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DuPont Performance Building Solutions
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RE: Engineering Analysis for Exterior Wall Assemblies Constructed with DuPont™ Thermax™ Brand NH Series Insulation Complying with NFPA 285 (Revised)
Jensen Hughes Project Number 1JJB05306.011

To Whom It May Concern:

This analysis provides a summary of various exterior wall constructions that incorporate DuPont™ Thermax™ Brand NH Series polyisocyanurate insulation that will meet the requirements of NFPA 285, *Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components.*

Section 2603.5.5 of the International Building Code (2000 through 2021 Editions) require exterior wall systems incorporating foam plastic insulation materials meet the requirements of NFPA 285 (1998, 2002, 2012 or 2019 Editions depending on Code edition).

DuPont Performance Building Solutions (DuPont™) has performed two successful NFPA 285 tests on exterior wall assembly which incorporated the DuPont™ Thermax™ Brand NH Series Insulation. These tests are documented in the following reports:

1. Metal Composite Material Panel Exterior Wall Construction – Reported in Intertek Testing Building & Construction Report No. M7526.01-121-24, dated January 27, 2022.

2. Fiber Cement Siding Exterior Wall Construction – Reported in Intertek Testing Building & Construction Report No. M7537.01-121-24, dated January 27, 2022.

The above referenced test reports describe the complete wall construction, include test photos and observations, and include the data generated during the test.

Based on the results of these NFPA 285 tests, additional testing of water-resistive barriers (WRB) materials per ASTM E1354, and our experience with the NFPA 285 fire test, it is our opinion that the various exterior wall configurations described in Tables 1 and 2, and shown in Figures 1, 2, and 3 will meet the performance requirements of NFPA 285. Opening header/jamb details shown in these Figures are to be used with these wall configurations, as required per the construction tables. Figures 4, 5, and 6 depict the use of one of the DuPont™

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Tyvek® WRB materials in conjunction with the Thermax™ Brand NH Series Insulation foam plastic insulation material. All tables and Figures are located at the end of this report.

When the interior gypsum wallboard layer is detailed to stop above the finished ceiling line in an exterior wall assembly (see Figure 7), the sprayed thermal barrier material (Item 5b or 5c in Table 1, Layer I, Base wall system) shall be applied directly to the Thermax™ Brand NH Series Insulation at the following thicknesses:

- GCP Monokote Z3306 – minimum ⅜-inch thickness
- International Cellulose Corporation Ure-K – minimum 1¼-inch thickness

The transition between the gypsum wallboard and the thermal barrier material shall be as shown in Figure 7.

# *Technical Justification*

The two successfully tested NFPA 285 wall assemblies, which formed the basis for the development of Tables 1 and 2 (located at the end of this report), were constructed as follows (interior to exterior):

**2-inch thick Thermax Brand NH Series Insulation Wall Assembly** (Intertek Report No. M7526.01-121-24. Dated January 27, 2022)

1. One layer of ⅝-inch thick Type X gypsum wallboard installed continuously over the interior face of the wall assembly
2. 3⅝-inch deep, 18-gauge steel studs, spaced 24-inches OC
3. Fiberglass insulation fully filling wall stud cavities
4. 2-inch thickness of DuPont™ Thermax Brand NH Series rigid polyisocyanurate insulation board. Board joints sealed with DuPont™ LiquidArmor™ CM Flashing and Sealant
5. DuPont™ Tyvek® CommercialWrap® WRB
6. 4-mm thick Mitsubishi Alpolic®/fr ACM panel system installed on ⅞-inch deep, 18-gauge steel hat channels installed horizontally resulting in a 2¾-inch air cavity space.
7. Wall opening framed with one layer of ⅝-inch thick Type X exterior gypsum sheathing on header and jambs. Header finished with 18-gauge “L” shaped steel flashing and covered with aluminum drip cap.

**3-inch deep Thermax Brand NH Series Insulation Wall Assembly** (Intertek Report No. M7537.01-121-24. Dated January 27, 2022)

1. One layer of ⅝-inch thick Type X gypsum wallboard installed continuously over the interior face of the wall assembly
2. 3⅝-inch deep, 18-gauge steel studs, spaced 16-inches OC
3. Fiberglass insulation fully filling wall stud cavities
4. 3-inch thickness of DuPont™ Thermax Brand NH Series rigid polyisocyanurate insulation board. Board joints sealed with DuPont™ LiquidArmor™ CM Flashing and Sealant
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 finished with 18-gauge “L” shaped steel flashing and covered with aluminum drip cap. $^{5}/_{4}$-inch × 4-inch Hardie window trim was fastened around the window perimeter over the window opening

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

1. Base wall constructions
2. Cavity insulation materials
3. Exterior sheathing materials
4. Additional continuous exterior insulation materials
5. Alternate WRB materials
6. Alternate exterior cladding materials

# *1.0 Base Wall Assemblies*

## 1.1 STEEL STUD-FRAMED AND GYPSUM WALLBOARD

The two tested wall assemblies were constructed with steel stud framing with interior gypsum wallboard. The walls were constructed using 3⅝-inch deep, 18-gauge studs, spaced either 16 or 24 inches on center. 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 I allows for minimum 3⅝-inch studs, of minimum 18-gauge, and at a maximum spacing of 24 inches on center. Both tested wall assemblies included a single layer of interior ⅝-inch thick Type X gypsum wallboard. This is, therefore, held as a minimum requirement for wall constructions using steel stud framing. Exterior gypsum sheathing is noted as optional.

## 1.2 CAST CONCRETE AND CMU BASE WALLS

Cast concrete base walls and concrete masonry unit base walls are also listed in Table 1 as accepted base wall construction. In an NFPA 285 test, a concrete or concrete masonry base wall will provide a greater degree of protection to the exterior wall components than a steel stud and base wall assembly will due to its increased rigidity, significantly higher thermal mass, and resulting increased level of fire performance. Table 2.1 of the ACI 216.1-07 document, *Code Requirements for Determining Fire Resistance of Concrete Masonry Construction Assemblies* and Table 1 of the National Concrete Masonry Association (NCMA) TEK Guide 7-1C, *Fire Resistance Rating of Concrete Masonry Assemblies*, both provide guidance for the minimum required thickness of cast concrete or CMU assemblies to prescriptively achieve hourly fire resistance ratings. Based on these documents a 3½-inch think cast concrete wall of normal weight, calcareous or siliceous gravel concrete will provide a 1-hour fire-resistance rating, which is twice as long as the duration of the NFPA 285 test. Similarly, NCMA TEK 7-1C indicates that a CMU block with an equivalent thickness of 2 inches will achieve a 30-minute fire resistance rating. CMU blocks used as the structural basis of an exterior wall, in our experience, are typically much thicker than 2-inches (typically 8-inch overall thickness, corresponding to nominal 4-inch equivalent thickness). Since the NFPA 285 test is a 30-minute duration, and the typical thickness of CMU blocks used to construct exterior wall assemblies are greater than the thickness corresponding to a 30-minute fire resistance rating, blocks of this thickness of greater will provide the necessary protection from an interior fire to prevent the ignition of combustible components of the exterior wall assembly. Based on these technical rationale, a concrete or CMU base wall assembly will provide the same or better fire performance than the tested steel stud and gypsum base wall assemblies.

Note that the installation of the ⅝-inch thick Type X gypsum wallboard is not a requirement when cast concrete or CMU base wall assemblies are used as these masonry wall assemblies will provide sufficient protection from interior fire exposures without the use of gypsum wallboard.

### 1.3 WOOD STUD-FRAMED AND GYPSUM WALLBOARD

Table 1 allows for the use of minimum 2×4 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, that minimum char damage is sustained by the wood studs throughout an NFP 285 test. Since only minimal char damage to the wood studs was observed during the NFPA 285 fire exposure, 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 ⅝-inch thick, Type X gypsum is used on both the interior and exterior faces of the assembly. The wood framed and steel framed NFPA 285 compliant assemblies in Table 1 require a single layer of ⅝-inch thick, Type X gypsum installed continuously 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 will also be required to be ⅝-inch thick Type X gypsum wallboard, as reflected in Table I. This will ensure sufficient protection is afforded to the wood stud framing from both the interior and the exterior face.

