

# Tech Solutions 513.0

## DuPont™ Thermax™ Wall System

This document presents an overview of issues facing designers today, particularly concerning steel stud wall construction. It describes how the DuPont™ Thermax™ Wall System addresses these challenges offering designers a streamlined, high performing wall assembly. This guide includes general design considerations for steel stud walls, details on extensive testing that has been conducted on the Thermax™ Wall System and sequencing guidelines.



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## INTRODUCTION

For more than 100 years, light gauge steel framing has been an important and growing part of the commercial wall construction market. Steel frame construction is light, strong, adaptable and consistent in tolerance and properties. The multitude of sizes and shapes of steel framing members far exceeds the number of wood-based options, enhancing the advantages of steel stud construction by offering designers and contractors versatility, along with saving time and money.

Among the many types of steel frame wall systems, one assembly style is most common: 3-1/2" to 6" deep steel framing members placed on 16" centers (Figure 1). Exterior gypsum is then attached to the outside framing surface; fiberglass batts are installed between the steel members; a sheet vapor retarder is added; and an interior sheathing of gypsum board is attached after the wiring and plumbing are installed. Often, an air/water-resistive barrier is installed over the exterior gypsum. Finally, an exterior finish is added – typically brick, architectural panels or some other aesthetic covering.

A wall assembly that uses the DuPont™ Thermax™ Wall System, featuring continuous insulation and fluid applied joint treatment, eliminates the need for batt insulation, exterior gypsum and a separate air/water-resistive barrier (Figure 2). With the Thermax™ Wall System, once the steel framing members are in place, **DuPont™ Thermax™ Brand Exterior Insulation** is attached to the outside framing surface, followed by **DuPont™ LiquidArmor™ Flashing and Sealant** and veneer steel stud ties. Spray polyurethane foam (SPF) can then be applied as an optional component to the interior of the stud cavity for additional air sealing and R-value.

### Thermax™ Wall System

DuPont's Thermax™ Wall System warranty tiers enable warranty coverage for a broad array of common building practices. Visit <https://www.dupont.com/building/us-canadian-construction-warranties.html> for more information.

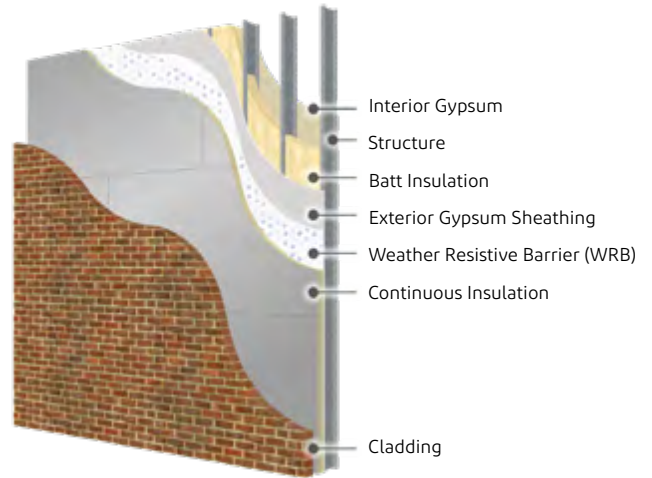


Figure 1: Typical Steel Stud Wall Assembly

### DuPont™ Thermax™ Wall System

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More than an insulated wall, the Thermax™ Wall System eliminates the need for batt insulation, gypsum and separate air/water resistive barrier and is a systematic approach to achieving efficiency at every level: simplified design, streamlined construction and reduced energy consumption. The three-in-one system includes insulation, and fluid applied joint treatment, and meets all applicable IBC and ASHRAE 90.1 requirements.

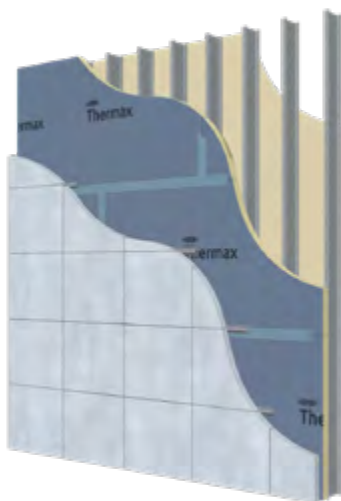


Figure 2a: Gold Warranty

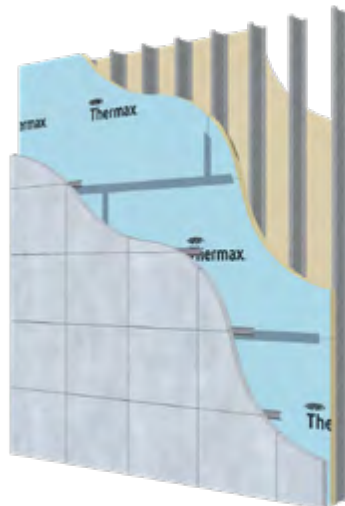


Figure 2b: Silver Warranty

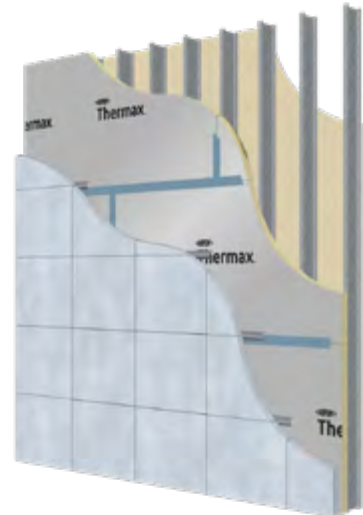


Figure 2c: Bronze Warranty

## ENERGY EFFICIENCY AND SUSTAINABILITY

### Energy Efficiency

The DuPont™ Thermax™ Wall System reduces the energy associated with heating and cooling the building and contributes to reduction in greenhouse gas emissions.

Energy, and optimizing its use in buildings, is one of the most important issues facing designers. Excessive heat flow through steel framed walls has long-term consequences for both the building owner and society at large as commercial buildings require vast amounts of energy. In fact, the U.S. Department of Energy reports 19 percent of all energy consumed in the United States is used in commercial buildings. The Thermax™ Wall System will continue to conserve energy through the life of a building with no additional maintenance during its use and requires no extra energy or utilities to operate over its useful life. The Thermax™ Wall System reduces the energy associated with heating and cooling the building and contributes to reduction in greenhouse gas emissions.

### Sustainability, LEED and EPDs

DuPont™ Thermax™ Brand insulation products save far more energy than it takes to manufacture. The long, useful life expectation as an insulation material makes Thermax™ a strong choice for commercial buildings maintaining a high level of building envelope performance.

**Thermax™ Brand Exterior Insulation (ci)** used in the Thermax™ Wall System can also be effectively recovered and re-used as both exterior or interior insulation products with minimal performance loss provided the material has not undergone significant physical damage beyond normal handling and wear-and-tear from weathering.

DuPont is committed to using resources more efficiently, providing value to our customers and stakeholders, delivering solutions for customer needs and enhancing the quality of life for current and future generations. To enable this, DuPont has



set sustainability goals since 1995 and publishes annual sustainability reports about the company's commitment to sustainability with regard to responsible use of land and resources; along with a commitment to implementing best practices and standards in all our manufacturing processes.

In addition to regular reporting on our commitments, DuPont participates in UL Certified Environmental Product Declarations (EPD). Third-party verified EPD reports and Life-cycle analyses are available for DuPont™ Styrofoam™ Brand and Thermax™ Brand products, contributing to MR credits within LEED v4.

The Thermax™ Wall System reduces the energy associated with heating and cooling the building, and contributes to reduction in greenhouse gas emissions.

### LEED Credits

The DuPont™ Thermax™ Wall System can help design professionals achieve credits in the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) program. Relevant credits include, but may not be limited to:

- EA Prerequisite (Minimum Energy Performance)
- EA Prerequisite (Optimize Energy Performance)
- EQ (Thermal Comfort)
- MR in LEED v4 (Life-cycle impact reduction, Environmental product Declaration, Sourcing of Raw Materials, Material Ingredients)
- ID (Innovation in Design)
- Regional Priority in LEED v4

To learn how the Thermax™ Wall System can contribute to LEED points for new construction and major renovations, read the Thermax™ Wall System and LEED information sheet at: [www.thermaxwallsystem.com](http://www.thermaxwallsystem.com). For more information on LEED, visit [www.usgbc.org](http://www.usgbc.org).

