JENSEN HUGHES
Advancing the Science of Safety

May 4, 2018

Dow Building Solutions
The Dow Chemical Company
1605 Joseph Drive
Midland, MI 48642

RE: Exterior Wall Analysis – Use of Gypsum Sheathing Over XPS Insulation in NFPA 285 Complying Wall Assemblies
JENSEN HUGHES Project No. 1JJB05306.011

To Whom It May Concern:

This letter constitutes my analysis concerning exterior wall assemblies that contain Dow Chemical's STYROFOAM™ Extruded Polystyrene Insulation (XPS) and is covered on the exterior face of the XPS with one layer of ⅝-inch thick, Type X gypsum sheathing.

To meet the requirements for use of foam plastic insulation in exterior walls of Types I, II, III, or IV buildings, per §2603.5.5 of the IBC, the exterior wall assembly is required to 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."

Dow Chemical has conducted a successful NFPA 285 using the configuration of XPS covered on its exterior face by one layer of gypsum sheathing. This successful test is reported in Intertek Testing Services, Final Report No. E5803.01-121-24, dated May 22, 2015.

Based on the results of the NFPA 285 test, additional testing of water-resistive barriers per ASTM E1354 and my experience with the NFPA 285 fire test, it is my judgment that the various configurations of exterior walls described in Figures 1 and 2 as well as those described in the attached Tables/Figure will meet the performance requirements of NFPA 285.

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.

If you have any questions, or if we can be of further assistance, please free to contact me.

Sincerely,

**JENSEN HUGHES**

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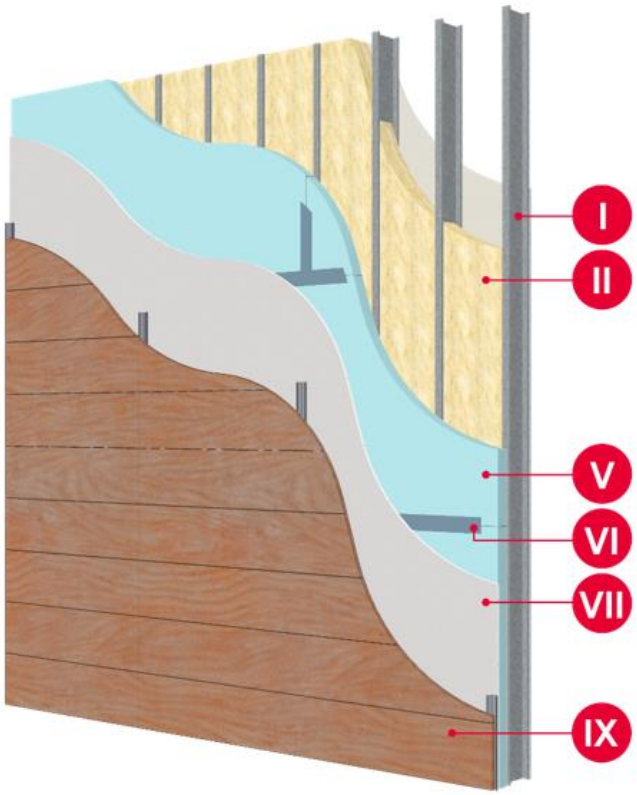


*Figure 1*

**Figure 1 (*Left*): Typical Layer Assembly**
Image shows a typical inverted wall assembly using STYROFOAM™ brand XPS with numerals that correspond to Tables 1-3.
Note that not all layers shown here are required in assembly, not all possible layers are shown, and layers have several different material selection options.
See Tables 1-3 for all layer and material selection options, and Figure 2 for examples of other common layer assemblies.

**Figure 2 (*Below*): Example Layer Assemblies**
Images in Figures 2-1 through 2-4 show four common layer assemblies. Note that not all assembly options are shown. See Tables 1-3 for layer and assembly options.