Depending on the fire resistance rating of the base wall assemblies in Table 1, the construction may deviate from the minimum requirements for NFPA 285 compliance. For example, if a 2-hour fire resistance rating is required for the exterior wall, a single layer of ⅝-inch thick, Type X gypsum on each side of the studs will not be sufficient to meet the fire-resistance rating. Additional layers of gypsum wallboard will be required to be added to the wall assembly. Additional layers of gypsum wallboard will only improve the overall wall assembly performance in accordance with NFPA 285.

## *2.0 Cavity Insulation Materials*

The tested assembly incorporated fiberglass insulation in the wall stud cavities. Replacing the fiberglass insulation with mineral wool insulation will not adversely impact the overall wall fire performance. The technical rationale for allowing non-combustible insulation materials to be installed in the wall cavity of an assembly is provided in the numerous UL design listings. These design listings describe wall assemblies (tested to the more severe ASTM E119 fire exposure conditions) where the inclusion of fiberglass or mineral wool insulation as an optional item can be incorporated into the assembly and will not adversely impact the fire-resistance rating of the assembly. The addition of any noncombustible insulation materials will result in an improvement in the overall wall fire performance.

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

Cavity insulation is required when the Thermax™ Brand NH Series Insulation is applied direct to studs. When exterior gypsum sheathing is included over the outside face of the studs prior to the installation of the Thermax™ Brand NH Series Insulation, then the interior stud cavities may be left empty.

# 3.0 Exterior Sheathing Materials

## 3.1 EXTERIOR GYPSUM SHEATHING

The two tested wall assemblies both had the Thermax™ Brand NH Series Insulation insulation applied directly to the exterior face of the steel stud framing. Therefore, the Thermax™ Brand NH Series Insulation was protected from the interior fire exposure of the NFPA 285 only by the interior layer of ⅝-inch thick gypsum wallboard and the stud cavity fiberglass insulation. Adding a layer of exterior gypsum sheathing to the stud framing will provide a greater degree of protection from an interior fire exposure and is therefore an allowable substitution. Since no exterior gypsum sheathing was included in the NFPA 285 tests there are no approved WRB materials over the exterior gypsum. The WRB must be provided over the exterior face of the Thermax™ Brand NH Series Insulation.

## 3.2 EXTERIOR FIRE-RETARDANT TREATED WOOD (FRTW) SHEATHING

Exterior FRTW sheathing is allowed over the exterior face of FRTW stud framing, under the constraint that one layer of exterior gypsum sheathing must be installed exterior to the FRTW sheathing. As explained in Item 1.3, based on Jensen Hughes NFPA 285 test experience, the interior fire exposure to a test assembly with wood stud framing and FRTW sheathing does not adversely impact the wall fire performance. However, the flame spread performance of the test assembly on the exterior face when burning in combination with other combustibles has not been evaluated. Therefore, if exterior FRTW sheathing is used over wood stud framing it must also be protected by a layer of exterior gypsum sheathing to prevent involvement of the FRTW sheathing in an exterior fire exposure. The same technical requirement exists if FRTW sheathing is applied over steel wall framing.

# 4.0 Alternate WRB Materials

In the tested assemblies DuPont™ LiquidArmor™ CM was applied to the board joints followed by DuPont™ Tyvek® CommercialWrap® WRB applied over the exterior face of the insulation and under the exterior cladding materials. Based on previous NFPA 285 testing and analyses of DuPont™ Thermax™ Brand NH Series Insulation the alternate joint sealing materials are allowed for use with the DuPont™ Thermax™ Brand NH Series Insulation. Alternate sheet good WRB products having similar flammability properties as the tested WRB are included in Table 4. 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 4 will not adversely impact the overall wall fire performance and will maintain compliance with NFPA 285.

# 5.0 Alternate Exterior Cladding Materials

The tested assemblies used Alpolic®/fr ACM panels and James Hardie Hardie® Plank Lap Siding as the two cladding materials. The ACM panel was tested with 2-inch thick DuPont™ Thermax™ Brand NH Series Insulation and the Hardie® Plank Lap Siding was tested with 3-inch thick DuPont™ Thermax™ Brand NH Series Insulation. Based on testing different DuPont™ Thermax™ Brand NH Series Insulation thicknesses with different claddings, different claddings are approved for varying thicknesses of DuPont™ Thermax™ Brand NH Series Insulation.

Testing an ACM panel is a worse-case scenario than a wall assembly tested with fiber cement panel as the ACM panel skins melt in an NFPA 285 and expose the combustible core. The fiber cement panel cladding remained in-place throughout the NFPA 285 test and continued to provide a physical barrier for direct flame impingement during an NFPA 285 test. Therefore, Table 1 limits the claddings approved to be used with 2-inch DuPont™ Thermax™ Brand NH Series Insulation and allows for a wider variety of cladding materials at a 3-inch thickness, correlating to the insulation thicknesses used in the two referenced NFPA 285 test reports.

It our opinion that the exterior wall combinations allowed by Table 1 will provide the same or better protection to the underlying combustibles as the tested Alpolic®/fr 4-mm ACM panels, and as the tested Hardie® Plank Lap Siding and ACM panels, in their respective tests.

## 5.1 ALTERNATE MCM PANEL MANUFACTURERS

(MCM panel systems are approved for general use in Table 1 as 2-inch thick DuPont™ Thermax™ Brand NH Series Insulation has been tested with successful results with Alpolic®/fr MCM panels. Although MCM panels are similar in the composition of their combustible cores, MCM panels provided by different manufacturers do not have identical core compositions and exhibit different burning characteristics. Consequently, the flammability of the cores differs from manufacturer to manufacturer. Table 1 does not limit the use of DuPont™ Thermax™ Brand NH Series Insulation to only the manufacturers with which successful test results have been obtained. However, in acknowledging the variation of panel flammability between manufacturers, Table 1 requires that an MCM panel system have achieved passing results of an NFPA 285 test with combustible insulation of a comparable type and thickness to be acceptable for use with DuPont™ Thermax™ Brand NH Series Insulation.

## 5.2 TERRACOTTA

Terracotta is a clay-based material similar to clay brick. A solid 1-¼ inch thickness of non-open jointed terracotta would be expected to provide nominally 28 minutes of fire-resistance by interpolating the information in Table 3 of the NCMA TEK 7-1C guide, assuming an ASTM E119 fire exposure. In an NFPA 285 test, the terracotta 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 terracotta would be expected to provide more than 25 minutes of fire-resistance when subjected to the fire conditions described in ASTM E119, which are more severe than the exterior fire exposure conditions of NFPA 285.

Based on this technical analysis, it is expected that 1¼-inch thick Terra Cotta cladding would perform superior to the tested ACM panel cladding used in the 2-inch thick DuPontTM ThermaxTM Brand NH Series Insulation test and comparable or better to the Hardie® Plank lap siding in the 3-inch thick DuPontTM ThermaxTM Brand NH Series Insulation test. Therefore, the terracotta is included in Table 1 with closed joint installations for use with maximum 3-inch (75 mm) thick DuPontTM ThermaxTM Brand NH Series Insulation.

## 5.3 METAL EXTERIOR WALL COVERINGS

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 as the MCM panel. The three metal 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 should justify 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 open up 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 2800°F[1], where the NFPA 285 apparatus is calibrated to produce a maximum temperature of 1314°F on the exterior face of the assembly during the test. Note that temperatures as high as 1700°F can be produced when combustibles of the test assembly become involved in the exterior fire. Minimum 26 gauge (0.0179-inch) steel panels will not melt through the test exposed 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] compared to the previously established melting temperatures. 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 2018 International Building Code, for these three materials to be used as weather coverings for exterior walls.

## 5.4 HARDIE® PLANK LAP SIDING

The allowance for use of $^{5}/_{16}$-inch thick Hardie® Plank lap siding is based on the two referenced NFPA 285 tests in this letter (ACM and Hardie® Plank lap siding) and our experience in observing tests that use fiber cement panel cladding. As previously described, the ACM panels melt and open during an NFPA 285 fire exposure test subjecting the underlying foam plastic insulation to direct flame impingement.