### The Thermax™ Wall System contributes to:

- ASHRAE 189.1
- International Green Construction Code
- NAHB Green Building Standard (ICC 700)

As shown in the EPD, the ratio of the energy saved over an assumed 60-year life of a small office building in the United States versus the energy usage used to produce Thermax™ Brand Exterior Insulation components ranges between 15 for southern climates and 28 for Northern climates, meaning that the energy saved is 15 to 28 times greater than the energy used to produce the product. For additional information see our case study and Thermax™ EPD on the UL website.

## THERMAL PERFORMANCE OF STEEL STUD WALLS

Thermal performance is really about minimizing energy use. Achieving desired thermal performance from a steel stud wall requires an understanding of how heat moves through such a wall. The key is in understanding the thermal properties of steel and how this affects the thermal properties of the wall system as a whole.

### Properties of Steel and the Effect on Walls

Steel is a very good conductor of heat. The R-value\* of steel varies with its precise makeup, but a representative value is about R-0.003 per inch according to the ASHRAE Handbook of Fundamentals. Figure 3 shows how the R-value of steel compares with other selected construction materials. (Note that the R-value of steel is so low that does not register on an R-value scale for common building materials).

The very low R-value of steel means that heat moves through it almost effortlessly. Even small amounts of steel can transport large amounts of heat from one place to another. This property has serious consequences in the real-world performance of steel stud walls. Typical steel stud wall design places batt insulation between the studs, which are then sheathed with other low R-value materials like gypsum board.

\*\* R means resistance to heat flow. The higher the R-value, the greater the insulating power. R-values are expressed in ft<sup>2</sup>·h<sup>2</sup>·F/Btu. R-value determined by ASTM C518.

The groundbreaking DuPont™ Thermax™ Wall System combines three simple parts – insulation, air barrier and flashing – into a system that achieves exceptional results.

This results in an uneven thermal resistance distribution over the wall. The steel studs act as thermal short circuits, where heat moves rapidly around the batt insulation, reducing the system's thermal performance (Figure 4).

ASHRAE 90.1 has tabulated both measured and calculated effective R-values for a variety of steel stud configurations, which reveals the actual effective thermal performance of batt insulation compared to its claimed R-value (Figure 5).

The data clearly show that adding more insulation between the studs does not significantly improve effective thermal performance, nor does increasing the stud size (from 3-1/2" to 6") or stud spacing (from 16" to 24"). Currently it is physically impossible to design a steel stud wall system with a system R-value over R-10 using only batt insulation in the stud cavity.

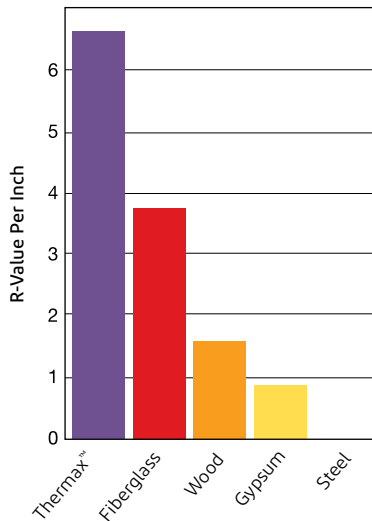


Figure 3: R-Values of Common Materials

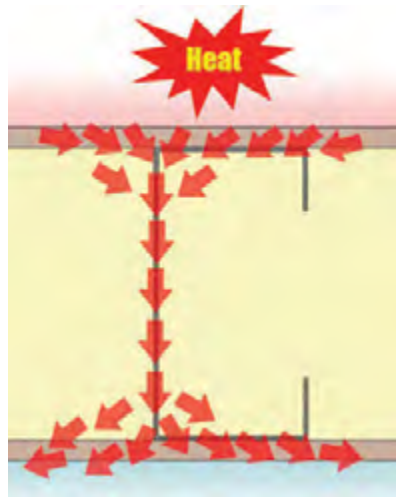


Figure 4: Steel Studs Act as Thermal Short Circuits

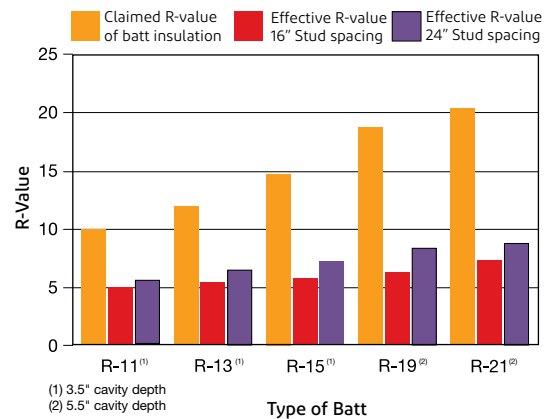


Figure 5: Effective R-Values of Batts at 16" and 24"

### Improving Performance with “ci”

The thermal performance of a steel stud wall can be improved with proper placement of the insulation. Insulation placed on the steel studs – rather than between them – will reduce thermal shorts in the system, resulting in better thermal performance.

When installed on the exterior of the studs, **DuPont™ Thermax™ Brand Exterior Insulation (ci)** provides an effective means of improving thermal performance in a steel stud wall, notably reducing thermal shorts. With the use of **Thermax™ Brand Exterior Insulation (ci)**, the thermal performance for the Thermax™ Wall System can easily achieve R-16 or more (Figure 6).

### Meeting Energy Codes

The International Energy Conservation Code (IECC) published by the International Code Council (ICC) specifies two possible routes to meet code-required energy performance in commercial buildings:

1. The Energy Efficiency Guidelines in Chapter 5 of the IECC
2. ASHRAE 90.1, “Energy Standard for Buildings Except for Low-Rise Residential Buildings”

Wall assemblies that incorporate the DuPont™ Thermax™ Wall System can easily meet or exceed these energy code

requirements. The energy code is changing for steel stud wall assemblies in recognition of the dramatic thermal short heat paths provided by the steel studs and are continuing to require increasing insulation. The changes require higher prescriptive levels of continuous insulation (ci) as a method to reduce the effect of thermal shorts and increase the energy efficiency and sustainability of the building (Table 1).

The prescriptive path to meeting the requirements outlines specific configurations for the various geographic locations or zones that must be used to meet the code requirements for walls, roofs and fenestrations (Figure 7).

In Table 1, the prescriptive R-Values for metal framed walls in each climate zone is tabulated for various versions of the Energy Code. The number designated with “ci” indicates the R-value of the continuous layer of insulated sheathing applied over the steel studs. For example, ASHRAE 90.1-2013 in Zone 5 calls for R-13 batt insulation between the studs and a layer of R10.0 continuous insulation over the studs. Table 2 lists the ASHRAE 90.1-2010 and 2013 requirements as well as the resulting U-factor and total R-value for the Thermax™ Wall System assembly.

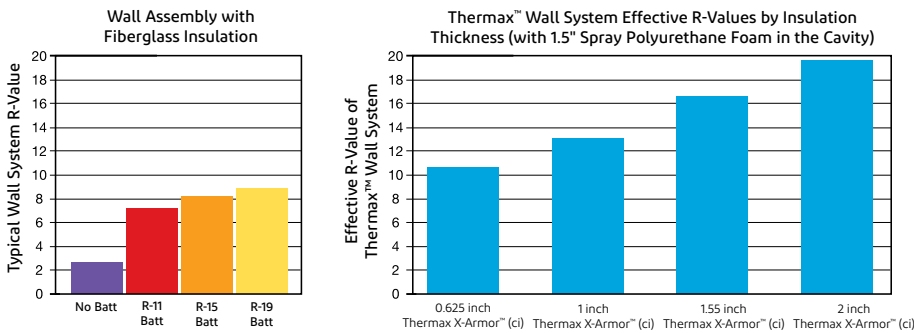


Figure 6: Effective System R-Values<sup>1</sup> for Steel Stud Walls

<sup>1</sup> System R-value includes other wall assembly components, such as interior gypsum and exterior sheathing.

Thermax™ Wall System can reduce thermal shorts, notably improving the performance of a steel stud wall, saving energy and money for the life of the building.

