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DuPont Performance Building Solutions
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RE: NFPA 285 Compliant Exterior Wall Constructions Incorporating DuPont™ Thermax™ and Spray Polyurethane Foam (SPF) with Non-Combustible Claddings (Revision 3)
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To Whom It May Concern:

Jensen Hughes has completed our engineering analysis of exterior wall assemblies compliant with NFPA 285, *Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components*, constructed using the Thermax™ Brand Rigid Insulation and spray polyurethane foam (SPF) which is a closed cell (CC), nominal 2.0 lb/ft^3 density, SPF plastic insulation material.

Use of these combustible materials in an exterior wall assembly requires compliance with NFPA 285 by the applicable building code requirements to ensure excessive vertical and lateral exterior flame spread will not occur during a fire event. Specifically, Section 2603.5.5 of the International Building Code (2000 through 2021 Editions) require exterior wall systems incorporating foam plastic insulation materials to meet the requirements of NFPA 285. Similarly, Section 1403.5 of the IBC (2000 through 2021 Editions) requires exterior wall assemblies on buildings of Types I, II, III, or IV construction that are greater than 40-feet above grade plane to comply with NFPA 285 if they incorporate a combustible water-resistive barrier (WRB) material.

DuPont has conducted numerous NFPA 285 tests of exterior wall assemblies incorporating the Thermax™ Brand Rigid insulation and various exterior cladding systems. Two successful NFPA 285 tests were conducted on an exterior wall assembly incorporating the Thermax™ Brand Rigid insulation with a SPF product applied to the Thermax and covered by the James Hardie Hardie® Plank Lap Siding exterior cladding material [1,2]. Other successful NFPA 285 tests also incorporated other SPF products installed in the wall stud cavity in addition to the Thermax™ Brand Rigid insulation material. The NFPA 285 test reports listed in the “References” section at the end of this analysis report [3 through 10] were used as the basis for developing the NFPA 285 compliance tables provided below.

Based on the results of these NFPA 285 tests, additional testing of WRB materials per ASTM E1354, and our experience with the NFPA 285 fire test, it is our opinion that the various configurations of exterior walls described in Table 1 through Table 3 will meet the performance requirements of NFPA 285. Wall construction details are shown in Figure 1.

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Table 1 – Max. 3-inch Thick Thermax™ Sheathing and Non-combustible Cladding

Wall Component	Materials
Base Wall System – Use either 1, 2, 3, 4, or 5	1) Concrete wall 2) Concrete Masonry Unit (CMU) wall 3) Standard clay brick wall (nominal 3⅝-inch thick brick) 4) Wood studs: nominal 2-inch × 4-inch or greater FRTW wood studs spaced at a maximum of 24-inch OC. Wall cavity empty (no insulation) or filled with fiberglass batt insulation (faced or unfaced) or mineral wool insulation (faced or unfaced). One layer of ⅝-inch thick Type X gypsum wallboard installed on interior face of wood studs. One layer of ⅝-inch thick Type X exterior gypsum sheathing installed on exterior face of wood studs. Minimum two top plates at floorlines. As an option, any thickness of plywood or OSB may be installed on exterior face of wood studs under exterior gypsum sheathing. 5) Steel studs: minimum 3⅝-inch depth, minimum 20-gauge at a maximum spacing of 24-inch OC with lateral bracing every 4 ft. vertically. One layer of ⅝-inch thick Type X gypsum wallboard on interior face of studs. Gypsum wallboard joints shall receive at a minimum a Level 2 finish with all fasteners covered with joint compound.
Floor Line Firestopping Required in curtain-wall construction	4 lb./cu ft. mineral wool friction fit in each stud cavity, at each floor line
Interior Vapor/Moisture barrier – Use either 1 or 2	1) None 2) Any 6-mil thick polyethylene film
Cavity Insulation – Use either 1, 2, 3, or 4 Or combination of 2 and 4 Or combination of 3 and 4	1) None – Screw end of fasteners that protrude into the stud cavity can be covered with a maximum of 1½-inch diameter plug of DuPont™ Froth-Pak Class A rated per ASTM E 84 2) Minimum 1¾-inch thickness of BASF Walltite LWP (covered in Intertek CCRR-0374) applied using sheathing or insulation as substrate and covering the width of the cavity and inside the stud flange. Window header protection as shown in Figure 1. 3) Minimum 1¾-inch thickness of Huntsman Building Solutions Heatlok HFO Pro (covered in IAPMO UES Evaluation Report No. ER-565) applied using sheathing or insulation as substrate and covering the width of the cavity and inside the stud flange. Window header protection as shown in Figure 1. 4) Fiberglass blown-in or batt insulation (faced or unfaced) or mineral wool blown-in or batt insulation (faced or unfaced)
Exterior Sheathing – Use either 1, 2, or 3 OR	1) None 2) ½-inch thick, exterior gypsum sheathing 3) ⅝-inch thick, Type X exterior gypsum sheathing
Multi-Function Sheathing & WRB Products	USG Securock® ExoAir® 430 System **Note:** This item replaces the exterior sheathings above. When this item is used the exterior sheathings are not required and additional WRBs shall not be used.
WRB Materials Applied to ***Exterior Sheathing Items 2 or 3*** – Use either 1 or 2	1) None 2) Any shown in Table 2 **Note:** Any WRB material shown in Table 2 can be applied directly over ***Base Wall Systems 1 through 4*** above, where able.

Wall Component	***Materials***
Exterior Insulation – Use either 1 or 2	1) None - If no exterior insulation is used, Exterior Sheathing Items 2 or 3 must be used for ***Base Wall Systems 4 or 5***. 2) DuPont™ Thermax™ Brand Rigid Insulation - Total thickness to be a minimum of ⅝-inch to maximum of 3-inches.
Exterior Insulation Joint Flashing – Use either 1 or 2	1) None – Only when a water-resistive barrier is applied to ***Exterior Sheathing Items 2 or 3*** or when a water-resistive barrier is applied to ***Exterior Insulation Item 2***. 2) Flash all exterior insulation joints and veneer tie penetrations with one of the following: a. DuPont™ LiquidArmor™ - CM Flashing and Sealant – max. 50-mil wet thickness, max. 4-inch width b. DuPont™ LiquidArmor™ - LT Flashing and Sealant – max. 35-mil wet thickness, max. 4-inch width. c. DuPont™ LiquidArmor™ - QS Flashing and Sealant – max. 50-mil wet thickness, max. 4-inch width d. DuPont™ Tyvek® Fluid Applied Flashing & Joint Compound+ – max. 25-mil wet thickness, max. 3-inch width e. Asphalt, acrylic, or butyl-based flashing tape – max. 4-inch width f. DuPont™ Great Stuff Pro™ - Use on joints that are ≤ ¼-inch width, vertical joints must be staggered & remove significant excess from the face of the Thermax™ **Note:** With either e) or f), a small amount of spray primer may be used to aid in adhesion; maximum 4-inch width.
WRB Materials Applied Over ***Exterior Insulation Item 2*** – Use either 1 or 2	1) None 2) Any shown in Table 3
Drainage Mat – Use either 1 or 2	1) None 2) DuPont™ Tyvek® DrainVent™ Rainscreen – For use with any listed exterior veneer only when no air gap is present between the veneer and the DrainVent™. May be used in conjunction with any WRB shown in Table 3, but not with WRBs from Table 2.