In our experience with running and observing NFPA 285 tests fiber cement boards do not sustain surface burning and they remain intact throughout an NFPA 285 fire exposure to continue to provide a physical barrier for direct flame impingement. Cracking of the fiber cement panels occurs due to the thermal exposure throughout the test, and this sometimes leads to discrete pieces of the panels falling away from the assembly late into the test. This loss of fiber cement cladding occurs only in the area of direct flame impingement from the

[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/

test apparatus (i.e., the area of most severe wall assembly exposure). However, unlike ACM panels, the fiber cement panels remain intact outside of the area of greatest exposure and continue to provide an exterior covering to the combustible insulation.

Several manufacturers (James Hardie, Nichiha, Allura, Swisspearl) produce fiber cement siding products which are nominally $^{5}/_{16}$-inch (0.312-inch) thick which have been used in successful NFPA 285 tests. UL Designs which include fiber cement panels over combustible components include EWS0045 and EWS0050 and UL Design EWS0050 describes an exterior wall assembly with the fiber cement panels installed over a combustible insulation material.

In addition to the Hardie® Plank lap siding test over 3-inch thick DuPont™ Thermax™ Brand NH Series Insulation, DuPont has conducted two other NFPA 285 tests using Hardie® Plank fiber cement siding installed in a shiplap manner. One test was conducted over 1-inch thick XPS insulation with FRTW exterior sheathing, and the other test was conducted over 3 inches of Thermax insulation with an altered formulation. Both wall test constructions passed the NFPA 285 test and based on the performance of the Hardie® Plank siding in this test Jensen Hughes feels that the fiber cement siding installed in a shiplap manner can be applied to the DuPont™ Thermax™ Brand NH Series Insulation as well.

## 5.5 BRICK

Table 3 of the NCMA TEK 7-1C indicates that an equivalent thickness of 2.7 inches for solid clay brick or 2.3 inches of hollow clay brick will provide a 1-hour fire resistance rating. Standard clay bricks used in NFPA 285 tests and common construction are 3⅝ inches thick and are either solid or have hollow openings in the core. Considering that an NFPA 285 test only exposes the exterior of the wall to direct flame exposure for 25 minutes, and the fire exposure on the exterior side of a wall in NFPA 285 is less than that of an ASTM E119 furnace exposure, the use of standard 3⅝-inch thick solid or hollow clay brick is acceptable as an exterior wall covering in lieu of the tested Hardie® Plank lap siding or ACM panels. Common clay brick is substantially thicker than the tested Hardie® Plank Lap Siding, has an increased ability to absorb heat, and has been tested in numerous other NFPA 285 compliant exterior wall assemblies protecting comparable amounts of foam plastic and spray polyurethane foam (SPF) insulation materials.

## 5.6 STUCCO

Table 8 of the NCMA TEK 7-1C 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.

As previously describe, an ASTM E119 test furnace exposure is significantly more severe than the fire exposure experienced by the exterior surface of a test assembly in 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 the NFPA 285 test using 3-inches of DuPont™ Thermax™ Brand NH Series

Insulation a nominal ¾-inch air gap existed between the insulation board and the fiber cement panel. Even with this air gap, the DuPont™ Thermax™ Brand NH Series Insulation exhibited limited fire spread/damage. Therefore, 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 plaster (stucco) could be used in lieu of the tested ACM panels or Hardie® Plank lap siding and still meet the test conditions of acceptance described in NFPA 285.

## 5.7 CORIUM THIN BRICK SYSTEM

Nominally 1-$^{5}/_{16}$-inch thick Corium brick tiles are inserted into a continuous interlocking galvanized steel or stainless steel backing sections which are mechanically fastened back to the steel wall framing. Joints are mortared to provide a continuous masonry layer separating underlying foam plastic insulation from the exterior fire. Based on the testing and technical justification described in the Glen Gery Thin Tech® Elite Series veneer (Section 5.8), it is the opinion of Jensen Hughes that this cladding system will also maintain NFPA 285 compliance of a wall assembly when installed over DuPont™ Thermax™ Brand NH Series Insulation.

## 5.8 GLEN GERY THIN TECH® ELITE SERIES MASONRY VENEER

The Glen Gery Thin Tech® is a thin brick system incorporating masonry units 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 and then held in place by the mortar joints around the support ties. This system is system is similar to the Corium thin brick system and typical thin brick systems.

Glen Gery has also conducted testing of another similar thin brick system, their Suretouch Masonry System at Intertek in August 2009 which incorporated 1¼-inch thick masonry units inserted into a 2½-inch thick polystyrene insulation support panel with imprinted masonry patterns. This system completely relied on the thin masonry stones to provide protection to the underlying combustibles.

The fire performance of 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. The test report[3] and Jensen Hughes engineering analysis report[4] are available in the footnote links.

## 5.9 CONCRETE OR PRECAST PANELS

The fire-resistance provided by concrete can be calculated per Table 1 of the NCMA TEK 7-1C document. Assuming siliceous aggregate 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 per the NCMA TEK 7-1C Guide. The fire-resistance ratings specified in the NCMA TEK 7-1C guide are based on an ASTM E119 fire exposure. The fire exposure conditions on the exterior side of an assembly during an NFPA 285 fire

[3] Brink Industry Association test report link – 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 link – 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

exposure are significantly less than that of ASTM E119, therefore, the thermal protection afforded to underlying combustible materials by a 1½-inch thick concrete/precast veneer will be greater than 18 minutes. In addition to the less severe exposure, the NFPA 285 test also only exposes the exterior of a wall assembly to the exterior flame plume for 25 minutes (the first 5 minute of the test is room burner only).

Based on the known fire performance of 1½-inches of concrete in an NFPA 285 test as discussed above, it was concluded that a non-open jointed minimum 1½-inch thickness of artificial stone will provide acceptable fire protection to underlying combustibles and will meet the test conditions specified in NFPA 285.

## 5.10 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. Due to their non-combustible nature, and their installation over a mortar bed, backed by fiber cement board, it is the opinion of Jensen Hughes that this installation is similar to the previously described thin brick systems and will provide the same level of protection by acting as a physical barrier, preventing direct flame impingement on the underlying combustibles throughout a fire test. The ceramic tile will also not contribute to sustainable surface burning.

## 5.11 MINIMUM ¾” THIN BRICK SYSTEMS AND ADHERE NATURAL STONE

See analysis provided above for Glen Gery Thin Tech® Elite System (see Section 5.8).

## 5.12 MIN 2-INCH CONCRETE MASONRY UNITS

The technical rationale for minimum 2-inch thick concrete masonry units (CMU) from Section 5.9 (minimum 1½-inch thick concrete or precast panels) applies for this exterior cladding material. Additionally, many UL designs (e.g., EWS0028, EWS0033, EWS0043, etc.) permit minimum 2-inch thick CMU with a maximum 2-inch air cavity space as an acceptable cladding over combustible insulation materials.

## 5.13 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 system 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.

### 5.14 CORNERSTONE BUILDING PRODUCTS

The cornerstone building products covered under this engineering analysis se are solid steel pre-formed metal panel systems. Depending on wall panel system, they can be 29-gauge (Cornerstone's AVP panel) 26, 24, 22, or 18-gauge. The technical justification for solid metal exterior wall panels (Section 5.3) is also applicable for the Cornerstone metal panels as these fall within the same category of exterior cladding materials.

### 5.15 TABS II PLUS SYSTEM

The Tabs II plus system is very similar to the Glen Gery Thin Tech® Elite Series mounting system (Section 5.8). It is a 26-gauge steel backing plate which is meant as a form for setting thin brick veneers. Essentially this system is supported by Section 5.3, as it is a steel wall covering, that also includes a thin brick covering over the exterior, and the joints between adjacent bricks are mortared. Therefore, sections 5.3 and 5.8 provide technical justification for use of this system in lieu of the Hardie® Plank lap siding exterior cladding. TABS II also offer a rainscreen material which is installed between exterior insulation and the steel backing panel and provides a water drainage channel in the interstitial space between the two. This rainscreen material is not included in the scope of this NFPA 285 approval letter and is not approved for use in conjunction with the DuPont™ Thermax™ Brand NH Series Insulation.