**Table 1: Changes To Prescriptive Insulation Requirements For Non-Residential Steel Stud Wall Assemblies**

Code	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8
2015 IECC	R13+5ci	R13+5ci	R13+7.5ci	R13+7.5ci	R13+7.5ci	R13+7.5ci	R13+7.5ci	R13+7.5ci
ASHRAE 90.1-2013	R-13	R-13+3.8ci	R-13+5ci	R-13+7.5ci	R-13+10ci	R-13+12.5ci	R-13+12.5ci	R-13+18.8ci
2012 IECC	R13+5ci	R13+5ci	R13+7.5ci	R13+7.5ci	R13+7.5ci	R13+7.5ci	R13+7.5ci	R13+7.5ci
ASHRAE 90.1-2010	R-13	R-13	R-13+3.8ci	R-13+7.5ci	R-13+7.5ci	R-13+7.5ci	R-13+7.5ci	R-13+7.5ci
2009 IECC/ ASHRAE 90.1-2007	R-13	R-13	R-13+3.8ci	R-13+7.5ci	R-13+7.5ci	R-13+7.5ci	R-13+7.5ci	R-13+7.5ci

**Table 2a: Meeting ASHRAE 90.1-2010 Building Envelope Requirements**

Climate Zone	Nonresidential Requirements <sup>2</sup> Steel Frame	Thermax™ Brand Insulation Thickness Required and Resulting U-Factor	Residential Requirements <sup>4</sup> Steel Frame	Thermax™ Brand Insulation Thickness Required and Resulting U-Factor
0	R-13 U= 0.124; R= 8.06	1.55" R-10.1; U-0.099	R-13 U= 0.124; R= 8.06	1.55" R-10.1; U-0.099
1	R-13 U= 0.124; R= 8.06	1.55" R-10.1; U-0.099	R-13 U= 0.124; R= 8.06	1.55" R-10.1; U-0.099
2	R-13 U= 0.084; R= 11.90	2" R-13; U-0.077	R-13 + 7.5 ci U= 0.064; R= 15.63	2.5" R-17.3; U-0.058
3	R-13 + 3.8 ci U= 0.084; R= 11.90	2" R-13; U-0.077	R-13 + 7.5 ci U= 0.064; R= 15.63	2.5* R-17.3; U-0.058
4	R-13 + 7.5 ci U= 0.064; R= 15.63	2.5" R-17.3; U-0.058	R-13 + 7.5 ci U= 0.064; R= 15.63	2.5* R-17.3; U-0.058
5	R-13 + 10 ci U= 0.055; R= 18.18	3.5" R-21; U-0.048	R-13 + 10 ci U= 0.055; R= 18.18	3.5" R-21; U-0.048
6	R-13 + 12.5 ci U= 0.049; R= 20.41	3.5" R-21; U-0.048	R-13 + 7.5 ci U= 0.064; R= 15.63	3.5" R-21; U-0.048
7	R-13 + 12.5 ci U= 0.049; R= 20.41	3.5" R-21; U-0.048	R-13 + 15.6 ci U= 0.042; R= 23.8	4" R-24; U-0.042
8	R-13 + 18.8 ci U= 0.037; R= 27.03	4.25** R-27.8; U-0.036	R-13 + 18.8 ci U= 0.037; R= 27.0	4.25** R-27.8; U-0.036

\*Assembly U-factor is calculated with 5/8" interior gypsum on 6" steel stud with empty cavity and indicated thickness of Thermax™ Brand Insulation.

**Table 2b: Meeting Ashrae 90.1-2013 Building Envelope Requirements For U.S. Climate Zones Using The Thermax™ Wall System**

Climate Zone	Nonresidential Requirements	Thermax™ XARMOR™ (ci) Thickness Required and Resulting U-Factor	Residential Requirements	Thermax™ XARMOR™ (ci) Thickness Required and Resulting U-Factor
1	R-13 U= 0.124; R= 8.06	2"	R-13 U= 0.124; R= 8.06	2"
2	R-13 + 3.8 ci U= 0.084; R= 11.90	2.75"	R-13 + 7.5 ci U= 0.064; R= 15.63	3.5"
3	R13+5 U=0.077; R=TBD	3"	R-13 + 7.5 ci U= 0.064; R= 15.63	3.5"
4	R-13 + 7.5 ci U= 0.064; R= 15.63	3.5"	R-13 + 7.5 ci U= 0.064; R= 15.63	3.5"
5	R13+10 ci U=0.055; R=TBD	3.75"	R13+10 ci U=0.055; R=TBD	3.75"
6	R13+12.5 ci U=0.049; R=TBD	4.25"	R13+12.5 ci U=0.049; R=TBD	4.25"
7	R13+12.5 ci U=0.049; R=TBD	4.25"	R-13 + 15.6 ci U= 0.042; R= 23.8	4.5" + 0.625"
8	R13+18.8 ci U=0.037; R=27.0	4.5" + 1"	R-13 + 18.8 ci U= 0.037; R= 27.0	4.5" + 1"

<sup>1</sup> The ASHRAE commercial nonresidential requirements are used as the baseline for Thermax™ Wall System.

<sup>2</sup> All occupancies other than residential

<sup>3</sup> Includes 1.5" layer of Styrofoam™ Brand SPF (CM Series)

<sup>4</sup> Spaces in buildings used primarily for living and sleeping. Residential spaces include, but are not limited to, dwelling units, hotel/motel guest rooms, dormitories, nursing homes, patient rooms in hospitals, lodging houses, fraternity/sorority houses, hostels, prisons and fire stations.



## “R U” Confused?

Component R-values or Assembly U-factor. Which is a more accurate measurement of thermal performance? Adding together component R-values does not result in an accurate wall system R-value. For example, heat moves around the batt insulation, reducing its effect on the overall wall system. Scientific measurements of whole wall systems have shown that R-13 batt insulation in 16” o.c. walls adds only R-5.3 to the assembly. However, the U-factor is a measure of heat transmission through the entire assembly, therefore, the U-factor is more important when considering overall thermal performance. The lower the U-factor, the more energy-efficient the wall assembly.

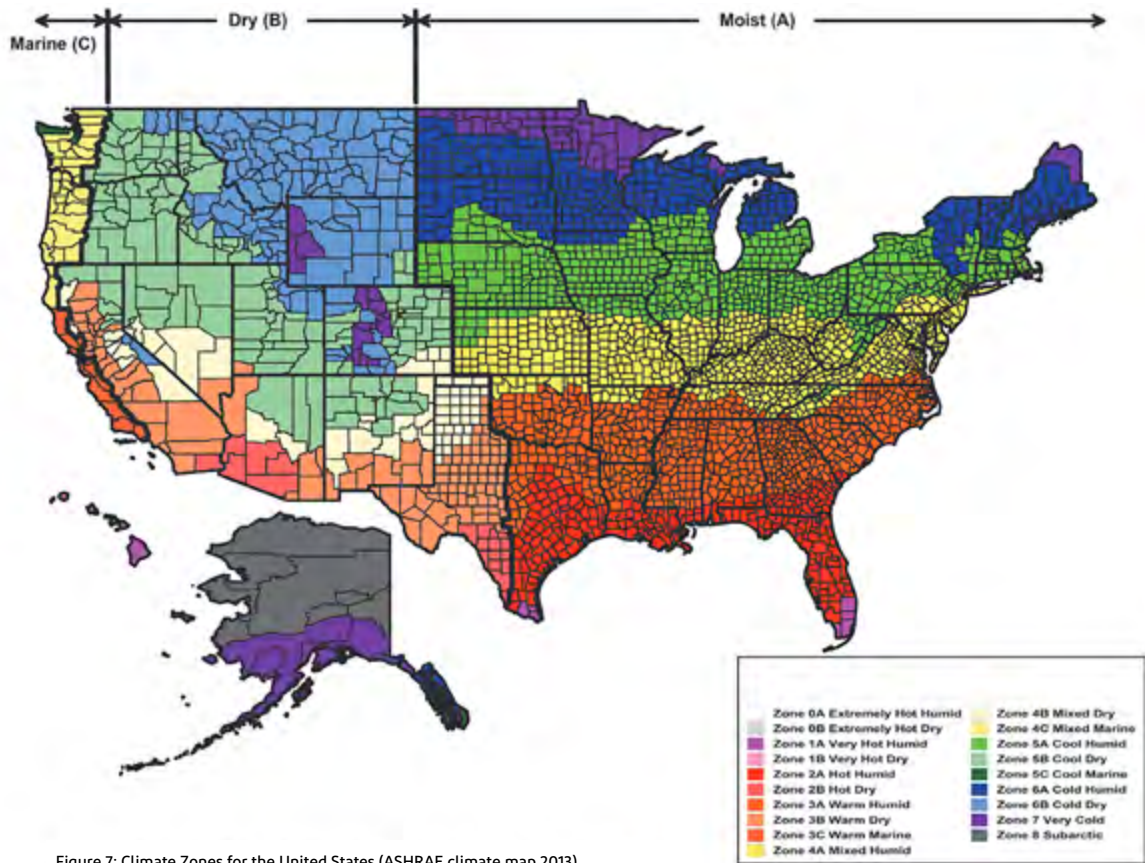


Figure 7: Climate Zones for the United States (ASHRAE climate map 2013)

### Approvals – The DuPont™ Thermax™ Wall System meets the following building codes and standards:

- ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings
- International Building Code (IBC) and the International Energy Conservation Code (IECC)
- ASTM E84 (Class A) – Standard Test Method for Surface Burning Characteristics of Building Materials
- ASTM E330 – Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference
- ASTM E331 – Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors and Curtain Walls by Uniform Static Air Pressure Difference
- ASTM E2357 – Standard Test Method for Determining Air Leakage of Air Barrier Assemblies
- NFPA 285 – Standard Fire Method for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components Using the Intermediate-Scale, Multistory Test Apparatus



Designers are not strictly confined to the specific steel stud configurations for each zone. Wall systems can comply if they meet the resulting U-factor for the specific configuration as indicated in the standard’s Appendix A: ASHRAE 90.1 5.5.3(b) Maximum *U-Factor, C-Factor or F-Factor* for the entire assembly. The values for typical construction assemblies listed in Normative Appendix A shall be used to determine compliance.