Wall Component	Materials
Exterior Veneer – Use either 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,12, 13, 14, or 15	1) Minimum 5/16-inch thick James Hardie Hardie® Plank Lap Siding fiber cement board (or equivalent) installed with a 1¼-inch overlap. Siding installed over maximum ⅞-inch deep, minimum 20-gauge vertical hat channels. 2) Terracotta cladding – Use any terracotta cladding system in which terracotta is minimum 1¼-inch thick. Any standard installation technique can be used. 3) Sheet metal exterior wall coverings including steel (minimum 0.0179-inch thick), aluminum (minimum 0.080-inch thick), or copper (minimum 0.0179-inch thick). Any standard installation technique can be used. 4) Brick - Standard nominal 4-inch thick, clay brick with standard type brick veneer anchors, installed maximum 24-inches OC vertically on each stud. Air gap between exterior insulation and brick to be a maximum of 2½-inches. WRB from Table 2 can be used over the exterior insulation. 5) Stucco – Minimum ¾-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 can be 1 or 2 layers of asphalt building paper but shall not be full-coverage asphalt or butyl-based self-adhered membranes. WRB from Table 2 can be used as the secondary water-resistive barrier. 6) Corium™ Thin brick system. 7) Minimum 1¼-inch thick limestone or natural stone veneer or minimum1¼-inch thick cast artificial stone veneer. Any standard installation technique such as ship-lap, etc. can be used. 8) Glen-Gery Thin Tech Elite Series – Masonry veneer 9) Concrete or precast concrete panels – Minimum 1½-inch thick panel. Air gap between exterior insulation and concrete panel shall be as per wall design. Any standard installation technique can be used. 10) Ceramic tile (min. ⅜-inch thick) bonded using non-combustible mortar adhesive to minimum ½-inch thick cement board or gypsum sheathing. 11) Thin brick (min. ¾-inch thick clay brick) fully adhered with cementitious mortar (standard or polymer modified) to min. ½-inch thick cement backer board or gypsum sheathing. A secondary water-resistive barrier can be installed between the board/sheathing and the brick. The secondary water-resistive barrier shall not be full-coverage asphalt or butyl-based self-adhered membranes. 12) Natural stone or artificial stone (min. ¾-inch thick clay brick) fully adhered with cementitious mortar (standard or polymer modified) to min. ½-inch thick cement backer board or gypsum sheathing. A secondary water-resistive barrier can be installed between the board/sheathing and the stone. The secondary water-resistive barrier shall not be full-coverage asphalt or butyl-based self-adhered membranes 13) Concrete Masonry Units - Minimum 4-inch thick CMU, with a 2-inch maximum air gap between exterior insulation and the interior face of the exterior CMU. Any standard non-open-joint installation technique can be used 14) Cornerstone Building Products to include: • PBR Panel (Exposed fasteners) • PBU Panel (Exposed fasteners) • AVP Panel (Exposed fasteners) • Designer™ Series Panels (Exposed fasteners) • Shadow Rib™ Panels (Exposed fasteners) • NuWall® Panels (Exposed fasteners) • MasterLine 16 (Concealed fasteners) 15) Tabs II Plus Wall System - w/o Tabs II Plus “RainScreen” with Pre-attached wrap. Must use a WRB from Table 2.

Wall Component	***Materials***
Flashing of Windows, Doors, and Other Exterior Wall Penetrations.	As an option, flash window, door and other exterior penetrations with either: 1) DuPont™ LiquidArmor™ – CM Flashing and Sealant – max. 50-mil wet thickness, max. 12-inch width. 2) DuPont™ LiquidArmor™ – LT Flashing and Sealant – max. 35-mil wet thickness, max. 12-inch width. 3) DuPont™ LiquidArmor™ – QS Flashing and Sealant – max. 50-mil wet thickness, max. 12-inch width. 4) DuPont™ Tyvek® Fluid Applied Flashing & Joint Compound+ – max. 25-mil wet thickness, max. 3-inch width 5) Limited amounts of acrylic, asphalt or butyl-based flashing tape – max. 12-inch width. 6) DuPont™ DuraGard™ CM Transition Flashing – max. 12-inch width **Note:** Flashing tape used in wall openings may extend the wall width plus extend up to a maximum of 4-inches onto the exterior face of the sheathing. Flashing tape may be used on sheathing exterior corners where the flashing tape may extend a maximum of 4-inches onto the sheathing face on either side of the corner.
Mortar Net	As an option, non-full wall coverage mortar drop and drainage nets and meshes can be installed at base of wall and at shelf angles to permit water drainage. Maximum 12-inch high.
Opening Protection	All wall openings (windows, doors, etc.) are required to be protected with one layer of ⅝-inch thick Type X gypsum wallboard installed at opening header and jambs. Minimum 18-gauge “L” shaped steel flashing also required to be installed around opening header, jambs, and sill (door openings do not require sill protection). See Figure 1 for opening protection detail.

Table 2 – Allowed Water-Resistive Barrier Applied Over Exterior Sheathing and Under Exterior Insulation

Weather Resistive Barrier Manufacturer/Product
3M™ • 3M™ Self-Adhered Air and Vapor Barrier 3015
Carlisle • CCW-705FR w/ Primers • Barritech™ VP
Dörken Systems • Delta®-Foxx • Delta®-Foxx Plus • Delta®-Fassade S • Delta®-Vent S/Plus • Delta®-Maxx Plus
DOWSIL™ • DefendAir 200 • DefendAir 200C
Dryvit • Backstop® NT
DuPont • DuPont™ Tyvek® CommercialWrap® • DuPont™ Tyvek® CommercialWrap® D • DuPont™ Tyvek® ThermaWrap™ • DuPont™ Tyvek® Fluid Applied WB+ – nominal 25 wet mil thickness • WeatherMate™ • WeatherMate™ Plus
GCP Applied Technologies • Perm-A-Barrier® Aluminum Wall Membrane • Perm-A-Barrier® VPL • Perm-A-Barrier® VPL LT • Perm-A-Barrier® VPS
Henry Company • Air-Bloc® 17MR • Air-Bloc® 31MR • Air-Bloc® 33MR • Air-Bloc® 21 FR • Air-Block® All Weather STPE • BlueskinVP™ 160 • Metal Clad™ • Foilskin®
Hohmann & Barnard • Enviro-Barrier™ VP

Weather Resistive Barrier Manufacturer/Product
JX Nippon ANCI, Inc. • JX ALTA™ Commercial Wrap • JX ALTA™ HP Wrap • JX ALTA™ LP Wrap
Kingspan • Kingspan® GreenGuard® Max™ Building Wrap • Kingspan® GreenGuard® Classic Building Wrap • Kingspan® GreenGuard® C2000 Building Wrap • Kingspan® GreenGuard® Raindrop® 3D Building Wrap • Kingspan® GreenGuard® HPW™ Building Wrap
Momentive Performance Materials • GE SEC2500 SilShield® AWB • GE SEC2600 SilShield® AWB • GE SEC2600-R SilShield® AWB
Sto Corp • Sto Gold Coat® with StoGuard Fabric • Sto Emerald Coat® with StoGuard Fabric • Sto ExtraSeal™ w StoGuard Mesh
STS, Inc. • Wall Guardian™ FW-100A
Tremco • ExoAir 230 • ExoAir 430
VaproShield • WallShield® • WrapShield® • RevealShield™ • RevealShield SA™ • PanelShield SA™
W.R. Meadows • Air-Shield™ LMP (Gray) • Air-Shield™ LMP (Black) • Air-Shield™ TMP • Air-Shield™ LSR • Air-Shield Aluminum

Table 3 – Allowed Water-Resistive Barrier Applied Over Exterior Insulation

Weather Resistive Barrier Manufacturer/Product
DuPont • DuPont™ Tyvek® CommercialWrap® • DuPont™ Tyvek® CommercialWrap® D • DuPont™ Tyvek® ThermaWrap™ • WeatherMate™ • WeatherMate™ Plus
Kingspan • Kingspan® GreenGuard® Max™ Building Wrap • Kingspan® GreenGuard® C500 Building Wrap • Kingspan® GreenGuard® Raindrop® 3D Building Wrap
VaproShield • RevealShield™ • RevealShield SA™ • PanelShield SA™

Engineering Analysis

DuPont has performed two successful NFPA 285 fire tests on exterior wall assemblies constructed as follows (interior to exterior):

1. One layer of ⅝-inch thick Type X gypsum wallboard installed continuously over the interior surface of the wall assembly.
2. 3⅝-inch deep, 18 gauge steel studs spaced 16-inches on center.
3. Stud cavities filled with minimum 1¾-inch depth of SPF applied to the Thermax™ sheathing as the substrate. SPF may be either the BASF WALLTITE LWP or the Huntsman Heatlok HFO PRO closed cell (CC) SPF products.
4. 3-inch thickness of the Thermax™ polyisocyanurate foam plastic insulation board. All board joints covered with a 3-inch thickness of the DuPont™ LiquidArmor™ CM Flashing and Sealant applied at 50 mils wet.
5. DuPont™ Tyvek® CommercialWrap® WRB
6. 8¼-inch wide, $^{5}/_{16}$-inch thick James Hardie Hardie® Plank Lap Siding installed horizontally over ⅞-inch deep, 18-gauge steel hat channels installed vertically, 24-inches on center.
7. Wall opening framed with one layer of ⅝-inch thick Type X exterior gypsum sheathing on header and jambs. Header, jambs, and sill finished with 18-gauge "L" shaped steel flashing and the header was additionally covered with aluminum drip cap. $^{5}/_{4}$-inch × 4-inch Hardie window trim was fastened around the window perimeter.