## *Conclusion*

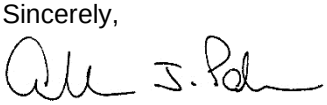
DuPont has conducted two successful NFPA 285 tests on exterior wall assemblies utilizing DuPont™ Thermax™ Brand NH Series Insulation installed behind an ACM panel system and a Hardie® Plank lap siding system. Based on this successful testing, alternative wall constructions were developed as shown in Tables 1 and 2. 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.

This analysis is based on the specific construction materials installed in the manner described in the referenced project drawings reviewed. 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 information is of assistance and if you have any questions, please feel free to contact me at 443-313-9891 or **aparker@jensenhughes.com**.

Sincerely,



Arthur J. Parker, P.E.
Sr. Fire Protection Engineer

*Table 1 –Wall Assemblies Using Thermax™ Brand NH Series Insulation*

| *Wall Component* | *Materials* |
|---|---|
| Base wall system – Use either 1, 2, 3, 4, or 5 | 1. Concrete wall<br>2. Concrete Masonry Unit (CMU) wall<br>3. Standard clay brick wall<br>4. Wood studs: nominal 2-inch × 4-inch or greater FRTW wood studs spaced at a maximum of 16-inch OC. Wall cavity 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 and exterior face of wood studs. Minimum two top plates at floorlines.<br>5. Steel studs: minimum 3⅝-inch depth, minimum 18-gauge, spaced maximum 24-inch O.C. with lateral bracing every 4 ft. vertically with:<br>a) 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, or<br>b) GCP Applied Technologies Monokote Z-3306 installed at a minimum ⅜-inch thickness over Thermax™ Brand NH Series Insulation, or<br>c) International Cellulose Corporation's Ure-K Thermal Barrier System installed at a minimum of 1¼-inch thickness over Thermax ™ Brand NH Series Insulation.<br><br>As an option, when steel studs are used exterior gyspum sheathing is not required.<br>Note: See Figure 7 for transition detail of interior ⅝-inch thick Type X gypsum wallboard to thermal barrier material. |
| Floor line firestopping - required in curtain-wall construction | 4 lb./cu ft. mineral wool (e.g., Thermafiber) in each stud cavity and at each floor line – friction fit in cavity, attached with Z-clips, or equivalent |
| Interior Vapor / Moisture barrier for use with Base Wall 4 or 5 | 1. None<br>2. Any 6-mil thick polyethylene film |
| Cavity Insulation – Use either 1, 2, or 3 or combination of 2 and 3 | 1. None – Only permitted when exterior gypsum sheathing is used.<br>2. Fiberglass batt insulation (faced or unfaced)<br>3. Mineral wool batt insulation (faced or unfaced)<br><br>Note: 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 E84. |

| *Wall Component* | *Materials* |
|---|---|
| Exterior sheathing – Items 1, 2 or 3 depending on base wall requirements | 1. No exterior sheathing required when base wall assemblies 1 through 3 are used.<br>2. ⅝-inch thick, Type X exterior gypsum sheathing is required with Base wall system 4.<br>3. Exterior gypsum sheathing (any thickness) is optional with Base wall system 5 when Cavity Insulation 2 or 3 are included in Base Wall stud cavity. Min. ⅝-inch thick, Type X exterior gypsum sheathing required when Base wall system 5 wall stud cavities do not utilize Cavity Insulation. |
| Exterior insulation | DuPont™ Thermax™ Brand NH Series Insulation – installed at a minimum thickness of ⅝-inch.<br>a) When installed at a maximum thickness of 2 inches, any cladding material (layer VII) listed in Table 1 may be used.<br>b) When installed at a maximum thickness of 3 inches, any cladding materials (layer VII) listed in Table 1 may be used, **excluding the following**:<br>- Metal Composite Material (MCM) panel systems<br>- Sheet metal claddings or wall coverings (e.g., steel, aluminum, copper) |
| Exterior insulation joint flashing | Flash all exterior insulation joints and veneer tie penetrations with one of the following:<br>a) DuPont™ LiquidArmor™ - CM Flashing and Sealant – max. 50-mil wet thickness, max. 4-inch width<br>b) DuPont™ LiquidArmor™ - LT Flashing and Sealant – max. 35-mil wet thickness, max. 4-inch width.<br>c) DuPont™ LiquidArmor™ - QS Flashing and Sealant – max. 60-mil wet thickness, max. 4-inch width<br>d) DuPont™ Tyvek® Fluid Applied Flashing and Joint Compound+ – max. 25-mil wet thickness, max. 3-inch width<br>e) DuPont™ WeatherMate™ Flashing – max. 4-inch width<br>f) Asphalt, acrylic, or butyl-based flashing tape – max. 4-inch width<br>g) DuPont™ Great Stuff Pro™ - Use on joints that are ≤ ¼-inch, vertical joints must be staggered & remove significant excess from the face of the Thermax™<br><br>Note: With either e) or f), a small amount of spray primer may be used to aid in adhesion; maximum 4-inch width. |

| *Wall Component* | *Materials* |
|---|---|
| WRB material applied over exterior insulation – Use either 1 or 2 | 1. None<br>2. Any shown in Table 2<br>As an option, WRB may be installed over Layer III, Exterior Sheathing. When installed on exterior sheathing, WRB shall not also be installed over Layer IV, Exterior Insulation<br>Note: Any WRB material shown in Table 2 can be applied over Base wall systems 1 through 5 above, where able, and when exterior sheathing is used. |
| Exterior Veneer – Use either 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, except where limited by insulation thickness per Exterior Insulation item (Layer IV) | 1. MCM System - Use any MCM, including Aluminum Composite Material (ACM) systems, that has been successfully tested by the panel manufacturer via the NFPA 285 test method. Acceptable NFPA 285 testing shall consist of successful NFPA 285 test results on a wall assembly incorporating a comparable thickness of combustible foam insulation (e.g., polyiso) behind the ACM. These ACM panel systems include:<br>• Reynobond® FR ACM<br>• Alpolic®/fr ACM<br>• Alucobond® PLUS ACM<br>2. Terracotta cladding – Use any non-open jointed terracotta cladding system in which terracotta is minimum 1¼-inch thick. Any standard installation technique such as ship-lap, etc. can be used.<br>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.<br>4. Minimum 5/16-inch thick James Hardie Hardie® Plank Lap Siding installed with a 1¼-inch overlap.<br>5. 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 2-inches. Minimum 18-gauge steel flashing installed around openings to close off air cavity at exterior wall openings.<br>6. 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.<br>7. Corium™ Thin brick system. Air gap between exterior insulation and thin brick system to be a maximum of 2-inches. Minimum 18-gauge steel flashing installed around openings to close off air cavity at exterior wall openings. |