As long as designers maintain the same or lower U-factor for a proposed wall assembly as is achieved by the specific wall configuration prescribed for the same zone using the methods outlined in Appendix A, the proposed wall assembly will meet the requirements of ASHRAE 90.1-2010 and 90.1-2013.

**AIR INFILTRATION IN STEEL STUD WALLS**

While insulation is the primary way to increase a building’s energy efficiency and to manage heating and cooling costs, it is important to consider another cause of significant energy loss – air infiltration. Air sealing the wall assembly creates a tighter building, which helps optimize energy savings, manage moisture intrusion, reduce demand on the heating and cooling system, and minimize the carbon footprint.

**Spray Foam Test Results**

To address the high cost of air infiltration, most regions of the United States have air barrier requirements for commercial walls. The DuPont™ Thermax™ Wall System has passed ASTM E2357 “Standard Test Method for Determining Air Leakage of Air Barrier Assemblies,” a standard in the industry that has strong support from industry associations such as the Air Barrier Association of America and the U.S. Department of Energy.

Unlike air barrier material tests, ASTM E2357 tests the air leakage of an 8’ x 8’ wall assembly. The test involves two walls – an opaque wall and a penetrated wall. The standard specifies that penetrations meet specific requirements for size, type and location. The walls are tested for air leakage and are then subjected to a series of wind loadings. They are then tested again for air leakage. The wind loadings begin with sustained positive and negative pressure for one hour, followed by 2,000 cycles of combined positive and negative wind loading, and finally, 3-second gust loading at 25.08 psf maximum.

Following the required test standard parameters, the Thermax™ Wall System was subjected to extreme wind loading conditions – beyond the force of Hurricane Katrina – to demonstrate the assembly’s strength and integrity. To pass this test, the air leakage rate following the test must be below the required level, and there must be no evidence of cracks, buckles or visible damage of any kind. The extreme loading (10-second loading both positive and negative forces) was performed on the opaque and penetrated systems to a pressure >130 psf with no visible signs of damage. Results are given in Table 3.

**Styrofoam™ Brand Sill Seal Foam Gasket**

Another air sealing product from DuPont is an excellent choice for steel stud wall assemblies. **Styrofoam™ Brand Sill Seal Foam Gasket** is a flexible polyethylene foam gasketing strip that can help reduce air infiltration between a concrete foundation and sill plate, around windows and doors – and even between floors. The closed-cell polyethylene foam compresses to seal gaps in irregular surfaces, helping reduce air infiltration for a tighter building envelope and enhanced energy savings. It provides excellent and enduring resistance to water and water vapor.

**Table 3: ASTM E2357 Test Results For The Thermax™ Wall System**

Opaque Wall	Test Pressure	Before Loads	After Sustained, Cycled and Gust Loading
Infiltration	6.27 psf	<0.01 cfm/ft²	<0.01 cfm/ft²
Exfiltration	6.27 psf	<0.01 cfm/ft²	<0.01 cfm/ft²
Penetrated Wall	Test Pressure	Before Loads	After Sustained, Cycled and Gust Loading
Infiltration	6.27 psf	<0.01 cfm/ft²	<0.01 cfm/ft²
Exfiltration	6.27 psf	<0.01 cfm/ft²	<0.01 cfm/ft²

## MOISTURE CONSIDERATIONS

### Moisture Condensation in Steel Stud Walls

Moisture damage to wall systems can be expensive for both owners and designers. Moisture condensation in a wall system (as opposed to bulk water intrusion from leaks) is an insidious means by which moisture damage can occur. There are many methods to help reduce moisture problems caused by condensation. The first step to selecting the right method for a given steel stud wall system is to understand how condensation works.

### Principles of Condensation

Condensation is the change of water vapor into liquid water. The temperature at which this change occurs is the dew point. Condensation occurs when the temperature of the air holding the water vapor is lowered to the dew point temperature. Cold temperatures increase the likelihood of condensation; warm temperatures reduce it.

### Controlling Condensation in Steel Stud Walls

Adjusting the permeability of the layers in a wall assembly can help manage moisture. But this is not the only method.

Since condensation is caused by temperature changes, an efficient method for controlling condensation is to control the temperature within the wall assembly with the proper application of thermal insulation. Thermal insulation not only helps reduce heat flow, it also changes the temperature gradient in the wall. Proper placement of the right amount of insulation can dramatically reduce the potential for condensation in a steel stud wall. A typical steel stud wall consists of steel studs with batt insulation in the stud cavity. The outside surface of the steel stud assembly is typically faced with exterior gypsum with a brick exterior fascia. Figure 9 shows the temperature of the interior surface of the exterior gypsum when it is analyzed with the conditions of 70°F and 35 percent relative humidity on the inside and 0°F and 80 percent relative humidity on the outside.

In Figure 8, the interior surface of the exterior gypsum is 12°F. At this low temperature, the potential for condensation of any

An efficient method for controlling condensation is to control the temperature within the wall assembly with the proper application of thermal insulation. A typical steel stud wall using batt insulation has a higher chance for condensation creating potential moisture problems in the wall cavity.

water vapor that reaches this surface is very high. Sealing the cavity with low permeance materials like polyethylene film is a possible solution, but it demands excellent installation and the wall will forever be dependent on the film's quality. In addition, the thermal performance of this solution is not very good. The entire system will have an effective R-value of about R-9.31, far less than the R-13 anticipated from the installation of batt insulation in the cavity.

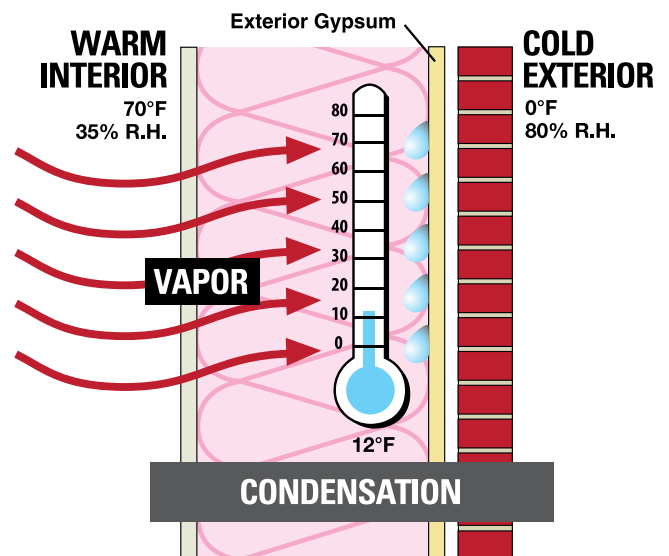


Figure 8: Temperature within a Typical Steel Stud Wall

## REDUCING CONDENSATION IN STEEL STUD WALLS

### Drying Potential

A related issue to condensation is evaporation, or drying potential. Drying potential is important as it plays a role in the ability of a wall assembly to dry out if bulk water intrusion (e.g., a leak) has occurred. Many experts often discuss drying potential as it relates to water vapor permeability, but rarely discuss the relationship between drying potential and temperature. Temperature has a very strong effect on drying potential: The warmer the surface, the more rapidly it will dry. Unlike a typical steel stud wall assembly, the DuPont™ Thermax™ Wall System provides a warm, conditioned cavity, which allows water that enters the cavity to evaporate quickly.