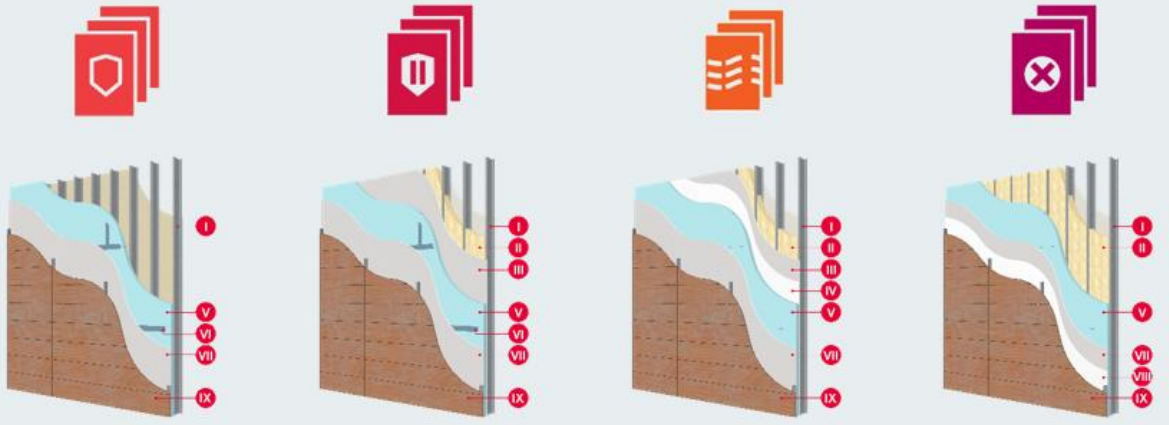

***Figure 2-1 Max Armor***
*Insulation with seam treatment as WRB, insulation within structure*

***Figure 2-2 Dual Armor***
*Insulation with seam treatment as WRB, exterior gypsum, insulation within stud structure*

***Figure 2-3 Classic***
*Insulation with separate WRB over exterior gypsum, insulation within structure*

***Figure 2-4 Other***
*Insulation with separate WRB over insulation, insulation within structure*

*Figure 2*

**Table 1 – Walls Containing STYROFOAM™ XPS Insulation Covered By Gypsum Sheathing**

| Layer | Wall Component | Materials |
|---|---|---|
| **I** | Base wall system – Use either 1, 2, or 3 | 1. Concrete wall<br>2. Concrete Masonry wall<br>3. 1 layer – ⅝-inch thick, Type X, Gypsum wallboard on interior, installed over steel studs: minimum 3⅝-inch depth, minimum 20-gauge at a maximum of 16-inch OC with lateral bracing every 4 ft. vertically |
| **REQ** | Floorline Firestopping | 4 lb./cu ft. mineral wool (e.g., Thermafiber) in each stud cavity and at each floorline – attached with Z-clips or equivalent |
| **II** | Cavity Insulation – Use either 1, 2, or 3 | 1. None<br>2. Fiberglass batt insulation (faced or unfaced)<br>3. Any noncombustible insulation (faced or unfaced) |
| **III** | Exterior sheathing applied over base wall system – Use either 1, 2, or 3 | 1. None<br>2. ½-inch thick, exterior type gypsum sheathing<br>3. ⅝-inch thick, Type X, exterior type gypsum sheathing |
| **IV** | Weather-resistive barrier applied to gypsum sheathing – Use either 1 or 2 | 1. None<br>2. Any shown in Table 2 |
| **V** | Exterior insulation | STYROFOAM™ Type IV or Type X per ASTM C578 – Total thickness to be a minimum of ½ inch to maximum of 3 inches when installed using Special Conditions (see below) |
| **VI** | Sealing of exterior insulation – Use either 1 or 2 | 1 – None<br>2 - Seal all exterior insulation joints and as an option veneer tie penetrations with either:<br>a) Dow LIQUIDARMOR™ – CM Flashing and Sealant – max. 60-mil wet thickness, max. 5-inch width<br>b) Dow LIQUIDARMOR™ – LT Flashing and Sealant – max. 35-mil wet thickness, max. 5-inch width<br>c) Acrylic, asphalt or butyl-based sealing tape – max. 4-inch width |
| **VII** | Exterior Sheathing applied over exterior insulation – Use either 1 or 2 | 1 – One layer of ⅝-inch thick, Type X gypsum sheathing.<br>2 – One layer of ⅝-inch thick DensElement™ sheathing – The joints of the DensElement™ sheathing may be sealed with R-Guard® FastFlash® Liquid Flashing or approved equivalent.<br>Note: Gypsum sheathing must be mechanically attached such that attachments are provided as a minimum, every 24 inches around the perimeter and in the field of the sheathing. |
| **VIII** | Water-resistive barrier applied on exterior sheathing that covers the XPS – Use either 1 or 2 | 1. None<br>2. See Exterior Veneer section for Water-resistive barriers allowed with specific veneers. |
| **IX** | Exterior Veneer – Use either 1, 2, 3, 4 or 5 | 1. Exterior veneers of noncombustible materials (e.g., precast concrete, stone, brick, steel, aluminum, etc.) The following veneers are allowed for use with water-resistive barriers in Table 3:<br>• Terracotta cladding – Use any terracotta cladding system in which terracotta is minimum 1¼-inch thick. Any standard installation technique can be used.<br>• Metal exterior wall panels or coverings such as steel, aluminum, zinc etc. Any standard installation technique can be used. |