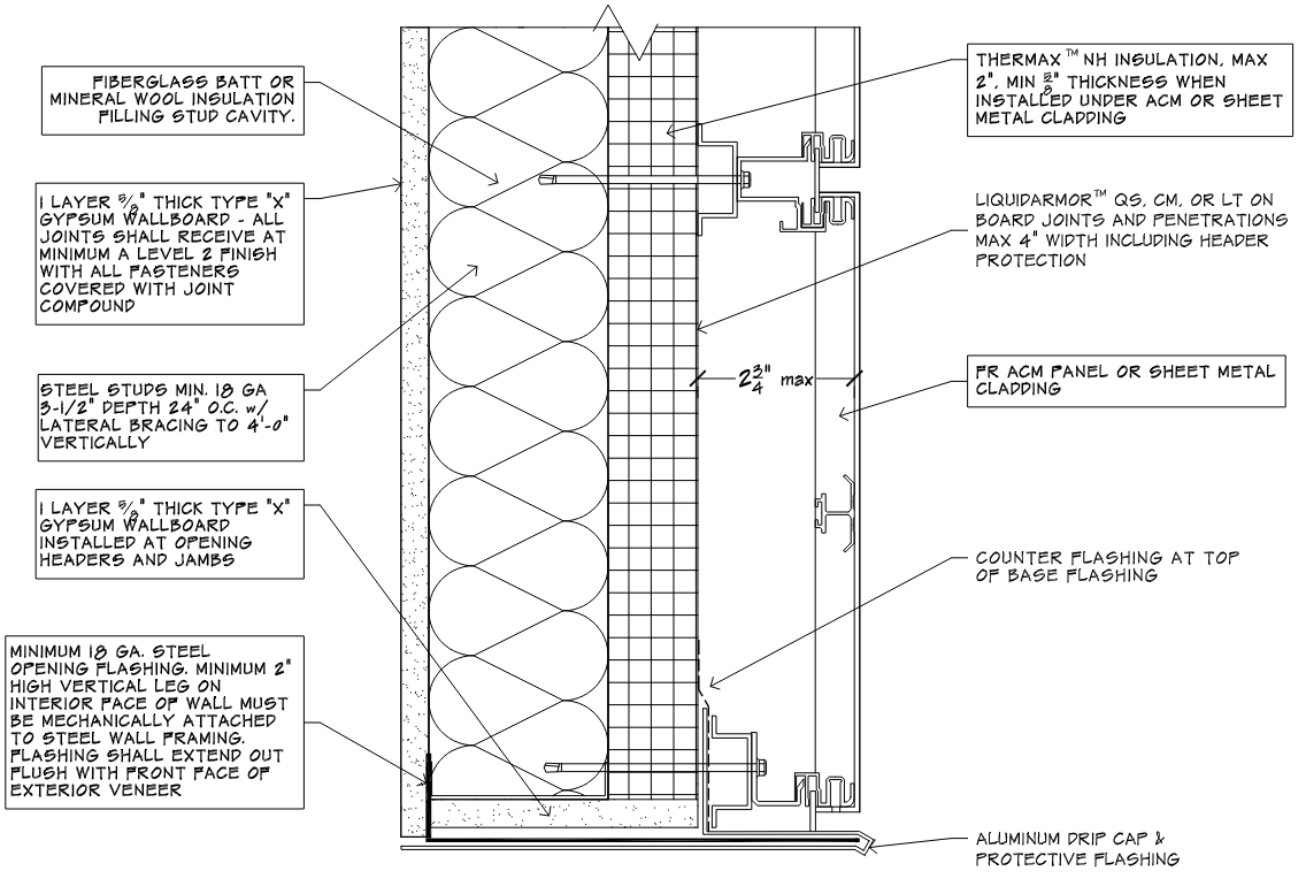
| | |
|---|---|
| Exterior Veneer – Use either 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, except where limited by insulation thickness per Exterior Insulation item | 8. Minimum 1¼-inch thick limestone or natural stone veneer or minimum 1¼-inch thick cast artificial stone veneer. Any standard installation technique such as ship-lap, etc. can be used. Air gap between exterior insulation and stone to be a maximum of 2-inches. Minimum 18-gauge steel flashing installed around openings to close off air cavity.<br>9. Glen-Gery Thin Tech Elite Series – Masonry veneer<br>10. Concrete or precast concrete panels – Minimum 1½-inch thick. Any standard installation technique can be used. Air gap between exterior insulation and concrete panel to be a maximum of 2-inches. Minimum 18-gauge steel flashing installed around openings to close off air cavity at exterior wall openings.<br>11. Ceramic tile (min. ⅜-inch thick) bonded using noncombustible mortar adhesive to minimum ½-inch thick cement board or gypsum sheathing.<br>12. 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.<br>13. Minimum ¾-inch thick natural stone or artificial stone 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<br>14. Concrete Masonry Units - Minimum 2-inch thick panel, with a maximum 2-inch air gap between exterior insulation and the interior face of the exterior CMU. Any standard non-open-joint installation technique can be used. Minimum 18-gauge steel flashing installed around openings to close off air cavity at exterior wall openings.<br>15. Knight Wall CI or MCI Systems may be used as support for the following cladding systems. The installation of any of the following systems shall comply with their previous description in this table:<br>a) ACM system<br>b) Terracotta cladding<br>c) Sheet metal exterior wall panels or coverings (e.g., steel, aluminum, or copper)<br>d) $^{5}/_{16}$-inch thick James Hardie Hardie® Plank Lap Siding<br>e) Brick - Standard nominal 4-inch thick, clay brick<br>f) Stucco – Minimum ¾-inch thick<br>g) Corium™ Thin brick system<br>h) Minimum 1¼-inch thick Limestone or natural stone veneer or minimum 1¼-inch thick cast artifical stone veneer.<br>i) Glen-Gery Thin Tech® Elite Series – Masonry veneer<br>j) Minimum 1½-inch thick concrete or precast concrete panels |

| *Wall Component* | *Materials* |
|---|---|
| | k) Ceramic tile (min ⅜-inch thick)<br>l) Thin brick (minimum ¾-inch thich clay brick) fully adhered with cementitious mortar (standard or polymer modified) to min. ½-inch thick cement backer board or gypsum sheathing.<br>m) Natural stone or artificial stone (minimum ¾-inch thich clay brick) fully adhered with cementitious mortar (standard or polymer modified) to min. ½-inch thick cement backer board or gypsum sheathing.<br><br>16. Cornerstone Building Products, including:<br>• PBR Panel (Exposed fasteners)<br>• PBU Panel (Exposed fasteners)<br>• AVP Panel (Exposed fasteners)<br>• Designer™ Series Panels (Exposed fasteners)<br>• Shadow Rib™ Panels (Exposed fasteners)<br>• NuWall® Panels (Exposed fasteners)<br>• MasterLine 16 (Concealed fasteners)<br><br>17. Tabs II Plus Wall System w/o Tabs II Plus “RainScreen” with Pre-attached wrap. |
| Flashing of window, door, and other exterior wall penetrations. | As an option, flash window, door and other exterior penetrations with either:<br>a) DuPont™ LiquidArmor™ – CM Flashing and Sealant – max. 60-mil wet thickness, max. 12-inch width.<br>b) DuPont™ LiquidArmor™ – LT Flashing and Sealant – max. 35-mil wet thickness, max. 12-inch width.<br>c) DuPont™ LiquidArmor™ – QS Flashing and Sealant – max. 60-mil wet thickness, max. 12-inch width.<br>d) DuPont™ Tyvek® Fluid Applied Flashing and Joint Compound+ – max. 25-mil wet thickness, max. 3-inch width<br>e) DuPont™ DuraGard™ CM Transition Flashing – max. 12-inch width<br>f) Limited amounts of acrylic, asphalt or butyl-based flashing tape – max. 12-inch width.<br>g) Hohmann & Barnard Textroflash™ Flashing<br>h) DOWSIL™ DEFENDAIR 200 or DOWSIL™ DEFENDAIR 200C<br><br>Note: Self-adhered flashing membrane used in wall openings may cover the wall width of rough opening plus extend up to a maximum of 4 inches onto the exterior face of the sheathing. Self-adhered flashing membrane 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. |

### *Table 2. Allowed WRB Materials Installed Over Foam Insulation*

| |
|---|
| **DuPont™**<br>• DuPont™ Tyvek® CommercialWrap®<br>• DuPont™ Tyvek® CommercialWrap® D<br>• DuPont™ Tyvek® ThermaWrap™<br>• DuPont™ WeatherMate™<br>• DuPont™ WeatherMate™ Plus |
| **Kingspan**<br>• Kingspan® GreenGuard® Max™ Building Wrap<br>• Kingspan® GreenGuard® Classic Building Wrap<br>• Kingspan® GreenGuard® C2000 Building Wrap<br>• Kingspan® GreenGuard® Raindrop® 3D Building Wrap<br>• Kingspan® GreenGuard® HPW™ Building Wrap |
| **VaproShield**<br>• RevealShield™<br>• RevealShield SA™<br>• PanelShield SA™ |

Note: All WRB materials to be installed at indicated or recommended application rates per manufacturer's installation instructions




NOTES:
- BOLDED, BOXED ITEMS ARE CRITICAL ITEMS TO MAINTAIN COMPLIANCE WITH NFPA 285
- FIBERGLASS BATT INSULATION OR MINERAL WOOL ARE OPTIONAL IN WALL STUD CAVITY WHEN EXTERIOR GYPSUM SHEATHING IS INSTALLED DIRECT TO STUDS UNDERNEATH THERMAX NH. REFER TO FIGURE 2
- THERMAX NH MAXIMUM THICKNESS MAY BE INCREASED TO 3" WHEN EXTERIOR CLADDING MATERIAL LISTED IN LAYER VIII FROM TABLE 3 IS USED EXCEPT FOR ACM PANEL OR SHEET METAL CLADDING.