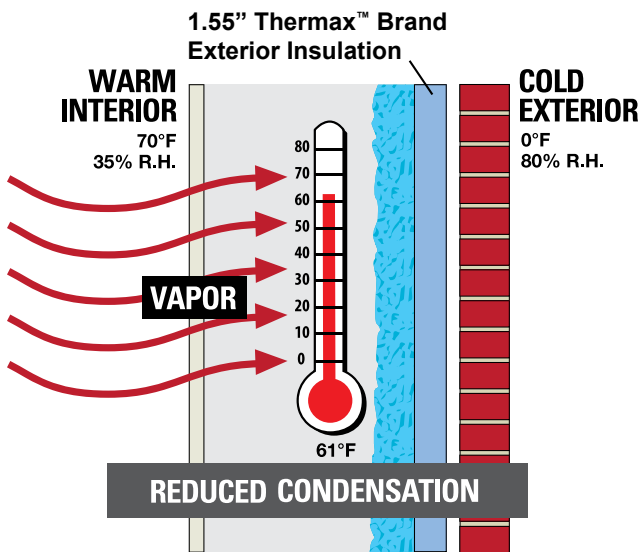


Figure 9: Temperature Within a Steel Stud Wall With 1.55" Thermax XARMOR™ (ci) Exterior Insulation.

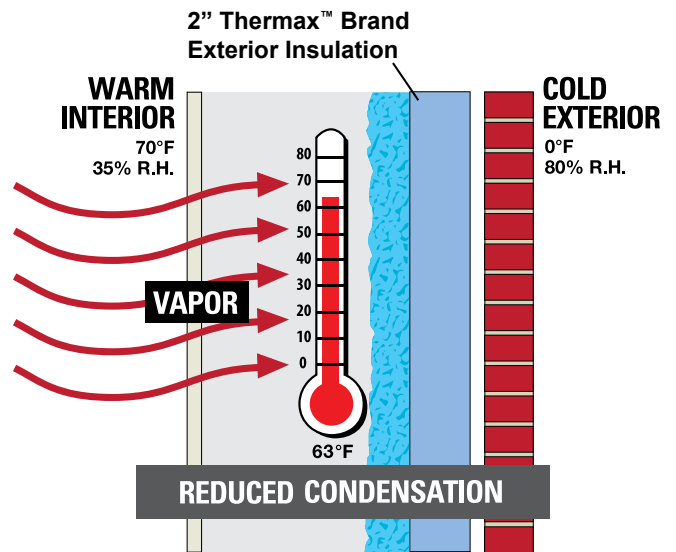


Figure 10: Temperature Within a Steel Stud Wall With 2" Thermax XARMOR™ (ci) Exterior Insulation.

The wall's performance can be improved even more by using 2" thick Thermax™ Brand Exterior Insulation (Figure 10). The temperature of the insulation's interior surface has been increased to 63°F. The cavity is now essentially a conditioned

space and the chance for condensation is near zero. This increase in the thickness of Thermax™ Brand Exterior Insulation results in a total effective R-value of R-19.7.

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## DESIGN CONSIDERATIONS

### Structural Considerations for Steel Stud Wall Design

Steel stud wall construction requires lateral bracing in order to effectively transfer wind and seismic loads to the studs and from there to the primary structural components of the building. The system of studs braced effectively will also resist twisting motion from the applied load according to the engineered design. International Building Code (IBC) Chapter 22, covering the use of steel in commercial construction, requires that the lateral bracing design follow the recommended design practice provided by the American Iron and Steel Institute (AISI). Out-of-plane (or suction/transverse) loads must also be considered and will be discussed briefly.

### AISI All-Steel Bracing Design Method

The AISI All-Steel Method is the recommended bracing practice for the DuPont™ Thermax™ Wall System based on both structural and building sequencing factors.

The all-steel method is a bracing design that uses horizontal or diagonal steel members that are attached through the center of a stud space via cutouts or on the face of the stud on the interior and exterior. Combinations of these techniques are commonly used and can be mixed to account for openings and other design situations. A large variety of products are available for bracing designs.

Many steel stud manufacturers also produce accessory lines that include bracing products. Some steel stud manufacturers provide guidance and recommendations on designs for common wall designs.

All-steel method designs ignore bracing contributions from the rigid sheathing and stand alone to provide lateral bracing strength to the structure. It is understood that the addition of rigid sheathing to the surface of the studs will aid in bracing the wall when initially installed; but what is not clearly understood is how to design for a reduction in this value due to wind loading on the wall that causes the rigid sheathing to hollow out around the mechanical fasteners.

This technique allows greater flexibility in the types of sheathing products that can be used in a steel stud wall design. It also allows for greater flexibility in determining when interior drywall is installed – a benefit that buys time for other trades to complete work in the stud cavity before it is enclosed.

By using all-steel bracing, foam plastic insulation can be placed outboard of the studs. This continuous thermal break provides a great energy benefit.





### Use of Foam Plastic Insulation in Wall Construction

Two methods are common for using foam plastic insulation as a component of steel stud walls: installing foam in the cavity space to replace or supplement the fiberglass often used in this space and installing foam outboard of the primary framing.

Installing foam plastic insulation in the stud cavity space is useful when insulation outboard of the stud is not possible due to space considerations or when a direct replacement for fiberglass is desired. In many cases, this interior solution is used on an exterior single-wythe masonry wall, and the stud space is created by Z-furring as part of a finished gypsum interior wall. Either rigid foam plastic insulation or spray polyurethane foam plastic insulation may be used.

### Transverse Loading

A final consideration for bracing of cavity wall construction is transverse loading that would tend to pull the veneer away from the primary framing unless anchored appropriately.

The IBC Chapter 14 (Exterior Walls) requires that the veneer (brick or other material) be connected directly to the stud on a regular grid horizontally and vertically. Review the recommended veneer-tie products for this application on page 19. The manufacturer can provide further information on the spacing required (generally every 16" on center). Alternate veneers should be designed with attachment points to meet these requirements.

### Fire Design Considerations for Steel Stud Walls Using Foam Plastic Insulation

To meet energy code requirements (refer to ASHRAE 90.1 and the IECC) for conditioned buildings, steel stud designs need insulation. Foam plastic insulation is frequently incorporated into commercial wall designs as a single component or in combination with other insulation products to meet insulation U-factor requirements. When specified for a steel stud project, foam plastic insulation and the full wall assembly design must first comply with several requirements in order to be used successfully. See the 'Seven Elements of 2018 IBC Chapter 26' on page 14.

When installed on the exterior of the studs, foam plastic insulation can provide a full thermal break from the interior to the exterior of a structure. This is a common installation for anchored veneer masonry and steel stud cavity wall construction.

### 2009, 2012, 2015 and 2018 IBC Foam Plastic Insulation

Foam plastic insulation products have some of the most stringent requirements governing their use, especially in commercial construction. The IBC Chapter 26 (Plastic) regulates use of plastic materials used in construction. Insulation products made with materials other than plastics will have different requirements; however, these products have other limitations that must be understood.

This discussion on the DuPont™ Thermax™ Wall System follows the prescriptive compliance path laid out in the IBC, Chapter 26, Section 2603.5: "Exterior Walls of Buildings of Any Height."



## SEVEN ELEMENTS OF 2018 IBC CHAPTER 26

There are seven elements to this section of the code that define foam plastic insulation products and their specific use in a commercial wall of Type I, II, III or IV construction.



### 2603.5.1 Fire-Resistance Rated Walls

Many third party listed hourly rated wall assemblies are available. Please contact a DuPont Technical Professional for further information on the assembly details.

### 2603.5.2 Thermal Barrier

Any foam plastic must be separated from the interior of a building by an approved thermal barrier per Section 2603.4. DuPont™ Thermax™ Brand Insulation has approval to be left exposed to the interior without additional thermal barrier per FM 4880. If the optional component of spray polyurethane foam is used in the stud cavity, 5/8" gypsum on the interior of the stud (or other approved thermal barrier) would be required.

### 2603.5.3 Potential Heat

The potential heat energy of foam plastic insulation in any portion of the wall cannot exceed the potential heat energy of the foam plastic insulation contained in the wall assembly tested in accordance with Section 2603.5.5. The National Fire Protection Association's NFPA 285 testing has been conducted on the Thermax™ Wall System and approvals have been obtained with several veneers as listed on page 20. The potential heat energy of DuPont™ Thermax™ Brand Exterior Insulation per NFPA 259 testing is approximately 9,000 Btu/lb.

### 2603.5.4 Flame Spread and Smoke Developed Indices

Foam plastic insulations must have a flame spread index of 25 or less and a smoke developed index of 450 or less as determined in accordance with ASTM E84 (Class A). DuPont™ Thermax™ XARMOR™ (ci) complies with this requirement up to a maximum thickness of 4.25".