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| | | • Brick - Standard nominal 4-inch thick, clay brick with brick veneer anchors – standard types – installed maximum 24 inches OC vertically on each stud. Air gap between exterior insulation and brick to be as per wall design.<br>• Stucco – Minimum ¾-inch thick, exterior cement plaster and lath. A secondary water-resistive barrier can be installed between the Exterior sheathing that is over the Exterior Insulation and the lath. The secondary water-resistive barrier shall not be full-coverage asphalt or butyl-based self-adhered membranes.<br>• Corium™ Thin brick system.<br>• Fiber-cement siding – minimum ¼-inch thick. Any standard installation technique can be used. A maximum 1½-inch air gap allowed behind the fiber-cement siding.<br>• 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.<br>• StoneLite natural stone wall panels by Stone Panels, Inc.<br>• Glen-Gery Thin Tech Elite Series – Masonry veneer<br>• Concrete or precast concrete panels – Minimum 1½-inch thick panel, with a 2-inch maximum air gap between exterior insulation and concrete panel. Any standard installation technique can be used.<br>• Ceramic tile (min. ⅜-in. thick) bonded using noncombustible mortar adhesive to minimum ½-in. thick cement board or gypsum sheathing.<br>• 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 exterior sheathing and the brick. The secondary water-resistive barrier shall not be full-coverage asphalt or butyl-based self-adhered membranes.<br>• 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 exterior sheathing and the stone. The secondary water-resistive barrier shall not be full-coverage asphalt or butyl-based self-adhered membranes<br>• Knight Wall Systems to include:<br>  ○ Terracotta cladding – Use any terracotta cladding system in which terracotta is minimum 1¼-inch thick. Any standard installation technique can be used.<br>  ○ Metal exterior wall panels or coverings such as steel, aluminum, zinc etc. Any standard installation technique can be used.<br>  ○ Brick - Standard nominal 4-inch thick, clay brick with brick veneer anchors – standard types – installed maximum 24 inches OC vertically on each stud. Air gap between exterior insulation and brick to be as per wall design.<br>  ○ Stucco – Minimum ¾-inch thick, exterior cement plaster and lath attached to minimum ½-inch thick backer board. A secondary water-resistive barrier can be installed between the exterior sheathing and the lath. The secondary water-resistive barrier shall not be full- |