A complete description of the tested wall constructions, the test observations, and the test results are provided in Intertek Building & Construction Test Report No. N4815.01-121-24, dated June 9, 2022 [1] and ICC-NTA Test Report No. DDPS082422-45, dated August 24, 2022 [2].

The analysis which follows provides the technical substantiation for modifications to the tested wall assemblies for the following wall construction features:

1. Alternate base wall assembly construction
2. Stud cavity insulation materials

3. Exterior sheathing materials
4. Alternate WRB materials
5. Alternate exterior cladding materials
6. Alternate miscellaneous wall materials

ALTERNATE BASE WALL ASSEMBLY CONSTRUCTION

Concrete and CMU Block Walls

Additional base wall assemblies listed in Table 1 include a concrete wall and a concrete masonry wall. In an NFPA 285 test, a concrete or concrete masonry base wall will provide improved protection to the wall assembly from the burn room fire exposure based on its increased rigidity, significantly higher thermal mass, and increased level of fire performance. Table 1 of the National Concrete Masonry Association (NCMA) TEK Guide 7-1C, *Fire Resistance Rating of Concrete Masonry Assemblies* [11], provides minimum concrete thicknesses for various hourly fire-resistance ratings. A normal calcareous or siliceous gravel concrete wall with a minimum thickness of 2-inches will provide a 30-minute fire-resistance rating; a rating equal to the duration of the NFPA 285 test. Any exterior wall assembly will typically require a concrete wall thickness greater than 2-inches for structural reasons, and concrete block is typically much thicker than 2-inches, again for structural reasons. Based on the documented fire performance of concrete construction, a concrete or concrete block base wall assembly will provide the same or better fire performance than the tested steel stud and gypsum base wall assembly.

Standard Clay Brick Wall

Standard clay bricks have overall nominal dimensions of 3⅝ × 2¼ × 8-inch (D×H×L), and typically have hollow cores within them. Table 3 of the NCMA TEK 7-1C document [11], the equivalent thickness of hollow brick or tile or clay tile needed to achieve a 1-hour fire-resistance rating is 2.3-inches. The equivalent thickness of typical hollow core commercial masonry brick that has an overall thickness of 3⅝ inches is approximately this thickness. Therefore, a standard clay brick wall will provide approximately a 1-hour fire-resistance rating. This is very close to the amount of fire protection a steel stud wall assembly with interior/exterior ⅝-inch thick Type X gypsum wallboard will provide. Therefore, a standard clay brick wall is an acceptable substitute for a steel stud and gypsum wallboard base wall assembly. This performance comparison does not take into account the improved structural performance of the wall assembly. This structural performance must be considered when performing a material installation over an existing clay brick wall assembly.

Wood Stud-Framed Walls

Table 1 allows for the use of minimum 2×4-inch dimensional fire-retardant treated wood (FRTW) lumber studs, spaced at maximum 24-inches on center. Through Jensen Hughes' experience from conducting and witnessing NFPA 285 tests, we have observed that when wood studs are used within a base wall assembly that has ⅝-inch thick, Type X interior and exterior gypsum coverings, minimal char damage is sustained by the wood studs throughout an NFPA 285 test. Since the wood studs only experience minimal char damage during an NFPA 285 test, vertical and lateral flame propagation does not occur from the compartment of fire origin such that failure criteria are observed. Based on this observed test assembly performance, it is Jensen Hughes' opinion that FRTW wood studs can be used as the framing for the base wall assembly as long as one layer of ⅝-inch thick, Type X gypsum is used on both the interior and exterior faces of the assembly.

All NFPA 285 compliant assemblies in Table 1 (Except for the concrete and masonry Base Wall Systems 1, 2, and 3) require one layer of ⅝-inch thick, Type X gypsum installed continuously installed over the entire interior face of the exterior wall assembly. However, when FRTW wood studs are used to frame an exterior wall, the exterior gypsum wallboard is also required to be ⅝-inch thick Type X gypsum wallboard, as reflected in Table 1. This will ensure sufficient protection is afforded to the FRTW wood stud framing from both the interior and the exterior face.

Base Wall System 4 also allows for plywood or OSB to be installed on the exterior face of the wood studs and under the exterior gypsum sheathing. When located behind the exterior gypsum sheathing, and in the wall stud cavity, the additional layer of plywood or OSB will not adversely impact the compliance of the wall assembly with NFPA 285 as it will be protected by the interior and exterior layers of gypsum wallboard. The optional use of plywood in fire-resistance rated wall assemblies is includes in a number of UL fire resistance design listings (e.g., UL Designs U302, V419, and V423). Wall assemblies tested to the more severe ASTM E119 fire resistance test standard has determined that this added combustible layer does not adversely impact the overall wall fire performance. In an NFPA 285 wall assembly incorporating wood studs, the plywood is protected in a manner similar to the wood studs with gypsum wallboard on the interior and exterior sides of the base wall assembly, shielding the plywood or OSB from direct flame impingement during the 30 minute NFPA 285 test.

Steel Stud Wall Assemblies

The successfully tested NFPA 285 wall assembly which formed the basis for this engineering evaluation letter utilized 3⅝-inch deep, 18-gauge steel stud spaced at 16-inches on center. The interior surface of the stud framing was covered with a single layer of ⅝-inch thick Type X gypsum wallboard. Several of the referenced test assemblies [4, 5, 6, and 9] had a base wall consisting of a 3⅝-inch deep, 20-gauge steel stud spaced at 24-inches on center. Through Jensen Hughes' experience from conducting and witnessing NFPA 285 tests, we have observed that wall assemblies framed with 3⅝-inch deep, 20-gauge steel stud spaced at 24-inches on center do not adversely impact the overall wall fire performance.

A steel stud/gypsum wallboard base wall assembly incorporating heavier gauge studs, decreased stud spacing, and/or deeper studs will provide improved fire performance of the wall assembly. Commentary in the front of the UL Fire Resistance Directory as well as Section 12.5 of ASTM E2032, *Standard Guide for Extension of Data from Fire Endurance Tests*, supports this conclusion. Therefore, Table 1 allows for minimum 3⅝-inch studs, of minimum 20-gauge, and at a maximum spacing of 24-inches on center.

STUD CAVITY INSULATION MATERIALS

CC SPF Insulations

One of the successfully tested NFPA 285 wall assemblies which formed the basis for this engineering evaluation letter [1] incorporated the BASF Walltite LPW SPF applied in all stud cavities, applied to the interior side of the DuPont™ Thermax™ Rigid Brand insulation at a nominal thickness of 1¾-inches. This successful NFPA 285 test supports the use of the BASF Walltite LWP SPF in an exterior wall assembly with the Thermax™ insulation material and non-combustible exterior cladding materials.

The second successfully tested NFPA 285 wall assembly which formed the basis for this engineering evaluation letter [2] incorporated the Huntsman Building Solutions' Heatlok HFO PRO SPF applied in all stud cavities, applied to the interior side of the DuPont™ Thermax™ Rigid Brand insulation at a nominal thickness of 1¾-inches. This successful NFPA 285 test supports the use of the Huntsman Heatlok HFO PRO SPF in an exterior wall assembly with the Thermax™ insulation material and non-combustible exterior cladding materials.

Fiberglass, Mineral Wool, or other Non-Combustible Batt Insulation Materials

The referenced NFPA 285 wall assemblies for this analysis [1,2] contained the combustible CC SPF spray applied into all wall stud cavities. Based on the fire performance of this tested assembly and the experience of

Jensen Hughes personnel in conducting and witnessing NFPA 285 tests, the inclusion of any fiberglass, mineral wool, or other non-combustible insulation, will not adversely impact compliance of the wall assembly with NFPA 285. Rather, the inclusion of fiberglass, mineral wool, or other non-combustible insulation in the stud cavity of a wall assemblies typically improves the overall wall fire performance. When compared to an empty stud cavity, the inclusion of fiberglass or mineral wool insulation will increase the amount of insulation and thermal protection that the stud wall provides to the exterior combustible components; especially when the Thermax™ Rigid Brand sheathing is installed directly to studs and does not have exterior sheathing separating it from the stud cavity. When compared to foam plastic insulation, fiberglass and mineral wool do not have the heat content that foam plastic insulation does and therefore will reduce the overall combustible load within the wall assembly and will not contribute to a fire that reaches the stud cavity.