### 2603.5.5 Vertical and lateral fire propagation

The wall assembly must be tested in accordance with NFPA 285. The test is referred to in the industry as the Multistory Flammability Test. The Thermax™ Wall System is approved with several veneer types per NFPA 285 testing (see page 20 for further details).

### 2603.5.6 Label Required

This section requires proper labeling of the foam plastic by an approved agency. The bundle unit label of DuPont™ Thermax™ XARMOR™ (ci) shows the Underwriters Laboratories (UL) logo as its approved agency.

### 2603.5.7 Ignition

DuPont™ Thermax™ Sheathing and Thermax™ XARMOR™ (ci) were both tested and passed NFPA 268 without the use of cladding. With a third party engineering judgement, any cladding that meets the exceptions shown below, or, has passed NFPA 268 by itself can be installed over Thermax™ Sheathing, Thermax™ (ci) or Thermax™ XARMOR™ (ci) and meet this requirement:

- Thermal barrier (for example, ½" exterior gypsum wall board)
- Concrete or masonry (min. 1" thick)
- Glass fiber reinforced concrete panels (min 3/8" thick)
- Metal panel veneer (min. .019" thick aluminum or .016" thick corrosion-resistant steel)
- Stucco (min. 0.875" thick)



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## WEATHER PROTECTION FOR EXTERIOR WALL ASSEMBLY

### Drainage Plane

Commercial steel stud wall construction must shed water effectively to the exterior to meet the requirements of the IBC. Chapter 14 (Exterior Wall) of the IBC describes the necessary requirements for a drainage plane in a variety of wall constructions using a prescriptive method including a water-resistive barrier (WRB) and flashing. However, the IBC also provides an exception in Section 1403.2 that allows a wall system to be tested under ASTM E331 to show an appropriate level of water resistance to meet the commercial code requirements. This exception removes a requirement for an explicit WRB and flashing, and in some cases, a combination of the exterior sheathing and flashing materials can be used to create a system that works as the drainage plane.

The DuPont™ Thermax™ Wall System was tested in accordance with ASTM E331 and has passed its rigorous testing requirements. Although the exception does not require flashing explicitly, the use of flashing material on the areas listed in this section of the code are all areas that require attention when detailing a system that can pass the ASTM E331 test protocol.

### 2018 IBC Section 1404 Installation of Wall Coverings (Flashing)

Flashing shall be installed in such a manner so as to prevent moisture from entering the wall or to redirect it to the exterior. Flashing shall be installed at the perimeters of exterior door and window assemblies, penetrations and terminations of exterior wall assemblies, exterior wall intersections with roofs, chimneys, porches, decks, balconies and similar projections and at built-in gutters and similar locations where moisture could enter the wall. Flashing with projecting flanges shall be installed on both sides and the ends of copings, under sills and continuously above projecting trim.

### ASTM E331 Testing

ASTM E331 was selected to demonstrate the water-resistive nature of the Thermax™ Wall System as it is referenced specifically in the building code and is a readily accepted standard in the industry.

This test method consists of a complete 8' x 8' wall mock-up that is exposed to a calibrated nozzle water spray rack while under pressure. The pressure differential is applied to simulate wind-driven rain. This test simulates 8" of wind-driven rainfall/hour. The pressure can be increased in an attempt to further draw the water through the system, simulating hurricane wind conditions. DuPont tested the wall mock-up at 6.24 psf to simulate wind-driven rain.

The IBC requires that the test be run for 2 hours at that pressure. There must be no visible leak for the wall to pass this test. The wall is examined thoroughly for any transport of water through the wall, fasteners or other penetrations and also at each component interface. No leaks were identified in the Thermax™ Wall System assembly, thus resulting in a pass of ASTM E331. DuPont conducted the ASTM E331 test at a third-party, IAS Accredited testing laboratory.

### Lab Penetration HydroHead Testing

The Heckmann Building Products POS-I-TIE System was used as the brick veneer wall tie in the ASTM E331 tested assembly. DuPont also tested other veneer ties to assess that they would meet or exceed the same water hold-out potential as the POS-I-TIE System. Based on a modified HydroHead test apparatus (AATCC 127), a column of water (for pressures seen in the ASTM E331 test) is placed on the surface of the wall section (tie/ flashing/ board sample or tie/board sample). The test sample was then allowed to sit for an extended period of time and examined for leaks.

As a result of the testing DuPont recommends proper sealing of the wall tie. When a veneer tie is near a board joint, the board joint should be covered with DuPont™ LiquidArmor™ Flashing and Sealant before inserting the brick tie. When the veneer tie is located in the field of the board, the veneer tie with a sealing washer mechanism will typically provide adequate protection from water intrusion and no flashing treatment is required behind the veneer tie. Fluid applied flashing may be applied prior to inserting the veneer tie insertion, though, if extra protection from water is desired.

## SYSTEM COMPONENTS

### DuPont™ Thermax™ Brand Exterior Insulation

Thermax™ Brand Insulation is the core component of the DuPont™ Thermax™ Wall System, and is available in three tiers for the system:

- **GOLD** – DuPont™ Thermax™ XARMOR™ (ci), with a 4 mil gray embossed aluminum front facer and 1 mil embossed aluminum back facer, making it the most durable option of the three
- **SILVER** – DuPont™ Thermax™ (ci), with a 1.25 mil blue embossed aluminum front facer and 1 mil smooth aluminum back facer
- **BRONZE** – DuPont™ Thermax™ Sheathing, with 1 mil smooth aluminum facers on both sides, allowing for a more economic option.

With more than 30 years of proven performance, Thermax™ Brand Exterior Insulation features a distinct free-rise technology for better product consistency, durability and fire performance than most generic polyisocyanurate insulations. An integral, durable thermoset-coated aluminum facer provides a drainage plane and water-resistant barrier, eliminating the extra step of installing a membrane or building wrap. The foam core provides one of the highest\* R-values available (R-6.9 at 1") for long-term thermal performance.



With its low permeability rating and high insulating value, Thermax™ Brand Exterior Insulation reduces the potential for condensation within the wall assembly.

### LiquidArmor™ Flashing and Sealant

DuPont™ LiquidArmor™ Flashing and Sealants are an elastomeric, liquid applied flashing engineered to have exceptional seal. They are used to protect the building superstructure from moisture intrusion at critical areas like board joints and penetrations. Fluid applied flashing with high performing ingredients such as LiquidArmor™ does not need any other accessories for gaps <1/4" wide. It will conform, fill and bridge narrow gaps between dissimilar materials easily without cutting or measuring.

In the Thermax™ Wall System, LiquidArmor™ Flashing and Sealant is used to seal joints of Thermax™ Brand Insulation and penetrations, such as around windows and doors. DuPont offers two formulations of LiquidArmor™ for all-weather application. LiquidArmor™ CM is an acrylic-based formulation used at temperatures 35 F degrees and rising. LiquidArmor™ QS is a quick-setting, spray (or brush) applied, acrylic-based formulation used at temperatures of 40°F and rising. LiquidArmor™ LT is a silicon-based formulation that can be used at temperatures as low as -20 F. Air barrier and water barrier performance of Thermax™ Wall System is met when LiquidArmor™ is used.

Spray polyurethane foam is an optional component in the Thermax™ Wall System. See our current detail set for current spray foam recommendations

**Table 4: Typical Physical<sup>1</sup> Properties Of Thermax™ Brand Exterior Insulation**

Property and Test Method	Value
Thermal Resistance <sup>2</sup> , ASTM C518, R-value	6.9
Compressive Strength <sup>3</sup> , ASTM D1621, psi	25.0
Flexural Strength, ASTM C203, psi	55.0
Water Absorption, ASTM C209, % by volume, MAX	0.1
Water Vapor Permeance, ASTM E96, perms	<0.03
Maximum Use Temperature, °F	250
Surface Burning Characteristics <sup>4</sup> , ASTM E84 for both core AND finished product	Class A
• Flame Spread	25
• Smoke Developed	<450
UV Resistance, days	180

<sup>1</sup> These are typical properties, not to be construed as specifications.

<sup>2</sup> R-value at 1" @ 75°F mean temperature. R-value expressed in ft<sup>2</sup>·h·°F/Btu.

<sup>3</sup> Vertical compressive strength is measured at 10 percent deformation or at yield, whichever occurs first.

<sup>4</sup> Calculated flammability values for this or any other material are not intended to represent hazards that may be present under actual fire conditions.