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| | | coverage asphalt or butyl-based self-adhered membranes.<br>○ Corium™ Thin brick system.<br>○ 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.<br>○ StoneLite natural stone wall panels by Stone Panels, Inc.<br>○ Glen-Gery Thin Tech Elite Series – Masonry veneer<br>○ Concrete or precast concrete panels – Minimum 1½-inch thick panel, with a 2-inch maximum air gap between exterior insulation and concrete panel. Any standard installation technique can be used.<br>○ Ceramic tile (min. ⅜-in. thick) bonded using noncombustible mortar adhesive to minimum ½-in. thick cement board or gypsum sheathing.<br>○ 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 exterior sheathing and the brick. The secondary water-resistive barrier shall not be full-coverage asphalt or butyl-based self-adhered membranes.<br>○ 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 exterior/sheathing and the stone. The secondary water-resistive barrier shall not be full-coverage asphalt or butyl-based self-adhered membranes<br>• NCI Building Group to include:<br>○ PBR Panel (Exposed fasteners)<br>○ PBU Panel (Exposed fasteners)<br>○ AVP Panel (Exposed fasteners)<br>○ Designer™ Series Panels (Exposed fasteners)<br>○ ShadowRib™ Panels (Exposed fasteners)<br>○ NuWall® Panels (Exposed fasteners)<br>○ MasterLine 16 (Concealed fasteners)<br><br>2 – Exterior veneers of noncombustible materials (e.g., precast concrete, stone, brick, etc.) The following veneers are allowed for use with water-resistive barriers in Table 2:<br><br>1. Brick – Standard nominal 4-inch thick, clay brick. Brick veneer anchors – standard types – installed maximum 24 inches OC vertically on each stud. Air gap between exterior insulation and brick to be as per wall design.<br>2. Concrete – 2 inches thick or greater. Air gap between exterior sheathing over the exterior insulation and the concrete to be as per wall design. Any standard non-open-joint installation technique can be used.<br>3. Concrete masonry units – 4 inches thick or greater. Maximum 2-inch air gap between exterior insulation and CMU. |

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| | | 4. Stone Veneer – Minimum 2-inch thick, Limestone or natural stone veneer or minimum 1½-inch thick cast artificial stone veneer. Any standard non-open-joint installation technique such as ship-lap, etc., can be used.<br>5. Terracotta cladding – Use any terracotta cladding system in which terracotta is minimum 1¼-inch thick. Any non-open-joint installation technique such as ship-lap, etc. can be used.<br><br>3 – Exterior veneers of NFPA 285 complying MCM materials are allowed for use with water-resistive barriers shown in Table 3. Permitted veneer systems include:<br>• MCM panel systems – Use any Metal (steel, aluminum, etc.) Composite Material system. Any standard installation technique can be used. MCM panel systems such as:<br>○ CEI Composites R4000 System using Reynobond® FR ACM or Alpolic® FR ACM.<br>• Knight Wall System to include:<br>○ MCM System – Use any Metal Composite Material system that has been successfully tested by the panel manufacturer via the NFPA 285 test method. Any standard installation technique can be used. MCM panel systems such as:<br>○ CEI Composites R4000 System using Reynobond® FR ACM or Alpolic® FR ACM.<br><br>4 – High-Pressure Laminate (HLP) exterior veneers are allowed for use when the HPL veneer and the water-resistive barrier contemplated for use have been successfully tested together per NFPA 285<br><br>5 – Exterior veneers of NFPA 285 complying combustible materials are allowed for use when the combustible veneer and the water-resistive barrier contemplated for use have been successfully tested together per NFPA 285. |
| **REQ** | Special Conditions | Use header treatment shown in Figure 3 for all window and door openings in wall. |
| **NOT SHOWN** | Flashing of window, door and other exterior wall penetrations. | As an option, flash window, door and other exterior penetrations with either:<br>1. Dow LIQUIDARMOR™ – CM Flashing and seal any – max. 60-mil wet thickness, max. 12-inch width.<br>2. Dow LIQUIDARMOR™ – LT Flashing and seal any – max. 35-mil wet thickness, max. 12-inch width.<br>3. Limited amounts of acrylic, asphalt or butyl-based flashing tape – max. 12-inch width.<br>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. |