This is further supported by many fire-resistance rated wall designs from the UL Online Fire Resistance Directory. Many wall design listings describe wall assemblies, tested to the more severe ASTM E119 fire exposure conditions, where the inclusion of fiberglass or mineral wool insulation is an optional item in the assembly. The optional inclusion of the stud cavity insulations indicates that their inclusion will not adversely impact the fire-resistance rating of the assembly. An increase in the fire resistance performance of a wall assembly will result in the base wall assembly providing a greater degree of thermal protection to the exterior combustible components from an interior fire exposure.

The fiberglass or mineral wool insulation can be faced or unfaced. The minimal amount of fuel loading added to the assembly by these facer materials is very low and the facers are protected on both sides by the interior gypsum wallboard or the exterior gypsum sheathing.

EXTERIOR SHEATHING MATERIALS

Exterior Grade Gypsum Sheathing

The referenced test assembly had no exterior gypsum sheathing and Thermax™ Rigid Brand sheathing was installed directly to the studs. When a wall assembly is compared to the tested assembly that had the Thermax™ Rigid Brand sheathing direct to the studs, it is the opinion of Jensen Hughes that the installation of gypsum sheathing underneath the Thermax™ is a more conservative installation scenario. Exterior gypsum sheathing will provide thermal separation between the Thermax™ Rigid Brand sheathing and the potential spray foam insulation installed in the stud cavity and will also provide greater protection to the Thermax™ Rigid Brand sheathing from an interior fire source. It is acknowledged that the use of exterior gypsum sheathing may warrant the use of a combustible WRB material, but any WRB materials used over the exterior sheathing are approved based (per Table 2 above) on comparative flammability evaluations based on WRB materials included in NFPA 285 tests. Based on this rationale, it is the opinion of Jensen Hughes that the wall assemblies approved under Table 1 may use Thermax™ Rigid Brand sheathing direct to the studs, or the Thermax™ sheathing installed over ½- or ⅝-inch thick exterior gypsum sheathing.

Securock ExoAir 430 Panel

The Securock ExoAir 430 panel is an exterior grade gypsum sheathing product with a factory applied fluid applied weather barrier to it. Specifically, Tremco's ExoAir 430 WRB is applied to United States Gypsum's Securock sheathing. Based on the fluid applied WRB material used in referenced test [9] and WRB materials installed behind Thermax™ Rigid Brand sheathing in other tests Jensen Hughes has witnessed, it is the opinion of Jensen Hughes that the flammability of the Tremco ExoAir 430 compares favorably and is an acceptable material to be installed under the Thermax™ Rigid Brand sheathing.

ALTERNATE WRB MATERIALS

WRB Materials Installed Over Exterior Gypsum Sheathing and Under Exterior Insulation

In the referenced test [9], the DuPont™ Tyvek® Fluid Applied WRB was installed over the exterior gypsum sheathing and under the Thermax™ sheathing. Alternate sheet good WRB products having similar or better flammability properties as the tested WRB are approved in Table 2 for installation over exterior sheathing and under the Thermax™ sheathing. Comparative fire performance properties were either developed by testing conducted by Jensen Hughes on these materials in accordance with ASTM E1354 (Cone Calorimeter apparatus) or by ASTM E1354 test reports provided to Jensen Hughes from various WRB manufacturers who performed testing at accredited third-party laboratories. Given that these alternate materials would be expected to perform similarly based on comparative fire performance properties, it is our engineering opinion that the materials listed in Table 2 will not adversely impact the overall wall fire performance and will maintain compliance with NFPA 285.

WRB Materials Installed Over Exterior Insulation

Referenced tests [1, 2, 7, and 9] incorporated DuPont™ Tyvek® CommercialWrap® over the continuous Thermax™ sheathing exterior insulation. Therefore, alternate sheet good WRB products having similar flammability properties as the tested WRB are included in *Table 3* for use over Thermax™ sheathing in NFPA 285 compliant exterior wall assemblies. Comparative fire performance properties were developed by testing conducted by Jensen Hughes on these materials in accordance with ASTM E1354 (Cone Calorimeter apparatus). Given that these alternate materials would be expected to perform similarly based on comparative fire performance properties, it is our engineering opinion that the materials listed in Table 3 will not adversely impact the overall wall fire performance and will maintain compliance with NFPA 285.

EXTERIOR CLADDING MATERIALS

Fiber Cement Board (Minimum $^5/_{16}$-inch thick)

The allowance for use of $^5/_{16}$-inch thick Hardie® Plank Lap Siding is based on the referenced NFPA 285 tests in this analysis report [1 and 2] and our experience in observing tests which used other manufacturer's fiber cement panel cladding.

DuPont's successful NFPA 285 tests shows that wall assemblies using Thermax™ sheathing passed the NFPA 285 test when fiber cement panels were installed over the Thermax™ sheathing. Based on Jensen Hughes' experience with conducting and witnessing NFPA 285 tests, fiber cement boards prevent ignition and free surface burning of the underlying foam plastic insulation materials and remain intact during a fire test. Various manufacturers (James Hardie, Nichiha, Allura, Swiss Pearl) produce fiber cement siding products which are nominally $^5/_{16}$-inch (0.312-inch) thick which have been used in successful NFPA 285 tests. For reference, Swiss Pearl panels are specified over combustible foam plastic insulation in a compliant exterior wall design in UL Design EWS0050.

Additionally, referenced test report [10] documents a DuPont sponsored test where the same James Hardie Plank was installed in a horizontal ship lap configuration over 3-inches of DuPont's newer version of the Thermax™ sheathing, Thermax™ NH sheathing. Although the foam insulation product differed from standard Thermax™ sheathing in this test, the performance of the Hardie Plank lap siding was indicative of typical performance of fiber cement products in NFPA 285 tests. There was some cracking and minor fall away of boards in the first 2-feet above the window header in this test. However, the amount of material that fell away was not as severe as is typically seen when ACM panels melt and open up in NFPA 285 tests.

Therefore, it is therefore the opinion of Jensen Hughes that fiber cement siding is an acceptable wall covering material for use over Thermax™ sheathing as specified in Table 1.

Terracotta Cladding

Terracotta is included in Table 1 based on the successful testing documented in DuPont's referenced test report [7], which included 3-inches of Thermax™ sheathing and BASF Spraytite® insulation in the stud cavity of the wall assembly. The exterior wall covering for this NFPA 285 wall assembly consisted of an ACM panel cladding system. It can be seen from photographic documentation provided in referenced report [7] that the ACM panel located directly above the window opening in the test melted and allowed the insulation underneath to be exposed to direct exterior flames and combust, leading to further elevated temperatures on the exterior face of the wall. This is typical performance of ACM panel systems in NFPA 285 tests, where approximately 20 to 25 minutes into the test the exterior cladding is compromised, allowing combustible materials beneath the cladding to burn and potentially contribute to exterior flame spread over the assembly.

Terra Cotta is a clay-based material similar to the clay brick. According to Table 3 of the NCMA TEK 7-1C guide [11] a solid 1¼-inch thickness of non-open jointed Terra Cotta would be expected to provide nominally 28 minutes of fire-resistance (in accordance with ASTM E119) by interpolating the information in Table 3. In an NFPA 285 test, the Terra Cotta exterior veneer would be required to provide only 25 minutes of protection as the window burner is not ignited until 5 minutes into the test. Based on the data in Table 3 of the NCMA TEK 7-1C guide, a minimum 1¼-inch thickness of Terra Cotta would be expected to provide more than 25 minutes of fire-resistance when subjected to the fire conditions described in ASTM E119.

Based on this technical rationale, it is expected that 1¼-inch thick Terra Cotta cladding would perform superior to the ACM panel cladding used in the DuPont referenced test report [7]. As noted in the referenced test report, the ACM panel melted and exposed the insulation underneath to fire, while the Terra Cotta is a masonry type material that would not melt in an NFPA 285 test. Therefore, the Terra Cotta is included in Table 1 for use with maximum 3-inch thick Thermax™ sheathing insulation.