***Figure 1. Exterior wall construction with ACM exterior veneer***

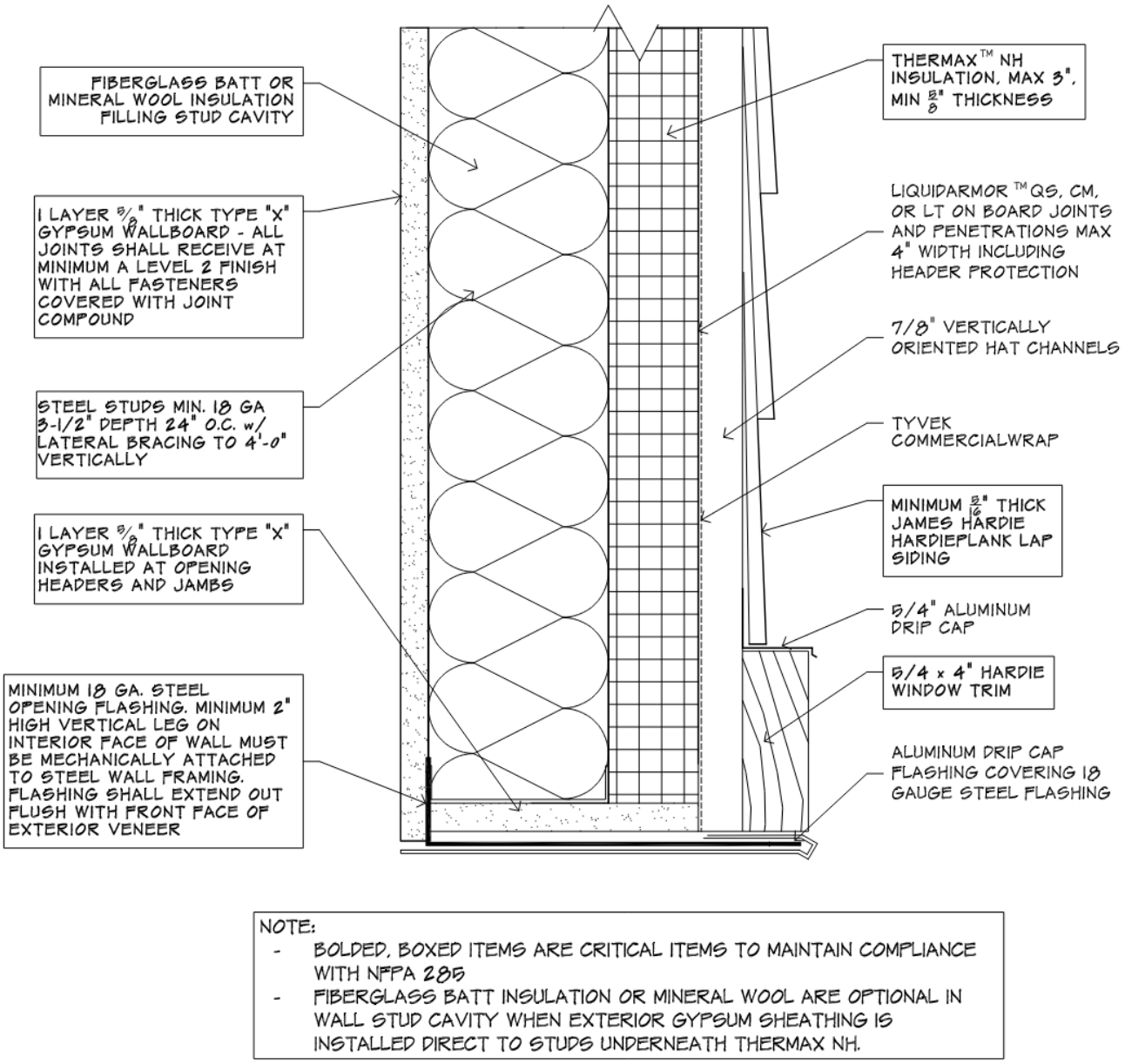



***Figure 2. Exterior wall construction with James Hardie Hardie® Plank Lap Siding exterior veneer***

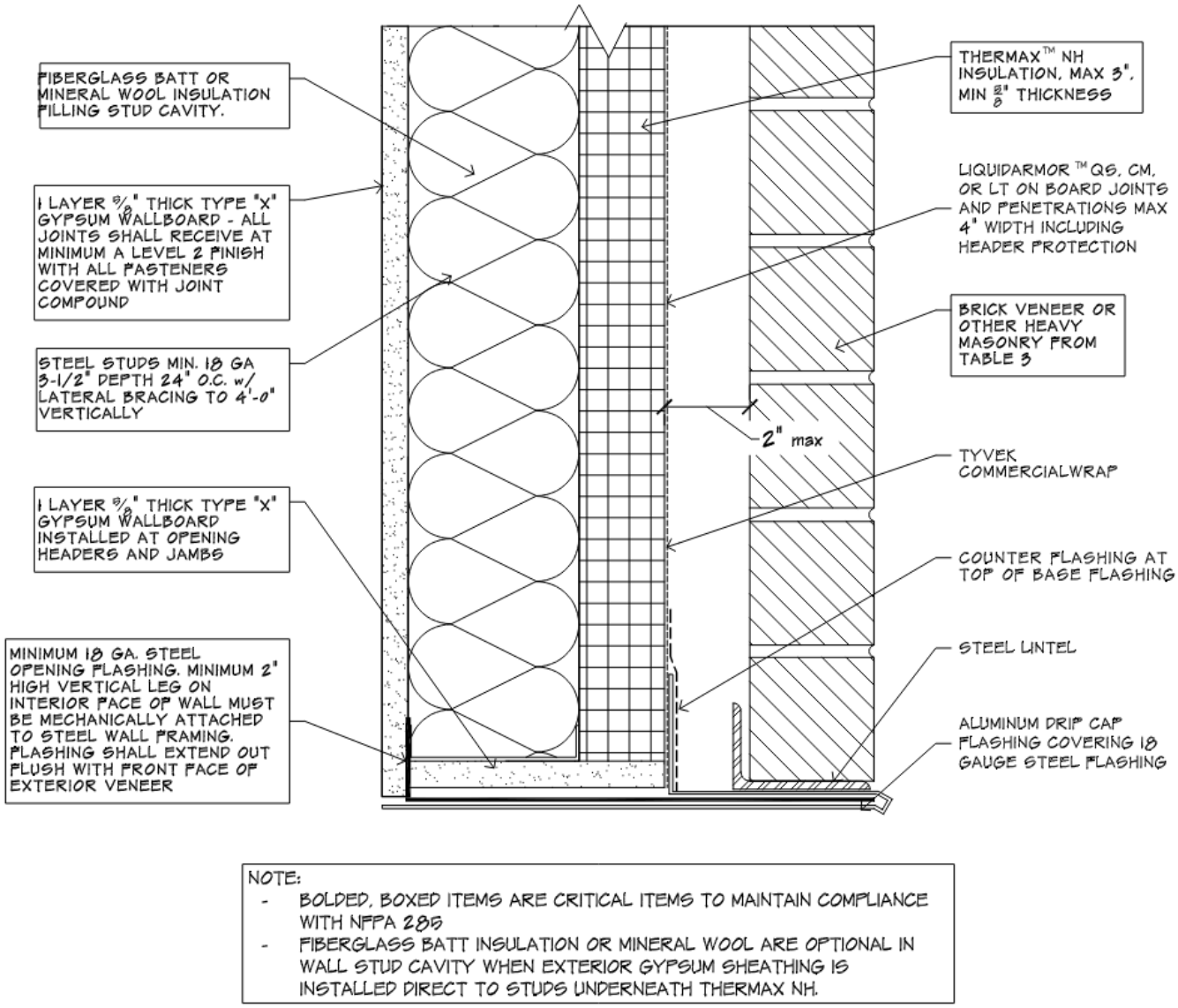



***Figure 3. Exterior wall construction with brick exterior veneer (depicts exterior veneer systems other than Hardie® Plank where air cavity space exists between insulation and exterior veneer)***