**Table 2 – Allowed Weather-resistive Barriers**

| Weather-resistive Barrier – Over Sheathing and Under Foam Insulation – Layer IV |
|---|
| **3M™** – 3M™ Self-Adhered Air and Vapor Barrier 3015 |
| **BASF –**<br>• Enershield HP<br>• Enershield I |
| **Carlisle –**<br>• CCW-705FR w/ Primers<br>• Barritech™ VP<br>• Barritech™ NP |
| **Cosella-Dörken –**<br>• Delta®-Foxx<br>• Delta®-Foxx Plus<br>• Delta®-Fassade S<br>• Delta®-Vent S/Plus<br>• Delta®-Maxx Plus |
| **Dow Chemical –**<br>• WeatherMate™<br>• WeatherMate™Plus |
| **Dow Corning®** - DefendAir 200 |
| **Dryvit** - Backstop® NT |
| **DuPont –**<br>• DuPont™ Tyvek® CommercialWrap®<br>• DuPont™ Tyvek® CommercialWrap® D<br>• DuPont™ Tyvek® ThermaWrap™<br>• DuPont™ Tyvek® Fluid Applied WB+ – nominal 25 wet mil thickness |
| **Henry Company –**<br>• Air-Bloc® 32MR<br>• Air-Bloc® 31MR<br>• Air-Bloc® 33MR<br>• BlueskinVP™ 160<br>• Air-Bloc® 21 FR<br>• Metal Clad™<br>• Foilskin® |
| **Hohmann & Barnard –**<br>• Enviro-Barrier™<br>• Enviro-Barrier™ VP |
| **JX Nippon ANCI, Inc.**<br>• JX ALTA Commercial Wrap<br>• JX Alta HP Wrap<br>• JX ALTA LP Wrap |
| **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 |

| Weather-resistive Barrier – Over Sheathing and Under Foam Insulation – Layer IV |
|---|
| **Momentive Performance Materials –**<br>• GE SEC2500 SilShield* AWB<br>• GE SEC2600 SilShield* AWB<br>• GE SEC2600-R SilShield* AWB |
| **Polyguard Products –**<br>• Airlok Flex® applied at a maximum 40 mils WFT<br>• Airlok Flex® WG applied at a maximum 20 mils WFT<br>• Airlok Flex® VP applied at a maximum 32 mils WFT |
| **Sto Corp –**<br>• Sto Gold Coat® with StoGuard Fabric<br>• Sto Emerald Coat® with StoGuard Fabric<br>• Sto ExtraSeal™ w StoGuard Mesh |
| **STS, Inc. -** Wall Guardian™ FW-100A |
| **VaproShield –**<br>• WallShield®<br>• WrapShield®<br>• RevealShield™<br>• RevealShield SA™ |
| **W.R. Grace –**<br>• Perm-A-Barrier® NPL<br>• Perm-A-Barrier® VPL<br>• Perm-A-Barrier® VPS<br>• Perm-A-Barrier® Aluminum Wall Membrane |
| **W.R. Meadows –**<br>• Air-Shield™ LMP (Gray)<br>• Air-Shield™ LMP (Black)<br>• Air-Shield™ TMP<br>• Air-Shield™ LSR |

**Note:** all barriers to be installed at indicated or recommended application rates and per manufacturer's installation instructions.

**Table 3 – Allowed Weather-resistive Barriers**

| Weather-resistive Barrier – Over Sheathing and Under Veneer – Layer VIII |
|---|
| **3M™** – 3M™ Self-Adhered Air and Vapor Barrier 3015 |
| **Carlisle –**<br>• Barritech™ VP<br>• Barritech™ NP |
| **Cosella-Dörken –**<br>• Delta®-Foxx<br>• Delta®-Foxx Plus<br>• Delta®-Fassade S<br>• Delta®-Vent S/Plus<br>• Delta®-Maxx Plus |
| **Dow Chemical –**<br>• WeatherMate™<br>• WeatherMate™Plus |
| **Dryvit** - Backstop® NT |
| **DuPont –**<br>• DuPont™ Tyvek® CommercialWrap®<br>• DuPont™ Tyvek® CommercialWrap® D<br>• DuPont™ Tyvek® ThermaWrap™ |
| **Henry Company –**<br>• Air-Bloc® 31MR |
| **Hohmann & Barnard –**<br>• Enviro-Barrier™ VP |
| **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 |
| **Momentive Performance Materials –**<br>• GE SEC2500 SilShield* AWB<br>• GE SEC2600 SilShield* AWB<br>• GE SEC2600-R SilShield* AWB |
| **Sto Corp –**<br>• Sto ExtraSeal™ w StoGuard Mesh |
| **STS, Inc.** - Wall Guardian™ FW-100A |
| **VaproShield –**<br>• WallShield®<br>• WrapShield®<br>• RevealShield™<br>• RevealShield SA™ |
| **W.R. Grace –**<br>• Perm-A-Barrier® NPL<br>• Perm-A-Barrier® VPL<br>• Perm-A-Barrier® VPS |