Metal Exterior Wall Coverings

DuPont has conducted successful NFPA 285 testing on exterior wall assemblies incorporating ACM panels installed over the Thermax™ insulation material [5, 7, 8, and 9]. Single skin, solid metal plate cladding systems are considered to be a less severe fire scenario compared to MCM panels as they do not have a combustible core (i.e., overall, less combustible material) and will provide the same or better protection to the underlying combustible insulation material. The three metal plate panel types included in Table 1 are aluminum, steel, and copper.

Accounting for aluminum plate cladding, it is the opinion of Jensen Hughes that the testing of an ACM panel justifies the same metal material to be used as the cladding without the combustible core. UL Designs EWS0037 and EWS0038 describe exterior wall assemblies with 0.080-inch thick solid aluminum panels installed over a combustible foam (Jensen Hughes was present to witness this testing at UL). These two designs provide a basis for the minimum thickness (minimum 0.080 inches) that aluminum paneling must be to maintain NFPA 285 compliance over a combustible foam insulation. Therefore, these UL designs in combination with the successful NFPA 285 test of the DuPont™ Thermax™ Brand NH Series Insulation covered by an ACM form the basis for the use of 0.080-inch aluminum plate cladding.

Accounting for steel plate cladding, knowing that the aluminum panel will melt and exposed the underlying insulation to the exterior window burner fire during a test (due to the approximate 1,220°F melting temperature for aluminum), the use of minimum 26-gauge solid steel panels would be expected to provide equivalent or better protection to an underlying combustible material since steel does not melt at temperatures produced by the NFPA 285 apparatus during the test. Steel melts between 2,597°F and 2,800°F[1], where the NFPA 285 apparatus is calibrated to produce a maximum temperature of 1,314°F on the exterior face of the assembly during the test. Note that temperatures as high as 1,700°F can be produced when combustibles within the test assembly become involved in the exterior fire. Minimum 26-gauge (0.0179-inch) steel panels will not melt through during the test and will continue to provide a physical barrier between an exterior flame exposure and the underlying combustible materials. Therefore, sheet steel cladding in lieu of ACM cladding will not adversely impact the overall wall assembly fire performance.

Accounting for sheet copper cladding, copper has a melting temperature of approximately 1,983°F[2]. Therefore, copper panels would not be expected to melt during an NFPA 285 exposure (ref. calibration temperatures in NFPA 285, Table 7.1.11), and the copper metal panel will perform similarly to a steel panel by remaining intact during the fire test and act as a flame barrier to the underlying combustible material, preventing direct flame impingement, unlike ACMs which will melt away. Therefore, minimum 25-gauge (0.0179-inch) thick copper panels would be expected to provide similar protection to underlying combustibles as the steel panels.

The minimum thicknesses established for of the aluminum, steel, and copper all exceed the minimum thicknesses specified in Table 1404.2, from the 2021 International Building Code, for these three materials to be used as weather coverings for exterior walls.

Brick

Common clay brick is a typical material used in NFPA 285 tests to evaluate the ability of wall systems to comply with NFPA 285 when heavy masonry claddings are installed over the exterior face of the wall assembly. DuPont's referenced test assemblies [3, 4, and 6] used exterior clay brick veneers as the exterior wall covering materials in those tests. Therefore, common clay brick is an acceptable material for use as the exterior wall covering.

The referenced tested wall assemblies with brick veneers incorporated a 2-inch air space between the back of the brick and the face of the Thermax sheathing. A review of the thermocouple data from these tests confirmed that the temperatures within the air cavity space were very low, indicating that minimal burning of the Thermax sheathing occurred. This is an expected wall fire performance as the brick provides significant thermal protection to the underlying foam plastic insulation materials from the exterior fire source. Further, when the 18-gauge "L" shaped steel flashing is installed around the wall opening perimeter (header, jambs, and sill), no fire penetration and minimal heating of the Thermax sheathing occurs. Based on the very good performance of the NFPA 285 brick faced wall assemblies, it is our engineering opinion that increasing the air cavity space between the brick and the Thermax sheathing to 2½-inches will continue to result in the wall assembly maintaining compliance with NFPA 285. This increase in the air cavity space is only applicable to exterior wall assemblies incorporating a brick veneer.

Stucco

Table 8 of the NCMA TEK 7-1C [11] indicates that a ¾-inch thickness of Portland cement-sand plaster will provide 20 minutes of fire-resistance. A nominal 20 minutes of fire-resistance means that the unexposed side of the ¾-inch thickness of Portland cement-sand plaster membrane would not exceed a maximum individual temperature rise of 325°F (181°C) above ambient during an ASTM E119 fire exposure test.

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[1] All Metals & Forge Group 2019, Melting Point of Metal & Alloys, 2013-2019, accessed 22 February 2019 **https://www.steelforge.com/literature/metal-melting-ranges/**

[2] https://www.metalsupermarkets.com/melting-points-of-metals/

The fire exposure conditions to the exposed side of a wall assembly tested in accordance with ASTM E119 are significantly more severe than the fire exposure conditions experienced by the exterior wall covering material in an NFPA 285 test. In an ASTM E119 test, the test sample is mounted onto the front of the test furnace and subjected to the fire exposure conditions generated within the furnace over the entire exposed wall surface. In an NFPA 285 test, only the exterior portion of the wall assembly directly over the window opening is subjected to full fire exposure conditions from the room burner and the window burner employed in this test method.

The temperature and heat flux produced by the burn room and window burner (as indicated in Table 8.1.6 of NFPA 285 for the calibration test) are significantly lower than what is produced by the test furnace in an ASTM E119 test. The time-temperature curve within the test furnace during an ASTM E119 fire exposure is 1,000°F (538°C) at 5 minutes, 1,300°F (704°C) at 10 minutes, and 1,550°F (843°C) at 30 minutes. In an NFPA 285 test, the average centerline temperatures measured 1-ft above the window opening are required to be 602°F (317°C) during the first 5 minutes, 870°F (466°C) between 5 and 10 minutes, 992°F (533°C) between 15 and 20 minutes, and 1,078°F (581°C) between 25 and 30 minutes into the test. The heat flux developed within the test furnace during an ASTM E119 fire exposure has been measured to be approximately 20 kW/m^2 at 5 minutes, 65 kW/m^2 at 15 minutes, and 88 kW/m^2 at 30 minutes [12]. Comparatively, the exposed surface heat fluxes generated during an NFPA 285 test 2-ft above the window opening are 9 to 19 kW/m^2 during the first 10 minutes of the test, 25 to 29 kW/m^2 during the middle 10 minutes of the test, and 34 to 38 kW/m^2 during the last 10 minutes of the test.

Thus, the thermal exposure conditions developed within an ASTM E119 test furnace are significantly more severe than the conditions developed on the exterior wall surface during an NFPA 285 test. Therefore, a material which provides a nominal 20 minutes of fire-resistance when subjected to the fire exposure conditions specified in ASTM E119 will demonstrate better fire-resistance performance in terms of remaining in-place, restricting heat passage to the unexposed surface, and preventing pyrolysis and ignition of materials on the unexposed surface during an NFPA 285 test. Additionally, during the NFPA 285 test, the exterior wall cladding is only subjected to the fire exposure conditions from the window burner for 25 minutes.

In a Portland cement-sand plaster (stucco) on metal lath wall system, no air gap would exist between the stucco and the insulation board. In DuPont's NFPA 285 tests incorporating brick veneers over the Thermax™ sheathing, a nominal 2-inch air gap existed between the insulation board and the brick. This gap remained open as the aluminum window flashing melted and hot gases and flame from the first floor burn room flowed into this air cavity. Even with this air gap, the Thermax™ sheathing complied with the NFPA 285 acceptance criteria. Thus, if the gap does not exist (as in a typical stucco exterior wall covering system), the insulation will exhibit less fire spread/damage.

Based on the above analysis, it was concluded that a minimum ¾-inch thickness of Portland cement-sand plaster (stucco) could be used in lieu of the tested 4-inch common clay brick and still meet the test acceptance criteria described in NFPA 285.

Natural Stone Materials

Several UL Design Listings allow minimum 2-inch thick natural stone as an optional exterior wall covering material. Stone such as granite, limestone, marble, and sandstone are naturally occurring and provide fire-resistance based on their thickness, density, and composition.

One means to assess the thermal performance of a material is to develop a thermal inertia value. The thermal inertia is the product of the thermal conductivity, k (W/m·K), density, ρ (kg/m3), and specific heat capacity, c_p (kJ/kg·K). A material which has a higher thermal inertia will absorb more heat and transfer the heat at a slower rate than a material with a lower thermal inertia. In order to provide the technical justification for the substitution of the minimum 2-inch thickness of natural stone materials in lieu of the tested 4-inch standard clay brick, the thermal inertia values for the materials were calculated.