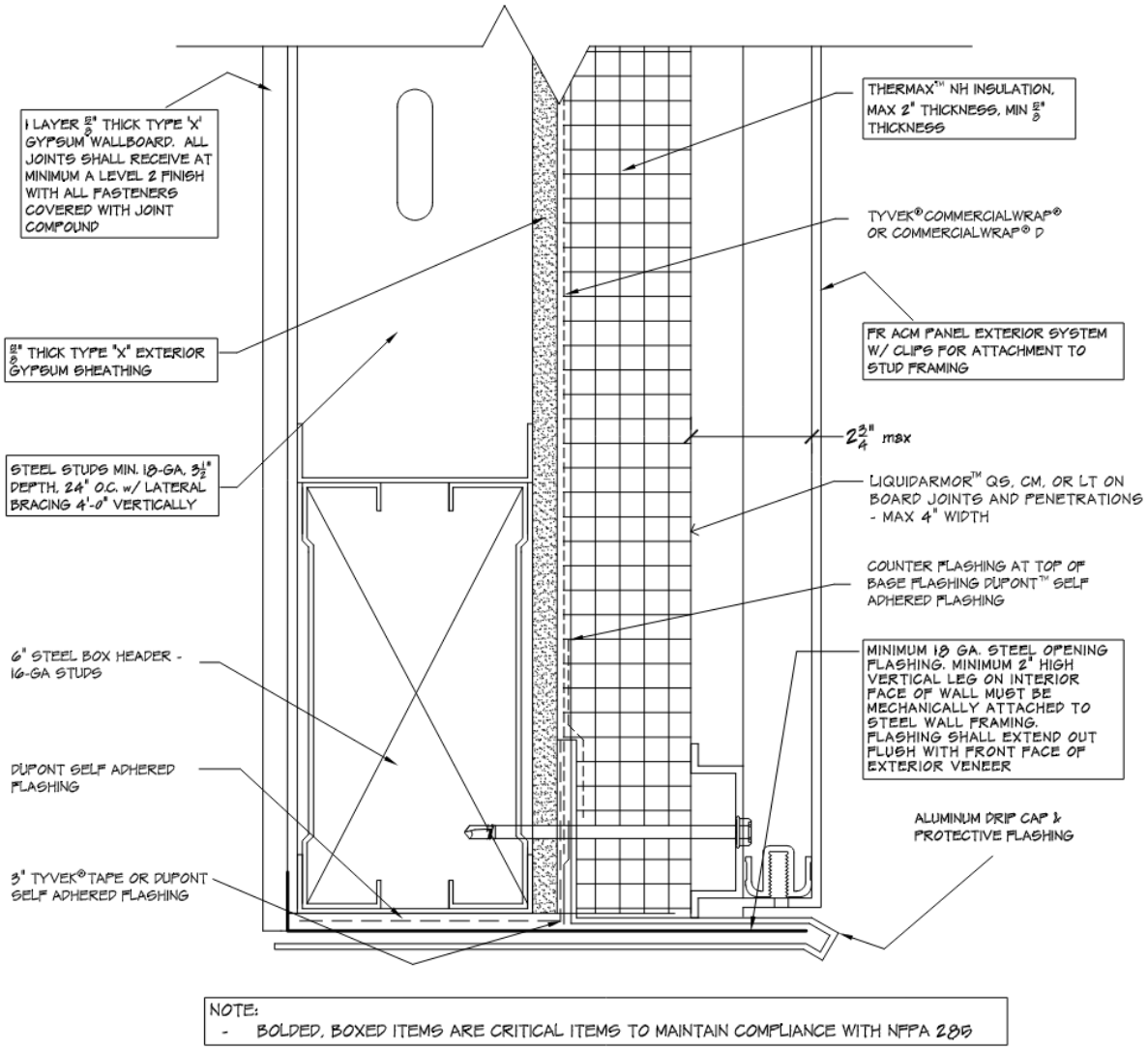



***Figure 4. Use of Tyvek® CommercialWrap® or CommercialWrap® D WRB behind Thermax™ insulation***

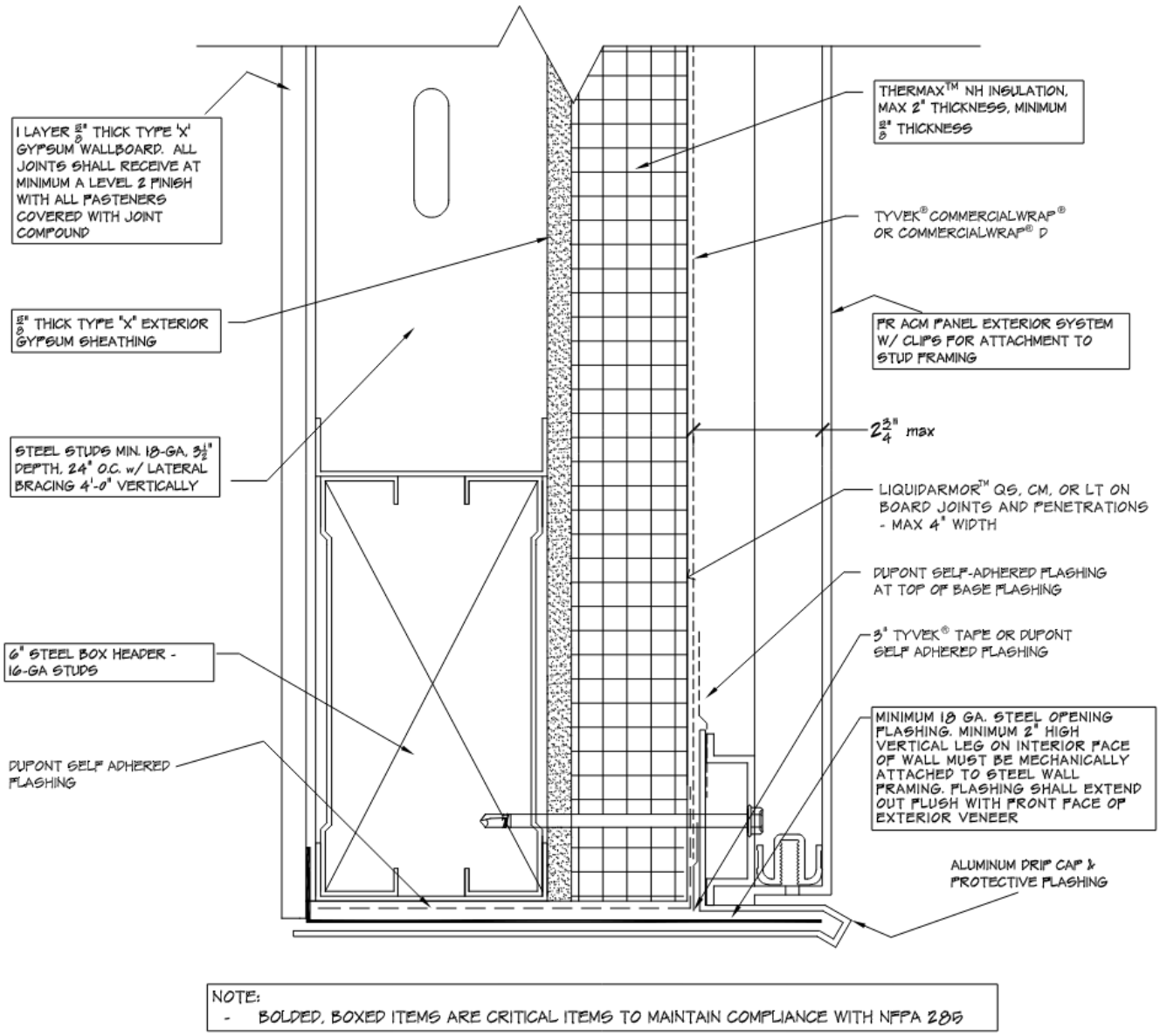



***Figure 5. Use of Tyvek® CommercialWrap® or CommercialWrap® D WRB over Thermax™ insulation***

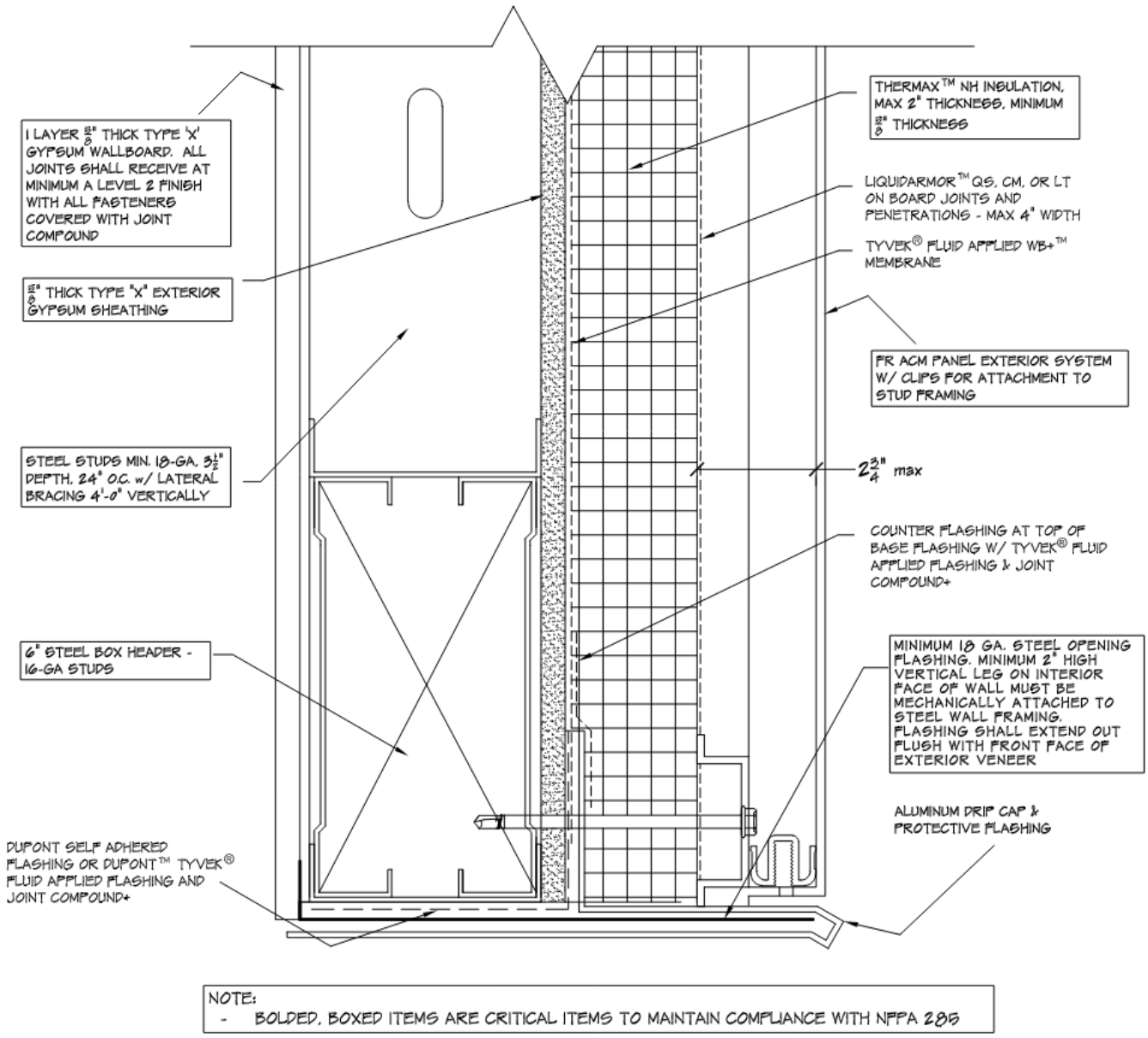