| Weather-resistive Barrier – Over Sheathing and Under Veneer – Layer VIII |
|---|
| **W.R. Meadows –**<br>• Air-Shield™ LMP (Gray)<br>• Air-Shield™ LMP (Black)<br>• Air-Shield™ TMP<br>• Air-Shield™ LSR |

**Note:** all barriers to be installed at indicated or recommended application rates and per manufacturer's installation instructions.

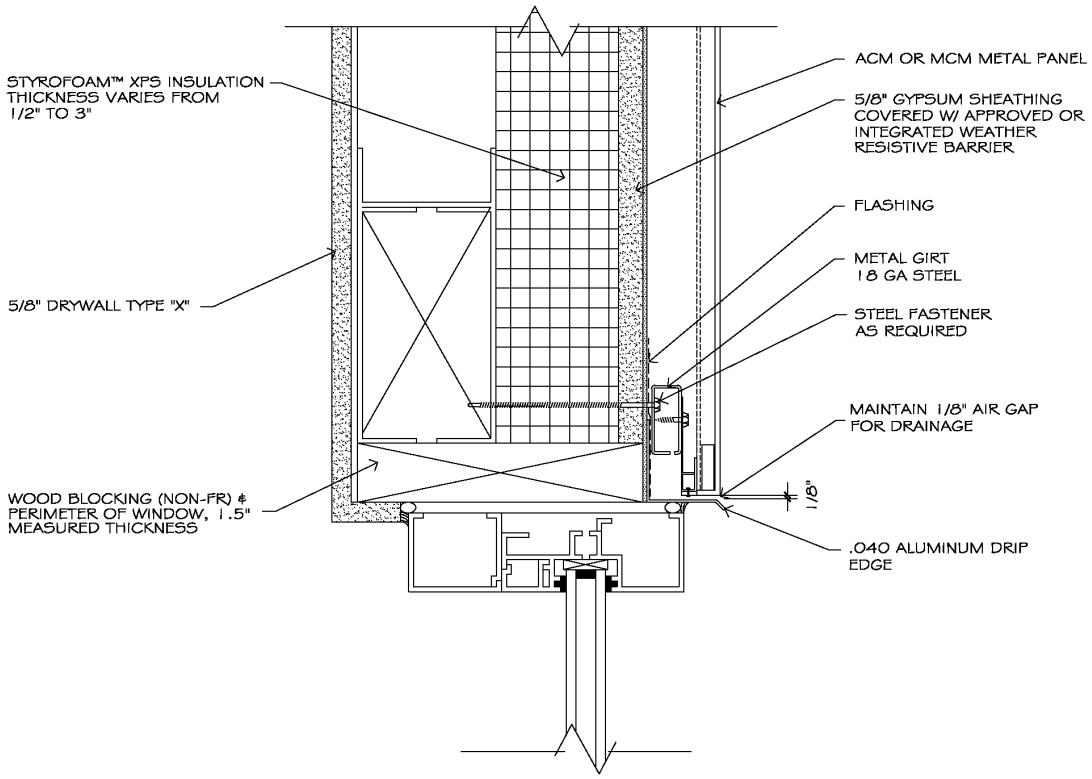


**Figure 3**