Published literature values for the thermal conductivity, specific heat capacity, and density for standard clay brick and limestone are provided below in Table 4 [13]. Table 4 also includes the calculated thermal inertia ($k\rho c_p$) for each material.

Table 4 – Thermal Properties for Brick, Various Natural Stone Materials, and Select Metals

Material	Thermal Conductivity (W/m·K)	Density (kg/m^3)	Specific Heat Capacity (kJ/kg·K)	Thermal Inertia (W^2·s/m^4·K^2)
Clay brick	0.69	1600	0.84	927
Limestone	1.26 – 1.33	2500	0.9	2,835 – 2,933
Granite	1.73 – 3.98	2640	0.82	3,745 – 8,616
Sandstone	1.83	2160 – 2300	0.71	2,806 – 2,988
Marble	2.07 – 2.94	2500 – 2700	0.80	4,140 – 6,350

The thermal inertia values for the natural stones range from more than double to more than nine times greater than standard clay brick. Therefore, a minimum 2-inch thickness of natural stone would be expected to provide improved thermal protection to the Thermax™ sheathing when compared to the tested standard clay brick.

Natural stone can also be applied such that either no air gap or a very limited gap would exist between the stone and the Thermax™ sheathing. In the NFPA 285 test using the Thermax™ sheathing, a nominal 2-inch wide air gap existed between the Thermax™ sheathing and the brick and the assembly still passed the NFPA 285 test.

The natural stone must be installed as a solid veneer without open joints (vertical or horizontal) as was with the brick veneer. The occurrence of open gaps, separations, etc. will provide a potential path for the fire to enter the wall cavity and spread within it.

Therefore, it is the opinion of Jensen Hughes that a non-open jointed, minimum 2-inch thickness of natural stone (limestone, granite, sandstone, and marble) may be used in lieu of the tested 4-inch clay brick and still meet the test acceptance criteria specified in NFPA 285; as reflected in Table 1.

Artificial Cast Stone

Artificial cast stone is typically a Portland cement-based precast concrete product manufactured to simulate natural stone. The fire-resistance provided by concrete can be calculated per Table 1 of the NCMA TEK 7-1C [11]. Assuming siliceous concrete, a minimum 2-inch thickness will provide approximately 30 minutes of fire-resistance and a minimum 1½-inches will provide approximately 18 minutes of fire-resistance. The fire-resistance ratings specified in the NCMA TEK 7-1C guide are based on an ASTM E119 fire exposure.

As detailed in the technical rationale for Stucco wall covering, the fire exposure conditions to the exposed side of a wall assembly tested in accordance with ASTM E119 are significantly more severe than the fire exposure conditions experienced by the exterior wall covering material in an NFPA 285 test. While the 1½-inch thick artificial cast stone (assuming siliceous concrete) will only provide approximately 18 minutes of fire-resistance, the artificial stone will only be exposed to the fire conditions of the window burner for 25 minutes during the NFPA 285 test and the exposure conditions will be significantly less.

Artificial cast stone can also be applied over a metal lath such that either no air gap or a very limited gap would exist between the stone and the foam insulations. In DuPont's brick veneer NFPA 285 tests a nominal 2-inch wide air gap existed between the Thermax™ sheathing, and the tested assemblies passed the NFPA 285 test.

The cast stone must be installed as a solid veneer without open joints (vertical or horizontal) as was with the brick veneer. The occurrence of open gaps, separations, etc. will provide a potential path for the fire to enter the wall cavity and spread within it. Based on this analysis, it is concluded that a non-open jointed minimum 1½-inch thickness of artificial stone will provide comparable fire performance as the tested 4-inch clay brick in an NFPA 285 fire exposure and will meet the acceptance criteria specified in NFPA 285.

Thin Brick

Thin brick is included in Table 1 for use with maximum 3-inch thick Thermax™ sheathing based on several technical factors.

The thin brick line item in Table 1 specifies that the installation of the thin brick must be a mortar-based adhesion application over minimum ½-inch thick fiber cement or gypsum board. In our experience, thin brick cladding products have a variety of installation methods including both adhesion-based and mechanically fastened. The specified mortar-based adhesion method ensures that the thin brick cladding layer will be a closed joint system and that no air gap will be present between the cladding and the Thermax™ sheathing. This thin brick installation method is more conservative than open jointed systems or systems that incorporate air gaps between the Thermax™ sheathing and the exterior wall covering.

Fiber cement board on its own has been justified as an acceptable cladding material over 3-inch thick Thermax™ sheathing. Therefore, when covered by an additional minimum ½-inch of clay brick and mortar adhesive and the air gap eliminated, this constitutes a more conservative installation.

The NFPA 285 fire performance of a thin brick system is also documented by the Brick Industry Association (BIA) who conducted a successful NFPA 285 test on a generic thin brick system incorporating ½-inch thick thin brick masonry units over a ½-inch thick fiber cement board substrate. The test report[3] and Jensen Hughes' engineering analysis[4] reports are publicly available at the links provided in this page's footnotes. The thin brick system in this NFPA 285 test was installed over 3-inches of extruded polystyrene insulation (XPS). In light of the results from this test program, it is our opinion that the use of this cladding system over a thermoset phenolic insulation (Thermax™ sheathing) as opposed to a thermoplastic insulation (XPS) will yield better fire performance of the overall wall assembly. Since thermoplastic insulations melt at low temperatures, the potential exists for melting of the insulation behind the cladding and creating an air gap that could support combustion. In the case of the use of Thermax™ sheathing, if there is no air gap present in the initial installation, then there is minimal chance that one will be created when the wall is exposed to fire from the interior or exterior.

Therefore, it is the opinion of Jensen Hughes that the use of thin brick systems installed as described in Table 1 over maximum 3-inches of Thermax™ sheathing will maintain compliance with NFPA 285.

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[3] Brick Industry Association Thin Brick NFPA 285 Test Report – https://www.gobrick.com/docs/default-source/Why-Choose-Brick/Fire-and-Windstorm/nfpa-285---bia-thin-brick-fire-test-summary-report---i8508-02-121-24-r0.pdf?sfvrsn=0

[4] Jensen Hughes Analysis Report - https://www.gobrick.com/docs/default-source/Why-Choose-Brick/Fire-and-Windstorm/ltr-rpt-bia-thin-brick-fire-test---extrapolation-of-data-engineering-analysis-report-revised-final-(8-17-20).pdf?sfvrsn=0

Glen Gery Thin Tech Elite Series Masonry Veneer, Corium Thin Brick System, and Tabs II Plus Wall System

All three of these thin brick systems incorporate masonry units ranging from ½-inch to 1¼-inches thick, set into a 26-gauge steel support panel with preformed tabs to allow the bricks to snap into place, or be adhered via construction adhesive, after which the brick units are held in place by the mortar joints around the support tabs. The 26-gauge sheet steel forms are mechanically attached back to the substrate wall behind, which would be the Thermax™ sheathing immediately beneath the thick brick system.

The Tabs II wall system was tested in a 2-hour ASTM E119 test, as documented in Omega Point Laboratories Final Test Report No. 16976-119158A, dated October 30, 2004. The relevant part of this test assembly was that the exposed face was covered by the Tabs II thin brick system. The test report documents that the Tabs II wall system consisted of the 26-gauge sheet steel Tabs II panels, secured with fasteners into the studs and runners spaced 8-inches O.C. The bricks used on the exterior face of the system were ½-inch thick and were held in place with Tabs II Wall Adhesive applied to the back face of each brick per the manufacturer instructions. The joints between adjacent bricks were finished with a mixture of Type "N" mortar mix, Portland cement, Tabs II acrylic latex mortar bonding additive, and water. The test report documents that after the test assembly was removed from the furnace after the 2-hour ASTM E119 exposure, all of the ½-inch bricks remained in-place on the exposed face of the assembly. Based on the previous discussion in the Stucco wall covering section comparing the severity of the ASTM E119 test exposure to the NFPA 285 test exposure, it is the opinion of Jensen Hughes that the bricks of the Tabs II system would also remain in place during an NFPA 285 test due to its less severe fire exposure.

