a running bond pattern using Type N mortar, a nominal 2-inch from the spray foam insulation.
Openings	4-inch-by-4-inch-by-$^1/_4$-inch steel lintel installed above the opening, extending past the opening by 8 inches on both sides; two pieces of 2-inch-by-7-inch by No. 20 GA thick aluminum must be installed to protect the opening and must be applied on both interior and exterior faces. Aluminum attached nominally 24 inches on center with $^3/_{16}$–inch-by-$1^1/_4$ inch-long self-drilling screws to the interior of the assembly. The sides and top of the assembly are to be covered with steel flashing.

For **SI:** 1 inch = 25.4 mm.

Lapolla ESR 2629

4.7 Exterior Walls in Types I, II, III and IV Construction:

SPRAYTITE 81206 and WALLTITE (US and US-N) may be installed in or on exterior walls of buildings of Type I, II, III and IV construction complying with IBC Section 2603.5 and as described in this section. The maximum thickness of the foam plastic is 3 inches (76 mm) when installed on the exterior of the sheathing or $3^5/_8$ inches (92.1 mm) when installed in stud cavities. The potential heat of SPRAYTITE® 81206 and WALLTITE® (US and US-N) spray-applied insulations is 1961 Btu/ft^2 (22.3 MJ/m^2) per inch of thickness. The wall assembly must be as described in Table 3 or 4.

TABLE 3—NFPA 285 COMPLYING WALLS—SPF ON EXTERIOR

WALL COMPONENTS	MATERIALS
Base wall system— Use either 1, 2 or 3	1—Concrete wall 2—Concrete masonry wall 3—1 layer of $^5/_8$-inch-thick Type X gypsum wallboard on interior, installed over minimum $3^5/_8$-inch-depth, minimum No. 20-gage steel studs at a maximum of 24 inches on center with lateral bracing every 4 feet vertically
Floorline firestopping	4 pcf mineral-fiber insulation friction-fit in each wall stud cavity at each floor line.
Cavity insulation— Use either 1, 2, or 3	1—None 2—Fiberglass batt insulation (faced or unfaced) 3—Mineral-fiber insulation (faced or unfaced)
Exterior sheathing— Use either 1, or 2	1—None 2—Minimum $^1/_2$-inch-thick Type X exterior gypsum sheathing
Exterior Insulation	Maximum 3-inch thickness of SPRAYTITE 81206 or WALLTITE (US & US-N)
Exterior wall covering—Use either 1, 2, 3 or 4	1—Brick —Standard type brick veneer anchors installed maximum 24 inches on center, vertically on each stud —Maximum 2-inch air gap between exterior insulation and brick —Standard nominal 4-inch-thick, clay brick 2—Stucco – Minimum $^3/_4$ –inch-thick, exterior cement plaster and lath. A secondary water-resistive barrier can be installed between the exterior insulation and the lath. The secondary water-resistive barrier shall not be full-coverage asphalt or butyl-based self-adhered membranes. 3—Minimum 2-inch-thick Limestone, natural stone or minimum $1^1/_2$–inch-thick cast artificial stone. Any standard non-open-jointed installation technique such as ship-lap, etc. can be used. 4—Terracotta cladding – Use any terracotta cladding system in which the terracotta is minimum $1^1/_4$ inch. Any standard non-open-jointed installation technique such as ship-lap, etc. can be used.

For **SI:** 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pcf = 16.01 kg/m^3.

TABLE 4—NFPA 285 COMPLYING WALLS—SPF IN WALL CAVITY

WALL COMPONENTS	MATERIALS
Base wall system— Use either 1, 2 or 3	1—Concrete wall 2—Concrete masonry wall 3—1 layer of $^5/_8$-inch-thick Type X gypsum wallboard on interior, installed over minimum $3^5/_8$-inch-depth minimum No. 20-gage steel stud at a maximum of 24 inches on center with lateral bracing every 4 feet vertically
Floorline firestopping	4 pcf mineral fiber insulation friction-fit in each wall stud cavity at each floor line.
Cavity Insulation— Use either 1, 2, 3 or combination of 1 and 2 or combination or 1 and 3	1—Maximum $3^5/_8$ inch thickness of SPRAYTITE 81206 or WALLTITE (US & US-N) applied using exterior gypsum sheathing as the substrate and covering the width of the cavity and the inside the steel stud framing flange. 2—Fiberglass batt insulation (faced or unfaced) on the exterior side of the foam plastic 3—Mineral wool insulation (faced or unfaced) on the exterior side of the foam plastic
Exterior sheathing	$^5/_8$-inch-thick Type X exterior gypsum sheathing
Exterior wall covering	Any noncombustible exterior wall covering material. Details of the exterior wall covering must be provided by the report holder, designer or specifier to the code official, with a fire engineering analysis demonstrating that the addition of the wall covering will not negatively affect conformance of the assembly with the requirements of IBC Section 2603.5.

For **SI:** 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pcf = 16.01 kg/m^3.