**Table 5: Typical Liquid Properties for LiquidArmor™ LT Flashing and Sealant**

Property	Typical Value
Form	Gray, trowel-applied flashing and sealant
Volatile Organic Compounds (VOC)	52
Specific Gravity	1.6
Shelf Life	12
Working Time (ASTM C98)	30



## EXPOSURE RATING

### Water Absorption Testing

It is important to understand the water absorption characteristics of common sheathing materials used in cavity wall construction due to the possibility that water may penetrate the sheathing layer. A common sheathing material is 5/8" thick exterior gypsum. Water absorption testing was conducted by DuPont comparing 5/8" thick exterior gypsum sheathing to 5/8" thick **DuPont™ Thermax™ Brand Exterior Insulation**. Table 4 outlines the water absorption comparison based on three different industry water absorption test procedures: ASTM C473, which is commonly used by the gypsum sheathing industry, and ASTM C272 and ASTM D2842, which are both used by the foam sheathing industry. The samples were prepared for testing according to three different protocols.

**Table 7: Water Absorption Testing Sample and Description**

Sample Preparation Reference	Description
#1 Control Gypsum	Standard 5/8" gypsum sample ("control")
#2 Gouged Gypsum	Gouged, where a cement trowel was dragged across the surface of the sample, gouging the gypsum board facer and core
#3 1/4" Hole Gypsum	1/4" drill bit was used to drill a hole through the gypsum sample thickness
#1 Control Thermax™ XARMOR™ (ci)	Standard 5/8" sample ("control") Thermax™ XARMOR™ (ci) board
#2 Gouged Thermax™ XARMOR™ (ci)	Gouged, where a cement trowel was dragged across the surface of the sample, gouging the Thermax™ XARMOR™ (ci) board facer and core
#3 1/4" Hole Thermax™ XARMOR™ (ci)	1/4" drill bit was used to drill a hole through the Thermax™ XARMOR™ (ci) sample thickness

The average value of repeated tests for each sample is listed in Table 8. The data show that per ASTM C473, testing the exterior gypsum had a water absorption approximately 21 times that of **Thermax™ Brand Exterior Insulation**. The data also show that according to ASTM D2842 testing the exterior gypsum had a water absorption approximately 17 times that of **Thermax™ Brand Exterior Insulation**. Gypsum sheathing absorbed more water than **Thermax™ Brand Exterior Insulation** for all sample preparations, and for all three water absorption methods used.

**Table 8: Water Absorption Testing of 5/8" Exterior Gypsum and 5/8" Thermax™ Brand Exterior Insulation**

Property and Test Method	Control Gypsum #1	Gouged Gypsum #2	1/4" Hole Gypsum #3	Control Thermax XARMOR™ (ci) #1	Gouged Thermax XARMOR™ (ci) #2	1/4" Hole Thermax XARMOR™ (ci) #3
Water Absorption, ASTM C473, Section 14, 2-hour test, % by volume	1.9	2.3	2.1	0.1	0.1	0.1
Water Absorption, ASTM C578-03b and ASTM C272-01, % by volume	7.5	9.1	5.8	0.3	0.3	0.3
Water Absorption, Procedure B, ASTM D2842-01, % by volume	15.2	19.0	16.7	0.8	1.0	1.0

Note: Test results apply only to the materials being tested. Values represent the average of those tested samples.

### UV Testing

The DuPont™ Thermax™ Wall System has been tested for suitable performance when left exposed up to 180 days. **DuPont™ Thermax™ Brand Exterior Insulation** was exposed to outdoor elements in both subtropical and cold northern U.S. climates for more than six months with no detrimental effects noted in the durability or physical appearance of the product.

### Exposure to Mortar

The exterior facer of **Thermax™ Brand Exterior Insulation** was also tested for extended contact with a high pH material per ASTM D1308. Testing was conducted with a solution that had a pH of approximately 12.5, similar to the pH of uncured mortar/concrete. This solution was placed on the surface of the **Thermax™ Brand Exterior Insulation** and allowed to sit for a period of 28 days while maintaining the pH of 12.5. During this 28-day period the samples were checked for any detrimental effects that the solution would have on the surface of the **Thermax™ Brand Exterior Insulation**, such as facer deterioration or discoloration. No detrimental effects were noted during this testing, thus qualifying this material for incremental contact with mortar during the build-up of a brick veneer assembly. ASTM E330 Wind Load Testing This testing resulted in the assembly passing wind loading criteria (10-second loading period) of 50 psf when subjected to negative wind loading and 75 psf when subjected to positive wind loading. *(Note: 50 psf is approximately 141 mph wind velocity under ideal conditions.)*

### ASTM E330 Wind Load Testing

This testing resulted in the assembly passing wind loading criteria (10-second loading period) of 50 psf when subjected to negative wind loading and 75 psf when subjected to positive wind loading. *(Note: 50 psf is approximately 141 mph wind velocity under ideal conditions.)*

To represent a wall system with the least strength, testing was conducted with 5/8" thick **Thermax™ Brand Exterior Insulation** only – and without **LiquidArmor™ Flashing and Sealant** or spray polyurethane foam in the stud cavity or in any bracing of the studs. Testing was conducted on **Thermax™ XARMOR™ (ci)** alone, as this is the first product to go on the wall, and applying the flashing tape over joints and behind penetrations as well as spray foam in the stud cavity may not immediately occur.

In the wind load test, 5/8" thick **Thermax™ XARMOR™ (ci)** was attached to 18-gauge steel studs using several different fastening schedules, and at 16" and 24" o.c. stud spacings.

The goal of this testing was to determine the most robust fastening schedule that could be used to adhere **Thermax™ XARMOR™ (ci)** independent of the product thickness and stud spacing.

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## FASTENING DuPont™ Thermax™ (ci) EXTERIOR INSULATION

Because of the ASTM E330 testing, DuPont recommends a fastening pattern of 12" o.c. around the perimeter and 16" o.c. in the field (Figure 11). The Rodenhouse Inc. Thermal-Grip Fastener is recommended, but other designs may be acceptable.

Perimeter fasteners can be detailed to bridge the gap of abutting board joints due to the 2" diameter of the washer used to fasten the board to the studs. These self-sealing fasteners and washers do not need additional sealing. Tighten fasteners until washer lies tight and flat against the insulation board, thus creating a seal.

### Rodenhouse Thermal-Grip Fasteners

- 2" dia. washer with solid cap design (no keyholes)
- Pre-spotting prongs
- Stiffened center "Bullseye" ring prevents fastener pull-through
- Flexible perimeter compresses on surface and reduces tearing
- Flattens on surface of insulation
- Carbon Black UV Stabilizers



Figure 11: Fastening Pattern; Thermax™ Brand Exterior Insulation

Detailed installation tips: <http://rodenhouse-inc.com/brand/dow/>. For fastener type and frequency guidance to installing cladding over thick foam sheathing, refer to the Foam Sheathing Coalition, TechMatters: Guide to Attaching Exterior Wall Covering Through Foam Sheathing to Wood or Steel Wall Framing. Download details from [www.bia.org](http://www.bia.org).

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## RECOMMENDED VENEER TIES

### Heckman Building Products Thermal-Grip Installed on Pos-I-Tie System

- Two-piece system for attaching brick veneer to various existing backups
- Incorporates barrel-screw piece, which allows easy installation
- Neoprene washer helps prevent moisture penetration by sealing the hole in insulation/gypsum board backup
- The Thermal-Grip over-sized washer with the Original Pos-I-Tie Veneer Anchoring System reduces the thermal bridging from the cavity to the backup

### Hohmann and Bernard 2-Seal Thermal Wing Nut Anchor

- Dual Diameter barrel and factory installed EPDM washers to seal both the face of the insulation and the air/vapor barrier
- Thermal Wings designed to decrease thermal transfer through rigid insulation
- Self-sealing



## APPROVED VENEERS

Based on extensive third-party NFPA 285 testing, the following veneers are approved for use with the DuPont™

Thermax™ Wall System:

- Brick (clay) (Figure 12)
- Stucco (Figure 13)
- Metal Composite Metal (MCM) (Figure 14)
- Terracotta cladding
- Metal panel (Figure 14 shows option with Knight Wall System)
- Cement board siding – noncombustible siding per ASTM E136
- Masonry veneer
- Thin brick panels
- Concrete panels

**Note:** Approvals for the above claddings are specific to certain manufacturers. Please reference the relevant code report: ICC-ESR 1659 or contact DuPont Performance Building Solutions for a detailed list of these approved cladding options.

Design guides, CAD details and BIM models may be found at [www.thermaxwallssystem.com](http://www.thermaxwallssystem.com).