It was also witnessed in the Brick Industry Association (BIA) NFPA 285 test that was discussed in the Thin Brick wall covering section, that the bricks remained in place throughout that exposure as well. Based on the performance of the generic thin brick system in the BIA NFPA 285 test, and the performance of the Tabs II system in the ASTM E119 test, it is the opinion of Jensen Hughes that the Glen Gery Thin Tech Elites Series Masonry Veneer, the Corium Thin Brick System, and the Tabs II Plus Wall systems will all provide sufficient exterior protection to Thermax™ sheathing in an exterior wall assembly to maintain compliance with NFPA 285.

This justification conservatively omits the fact that if bricks were to fall away from the exterior surface of the system, the bricks are backed by 26-gauge sheet steel, which is an approved standalone wall covering per the Sheet Metal wall covering section of this technical justification report.

Concrete, Precast Panels, and Concrete Masonry Units

The fire-resistance provided by concrete can be calculated per Table 1 of the NCMA TEK 7-1C [11]. As detailed previously in the Stucco technical discussion section, fire-resistance ratings in accordance with ASTM E119 are developed based on significantly more severe exposure conditions than the NFPA 285 test. Therefore, a material that provides a fire-resistance rating equal to or greater than the duration of the NFPA 285 test will provide sufficient protection to underlying combustible when it is used as the exterior covering material over an exterior wall needing to comply with NFPA 285.

Assuming siliceous concrete, a minimum 2-inch thickness will provide approximately 30 minutes of fire-resistance. Thus, based on the 25-minute exterior fire exposure to the exterior wall covering in the NFPA 285 test, the 2-inch thickness of concrete will protect the Thermax™ sheathing and can be used in lieu of the tested brick veneer.

The fire-resistance provided by concrete masonry units (CMU) can also be calculated per Table 1 of the NCMA TEK 7-1C [11]. Assuming siliceous concrete, a minimum 2-inch equivalent thickness calculated using a 4-inch thick CMU will provide approximately 30 minutes of fire-resistance. Thus, based on the 25-minute exterior fire exposure to the exterior wall covering in the NFPA 285 test, the 2-inch equivalent thickness of CMU will protect the Thermax™ sheathing and can be used in lieu of the tested brick veneer.

The concrete or the CMU can be applied such that either no air gap or a very limited gap would exist between the concrete or CMU and the Thermax™ sheathing, as a nominal 2-inch wide air gap existed between the Thermax™ sheathing and the brick veneer in DuPont's NFPA 285 tested assemblies. The concrete or CMU must be installed as a solid veneer without open joints (vertical or horizontal) as was with the tested brick veneer. The occurrence of open gaps, separations, etc. will provide a potential path for the fire to enter the wall cavity and spread within it.

Based on this analysis, it is concluded that a minimum 2-inch thickness of concrete or a 4-inch thick concrete masonry unit with a maximum 2-inch air gap between it and the Thermax™ sheathing may be used in lieu of the tested 4-inch clay brick and still meet the test conditions specified in NFPA 285.

Minimum ⅜-inch Ceramic Tiles

Ceramic tiles are set in a minimum ⅛-inch thick mortar bed over minimum ½-inch thick fiber cement board. This is a similar installation compared to thin brick systems and will provide the same level of protection by acting as a flame barrier during the test as the ceramic tile is non-combustible and will not contribute to exterior flame propagation burning. Since fiber cement board on its own has been shown to remain in-place sufficiently to protect and prevent flame propagation over Thermax™ sheathing, it is the opinion of Jensen Hughes that when ceramic tile is adhesively bonded to the fiber cement board, direct flame impingement to the underlying foam plastic insulation material will not occur and compliance with NFPA 285 will be maintained.

Cornerstone Building Products

The Cornerstone Building Products systems are solid steel pre-formed metal panel systems. Depending on the wall panel system they range from 29- (AVP panel), 26-, 24-, 22-, or 18-gauge. The technical justification provided in the Solid Metal Exterior Wall Panels section is also applicable for the Cornerstone metal panels as these fall within the same category of exterior cladding materials.

Claddings with Knight Wall System

Knight Wall provides various attachment systems which have been successfully used in numerous NFPA 285 tests. The Knight Wall HCI and the Knight Wall CI systems are cladding attachment systems which support the exterior cladding system. Since this is a cladding attachment system, it is not an exterior wall cladding material. The Knight Wall HCI and CI systems can support the following exterior cladding systems listed within this analysis report:

a) ACM Systems
b) Terracotta cladding
c) Solid metal exterior wall panels
d) 5/16-inch thick Hardie® Plank Lap Siding
e) Brick
f) Stucco
g) Corium Thin brick system
h) Min. 1¼-inch Limestone or natural stone or cast artificial stone
i) Glen Gery Thin Tech® Elite Series masonry veneer
j) Min. 1½-inch thick concrete or precast concrete panels
k) Min. ⅜-inch thick ceramic tiles
l) Min. ¾-inch thin brick systems
m) Min. ¾-inch natural or artificial stone adhered to cement backer board.

MISCELLANEOUS MATERIALS

Exterior Insulation Joint Flashing

Referenced test [7] used DuPont™ LiquidAmor™ flashing over the board joints at a 50 mil thickness and 4-inch wide strip. Based on ASTM E1354 test data, various LiquidArmor flashing products are approved for use over the board joints at maximum installed thicknesses and widths that are equal to or less than the tested condition.

DuPont utilizes the LiquidArmor flashing products to seal the board joints on a Thermax wall system. Cone calorimeter testing has been conducted on the LiquidArmor flashing products and the Dow Corning DefendAir 200 WRB product. The testing indicated that the LiquidArmor flashing products have higher flammability properties than the DefendAir 200 WRB (proprietary testing conducted for Dow Corning), which is normally applied full wall coverage. Given this comparative analysis, it is Jensen Hughes opinion that the use of the Dowsil DefendAir 200 or Dowsil DefendAir 200C products used as flashing materials will not adversely impact compliance with NFPA 285.

Additionally, the IBC specifically states that flashing materials are not to be considered part of the water-resistive barrier product when assessing compliance of products in an exterior wall assembly. Through our extensive testing experience, we have never seen flashing products applied in small quantities over the face of the exterior wall assembly contribute to excessive vertical and/or lateral flame spread. Flashing materials are simply not applied in sufficient quantities and do not contain excessively high amounts of heat energy when applied over the board joints to contribute significantly to increasing the overall wall combustibility; especially when applied over foam plastic materials which, due to their nature, contain high amounts of heat energy. Knowing that flashing products do not contribute to excessive burning and do not support flame spread in a wall assembly, it is our opinion that the wall flashing materials, in the limits specified in the report, will not adversely impact the compliance with NFPA 285.

Drainage Mat

The Tyvek® DrainVent™ Rainscreen product was included in DuPont's FRTW wall test [14] and demonstrated that when located directly behind the exterior cladding material (Hardi Lap Siding), no significant vertical or lateral flame spread occurred. Subsequent cone calorimeter testing was conducted on the same Tyvek® DrainVent™ product tested in the FRTW wall assembly and the flammability properties were mid-range of WRB materials Jensen Hughes has evaluated when tested in accordance with ASTM E1354.

Mortar Net

Mortar net products are similar in construction to the Tyvek® DrainVent™ product and are placed at the bottom of the wall and along brick shelf angles to maintain open water drainage. Similar to flashing materials, these products are not used as full wall coverage and are placed in strips within the air cavity of the wall assembly, behind a masonry veneer. There are not adequate quantities of material to support vertical and lateral flame propagation within a masonry clad exterior wall assembly.

Jensen Hughes has conducted proprietary cone calorimeter testing on various mortar net type products and the flammability properties of these products are less than the Tyvek® DrainVent™ product tested in the FRTW wall assembly. In the FRTW wall assembly, the Tyvek® DrainVent™ was installed full wall coverage. The mortar net products are limited to a maximum 12-inch high strip of material located at the base of the wall and at brick shelf angles (which are typically installed every 3 floors). Given the relatively small amounts of mortar net material installed in a wall assembly, it is Jensen Hughes' opinion that the use of these products will not adversely impact the overall wall fire performance.