***Figure 6. Use of Tyvek® Fluid Applied WB+® WRB behind Thermax™ insulation.***

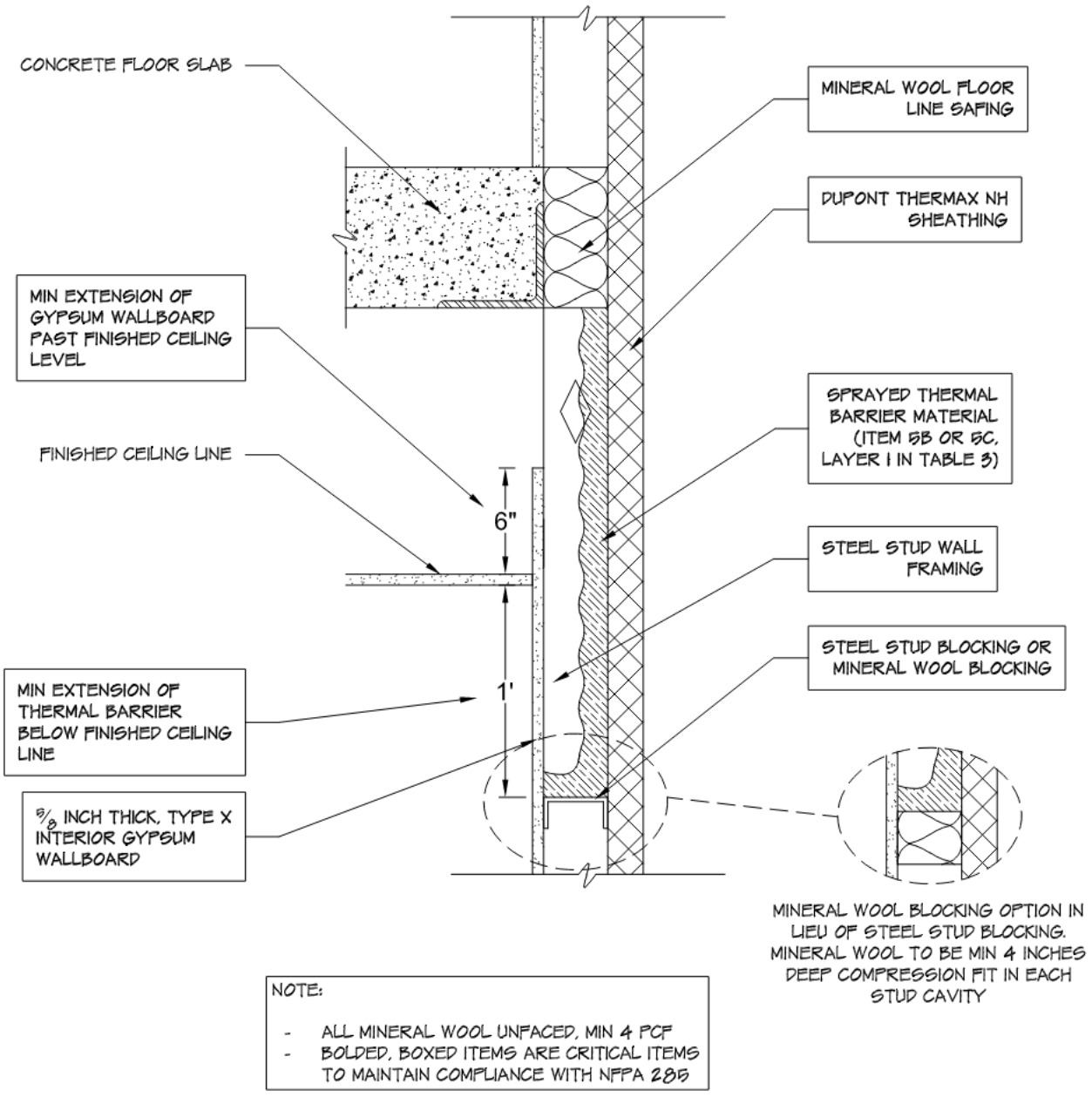



***Figure 7. Transition detail from interior gypsum wallboard to sprayed thermal barrier material above ceiling line.***