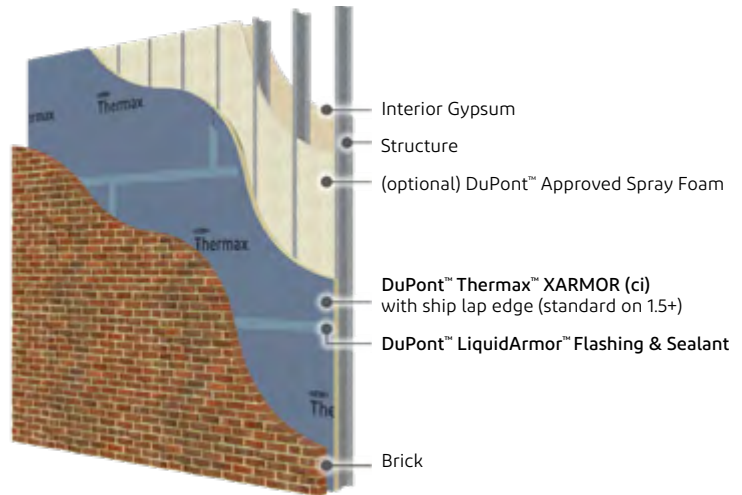


Figure 12: Brick

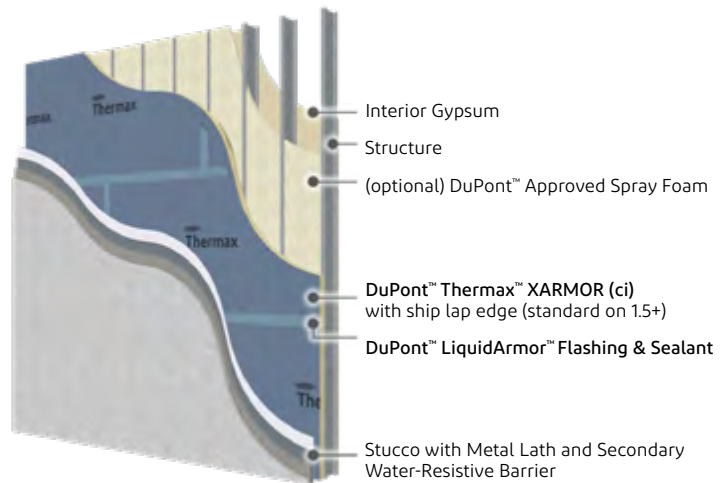


Figure 13: Stucco

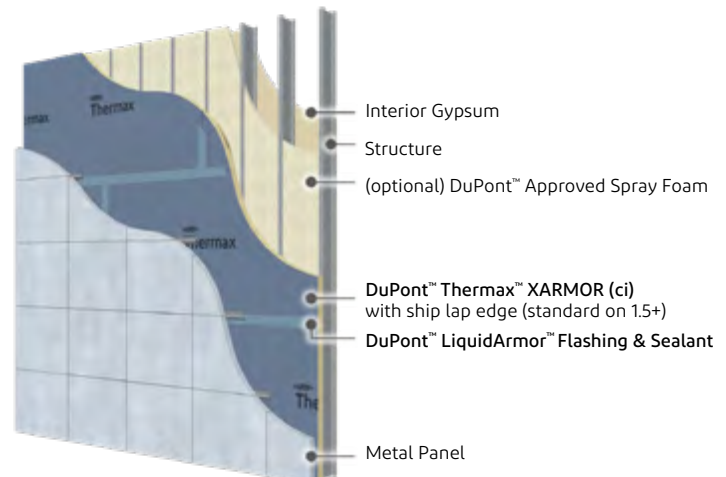


Figure 14: Metal Panel or MCM



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## LINTEL AND BRICK LEDGE SIZE

An important design consideration is to determine the appropriate size of lintels and brick ledge for adequate and uniform load bearing. A thicker sheathing such as **DuPont™ Thermax™ Brand Insulation** may require a wider lintel and brick ledge. Determining lintel and brick ledge size is the responsibility of the architect/designer.

According to the Brick Industry Association's Technical Note 31B: The steel for lintels, as a minimum, should comply with ASTM A36. Steel angle lintels should be at least 1/4" thick with a horizontal leg of at least 3-1/2" for use with nominal 4" thick brick, and 3" for use with nominal 3" thick brick.

### Masonry Drainage System

A masonry drainage system that prevents mortar droppings from forming a continuous dam is an important part of proper masonry construction. The system catches and permanently suspends mortar droppings in an irregular pattern above the weep hole vents, allowing weep holes to stay open.

### Summary

Since launch, the DuPont™ Thermax™ Wall System has been successfully used on projects from schools to luxury condos across North America. Designers, installers and building owners have been able to take advantage of the innovative 3-in-1 performance of thermal, air and water barriers in an easy to use wall assembly, saving time on job sites with realized operational energy savings and reduced carbon footprint. Contact a DuPont sales representative for information on specific case studies and LEED project examples.



For more information visit us at  
[thermaxwallsystem.com](http://thermaxwallsystem.com)  
or call 1-866-583-2583

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Illustrations are not intended to replace the need for design by appropriate professionals such as architects or engineers.

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#### DuPont Polyisocyanurate Insulation

**CAUTION:** This product is combustible and shall only be used as specified by the local building code with respect to flame spread classification and to the use of a suitable thermal barrier. For more information call the DuPont Contact Center at 866-583-2583 or contact your local building inspector. For emergencies contact Chemtrec 800-424-9300, CCN (Contract Number) 7442.

**WARNING: Rigid foam insulation does not constitute a working walkable surface or qualify as a fall protection product.**

#### DuPont Polyurethane Foam Insulation and Sealants

**CAUTION:** When cured, these products are combustible and will burn if exposed to open flame or sparks from high-energy sources. Do not expose to temperatures above 240°F (116°C). For more information call the DuPont Contact Center at 866-583-2583 or contact your local building inspector. For emergencies contact Chemtrec 800-424-9300, CCN (Contract Number) 7442. In an emergency, call 1-989-636-4400 in the U.S. or 1-519-339-3711 in Canada. When air sealing buildings, ensure that combustion appliances, such as furnaces, water heaters, wood burning stoves, gas stoves and gas dryers are properly vented to the outside. See website: <http://www.epa.gov/iaq/homes/hip-ventilation.html>. In Canada visit <http://archive.nrc-cnrc.gc.ca/eng/ibp/irc/bsi/83-house-ventilation.html>.

Froth-Pak™ Spray Polyurethane Foam contains isocyanate, hydrofluorocarbon blowing agent and polyol. Read the instructions and Material Safety Data Sheets carefully before use. Wear protective clothing (including long sleeves), gloves, goggles or safety glasses, and proper respiratory protection. Do not breathe vapor or mist. Use only with adequate ventilation. It is recommended that applicators and those working in the spray area wear respiratory protection. Increased ventilation significantly reduces the potential for isocyanate exposure, however, supplied air or an approved air-purifying respirator equipped with an organic vapor sorbent and a particulate filter may still be required to maintain exposure levels below ACGIH, OSHA, WEEL or other applicable limits. For situations where the atmospheric levels may exceed the level for which an air-purifying respirator is effective, use a positive-pressure, air-supplying respirator (air line or self-contained breathing apparatus). Spraying large amounts of foam indoors may require the use of a positive pressure, air-supplying respirator. Contents under pressure.

Isocyanate is irritating to the eyes, skin and respiratory system, and may cause sensitization by inhalation or skin contact. Froth-Pak™ foam should not be used by anyone who has been sensitized to isocyanates.

- Froth-Pak™ foam should not be used around heaters, furnaces, fireplaces, recessed lighting fixtures or other applications where the foam may come in contact with heat-conducting surfaces.
- Cured Froth-Pak™ foam is combustible and will burn if exposed to open flame or sparks from high-energy sources. Do not expose to temperatures above 240°F.
- Follow all applicable federal, state, local and employer regulations.

Great Stuff Pro™ sealant and adhesive products contain isocyanate and a flammable blowing agent. Read all instructions and (M)SDS carefully before use. Eliminate all sources of ignition before use. Cover all skin. Wear long sleeves, gloves, and safety glasses or goggles. Provide adequate ventilation or wear proper respiratory protection. Contents under pressure. Not to be used for filling closed cavities or voids such as behind walls and under tub surrounds.

Building and/or construction practices unrelated to building materials could greatly affect moisture and the potential for mold formation. No material supplier including DuPont can give assurance that mold will not develop in any specific system. This improper use of the product could result in the accumulation of flammable vapors and/or uncured material. Failure to follow the warnings and instructions provided with the product, and/or all applicable rules and regulations, can result in injury or death.

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