WALL OPENING PERIMETER PROTECTION

The exterior wall assembly successfully tested in accordance with NFPA 285 described above at the beginning of the Engineering Analysis section was constructed with one layer of ⅝-inch thick Type X gypsum wallboard installed at the header and jambs and 18-gauge "L" shaped steel flashing installed around the entire wall opening perimeter – header, jambs, and sill. This gypsum wallboard and 18-guage flashing installed around the opening perimeter protected the Thermax sheathing at the test wall opening from the fire and hot gases from the burn room exiting through the wall opening. The perimeter of all openings in the exterior wall assembly (windows, doors, loading docks, etc.) must be protected with the ⅝-inch thick Type X gypsum wallboard and the 18-gauge "L" shaped steel flashing to ensure adequate protection of the Thermax sheathing inside the wall assembly is provided. Sills do not need to be protected at door openings.

CONCLUSION

DuPont has conducted two successful NFPA 285 tests on an exterior wall assembly incorporating their Thermax™ sheathing covered by $^{5}/_{16}$-inch thick Hardie® Plank Lap Siding with SPF in the wall stud cavities. Additional successful NFPA 285 testing has been conducted on wall assemblies incorporating the Thermax™ Rigid Board insulation covered by either clay brick masonry veneers or ACM panel systems. Based on this successful testing, alternative wall constructions were developed as detailed in Table 1 of this letter. The additional wall construction features will result in wall assemblies which will still meet NFPA 285 and provide a comparable level of fire performance as the tested wall assemblies. The technical justification for the use of additional wall system components is provided above to support their use in an exterior wall assembly which will continue to meet the conditions of acceptance of NFPA 285.

REFERENCES

These NFPA 285 compliance tables are generated based on the following test reports:

1. Fiber Cement Board exterior wall construction – Reported in Intertek Testing Final Report No. N4815.01-121-24, dated June 9, 2022.
2. Fiber Cement Board exterior wall construction – Reported in ICC-NTA Testing Final Report No, DDPS082422-4, dated August 24, 2022.
3. Brick exterior wall construction – Reported in Southwest Research Institute Final Report No. 01.05805.01.001, dated November 2002.
4. Brick exterior wall construction – Reported in Southwest Research Institute Final Report No. 01.13104.01.001c, dated September 5, 2008.
5. Metal Composite Material Panel exterior wall construction – Reported in Southwest Research Institute Final Report No. 01.13104.01.001d, dated September 5, 2008.
6. Brick exterior wall construction - Reported in Southwest Research Institute Final Report No. 01.15822.01.001, dated September 9, 2010.
7. Aluminum Composite Material (ACM) Panel exterior wall construction – Reported in Intertek Testing Final Report No. J0651.01-121-24-R0, dated April 24, 2019.
8. Aluminum Composite Material (ACM) Panel exterior wall construction – Reported in Intertek Testing Final Report No. G101240263SAT-001, dated August, 29, 2013.
9. Aluminum Composite Material (ACM) Panel exterior wall construction – Reported in Southwest Research Institute Final Report No. 16046.01.610b, dated November, 30 2012

10. Fiber Cement Board exterior wall construction – Reported in Intertek Building and Construction Final Report No. M7537.01-121-24, dated January 27, 2022.
11. National Concrete Masonry Association (NCMA) TEK 7-1C, "Fire Resistance Rating of Concrete Masonry Assemblies," Herndon, VA, 2009.
12. Sultan, M.A., "Fire Resistance Furnace Temperature Measurements: Plate Thermometer vs. Shielded Thermocouples," *Fire Technology*, 42, pp 253-267, 2006.
13. National Fire Protection Association, Appendix B, *The SFPE Handbook of Fire Protection Engineering*, Fourth Edition, DiNenno, P.J. (ed.), National Fire Protection Association, Quincy, MA, 2008, pp. A-32 to A-33.
14. Fiber Cement Board exterior wall construction – Reported in Intertek Building and Construction Final Report No. M4492.03-121-24-R0, dated December 15, 2021

This analysis is based on the specific construction materials installed in the manner described in the referenced test report(s). Changes or modifications to the construction and/or materials used in the tested assembly may result in a different fire performance and may change this analysis.

This analysis does not address performance characteristics such as weatherability, durability, or structural issues.

We trust this engineering analysis will be of use to DuPont. Should you have any questions regarding our analysis, please contact us at 443-313-9891 or at **aparker@jensenhughes.com**.

Sincerely,

Daniel A. Martin

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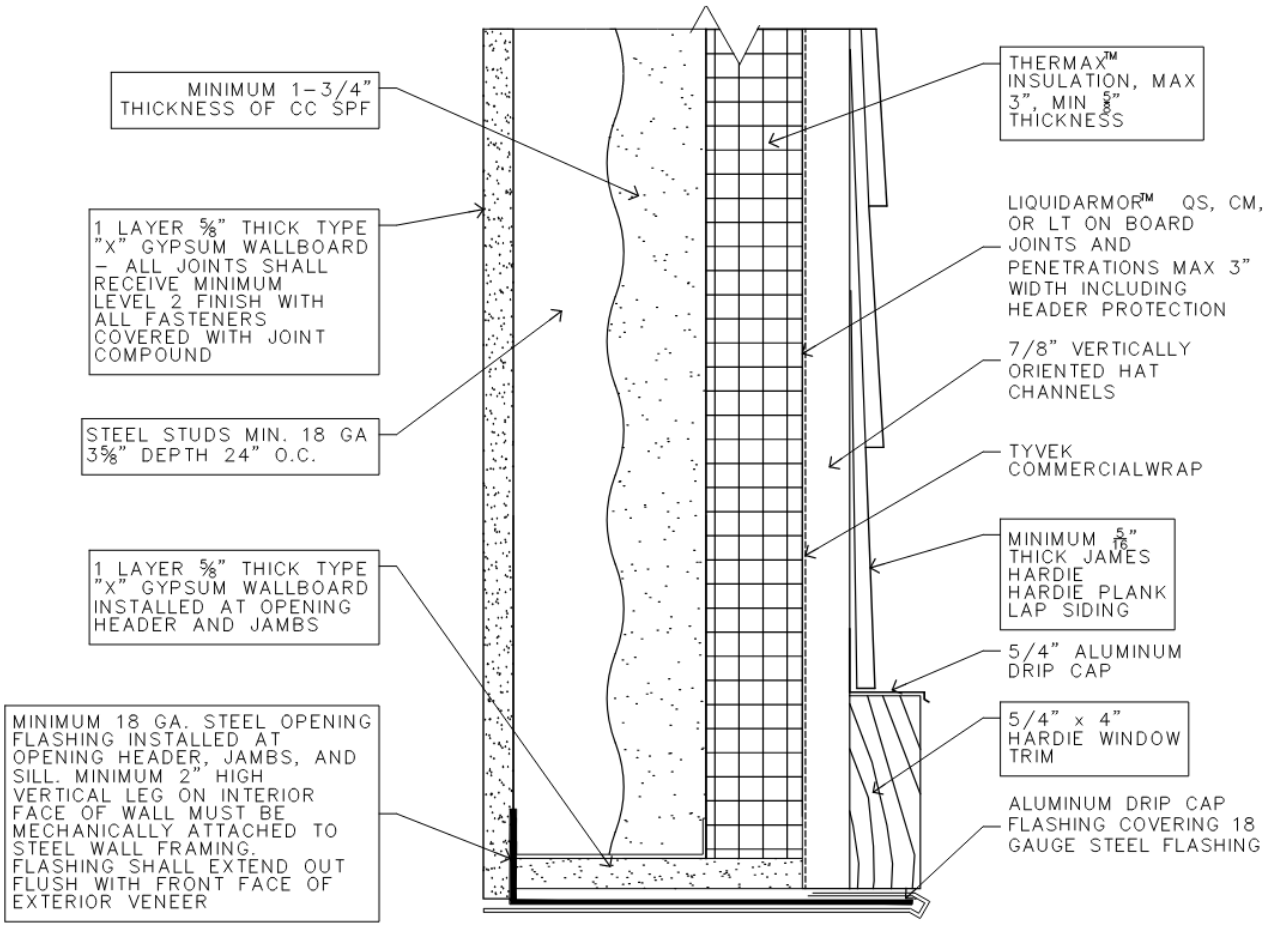

NOTE:
– BOLDED, BOXED ITEMS ARE CRITICAL ITEMS TO MAINTAIN COMPLIANCE WITH NFPA 285

Figure 1. Exterior Wall Construction – Thermax and CC SPF Spray Foam
Wall opening header shown. Perimeter protection required as noted – gypsum wallboard at header and jambs, 18-gauge steel flashing at header, jambs, and sill.